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Catarina Schreck Reis ^{a b}, Hélia Marchante ^{a c}, Helena Freitas ^a & Elizabete Marchante ^a

^a Department of Life Sciences, Centre for Functional Ecology, University of Coimbra, Coimbra, Portugal

^b Department of Education, Centre for Didactics and Technology in Teacher Education, University of Aveiro, Aveiro, Portugal

^c Department of Environment, Center for Studies of Natural Resources, Environment and Society, Escola Superior Agrária de Coimbra, Coimbra, Portugal

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RESEARCH PAPER

Public Perception of Invasive Plant Species: Assessing the impact of workshop activities to promote young students' awareness

Catarina Schreck Reis^{a,b}, Hélia Marchante^{a,c}, Helena Freitas^a and Elizabete Marchante^{a*}

^a*Department of Life Sciences, Centre for Functional Ecology, University of Coimbra, Coimbra, Portugal;* ^b*Department of Education, Centre for Didactics and Technology in Teacher Education, University of Aveiro, Aveiro, Portugal;* ^c*Department of Environment, Center for Studies of Natural Resources, Environment and Society, Escola Superior Agrária de Coimbra, Coimbra, Portugal*

Invasive species are one of the main threats to biodiversity worldwide. Even though they are identified and recognized as such by the Portuguese law, the majority of the population is not yet aware of this problem. Aiming to increase awareness about biological invasions among young students, a workshop on Invasive Plant Species was organized at the Botanical Museum of the University of Coimbra. A total of 170 teenager students from five schools participated in the workshop. Three activities were prepared, focusing on: (1) identification of invasive plants, (2) competition between native and invasive plants and (3) control of invasive plants. One year later, questionnaires were sent to the participants, aiming to appraise workshop effectiveness, and this questionnaire revealed that these students know more about invasive plant species than a comparable group of students that did not participate in the workshop. The results clearly showed that practical informal education activities may be effective in raising public awareness. Questionnaires were essential to evaluate the knowledge acquired and retained by the students during the workshop.

Keywords: *Biodiversity; Biological invasions; Environmental and scientific education; Evaluation of practical activities; Questionnaires*

*Corresponding author. Department of Life Sciences, Centre for Functional Ecology, University of Coimbra, P.O. Box 3046, 3001-401, Coimbra, Portugal. Email: elizabete.marchante@gmail.com

1. Introduction

Every person is a potential vector of introduction and spread of Invasive Alien Species (IAS), and, on the other hand, everyone can play a major role in helping to control them and/or prevent their introduction, so effective public awareness is essential to the management of IAS.

The present work describes the activities and outreaches of a workshop projected to raise awareness about plant invasions among teenager students. An introductory short talk and practical activities were organized, aiming to catch students' attention and engage them with this subject. One year later, an evaluation was performed in order to appraise the true effectiveness of the workshop developed.

1.1 *Why Talk about Invasive Plant Species in the Biodiversity Context?*

Many of the plants that we see nowadays were transported from their native ranges to other places in the world, being named exotic or alien plants. Some of these plants remain in the places where they were planted and grow without representing a threat to native species. However, others reproduce and disperse very quickly, maintaining self-sustaining populations at considerable distances from parent plants and becoming out of human control—these are invasive plants (Richardson et al., 2000). Besides overcoming geographical barriers, invasive plants overcome biotic and abiotic barriers, maintaining self-reproductive populations. Once introduced, invasive plants have the ability to increase their populations and distributions without direct human intervention, and may threaten native ecosystems, food production and even human health and economy (Mooney et al., 2005).

Biological invasions, not only by plant species but also by other organisms, are a widespread and significant component of human-caused global-environmental change (Mooney & Hobbs, 2000). Portuguese legislation (Decreto-Lei n.º 565/99, Ministério do Ambiente, 1999) lists about 400 exotic plant species as introduced in Portugal, and from these classifies 30 as invasive. More recently, Almeida and Freitas (2006) and Marchante, Freitas, and Marchante (2008a) referred over 550 exotic plant species introduced in mainland Portugal, including species that are considered as casuals, sub-spontaneous or invasive. Even though IAS are considered one of the main threats to the world biodiversity (Mooney et al., 2005; Richardson & Pyšek, 2006) and the problem is already recognized by the Portuguese law, this subject is still unfamiliar to a large part of the Portuguese population. The control and management of widespread invasive species is extremely difficult and costly. Therefore, the best way to deal with invasive species is to start by preventing their introduction (Commission of the European Communities, 2008), and for that raising public awareness is crucial.

1.2 *Why Invest in Public Awareness Activities about IAS?*

Together with limited resources and insufficient coordination among public administrations, lack of public awareness is recognized as contributing to the ineffective

management of IAS (Andreu, Vilà, & Hulme, 2009). The higher level of public awareness about invasive species could have huge implications in the improved success of biodiversity management success (Fisher & van der Wal, 2007) and even in the prevention of IAS that can threaten Europe biodiversity (Hulme, Nentwig, Pyšek, & Vilà, 2009). On the other hand, the inability to correctly identify a particular species, or even distinguish between a native and an invasive species can have harmful consequences to the wildlife (Somaweera, Somaweera, & Shine, 2010).

