# Public perceptions about the invasive plant pampas grass, Cortaderia selloana

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# Abstract

*Cortaderia selloana*, also known as pampas grass, is native to the Pampas region in South America. Nowadays, it is a widespread invasive plant in several regions of the World, including the south of the Atlantic Arc in Europe, where it has been used as an ornamental species. As such, citizens may play an important role in the dissemination of this invasive species, but on the other hand, if they are aware of its invasive behavior, can contribute to its control and prevent spread. An online survey was performed to better understand the perception and knowledge of Portuguese and Spanish citizens about pampas grass. 486 and 839 citizens answered the questionnaire in Portugal (PT) and Spain (ES), respectively. In general, most respondents were between 41 and 64 years old, mostly women in Portugal and equally women and men in Spain, with higher education and working mostly in the services sector. The majority of respondents in both countries recognized the plant, know it is invasive and many were able to name it, but fewer were aware of the legislation that limits its use, and most were not able to identify particular characteristics of the species. Respondents' occupation in PT and education in ES seem to influence their knowledge and perception about pampas grass. Our results confirm that education and raising awareness of citizens regarding invasive species is of the utmost importance so that citizens can be part of the solution and not the problem, especially when regarding ornamental species like pampas grass.


# Introduction

Invasive alien species (IAS) pose a major threat to biodiversity worldwide, with huge impacts on both human health and the economy (Mazza et al. 2014; IPBES 2019; Diagne et al. 2021). The average annual cost of invasions can be over US$160 billion, but this figure is underestimated, as the true cost of some of the world´s 100 worst invasive species remains unknown and the costs of invasive plants are usually lacking (Cuthbert et al. 2021; Diagne et al. 2021; Novoa et al. 2021). Damage cost is an order of magnitude higher than management expenditures, stressing the need for management actions and international policy agreements to reduce the burden of invasive species (Diagne et al. 2021). Impacts on human health from invasive plants include direct exposure, pathogens, disease vectors, toxins, contamination of edible foodstuff, allergens and indirect implications (Kumar Rai and Singh 2020). Actions to prevent and mitigate invasive species impacts requires the involvement and support of the entire society, but despite increasing investment in raising public awareness (Marchante and Marchante 2016; Verbrugge et al. 2021), many citizens, especially outside the scientific or technical world, are unaware of IAS consequences and do not always support their management (Novoa et al. 2017; Ricciardi and Ryan 2018; Potgieter et al. 2019; Cordeiro et al. 2020; Kowarik et al. 2021).

*Cortaderia selloana* (Schult. & Schult.f.) Asch. & Graebn., commonly known as pampas grass, is native to South America, namely southern Brazil, Uruguay and Argentina. This is a gynodioecious species, with hermaphrodite plants producing viable seeds in small amounts and being essentially pollen donors, implying that both hermaphrodite and female plants need to be relatively close so that widespread reproduction can occur (Connor 1973). The species was introduced worldwide essentially as an ornamental, spreading initially in urban zones, disturbed areas, estuaries, dune systems and along roads,

highways and rails, but later invaded natural habitats (Basnou 2009). The particular breeding system, and the fact that only female plants were initially propagated and commercialized (Robacker and Corley 1992; Grounds 1998), contributed to the ignorance of most people about its invasiveness. But, humans can also be responsible for their unintentional dispersal whenever they collect inflorescences and use them as decoration in stores, restaurants or homes. Nowadays, pampas grass is a widespread invasive species in California (Lambrinos 2001), New Zealand (Than and Aliaga 2010), South Africa (Robinson 1984) and southern Europe (Basnou 2009) particularly in Portugal (Marchante et al. 2014) and Spain (Gobierno de Cantabria 2017). It can change significantly the natural and seminatural habitats, threatening the conservation of natural vegetation (Domènech et al. 2006; Gallastegui and Prieto 2010), achieving the highest overall impact score when compared with other alien grasses (Nkuna et al. 2018). Pampas grass is also responsible for pollen allergies or respiratory distress on most sensitive people (Fernández et al. 2017), extending the period of grass allergies in Northern Spain for about three months every year (Rodríguez et al. 2021), and for skin cuts due to its sharp leaves (Dehnen-Schmutz 2015; González et al. 2020). In Portugal and Spain, the species is included in the national lists of invasive species since 2019 (Ministério do Ambiente 2019) and 2013 (MAGRAMA 2013), respectively. The species has not yet been included in the European Union´s list of invasive alien species (EU Regulation 1143/2014, The European Commission 2014), although *Cortaderia jubata*, a closely related species, is already on that list.

Understanding public perception of invasive species is important for better planning their management (Shackleton et al. 2019b), not only because citizens may contribute to their prevention (not using them) and dissemination, but also support or even promote their control. In the last decade, several studies have analyzed public and stakeholders' perceptions, engagement and knowledge about invasive species (Rai et al. 2012; Verbrugge et al. 2013; Shackleton et al. 2019a, b; Vaz et al. 2019; Cordeiro et al. 2020; Kowarik et al. 2021; Sosa et al. 2021). Being used as a decorative and ornamental species, people often consider pampas grass to be beautiful while disregarding its impacts as an invasive plant. From our experience during public awareness activities, our perception is that a large part of the Iberian population is still unaware of pampas grass invasiveness and the impacts it promotes on biodiversity, human health and economy. However, the perception of citizens was not properly explored, although this is particularly relevant when it comes to a species frequently used by citizens and that is so easily wind-dispersed through carefree use. A LIFE project (LIFE Stop Cortaderia - Urgent measures for controlling the spread of Pampa Grass (*Cortaderia selloana*) in the Atlantic area) is currently ongoing, with one of the main goals being to raise public awareness about this species in Portugal, Spain and France, among other tasks (http://stopcortaderia.org/). In this context, after developing numerous activities to raise public awareness, *e.g.*, public talks, training sessions and short courses, exhibitions, technical seminars, dissemination on social media, etc., a survey, using an online questionnaire, was implemented and distributed to analyze the public perceptions and knowledge about pampas grass in Portugal and Spain.

