Research Article

Public opinions and perceptions of peri-urban plant invasion: the role of garden waste disposal in forest fragments

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Abstract

Horticulture is an important source of alien plant species that could potentially escape the garden fence, survive in nature, reproduce abundantly and finally became harmful to natural ecosystems (i.e. invasive). Additionally, residential garden owners promote the invasion of alien species by dumping garden waste in nature. A surprisingly high number of garden waste deposits was found in lowland peri-urban forest fragments in NE Slovenia. A positive relationship between proximity to these deposits and the number of alien plant species originative from discarded plants has been observed. This fact encouraged us to assess public knowledge of and opinions about invasive alien plant species (IAP), the public's habits in managing garden waste disposal and thus their awareness of promoting invasions. We conducted a questionnaire-based survey shared among various interest groups on social media platforms in Slovenia. Our results showed relatively good knowledge among respondents about IAPs. Over half the respondents were able to list at least one IAP. The most frequently listed IAP was *Ambrosia artemisiifolia*, followed by *Solidago* sp. and *Fallopia* sp. More than 10% of respondents who own a private residential garden confirmed our assumption that they discarded garden waste in the natural environment – in nearby forests. Respondents who were aware that such an approach could present a possible threat of promoting IAPs were less likely to discard garden waste in forests. According to respondents' socio-demographic status, we hypothesize that overall public awareness of promoting IAPs by discarding garden waste in forests is probably lower than our survey response showed. Findings of this study should be used to improve awareness among the general public about IAPs and possible unintentional introduction paths and dispersal of IAPs, caused by inappropriate garden waste management. In the near future, more activities to improve awareness must be carried out. Our proposal is supported by the opinion of our respondents; 79% of them perceive their knowledge about IAPs as insufficient.

Key words: alien plants, invasive species, residential gardens, horticulture, ornamental flora, disposal habits

Introduction

The majority of invasive alien plants (IAPs) were introduced for ornamental and horticultural purposes without awareness that these plants can become environmentally deleterious (Reichard and White 2001; Lambdon et al. 2008; Kowarik 2010; Pyšek et al. 2012; Pergl et al. 2016; Gaggini et al. 2017; van Kleunen et al. 2018). Therefore, horticulture is

recognized as an important, continuously increasing source of IAPs (Pergl et al. 2016; Ward and Amatangelo 2018) that could potentially escape the garden fence, survive in nature, reproduce abundantly and finally became harmful to natural ecosystems. Pergl et al. (2016) reported that 30% of Czech ornamental flora escaped from cultivation and has appeared in natural habitats, 8% of which species are invasive. Because of the high number of ornamental flora species pool, even a small percent of IAPs is not negligible. Moreover, each naturalized plant species might be a potential invader in the future (Pyšek et al. 2015). Invasive alien plants are introduced into natural habitats by various natural and anthropogenic vectors (Bar-Massada et al. 2014; Brancatelli and Zalba 2018), among which frequent natural vectors dispersing IAPs' propagules are the wind (e.g. *Ailanthus altissima* (Mill.) Swingle, *Acer negundo* L., *Solidago* L. sp.), birds (e.g. *Prunus laurocerasus* L., *Prunus serotina* Ehr., *Phytolacca americana* L.) and streams. Frequent human activities also introduce propagules in natural habitats including disturbances, favored by IAPs (Gonzáles-Moreno et al. 2013); unintentional dispersal by vehicles, enabling rapid dispersal over long distances (Šajna et al. 2017) or by clothing and footwear during outdoor recreation; and deliberate introductions. Therefore, the proximity of human settlements to a natural area and house density increase IAP richness and abundance in natural areas (Gavier-Pizarro et al. 2010a, b; Gaggini et al. 2017). The most commonly invaded (semi-) natural habitats in Europe are meadows, followed by forests, where almost 32% of all naturalized alien species are present (Lambdon et al. 2008). Additionally, the close proximity of human settlement influences the composition of IAPs, because they are mainly represented by ornamental plants originating from residential gardens (Pergl et al. 2016; Ward and Amatangelo 2018).

Inappropriate management of gardens can also represent a continuous source for IAP introduction. One such way is the dumping of garden waste in natural habitats (Sullivan et al. 2005; Rusterholz et al. 2012; Gaggini et al. 2017). During our monitoring of IAPs in peri-urban forest fragments in NE Slovenia, we found a surprisingly high number of garden waste deposits (own *unpublished data*). Because these finds coincided with a positive relationship between proximity to garden waste deposits and number of alien plants, we concluded that these were surviving discarded ornamental plants. The issue of promoting invasions by discarding garden waste is well recognized among biologists (Batianoff and Franks 1998; Sullivan et al. 2005, 2009; Rusterholz et al. 2012; Hu and Gill 2015; Gaggini et al. 2017); however, we hypothesized that awareness of the importance of this issue is not necessarily shared by residential garden owners (GO). Our study was based on an on-line survey designed to collect data and personal opinions. We were interested in determining the share of residential GO depositing garden waste in natural areas and relating their decision to their

sociodemographic information. We were further interested in whether they recognize that this behavior represents a risk of IAP introduction. We expected this information to clarify whether an awareness program is needed to shift GO behavior. Generally, when addressing a nature conservation issue, we need an understanding of people's knowledge and attitudes on the issue. This is why we evaluated how many IAPs they recognized and which they perceived as the most widespread. Finally, we assessed their opinion on whether they were sufficiently informed about invasive alien species (IAS), which indicates their willingness to obtain additional knowledge – a trait crucial for the investment we make in changing peoples' actions.