Public awareness is therefore essential to draw different publics attention to the problem and the species involved. An educated public can help prevent introduction of IAS and to control IAS already present, which will contribute to mitigate the problems caused by these species. Conscious of the need to inform the public about this theme, a team gathering researchers from the Centre for Functional Ecology (CFE) of the University of Coimbra and from the Centre of Studies for Natural Resources, Environment and Society (CERNAS) of Agrarian School of Coimbra has been involved in promoting public awareness about invasive plants in Portugal (Marchante, Marchante, Morais, & Freitas, 2010) along with the scientific research on plant invasions. The activities developed have targeted different publics and include: (1) Field-work Projects to learn about invasive plant species and how to control them, (2) Training Courses about identification and control of invasive plants for professionals dealing with exotic plants, (3) a Web Page (www.ci.uc.pt/invasoras) about invasive plant species in Portugal, (4) Online questionnaires targeting several technical publics, and (5) Printed documentation aiming to create awareness about the problem and help to identify the most common and problematic invasive plants in Portugal (Marchante, Marchante, & Freitas, 2005a, 2005b; Marchante & Marchante, 2007; Marchante et al., 2008a; Marchante, Marchante, Morais, Schreck Reis, & Freitas, 2008b).

1.3 *Why Develop Practical Workshops for Young Students?*

In order to understand the relationships between people and IAS, an effective management that leads to minimize the spread of IAS must take into consideration the full spectrum of target publics (Reaser, 2001), as well as to be developed for specific target groups (Nuñez & Pauchard, 2010). However, young students are usually a less common target of awareness concerning IAS when compared with the general public (Bremner & Park, 2007; Somaweera et al., 2010) or stakeholders (Andreu et al., 2009; García-Llorente, Martín-López, González, Alcorlo, & Montes, 2008). Although many efforts have been made, it is worthwhile continuing to invest resources in public awareness and environmental education, since only by doing so, perceptions and hence attitudes can change in time (De Poorter, 2001). In fact, although students perceptions about biodiversity are in some cases low (Lindermann-Matthies & Bose, 2008), their active interest can be expressed if suitable didactic methods of communication are used (Strgar, 2007), which can reach successful impacts on the management of biodiversity (Fisher & van der Wal, 2007).

Biological invasions are a topic that has only been recently, and briefly, included in school curricula in Portugal. Since this is a relatively recent concern of the scientific community, it is not uncommon to find teachers that do not have a good knowledge on the subject. Apprehensive about giving incorrect or much incomplete information to the students, sometimes teachers choose not to refer to the subject of biological invasions in classes. However, the young student population should not be elapsd when developing awareness about invasive species in particular or biodiversity conservation in general, since the messages retained at this age can be of great importance in the development of environmental positive attitudes in the future.

1.4 Why Evaluate Public Awareness Activities?

Adequate evaluation of effectiveness is essential when communicating and raising-awareness, but it is frequently absent (O'Loughlin & Wegimont, 2007). It is consensual that greater public awareness is necessary in relation to IAS (Colton & Alpert, 1998; De Poorter, 2001; Hulme et al., 2009; Lindermann-Matthies & Bose, 2008; Marchante et al., 2010; O'Loughlin & Wegimont, 2007; Reaser, 2001), however it is hard to find references to the evaluation of the awareness activities developed and their effective impact on the public, which is essential to enhance the ability to meet the goals proposed (Krasny & Lee, 2002).

To be actually effective, public awareness must take into consideration local cases of IAS (Colton & Alpert, 1998), such as particular species that the public can easily find in their everyday life. It is recognized that scale matters in public awareness: one person can easily understand the consequences if activities affects him/her directly, but less if the consequences affects the local community, the nation, the continent, or even the globe (De Poorter, 2001).

In order to improve further public awareness initiatives, it was considered essential to perform the evaluation of the workshop. For that, one year after the workshop, questionnaires about plant invasions were sent to participants aiming to appraise the effectiveness of the workshop that were developed during the workshop and the knowledge acquired and retained by the students.

2. Methodology

The 'Invasive Plant Species—What are they? Where do they come from? What problems do they cause?' workshop was organized in the context of the Portuguese National Science and Technology Week, running from 24 to 28 November 2008, and took place in the Botanical Museum of the University of Coimbra. For five days, two sessions were offered each day, one in the morning and other in the afternoon (2 hours each). Each session included a short introductory talk and three activities. The evaluation of the workshop was performed one year later through a questionnaire sent to the students who had participated in the workshop and also to a comparable group that did not attend the workshop.

2.1 Target-Public

The workshop was addressed to students aged from 13 to 15 years old, which corresponds to the eighth and ninth grade in Portugal. This target public was selected considering the students' great potential to influence and raise public awareness both in the school and also in the larger community. In addition, biological invasions were recently included in the school curricula of these levels, although they are only briefly discussed. Invitations were sent to all 183 public and private schools from the Regional Direction of Education–Central Portugal. The first eight groups who registered were selected to participate. Each group had up to 24 students. Participants reached a total of 170 students from five different schools.