# Methods

# Target Public

Our target audience was a subgroup of the Portuguese and Spanish population with access to the internet, some level of environmental awareness or interest, or that was, to some degree, related to the LIFE Stop Cortaderia project, *e.g.* social media followers. Portugal and Spain were selected since these are the main territories included in the abovementioned project. Although internet-based surveys may limit the outreach of questionnaires, since the internet is not available to the entire population, in 2021 ca. 78% and 93% of the Portuguese and Spanish population, respectively, used the internet (The World Bank Group 2022), which results in very high levels of potential respondents.

# Questionnaires

Besides the high potential outreach, an online questionnaire was chosen due to the speed of implementation, the difficulties of applying it by postal or in-person simultaneously in the two countries, and due to the limitations during the Covid-19 pandemic. The questionnaire was made available online (using Google Forms) and divided into two sections: Section I aimed to characterize the respondents and their basic knowledge about pampas grass; if the respondents didn´t recognize the species, the questionnaire finished in section I; if they recognized it, the questionnaire continued to Section II, concerning more complex knowledge about the species. The questionnaire consisted of 11 questions, some of which with follow-up questions; most of the questions were close-ended, with only a few open-ended (Table 1; Supplementary Information 1, Table S1; Supplementary Information 2).

Table 1
Summary of the questionnaire, including the type of questions.

| Section | Aim | Question | Type of question | |
|---|---|---|---|---|
| I | Characterization of the respondent | Q1, Q2, Q3, Q5 | Close-ended | Multiple Choice<br>Single Response |
| | | Q4, Q5.1 | Open-ended | Short Answer |
| | Basic knowledge of the species | Q6, Q6.2 | Close-ended | Multiple Choice<br>Single Response |
| | | Q6.1 | Open-ended | Short Answer |
| II | Complex knowledge of the species | Q7 | Close-ended | Multiple Choice<br>Multiple Response |
| | | Q8, Q8.1, Q9 | | Multiple Choice<br>Single Response |
| | | Q8.2 | Open-ended | Short Answer |
| | Source of the knowledge | Q10 | Close-ended | Multiple Choice<br>Multiple Response |
| | Suggestions to plant instead of pampas grass | Q11 | Open-ended | Long Answer / Paragraph |

# Data collection

The questionnaire was disseminated through different platforms, *e.g.* social media, webpages and email lists from both the LIFE Stop Cortaderia project and citizen-science platform “INVASORAS.PT” (Marchante et al. 2017). It was available for approximately two months, from mid-April to mid-June 2020. Researchers of each country distributed the questionnaire among their country platforms, but since the questionnaire was shared frequently through social media and emails, in practice, the target audience might differ from the expected.

# Data analysis

Respondents' profile data was analyzed using simple descriptive statistics. Answers to open-ended questions or with multiple choice were rearranged into coherent groups to facilitate further analysis (Supplementary Information 1, Table S2). Regarding Q7, the statements were classified as “correct” and “incorrect” for further analysis, but because some respondents choose both correct and incorrect statements, a third category was created to accommodate this. To evaluate if there was an association

between the profile of the respondents (Section I, Q1 to Q5) and their knowledge and perception about pampas grass, a Chi-Square test ($\chi^2$) was applied between Q1 to Q5 and “basic knowledge of the plant” (Section I, Q6), “complex knowledge of the plant” (Section II, Q7 to Q9) and complementary information (Section II, Q10 and Q11). Meaningful positive associations are presented and discussed. When assumptions of the Chi-Square test were not met, Fisher´s Exact test (FET) was used instead. In the case of a positive association between variables, the strength of that association was measured using the Phi and Cramer´s V. An alpha level of 0.05 was used for all statistical tests. As the history of invasion and the date on which the species was listed as invasive in the legislation is different in the two countries, the analyses were performed on both Portugal and Spain separately, using IBM SPSS® Statistics software, version 27.

## Results

1325 questionnaires were received: 486 from Portugal (37%) and 839 from Spain (63%). From these, 118 respondents (9%) didn´t recognize pampas grass, responding only to Section I; both sections were analyzed for the other 1207 (91%) (437 for Portugal and 770 for Spain).

# Profile of respondents

The great majority of respondents live in the country where they answered the questionnaire (94.7% in Portugal, 97.5% in Spain), with few exceptions of people responding from other countries, *e.g.*, Germany, United Kingdom, Brazil, Italy and Switzerland (3%), among others. Most of the respondents were between 41 and 64 years old, followed by 26 and 40 years old, with just a few very young (below 18) and older than 65 years old responding to the questionnaire. Comparatively, more women answered the questionnaire in Portugal (68.5%), while in Spain men and women were almost equally represented. Both in Portugal (PT) and Spain (ES), around 80% of respondents have completed higher education and about half work in the services sector (43.4% in PT and 54.8% in ES), followed by environmental experts (22.8% in PT and 17.4% in ES) and only a small percentage had occupations related to nature (Table 2).

Table 2
Profile of the respondents by country (Portugal – 486 answers and Spain – 839 answers).

| | | PT (n=486) | ES (n=839) |
|---|---|---|---|
| Q1. Age | < 18 years old | 0.8% | 0.4% |
| | 18 – 25 years old | 8.9% | 4.9% |
| | 26 – 40 years old | 35.2% | 26.2% |
| | 41 – 64 years old | 51.4% | 60.2% |
| | 65 – 89 years old | 3.7% | 8.1% |
| | > 90 years old | 0.0% | 0.2% |
| Q2. Gender | Woman | 68.5% | 49.3% |
| | Man | 31.5% | 50.7% |
| Q3. Education | Basic Education | 1.9% | 3.8% |
| | High School | 14.9% | 16.7% |
| | Higher Education | 83.2% | 79.5% |
| Q4. Occupation | Related to Nature | 6.2% | 1.5% |
| | Producers | 0.8% | 2.4% |
| | Services sector | 43.4% | 54.8% |
| | Environmental experts | 22.8% | 17.4% |
| | Non-biology teachers | 9.7% | 8.1% |
| | Students | 8.0% | 4.1% |
| | Unemployed and retired | 7.4% | 8.8% |
| | Other | 1.7% | 2.9% |
| Q5. Country of Residence | Portugal | 94.7% | 0.1% |
| | Spain | 1.0% | 97.5% |
| | Other | 4.3% | 2.4% |

**Perception about** Cortaderia selloana

The great majority of the respondents (89.9% in PT and 91.8% in ES) recognized pampas grass and, from these, 78.9% in PT and 89.4% in ES named it correctly, using either the scientific or a common name.