2.2 Invasive Plant Species Workshop

On arrival, a brief introductory talk about invasive plants was given. Basic concepts, such as native, exotic and invasive plant, and the problems caused by these species were explained, some examples of the worse invasive plants in Portugal were given, describing the key characteristics for identification, the region of origin, the problems caused in the exotic range and their impacts on native biodiversity. Additionally, a list of simple things that everybody can do to prevent plant invasions was shown and discussed with the students. The presentation lasted about 20 minutes.

Afterwards, the group was divided into two smaller groups, with up to 12 students. Two practical activities were prepared and both sub-groups took part in both, one at a time. The activities focused on different issues of plant invasion, one about the competition between native and invasive plants (activity 1) and the other about control of invasive plants (activity 2). Finally, the students gathered again to learn how to recognize some of the worse invasive plant species in Portugal (activity 3). All activities were prepared using common and inexpensive materials, easily obtained.

2.3 Plant Invasion Questionnaire

About one year after the workshop, a questionnaire was prepared aiming to evaluate the long-term efficacy of the workshop based on the knowledge retained by the students. The questionnaire was distributed to the students who participated in the workshop and to students from the same schools and the same age range (13–15 years old), but that did not participate in the workshop. The latter worked as a control group.

The questionnaires (Appendix) consisted of four pages with a total of 10 questions. The first two pages had nine close-ended questions about definitions of native, exotic and invasive plants, problems associated with invasive plants and most efficient control methods. The other two pages included one single question with the 16 pictures of native and invasive plants that were presented at the workshop, and students were asked to write the common or scientific name of each plant and to indicate if the plant was native or invasive in Portugal.

A total of 340 questionnaires were sent to the participant schools and 150 questionnaires were responded, 68 (45.3%) from students that attended the workshop one year earlier, and 82 (54.7%) from students that did not attend the workshop. The questionnaires from participant students were answered by 30 girls and 38 boys, and the average age was 14.7 years old. The questionnaires from non-participant students were answered by 46 girls and 36 boys and the average age was 13.6 years old.

2.4 Data Analyses

The responses provided by participant and non-participant students in the workshop were analyzed using analysis of variance (1-way ANOVA) after confirming the assumption of homogeneity with the Bartlett test. Statistical analyses were carried out using STATISTICA 6.0.

3. Workshop Activities

3.1 Activity 1—Competing for Resources

This game was adapted from Vieira (2002), with some modifications. The activity was performed in a large indoor area, but it can also be carried out outdoors. For a group of 12 students, the materials used were: a rope of about 3 m to mark the starting point; 11 arcs of about 50 cm diameter or same size circles made with a rope; 33 paperboard resource cards: 11 WATER, 11 LIGHT and 11 NUTRIENTS; 12 arm or bracelet ribbons with the word INVADER.

Two different paths starting and ending together were set: one linear, direct path and one longer path, with several obstacles in the way. Along the way, the paths join in three intermediate points, where the resource cards were placed. At the end of both paths, there were ropes in the circle placed on the floor. The number of ropes was equal to the number of students playing as native species in the beginning of the activity (11) (Figure 1). The shorter path was used by students representing invasive plants (a ribbon with the word INVADER was used in the arm to identify

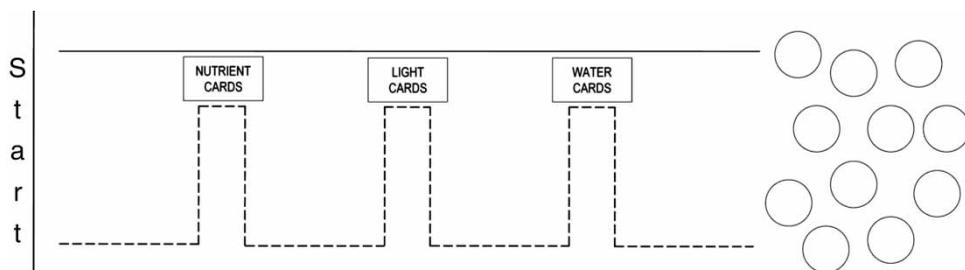


Figure 1. Schematic representation of the material distribution in the activity 'Competing for Resources'. — Path for students playing as invasive plants; - - - path for students playing as native plants; ○ habitats)

these students) and the longer path was used by students representing native plants. The cards represented the resources needed for plants to live. The circular ropes represented the plant *habitat*.

The activity was played in several rounds, the first one starting with only one invasive plant and all other students representing native plants. All students began to walk at the same time from the starting point, each group going through their correspondent path, invasive or native. Along the way, each student had to collect one card of each resource, reaching their place in one *habitat*; only students with the three resource cards could occupy a place in the *habitat*. The number of available cards was not enough for all the students. Since the student playing as an invasive plant followed an easier path, he/she was the first to collect all the three cards and to reach a place in the *habitat*. Students playing as native plants would have to follow the longer path and it could happen that some of the resource cards were not available to collect.

At the end of the first round, one or more native students, depending on the resource cards distribution, could not take place in one *habitat* since they did not have all the resources needed to live. For instance, if only one of each resource cards had been removed, all students but one had all cards and reached a place in the *habitat*. The discussion was encouraged by asking questions like: ‘What happened to this native plant? Why did not it get the resources needed for survival? Who took the resources that were previously available? Why has the invasive plant used more resources? Where did the invasive plant come from?’ were asked. But if three light cards or/and two water cards were removed, at the end of the round, several students could not enter the *habitat* since they did not have all the three resources necessary. In this case, questions like: ‘Why cannot these native plants live? Can they live only with food? Who took the water/light that they need? Why is the invasive plant population growing so rapidly? What is happening to the native plants?’ could be asked.

On the next round, students that did not achieve one *habitat* would play the game as invasive species. The activity went on, and before each round, one or more resource cards were removed, in a way that resources were not enough for all the players. At the end of each round, the students who could not collect the three resource cards were identified as invasive species and in the next round walked along the easier, shorter path. By the fourth or fifth round, more students were playing as invasive plants than as native plants. At the end of the game, when only two or three students were acting as native plants, the questions addressed were: ‘What happened to the native plants? What could happen to the native plants if we keep playing the game? How did the introduction of only one invasive plant affect the ecosystem?’

If no large space is available this activity can also be adapted to a small area like a classroom. Instead of having one shorter and one longer path, both paths can have the same length, but students acting as invasive plants can have barriers, like seats to cross over or a table to cross under, or can walk on one foot or inside a fabric bag.

3.2 Activity 2—Invading, Inventorying and Controlling

This activity was adapted from the Weed Invasion (2010) Website, with some modifications. It was performed in an indoor space of about 9 m², but could also be adapted outdoors. For a group of 12 students, the materials used were: 25 paperboard plant leaves with different shapes and colours (except green); 250 paperboard green leaves with the shape of a well-known invasive species (*Acacia longifolia* shaped leaves were used since it is a widespread invasive species along the Portuguese coast); 12 ropes with 2.5 m (four to make the ecosystem borders and eight to make the transects); tape-measure; two tweezers; two water sprinklers; two small brooms and spades. A cardboard was used to annotate data from inventories.

The activity aimed to simulate the evolution of one ecosystem during its invasion by an invasive plant species and finally the attempt to control the invader. Before starting the activity, students were divided into three groups; 4 students for the ‘invading group’, 2 students for the ‘inventorying group’ and 6 students for the ‘controlling group’.

The first group started by ‘constructing’ the ecosystem with four ropes, limiting a square, and distributing the leaves of native plants all over the ecosystem (Figure 2(a)). Then, they searched for the leaves of the invasive plant (*A. longifolia*) that were hidden in a more distant place of the Museum, simulating a trip to Australia (native range of *A. longifolia*), from where they brought seeds of *A. longifolia* that rapidly invaded the ecosystem (Figure 2(b)). During the construction and the invasion of the ecosystem, in order to stimulate the discussion, students were asked questions like: ‘How can the invasive plant get here? Why is the population of the invasive plant so big? How is the diversity of the native plants compared with the invaded community? What happened to the native plants after the arrival of the invasive plants?’

The second group was responsible for the inventory activity of the plants existing in the ecosystem, and allowed students to act as field biologists. First, transects were placed 50 cm apart from each other, both parallels and perpendiculars, forming 50 cm squares, using ropes with the help of the tape-measure (Figure 2(c)). Secondly, students chose four or five parcels to make inventories, counting all the plants present inside each parcel, native and invasive. Students were asked to select the parcels that better represented the number and proportion of the plants in the entire ecosystem. The concept of representative parcels was, for most of the students, difficult to understand, but at the end of the activity, when students were informed of the total number of native and invasive leaves distributed (25 native leaves and 250 invasive leaves were distributed in the 2.5 m² ecosystem, divided in 25 parcels) almost all students could easily decide on the parcel that had the closest proportional number of native and invasive plants in relation to the entire ecosystem. Questions like: ‘Is it easy to perform inventories in large areas? Is the inventory on only one small parcel enough to obtain representative results? What could be done to achieve the closest representative result?’ were asked to encourage debate.

The third group removed the ropes used to build transects, leaving only two ropes in order to divide the ecosystem in three rectangular parcels. Students were divided



Figure 2. Images showing several steps of the activity 2 ‘Invading, Inventorying and Controlling’: (a) creating the ecosystem with native plants; (b) simulating plant invasion; (c) setting transects for inventory; (d) manual control, with tweezers; (e) mechanical control, with brooms and spades; (f) chemical control, with water sprinklers

into three groups of two, and each group was responsible for controlling the invasive plants presented in one parcel in 45 seconds using different control methods: manual control, represented by the tweezers (Figure 2(d)); mechanical control, represented by brooms and spades (Figure 2(e)) and chemical control, represented by water sprinklers (Figure 2(f)). At the end, the advantages and disadvantages of each control method were discussed, questioning the students:

Which control method was more efficient? Does this method have disadvantages? Is there any method that does not have disadvantages and is totally effective? What happened to the native plants in each of the control methods? Is there any control method for invasive plants that does not affect native plants? How would you classify this method in terms of efficiency for controlling invasive plants? Do herbicides affect only the invasive plants? After the control actions, the ecosystem is free of invasive plants? What about the re-sprouts and the seeds in the soil? Would it be enough to perform only one control treatment?.

The discussion allowed students to better understand the message underlying the activity.