Almost all respondents (99% and 98% in PT and ES, respectively), said they don´t have pampas grass on their property.

When the association between the profile of respondents and their knowledge was explored, medium and small associations were found between the Portuguese respondents' occupation (Q4) and whether they recognize pampas grass (Q6) ($p$=0.003, FET; Cramer´s V value=0.214) and are able to name it (Q6.1) ($p$=0.002, FET; Cramer´s V value=0.186), respectively; there was also a small association between age (Q1, $p$=0.019, FET, Cramer´s V value = 0.124) and knowing the name of pampas grass (Q6.1) (Supplementary Information 3, Table S1). All respondents with occupations related to nature, producers and most students and environmental experts recognized the plant, while around 15% of respondents from the services sector, unemployed and retired people didn´t. As for the species name (Q6.1), around 80% of respondents knew it, but young, adults and respondents with occupations related to nature and environmental experts got it more right (Supplementary Information 4, Fig. S1). Regarding Spanish respondents, there was a small association between age (Q1, $p$=0.011, FET, Cramer´s V value=0.108) and gender (Q2, $X^2$ (1, N = 827) = 5.171, $p$ = 0.023, Cramer's V value=0.079) and recognizing the species (Q6), and a small association between gender (Q2, $X^2$ (3, N = 758) = 13.885, $p$ = 0.003, Cramer's V value=0.135) and knowing the name of pampas grass (Q6.1) (Supplementary Information 3, Table S1). Adult women recognized the plant more often, while more men attributed an incorrect name (Supplementary Information 4, Fig. S2).

When presented with different statements about pampas grass (Q7), 2/3 of the respondents selected only correct statements (71.6% in PT and 66.8% in ES), *e.g.*, "does not allow for native plants to grow" or "removing it can be very difficult and cost a lot of money"; a small percentage (6.6% in PT and 5.3% in ES) selected only incorrect answers, *e.g*, "it is not forbidden to have this plant" and "this plant can be used in decoration without negative consequences"; and 21.7% in PT and 27.9% in ES selected both correct and incorrect statements (Figure 1).

In Portugal, respondents´ occupation (Q4; $p$=0.002, FET; Cramer´s V value=0.197) showed a small association with the choice of the statements best suited for pampas grass (Q7), while in Spain, it was respondents' age (Q1; $p$=0.000, FET; Cramer´s V value=0.112) and gender (Q2; $p$=0.002, FET; Cramer´s V value=0.130) that presented a small association with Q7 (Supplementary Information 3, Table S2). Portuguese producers had the highest percentage of correct statements, followed by environmental experts and related to nature occupations; on the other hand, non-biology teachers and the services sector respondents selected most of the incorrect statements. Spanish young and adult women selected more correct statements than any of the other groups (Supplementary Information 4, Fig. S3).

When asked if pampas grass is invasive (Q8) and included or not in any legislation (Q8.1, Q8.2), most respondents recognized that the plant is invasive (90.4% in PT and 92.6% in ES) but, in general, they were not aware that a specific legislation limited its use (68.8% in PT and 82.9% in ES). Nevertheless, a big part of the respondents who knew about the legislation, also knew the correct name/number of the legal

instrument, *i.e.* Decree-Law nº 92/2019 in Portugal and Royal Decree nº 630/2013 in Spain, despite this being more pronounced in Portugal (63.7% in PT and 46.0% in ES; Figure 2a).

Figure 2 Answers from Portuguese and Spanish respondents to the questions Q8.2 – "If you answered yes to the previous question, which is this Decree-Law?" (a) and Q9 – "In your opinion, what do you see in the photos below?" (b). The original categories were classified as "correct", "incorrect" and "no answer" for further analysis.

Respondents' occupation (Q4) showed a medium association with their acknowledgment that pampas grass is invasive (Q8) for Portugal ($p$=0.001, FET; Cramer´s V value = 0.232) and a small association for Spain ($p$=0.011, FET; Cramer´s V value = 0.168); in Spain, there was also a medium association with respondents' age (Q1; $p$=0.000, FET; Cramer´s V value=0.227) (Supplementary Information 3, Table S3). In Portugal, all producers and those with occupations related to nature recognized its invasive behavior, followed by environmental experts and unemployed and retired people, while almost 20% of respondents working in the service sector did not recognize the species as invasive. Regarding Spain, most young and adult people and all respondents with related to nature occupations replied that pampas grass was invasive, followed by environmental experts, but more than 25% of students said the species was not invasive (Supplementary Information 4, Fig. S4).

Respondents education (Q3) showed a small association with awareness of legislation that limits pampas grass in both countries (Q8.1; Portugal: $X^2$ (2, N = 392) = 12.513, $p$ = 0.002, Cramer´s V value = 0.179 and Spain: $X^2$ (2, N = 707) = 12.124, $p$ = 0.002, Cramer´s V value = 0.131); occupation (Q4) also showed a medium association with Q8.1, but for Portugal only ($p$< 0.001, FET; Cramer´s V value = 0.286) (Supplementary Information 3, Table S3). Respondents with higher education replied more positively in both countries; environmental experts and occupations related to nature better acknowledge legislation in Portugal (Supplementary Information 4, Fig.S5).

Regarding the name of legislation legislation (Q8.2), there was a medium association with respondents occupation (Q4) in Portugal ($p$=0.008, FET; Cramer´s V value = 0.328) and with respondents education (Q3) in Spain ($p$=0.014, FET; Cramer´s V value = 0.200) (Supplementary Information 3, Table S3). More Portuguese producers and unemployed and retired people knew the specific Decreet-Law, while in Spain, respondents with higher education gave the most correct answers (Supplementary Information 4, Fig. S6).