In smaller areas or for smaller groups this activity can be adapted by building the ecosystem on a table, using smaller leaves and the control methods can also be replaced: the tweezers remain for manual control, small dropping-bottles can be used for chemical control and tooth-brushes can represent mechanical control.

3.3 Activity 3—Recognizing Native and Invasive Plants

Students were invited to watch a series of 16 pictures that included native and invasive plant species in Portugal. Firstly, pictures were shown for 30 seconds with both scientific and common names depicted, and with the indication of the invasive or native status. Afterwards the same pictures were presented, following a different sequence and with no information given. The students were asked to name the plant and if it was native or invasive in Portugal. The game was played with several teams that responded in turn; when one team gave the wrong answer, another could respond, creating a competitive dynamic interaction, enthusiastically received by the students.

The ‘Recognizing native and invasive plants’ activity confirmed that the knowledge of students about plants in general was low. Even emblematic native species, protected by law in Portugal like English Holly (*Ilex aquifolium*) (Decreto-Lei n.º 423/1989) or cork oak (*Quercus suber*, Decreto-Lei n.º 169/2001) were misidentified or referred as invasive or exotic; on the contrary, some of the most common invasive species (e.g. *Acacia dealbata*) were identified as native to Portugal.

In the end, students were offered printed documentation about invasive plants that included a few basic concepts and a website where they could search for more information.

4. Results

4.1 Invasive Plant Species Workshop

During the workshop students had the opportunity to learn key concepts about invasive plants on the brief introductory talk, and particularly on the practical activities that were developed. In general, participants managed to answer the questions and understand the concepts that were intended to transmit through the activities. Especially, the students from the 8th grade could integrate the new concepts with concepts learned during biology classes, namely ecosystem, population and food webs.

Students were engaged in the games from the beginning. The dynamics used were well received and understood by the students and teachers, and the themes exposed in the initial presentation were further explored and perceived. The way discussion was promoted by the monitors, asking several questions to the students during the development of the activities, stimulated the students to think in order to reach their own answers and conclusions. At the end of the session, the perception of the students concerning invasive species had improved considerably and they were challenged, together with the teachers, to organize activities about biological invasions in their schools.

4.2 Plant Invasion Questionnaire

The results from the questionnaires were analyzed in order to evaluate the concepts acquired about the invasive plant thematic by students who participated in the workshop. In addition, responses from these students were compared with responses from students who did not participate in the workshop.

Definition of native species was considerably well known by both groups of students, participants and non-participants, but uncertainty is still common when students are asked to distinguish exotic and invasive plants. All questions—concerning definitions, synonyms or differences between native, exotic and invasive plant species—were answered more correctly by students who participated in the workshop (Table 1—questions 1–3).

Students were also asked about the number of invasive plant species present in Portugal. This was one of the few questions, where the percentage of correct responses was statistically similar among non-participant and participant students (Table 1—question 4). Possibly, because students were not able to remember the exact number they responded randomly. However, all students who participated in the workshop and gave a wrong answer to this question chose the highest value given as their hypothesis (400), which suggests that these students got the idea that the presence of invasive plants is in fact a big problem that cannot be underestimated.

During the workshop, it was explained how plant species arrive to the exotic range and why they became invasive there. One year after, students who attended the workshop were more capable to choose the most complete answer about this issue by comparison with non-participant students (Table 1—question 5). The percentages shown represent the value of the only absolutely correct answer from the five hypotheses given. Many students gave incomplete answers by choosing only 1 of the 3 partially

Table 1. Percentage of correct answers given by participant and non-participant students of the workshop about invasive plants (answers to questions 1–5, 7 and 8 of the questionnaire)

Questions	Participants (%)	Non-participants (%)	Significance (<i>p</i>)
1. Synonyms of native plant	57.4	39.0	0.0252
2. Differences between invasive and exotic species	76.5	61.0	0.0432
3. Definition of native plant	80.9	62.2	0.0121
3. Definition of exotic plant	44.1	24.4	0.0105
3. Definition of invasive plant	44.1	28.1	0.0407
4. Number of invasive plant species reported in Portugal	39.7	51.2	n.s.
5. How invasive plants arrive in Portugal	38.2	6.1	0.000
7. Existence of legislation for the introduction of non-native species in Portugal	73.5	45.1	0.0004
8. Best approach for controlling invasive species	48.5	35.4	n.s.

correct options, but even in this case, significant differences could be found between the two groups of students: 47.6% for non-participants against 30.9% for participants in the workshop.

Students were asked about the Portuguese legislation concerning the introduction of exotic species in nature. The question was presented to the students with a 'yes' or 'no' answer, which could influence the response, namely helping the non-participant students. However, significantly more students that participated in the workshop knew about the law than non-participant students (Table 1—question 7), showing that this was one of the messages that students retained from the workshop.

Advantages and disadvantages of three of the most common control methods of invasive plant species were discussed in the 'Invading, Inventorying and Controlling' activity. In the questionnaire, students were asked to choose the most complete response concerning control among five, being three incomplete, one wrong and one complete. Differences between participants and non-participant students were not statistically significant, although there is a tendency for a better understanding of the concepts concerning invasive plant species by the participant students (Table 1—question 8).

When students were asked to indicate the environmental problems that could be caused by invasive plant species (Table 2—question 6), less than 7.4% of the participant students identified problems that were not directly caused by invasive plants (increase of CO₂ level, sea level rise and increase of air pollution), but many more non-participant students selected them. Problems such as biodiversity loss, changes in food-webs, decrease of available resources for native plants and high costs in control actions, all referred to several times in the talk and practical activities in the workshop, were mainly identified by participant students.

Table 2. Problems that students believed to be caused by invasive plants (answers to question 6 of the questionnaire)

Problems	Participants (%)	Non-participants (%)	Significance (<i>p</i>)
Biodiversity loss	60.3	29.3	0.0001
Reduction in agricultural productivity	55.9	53.7	n.s.
Increase of CO ₂ level	7.4	35.4	0.00003
High economic costs in control actions	61.8	40.2	0.008
Sea level rise	2.9	7.3	n.s.
Public health problems such as allergies	72.1	59.8	n.s.
Landscape scenery change	80.9	68.3	n.s.
Increase of erosion problems	10.3	18.3	n.s.
Changes in water resources	19.1	25.6	n.s.
Increase of air pollution	1.5	15.9	0.002
Changes in food-webs	67.6	36.6	0.0001
Decrease of available resources for native plants	82.4	63.4	0.009

Table 3. Most effective measures to prevent spread of invasive plant species (answers to question 9 of the questionnaire)

Measures	Participants (%)	Non-participants (%)	Significance (<i>p</i>)
Awareness	66.2	42.7	0.004
Control	80.9	59.8	0.005
Inspection	67.6	59.8	n.s.
Only one measure selected	27.9	50	0.006
Only two measures selected	13.2	6.1	n.s.
All three measures selected	54.4	32.9	0.008
Incorrect or unanswered	4.5	11	n.s.

When students were asked to mark the most effective measure to avoid proliferation of invasive plant species, considerable differences were found between participants and non-participant students (Table 3—question 9). Most non-participant students selected only one of the measures in opposition to all three measures selected by the majority of participant students. Control was the main selected measure chosen by participant students, probably due to the importance given to the subject in the workshop. Non-participant students have chosen control and inspection equally.

The same pictures of native and invasive species used in activity 3 of the workshop were presented to the students in the questionnaire. Students were asked to indicate if each species was native or invasive in Portugal, and additionally to identify their common or scientific name, both being accepted if correct. Ten species (five native and five invasive) were recognized by more than 50% of the participant students, while only four native species were recognized by more than 50% of the non-participants (Table 4—question 10). Significant differences in species recognition were found between participant and non-participant students for almost all invasive species (exception for *Ailanthus altissima*), while for native species differences were only found for *Ilex aquifolium*, a species that is particularly emblematic for Christmas time and is protected by the Portuguese law.

Identification (specifically being able to attribute a name) of plant species proved to be particularly difficult for both participant and non-participant students. The percentage of students who correctly named the species was very low in both groups and the only species that were correctly identified by more than half of the students were all native (*Olea europaea*, *Quercus suber*, *Quercus robur* and *Ilex aquifolium*). However, some significant differences between the two groups were found and all concerned invasive species (*Ipomoea acuminata*, *Ailanthus altissima*, *Acacia dealbata* and *Eichhornia crassipes*) were more effectively identified by participant students (Table 4—question 10).

5. Discussion

The importance of public awareness about invasive species and the implications it can have on public participation in environmental conservation have been reported in

Table 4. Percentage of participant and non-participant students that recognized and named native and invasive plants correctly (answers to question 10 of the questionnaire)

Species	Recognizing native and invasive plant species			Naming native and invasive plant species		
	Participants (%)	Non-participants (%)	Significance (<i>p</i>)	Participants (%)	Non-participants (%)	Significance (<i>p</i>)
<i>Acacia longifolia</i>	55.9	35.4	0.0117	8.8	2.4	n.s.
<i>Ipomoea acuminata</i>	47.1	17.1	0.0001	5.9	0.0	0.0260
<i>Ailanthus altissima</i>	47.1	37.8	n.s.	7.4	0.0	0.0123
<i>Arbutus unedo</i>	63.2	59.8	n.s.	36.8	42.7	n.s.
<i>Carpobrotus edulis</i>	41.2	20.7	0.0063	4.4	6.1	n.s.
<i>Lavandula</i> sp.	35.3	32.9	n.s.	14.7	19.5	n.s.
<i>Cistus ladanifer</i>	33.8	36.6	n.s.	1.5	0.0	n.s.
<i>Oxalis pes-caprae</i>	52.9	20.7	0.0000	2.9	4.9	n.s.
<i>Acacia dealbata</i>	72.1	39.0	0.0000	33.8	13.4	0.0028
<i>Eichhornia crassipes</i>	48.5	19.5	0.0001	5.9	0.0	0.0260
<i>Olea europaea</i>	79.4	65.9	n.s.	63.2	62.2	n.s.
<i>Quercus suber</i>	79.4	65.9	n.s.	61.8	53.7	n.s.
<i>Cortaderia selloana</i>	69.1	35.4	0.0000	10.3	13.4	n.s.
<i>Quercus robur</i>	63.2	61.0	n.s.	48.5	63.4	n.s.
<i>Ilex aquifolium</i>	70.6	42.7	0.0005	67.6	67.1	n.s.
<i>Tradescantia fluminensis</i>	54.4	20.7	0.0000	7.4	8.5	n.s.