When three detailed photos of pampas grass were presented, asking what was shown (Q9) a high percentage of respondents didn't reply/ knew the answer (PT 33.0%, ES 56.1%); in each country, the percentage of people who gave correct and incorrect answers was similar (PT: 36.8% correct and 30.2% incorrect; ES: 21.0% correct and 22.9% incorrect) (Figure 2b).

Portuguese respondents´ education (Q3; $p$=0.000, FET; Cramer´s V value = 0.199) and occupation (Q4; $p$=0.003, FET; Cramer´s V value = 0.188) showed a small association with identifying correctly the pampas grass photos (Q9) (Supplementary Information 3, Table S4): unemployed and retired people,

environmental experts and respondent´s with higher education gave the most correct answers, while producers and respondents with basic education got it more wrong (Supplementary Information 4, Fig. S7).

# Complementary information

More than half of Portuguese respondents learned about pampas grass being invasive (Q10) through academic and scientific activities (which grouped several options, both from the list given and “other”; Supplementary Information 1, Table S2), while most Spanish mentioned the observation of reality and family or friends (Figure 3). When considering academic and scientific activities separately (Q10b), academic training was the main source of information for acknowledging pampas grass as an invasive species in both countries (Figure 4); in Portugal, the platform Invasoras.pt (webpage, social media and activities) also gave a big contribution, while in Spain, diverse social media platforms play that role. No meaningful association was found between respondents' profiles and the main sources they learned that pampas grass is invasive (Q10).

Finally, when asked about alternative species to use in gardens instead of pampas grass (Q11), most respondents, in both countries, suggested “safe” plants, although a reasonable proportion was not able to provide an alternative (Figure 5). A minority suggested “unsafe” species as alternatives, a few of them being invasive plants, such as *Acacia dealbata* Link, *Arundo donax* L. and *Carpobrotus edulis* (L.) N. E. Br..

There was only a small association between respondents' occupation (Q4) and alternative species suggested to use instead of pampas grass (Q11) in Portugal, but it was non-significant (*p=0.060*).

# Discussion

*Cortaderia selloana*, cultivated worldwide for its panicles with blooming flowers, has increased considerably its distribution along the south of the Atlantic Arc (Portugal, Spain and France) in the last decades, and this invasion has been rapid and evident (Domènech et al. 2005; Basnou 2009). Considering that citizens collect pampas grass panicles for decorative use and that in doing so they can disperse the seeds (if available), it was particularly important to understand people´s perception of this species. Contrary to our perception of the general population, our results show that a very high percentage of Portuguese and Spanish environmentally aware citizens not only recognize and identify pampas grass but also acknowledge its invasive behavior. This level of knowledge and perception is in the same line of previous studies with other invasive plants widely dispersed where a large proportion of citizens recognize species and its invasive status (Dehnen-Schumutz et al. 2010; Junge et al. 2019; Cordeiro et al. 2020). Comparing with the invasive silver wattle (*Acacia dealbata*) (Cordeiro et al. 2020) and other *Acacia* species (Vaz et al. 2019), which are older introductions and more widespread species, citizens even recognize more the pampas grass, possibly because it has increased its distribution faster and more notably in the last two decades, is more commonly used for decoration and is a very showy species.

The general knowledge about pampas grass and its invasive status was found to be equivalent in Portugal and Spain. Since pampas grass is a very showy and decorative species and has been widely planted around the Iberian Peninsula as an ornamental plant in public and private gardens (González et al. 2020), and is easy to identify, its recognition through a single photograph was expected, even if respondents do not have the plant in their properties. However, the high percentage of respondents that recognized its invasive status somewhat surprised us, contrasting with our everyday experience: people often use pampas grass plumes decoratively in shops and restaurants (*authors personal observations*); social media *influencers* are often recommending the use of its plumes as ornamental in social events (*e.g.* in Instagram); in numerous public awareness activities both of LIFE STOP Cortaderia and INVASORAS.PT platform, participants frequently say that pampas grass is beautiful and admit not being aware of its invasiveness (*authors personal observation*). As such, these results suggest respondents may have been mostly citizens already sensitized about the subject, but this could be expected when we selected our target audience and form of dissemination (see Limitations section below). On the other hand, these results may also reflect the success of the large investment of LIFE Stop Cortaderia over the last three years in both countries (González et al. 2020; Association Amica 2021) and INVASORAS.PT platform in Portugal for almost two decades (Marchante and Marchante 2016; Marchante et al. 2017; Cordeiro et al. 2020), to raise awareness of pampas grass. Still, and despite recognizing pampas grass and its invasive potential, only a small part of respondents was aware of the existence of legislation that limits its use, mainly citizens with higher education.

Some associations were found between respondents' profile and their perception and knowledge of pampas grass, most often age, education and occupation: associations in Portugal were stronger with respondents' occupation, while in Spain they were stronger with respondents´ age and education. Young (underrepresented) and adults with higher education, occupations related to nature and environmental experts (low represented) and producers, were, in general, associated with higher percentages of correct answers or more knowledge about pampas grass, suggesting that higher education and formal training in environmental areas influences perception and increases knowledge about invasive species, as found by other authors (White et al. 2005; Lindemann-Matthies 2016; Potgieter et al. 2019; Cordeiro et al. 2020). In fact, academic and scientific activities, possibly most sought after by people with higher education, and particularly academic training and the platform INVASORAS.PT in Portugal, were selected as the main sources for respondents learning about the invasive behavior of pampas grass. This corroborates previous studies showing that informal education, along with formal education, increases knowledge and alters perceptions about invasive species (Bremner and Park 2007; Schreck Reis et al. 2013; Cordeiro et al. 2020; Sosa et al. 2021). In Spain, observation of reality and conversations with family and friends seemed to also play a major role in respondents' knowledge about pampas grass. This might be explained by the fact that the invasion by pampas grass is far more expressive, with more extensive continuous areas occupied by the species, in the north of Spain than in Portugal, specifically in Cantabria (González et al. 2020) where, probably, many Spanish respondents are from (eventual bias associated to the LIFE Stop Cortaderia, where most of the work occurs). In addition, invasion by pampas grass in Spain is older, with different governmental and even public health entities acknowledging the problem (Herrera

and Campos 2006; MAGRAMA 2013; Gobierno de Cantabria 2017; Gomez et al. 2018; Rodríguez et al. 2021) earlier than in Portugal, where the species was included in the legislation as invasive species only in 2019 (Ministério do Ambiente 2019). In areas where the species is widely dispersed, such as the northern coast of the Iberian Peninsula, many citizens already recognize its invasive status and negative consequences, and this increased awareness may represent a growing willingness to halt the expansion of pampas grass and even collaborate on strategies for its control and removal. In fact, increased public awareness is a key factor for the success of projects like LIFE Stop Cortaderia (González et al. 2020) and others (*e.g.* Fundo Ambiental 2021), especially in areas where the species is relatively confined and citizens participation is essential to achieve local eradication. In this context, it shouldn´t be neglected the strong impact of projects such as LIFE Stop Cortaderia, in both countries, or INVASORAS.PT in Portugal, both with strong investment in raising social and stakeholders' awareness regarding harmful effects of pampas grass in the natural and transformed ecosystems.

Despite the general high level of awareness shown by the results, between 15% and 20% of the respondents from the services sector (particularly in Portugal, where they were over 40% of all respondents) either did not recognize the species, or its invasive status or choose incorrect statements to describe it (Supplementary Information 4). This may coincide with the type of citizens we encounter during awareness-raising activities who consider pampas grass just a beautiful ornamental plant that does not pose a threat to ecosystems, human health or the economy (*authors personal observations*), which is a general conception for many appealing invasive species (Potgieter et al. 2019). This also highlights the need to focus more awareness-raising activities on such target audiences.

# Limitations of the study

Some biases were identified that prevented us from sampling a representative subgroup of the entire population, and limited our target audience. Online surveys require initiative from respondents and, as such, people who are interested in environmental issues or are somehow related to the theme (e.g., "followers" of LIFE Stop Cortaderia project, in Portugal and Spain, and the platform INVASORAS.PT in Portugal), were probably more willing to voluntarily answer the questionnaire, regardless of their occupation. About half of respondents were workers from the services sector (*e.g.*, lawyers, administrators, assistants, bank officers, merchants, managers, nurses, mechanics, drivers, psychologists, economists, veterinarians, musicians…), whereas the expected occupations, with higher awareness to the topic, namely environmental experts (*e.g.* biologists, environmental engineers, forest technicians) and occupations related to nature (*e.g.* farmers, agronomists, landscape architects) were less represented. At least in Portugal, citizens who participate in INVASORAS.PT activities, often do not have a nature-related occupation, despite their interest in the topic (*authors personal observations*). In addition to "occupation", information on respondents´ interest in nature thematics and/or their relationship with environmental groups and activities could have been more informative, eventually showing that part of the citizens working in the services sector already had some interest in biological invasion or at least environmentally conscious. Despite this being a common issue to online surveys (Fricker, R.D. 2012), we need to consider that our results are probably biased towards respondents that are somehow more sensitized about this

subject. The respondents were also biased toward adults, probably because this theme is not of interest to the younger public, many disconnected from nature (Battisti 2016; Battisti et al. 2018) and, being distributed exclusively online, made it eventually less reachable by senior citizens (Rebelo 2013). These difficulties could have been overcome with face-to-face questionnaires. Considering the above-mentioned biases, our results cannot be generalized to the entire Iberian population, but we acknowledge limiting our target audience to the population with access to the internet and some level of environmental awareness. Nevertheless, they are still valid and a good example of what can be achieved with public education and outreach, as shown by Oele et al. (2015), where after educational efforts they´ve seen a significant decrease in the selling of aquatic invasive species.

Despite these eventual biases (requirement of internet, initiative from respondents, interest in the topic), online surveys allow to reach more people from different geographic regions, with less effort and costs, since no field-work is necessary, thus facilitating international studies; they also allow to maintain anonymity, which can eliminate some interviewer biases and intimidation caused by the surveyor, allowing the respondents to express themselves more genuinely (Bird 2009; Pozzo et al. 2019).

# Conclusions

Our study suggests a reasonably high level of knowledge and perception from Portuguese and Spanish citizens with some level of environmental awareness regarding the invasive pampas grass (*Cortaderia selloana*): they recognize the species and its invasive behavior, are able to name it, but are less knowledgeable about the legislation that limits its use. The results from Portuguese and Spanish respondents were relatively similar, despite occupation being the factor that in Portugal showed more association with the respondents' knowledge and perception, while in Spain was age and education. In general, citizens with occupations related to the services sector, environment and nature showed more knowledge, along with citizens with higher education. Although results can not be extrapolated to the entire population, it shows the utmost importance of investing in public awareness and education, in order to change citizens' perception about an appealing and beautiful ornamental species, but with serious consequences to the environment, public health and the economy.

# Declarations


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## Authors' contributions

All authors contributed to the study conception and design, and the dissemination of the questionnaires. The data analysis and first draft of the manuscript were performed by Mónica R. Almeida, with regular

discussions and contributions from both co-authors. All co-authors revised and approved the final version of the manuscript.

### Availability of data and material

Authors declare that the records of the original data are available.

### Conflicts of interest

The authors declare that they have no conflicts of interest.