several studies, although mainly with adult public (Bremner & Park, 2007; Fisher & van der Wal, 2007), local authorities (Kowarik & Schepker, 1998), or stakeholders (García-Llorente et al., 2008). Well-informed public will understand the need of developing management projects of wildlife protection. Bremner and Park (2007) highlighted the importance of those involved in invasive species management to engage directly with the public, explaining and showing the need for habitat conservation. If the appropriate involvement is provided, the public will happily and voluntarily learn about what they can do to prevent invasive species and participate in the activities promoted to control these species (Marchante et al., 2008b).

After developing diverse initiatives to enhance public awareness about invasive plant species (Marchante et al., 2008b), we thought it would be important to develop the workshop 'Invasive Plant Species—What are they? Where do they come from? What problems do they cause?' particularly for young students. This was one of our first initiatives targeting non-adult publics and the results of the questionnaire clearly showed that it is worthwhile continuing to promote education and awareness on invasive species for this particular audience. Targeting young students contributes to prepare generations of citizens who have a more active and positive attitude towards nature conservation and in this case invasive species. As shown by the results of the questionnaire, this 2 hour workshop contributed to an increase of knowledge of the participants that lasted at least one year after they participated in the activities.

The observed low ability to recognize and identify plant species among students is not unique for this particular age group neither for Portuguese students, since the knowledge of students about identification of plants is equally low in other countries (Bebbington, 2005; Schussler & Olzak, 2008; Strgar, 2007). This inability was also observed when students were asked to distinguish between native and invasive plants. In Portugal, not only the general population but even the public who deal with exotic plants are sometimes not aware of this environmental problem (Marchante & Marchante, personal communication; <http://www.uc.pt/invasoras>). A recent questionnaire from Eurobarometer (The Gallup Organisation, 2010) showed that only 1% of the inquired Portuguese population considered invasive species to be the most important threat to biodiversity.

In this context, it was very important to start this workshop with the basic concepts and to show examples of some of the worse invasive plants in Portugal, and results showed that part of that information was retained by students 1 year later. The practical activities used proved to be very well adapted to the target public, making it very easy to engage the students in understanding the basic concepts and problems involved. In general, students easily answered the questions asked during the activities, showing that concepts were acquired. In some cases, students were even able to extend the discussions by relating to known concepts with recently acquired knowledge. Although IAS is only briefly discussed in school curricula, during the two practical activities students were confronted with terms that were familiar to them like *habitat*, ecosystem, food web and they were able to relate to them, particularly in the case of IAS. Teachers involved were also very enthusiastic about the activities, considering them to be well adapted for the students' level and curricula.

The three practical activities, together with the introductory talk, complemented each other and allowed students to understand subjects such as biological invasion process, impacts of invasive species, ecosystem recovery and resilience, and difficulties to control invasive species. Furthermore, students could see the importance of their involvement in both prevention and control of invasive plants. This was achieved by creating activities where the involvement of the students was very high, and key-information was acquired during the different practical activities instead of being transmitted only theoretically. During the practical activities, students had the chance of acting as native or invasive plants, or as biologists or environmental managers, which allowed them to be familiar with the problems associated with the plant invasions from different points of view.

At the end of each session, both the organizers and the participants were very pleased with the way the workshop was held. The activities developed showed that it is worthwhile to invest in public education and awareness, since it helps to prevent the spread of invasive species. The workshop also showed that it is not difficult or expensive to prepare practical activities that are interesting, making the most of commonly used material. The evaluation of the workshop assessed the knowledge effectively acquired about the subjects discussed. In addition, the comparison of the results with a control group was relevant to evaluate the knowledge about invasive plant species by students in Portugal. Results showed that attending the workshop significantly increased the students' knowledge about invasive plant species. Biological invasion, being a relatively recent topic of concern, is not much acknowledged by school teachers, which reinforces the need to develop activities to increase public awareness about this topic.

An essential part of this work was the evaluation process itself. More than showing that student participating in the workshop knew more about invasive plants, it is important to emphasize that evaluation of public awareness and environmental education activities is essential. Frequently, funds available for communication and public awareness are limited and therefore need to be used cost-effectively. To do that, effectiveness of activities and strategies need to be evaluated adequately, going further than asking to the participants if they enjoyed participating in the activities. Quite often, considerable investment is allocated to printing leaflets and other documentation, which are given to people without any further involvement or evaluation of their effectiveness in promoting changing of attitudes. We believe that leaflets and other documentation are important to inform the public, but ideally they should be used together with activities that engage the public, thus becoming more cost-effective.

6. Conclusions

The workshop about Invasive Plant Species showed that recognizing plants in general is not an easy task for Portuguese 13–15-year-old students; additionally their knowledge about exotic and invasive plants is very limited. However, this study also showed that teenage students, while attending and engaging themselves in well-developed activities, understand and actively retain the new information from subjects poorly

explored in the school curricula. This fact was clearly shown by the results of the questionnaire conducted after the workshop, and is even more relevant since the evaluation was only performed one year later, which validates the messages retained and the knowledge acquired. It is our understanding that the involvement of the students in the activities was also of utmost importance, allowing them to execute, interpret, discuss and reach their own conclusions. Although this was one of the first initiatives promoted by the research team targeting non-adult publics, the results clearly show that it is worthwhile continuing to promote education and awareness on invasive species for this particular audience.