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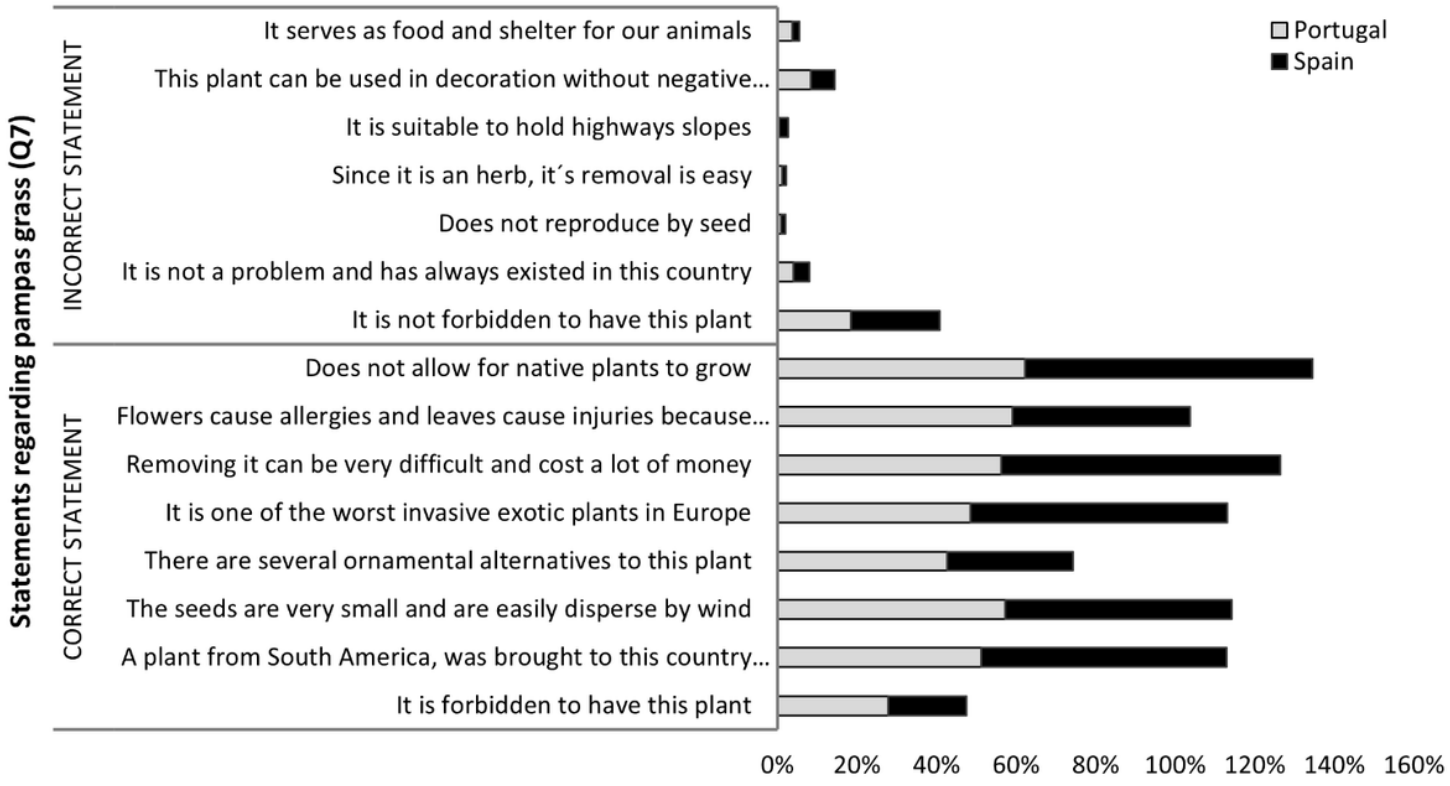
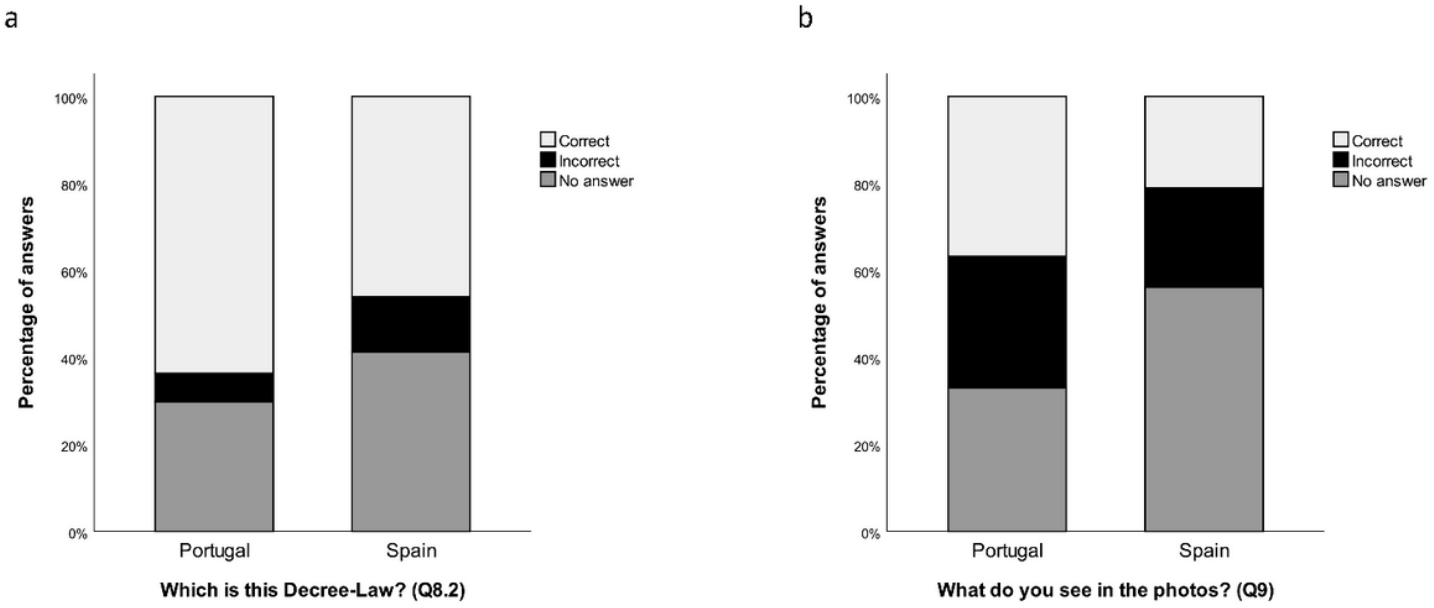
# Figures



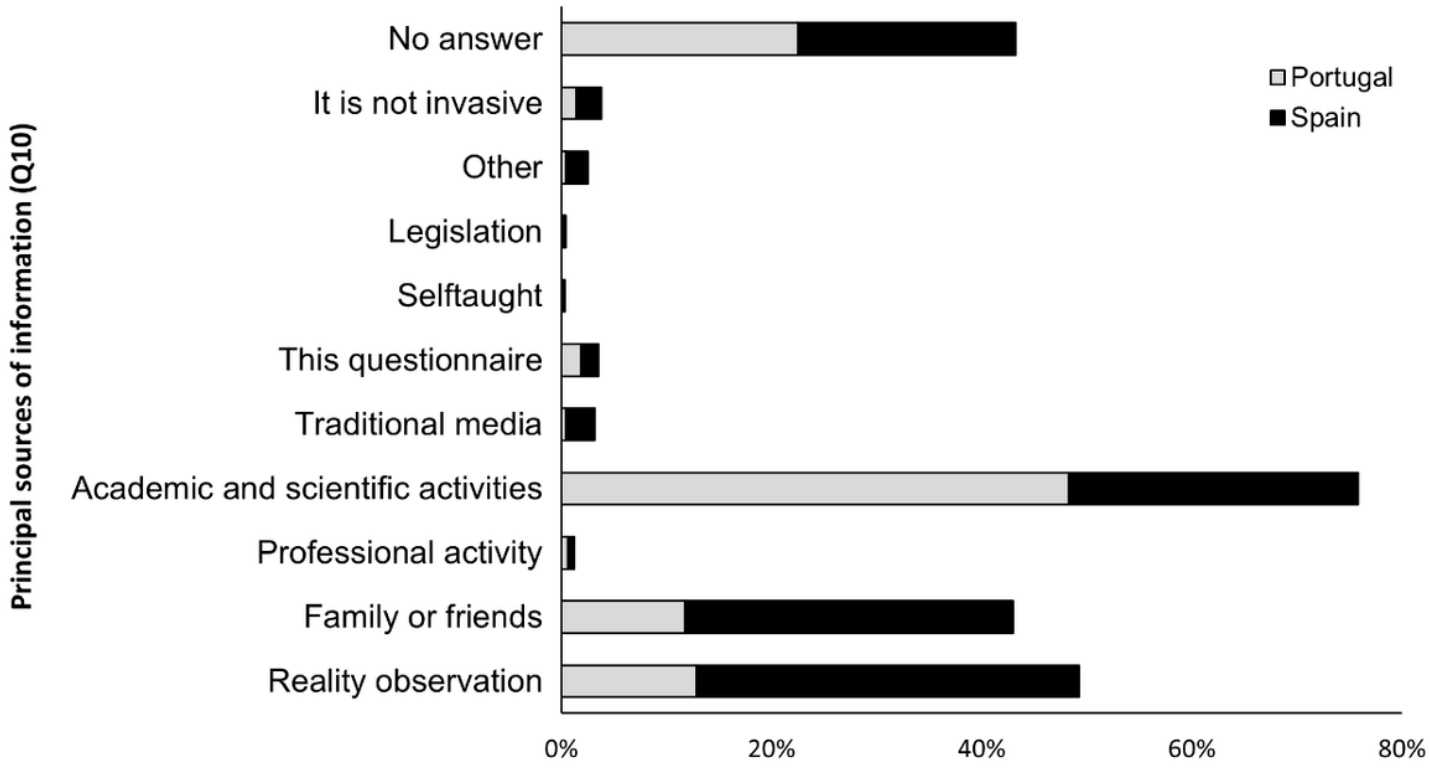

## Figure 1

Answers from Portuguese and Spanish respondents to the question Q7 – “Select the statements that, in your opinion, are most appropriate for this plant”. The original categories were classified as “correct” and “incorrect” for further analysis.