Web Link

Website developed by researchers of the CFE of University of Coimbra and CERNAS of Agrarian School of Coimbra about Invasive plant species in Portugal: <http://www.uc.pt/invasoras>

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Appendix. Questionnaire about Invasive Plant Species in Portugal

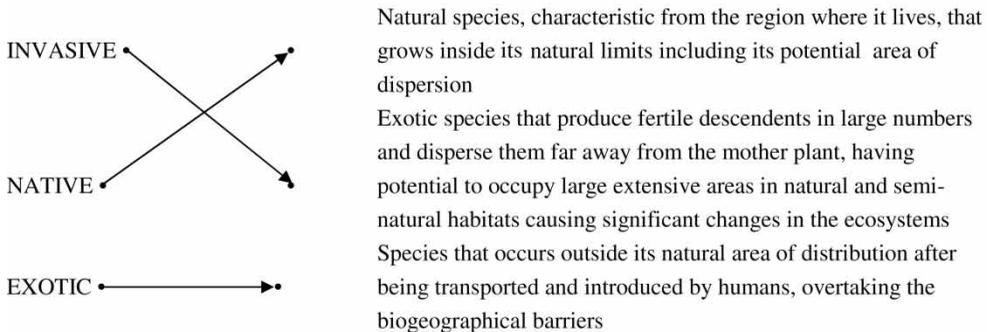
Part I – General Information

1. Gender: Female Male 2. Age: _____
3. Have you participated in the Workshop about Invasive Plants in November 2008, held at the Museum of Botany of University of Coimbra ? Yes No
4. School _____ Grade _____

Part II – Invasive Plants

1. Which of the following options contains only synonyms?
- native, exotic, spontaneous, indigenous
 - native, spontaneous, indigenous, autochthonous
 - native, spontaneous, introduced, autochthonous
2. From the following statements choose the most correct:
- exotic plants come from the north hemisphere and invasive plants come from the south hemisphere
 - exotic plants are found in Portugal for many centuries and invasive plants are found in Portugal for only a few decades
 - exotic plants grow outside their country of origin and invasive plants are exotic that disperse to areas without direct human intervention, causing negative impacts at many levels
 - there are no differences between exotic and invasive plants, both terms mean the same

3. Connect the terms on the left with the definitions on the right:



4. Which of the following values is closer to the number of invasive plant species in Portugal?
- 4
 - 40
 - 400

5. How did invasive plant species arrive to Portugal? Choose the most complete answer:

- they were brought to be used as ornamental plants
- they came by accident, mixed in seeds and cereals
- they were introduced for specific reasons as fixing littoral sand or drying humid soils
- all of the options listed above are correct
- none of the options listed above are correct

6. From the problems listed mark the ones that can be caused by invasive plant species:

- biodiversity loss
- reduction in agricultural productivity
- increase of CO₂ level
- high economic costs in control actions
- sea level rise
- public health problems such as allergies
- landscape scenery changes
- increase of erosion problems
- change of water resources
- increase of air pollution
- changes in food webs
- decrease of available resources for native plants

7. Is there a specific legislation concerning the introduction of non-native plants in Portugal?

- Yes
- No

8. Which of the following statements do you consider more correct:

- manual control is the most effective since it allows to carefully select the invasive plant species that need to be eliminated.
- chemical control is the most effective since it rapidly eliminate only invasive plant species.
- mechanical control is the most effective since it removes invasive plant species without damaging native plants.
- all controls are effective since in one action they eliminate all invasive plants species.
- ideally an integrated control (combination of several control types) should be used, always assuring several continuing controls

9. From the following measures mark the one you think is the most effective to avoid proliferation of invasive plants:

- public awareness activities about invasive plants species
- control actions to eliminate invasive plants
- inspection actions in the ornamental plants industry
- all the actions listed above are important
- none of the actions listed above are important

10. For each plant image identify its name and point out if it is native or invasive in Portugal

 <p>Name <u>Acacia longifolia</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Ipomoea acuminata</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>
 <p>Name <u>Ailanthus altissima</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Arbutus unedo</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Carpobrotus edulis</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Lavandula sp.</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Cistus ladanifer</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Oxalis pes-caprae</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>

 <p>Name <u>Acacia dealbata</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Eichhornia crassipes</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>
 <p>Name <u>Olea europaea</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Quercus suber</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Cortaderia selloana</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>	 <p>Name <u>Quercus robur</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>
 <p>Name <u>Ilex aquifolium</u></p> <p><input checked="" type="checkbox"/> native <input type="checkbox"/> invasive</p>	 <p>Name <u>Tradescantia fluminensis</u></p> <p><input type="checkbox"/> native <input checked="" type="checkbox"/> invasive</p>

Thank you very much for your collaboration.

For more information on Invasive Plants in Portugal go to www.uc.pt/invasoras