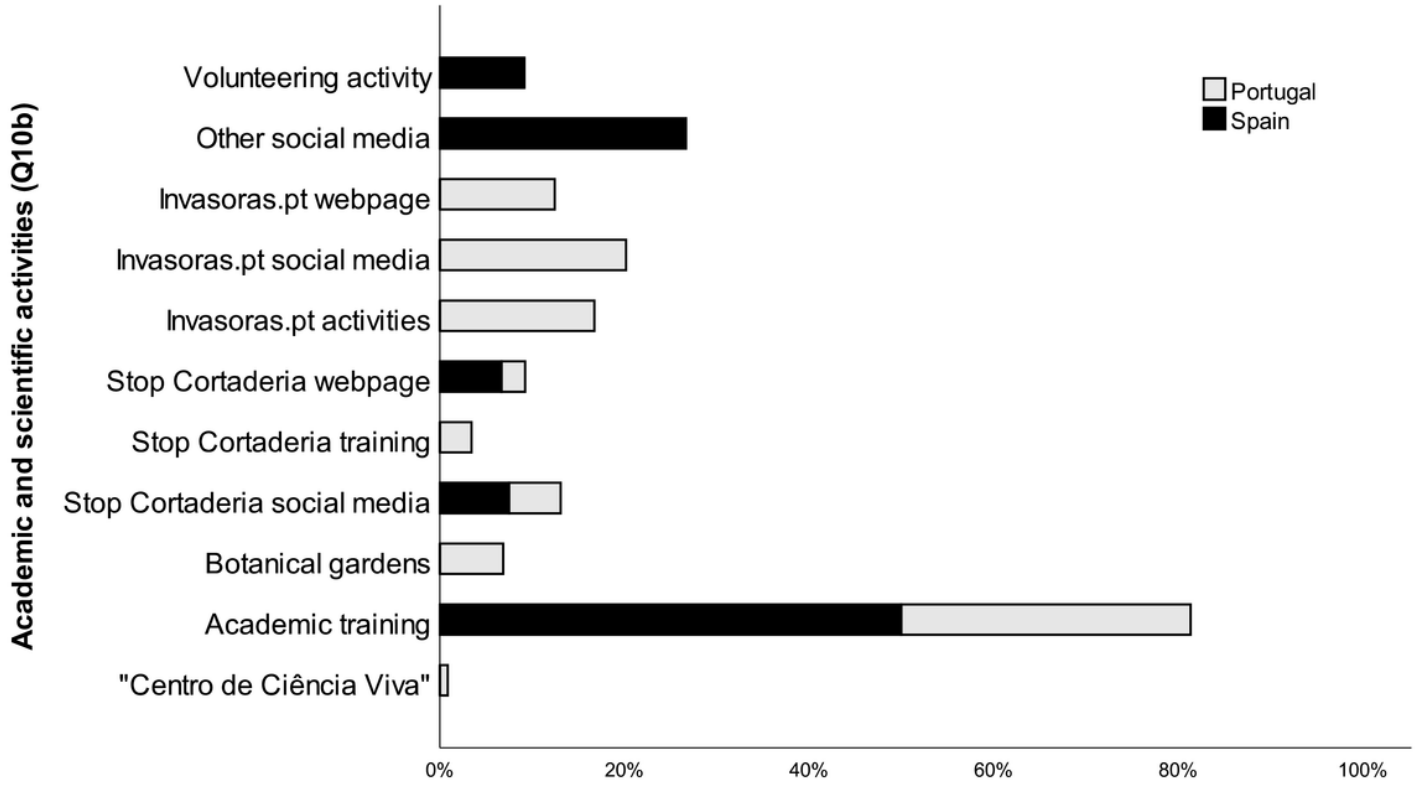
## Figure 2

Answers from Portuguese and Spanish respondents to the questions Q8.2 – “If you answered yes to the previous question, which is this Decree-Law?” (a) and Q9 – “In your opinion, what do you see in the photos below?” (b). The original categories were classified as “correct”, “incorrect” and “no answer” for further analysis.




## Figure 3

Main sources from which respondents´ learned that pampas grass is an invasive species (Q10).




## Figure 4

Academic and scientific activities (Q10b) from which respondents learned that pampas grass is an invasive species.

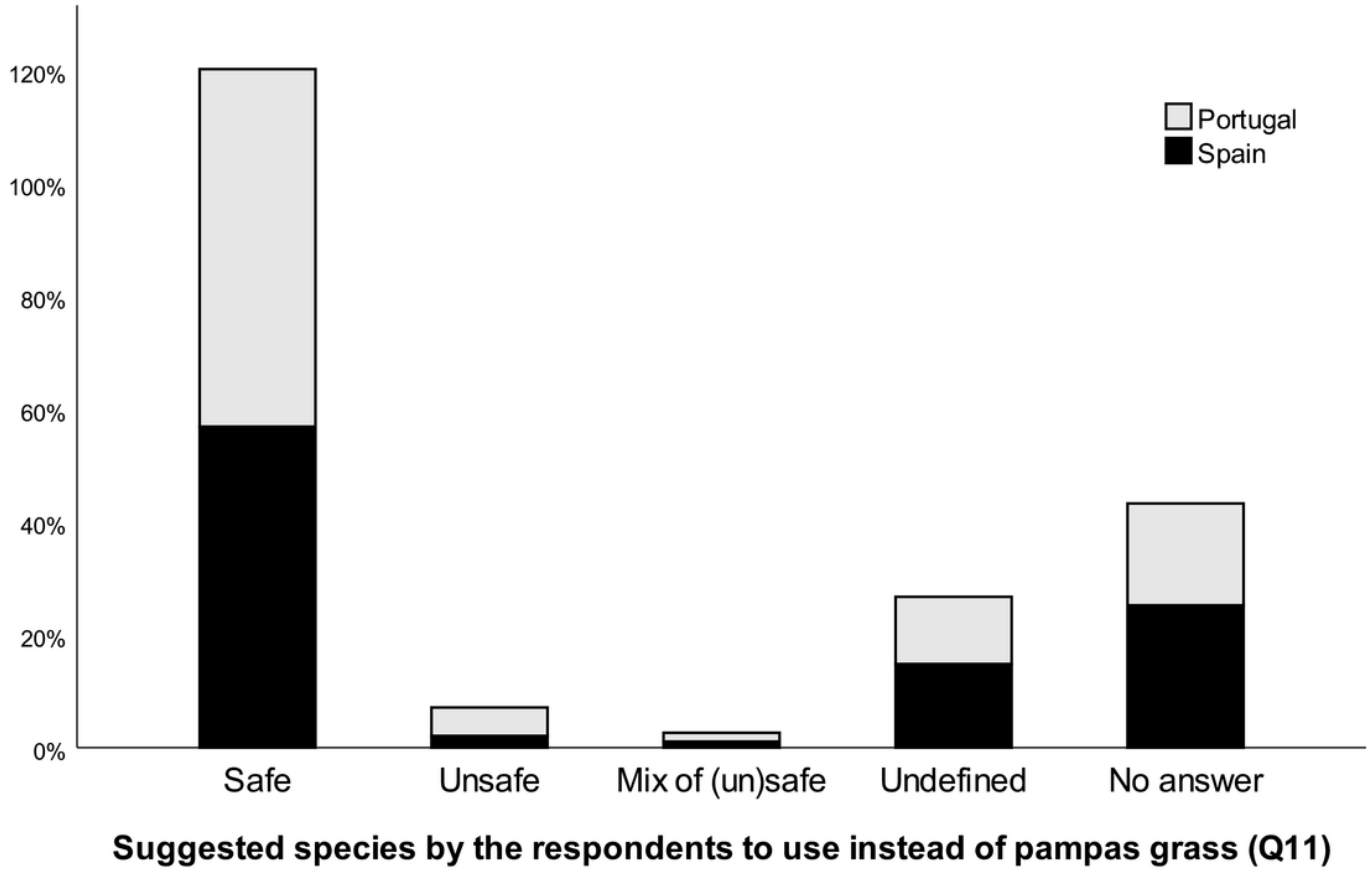



**Figure 5**

Categories of species suggested by the respondents to use as ornamentals in gardens instead of pampas grass. The description of each category is included in the methods section.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryInformation1.pdf
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