Materials and methods

Study area

Slovenia (20.273 km^2) is an European country located in the transition zone of the four main European biogeographical regions: sub-Mediterranean, Alpine (including Dinaric) and Pannonian. Because of its transitional geographical position, varied types of climate, wide elevation range and long history of traditional agricultural land use, Slovenia is characterised by high biodiversity and is among the European biodiversity hot spots (Mršić 1997). Forested area covers 60%, followed by meadows, fields and private gardens, orchards, vineyards and, lastly, 5% is occupied by urban areas and settlements (Pintar et al. 2015). One half of the 2 million population live in urban settlements, while the rest live in peri-urban and rural settlements (Vodeb et al. 2016). Peri-urbanization in Slovenia emerged from the urbanization of former rural areas in the urban fringe. Older peri-urban areas were developed from former villages, while more recent peri-urban areas are represented by newly built residential zones, mostly consisting of private, single-family, detached dwellings built in moderate density, still allowing some agricultural use of these areas (Vodeb et al. 2016). The countryside around urban areas is characterised by small fields, orchards and vineyards, intensively managed grasslands and forest fragments, intermixed with detached residences and often accompanied by vegetable and ornamental gardens, few fruit trees, lawns and hedges. In line with the EU Cohesion Policy, Slovenia is divided into two cohesion regions with similar number of inhabitants: the more developed west and the less developed east Slovenia. The population in western Slovenia attain on average higher educational levels and lower unemployment rate. The majority of Slovenian population is concentrated around the capital and other urban areas. On the other hand, eastern Slovenia is characterised by agriculture and more scattered settlement than the western part (Partnership Agreement 2014).

Table 1. Socio-demographic and spare time characteristics of the respondents (N = 271).

Characteristics (N of levels)	Variables	%
Gender (2)	Male/Female	19/81
Age (4)	< 20	6
	21–40	52
	41–60	36
	> 61	7
Education (4)	Less than high school	4
	High school	36
	Master's degree	55
	PhD	6
Residence (2)	West Slo./East Slo.	56/44
Spare time in nature (2)	Yes/No	97/3
Most frequent activity in nature (5)	Fishing	1
	Mushrooming	3
	Gardening	28
	Recreation	64
	Other	4
Garden owner (2)	Yes/No	80/20

Table 2. Dependent variables of interest and their levels.

Dependent variables	Attributes
General knowledge about invasive species	
Familiar with the term "IAS"	Categorical: Yes – No
Providing correct definition of the term IAS	Categorical: Yes – No
Opinion on being insufficiently informed about IAS	Categorical: Yes – No
Impact of threats (floods, climate change, habitat loss with degradation, pollution, IAS) on local biodiversity	Ordinal: 1 – no impact, 5 – strong impact
Knowledge of and perceptions about the IAPs	
Ability to recall IAP(s) from the domestic environment	Categorical: Yes – No
Perception of the impact of the most widespread IAPs in domestic surrounding	Ordinal: 1- negative, 5 – positive
Negative consequences caused by the most widespread IAP	Categorical: 4 levels (dummy coded)
Recognition of different IAPs in photos	Categorical: Yes – No
Perceived negative impacts and benefits of selected IAPs	Categorical: Yes – No
Awareness of promoting new invasions	
Disposal of garden waste in forests	Categorical: Yes – No
Recognition of activities that could promote plant invasions	Categorical: 4 levels (dummy coded)

Data collection

The online questionnaire-based survey (in the Slovenian language) was developed using the open-source online application EnKlikAnketa (1KA) (1KA 2019). The anonymous questionnaire was shared on social media platform Facebook across the entire Slovenia, where it was present for 3 weeks in May 2019. We shared the link of the survey within various groups of interest (e.g. gardeners, cyclists, educational institutions, retirement society groups) by inviting everyone to participate in the survey or share it further. We used the probability sampling method, which assumes that every member of a population has an equal chance to be reached. However, sample collection through social media could be bound to some limitations, which we further considered in the interpretation of the results. The first section (Table 1) was designed to gather socio-demographic variables, background knowledge about the IAS (IAPs) and opinions about threats to local biodiversity (Table 2). Answers enabled a study of respondents'

behavior and awareness concerning garden waste disposal in nature, thus promoting IAPs this way. Background knowledge was evaluated by the respondents' IAPs recognition and their opinion about the IAPs' benefits and damaging impacts. The respondents could choose from a list of the widespread IAPs in forests (according to the Ministry of the Environment and Spatial Planning of Republic of Slovenia): *Ambrosia artemisiifolia* L., *Erigeron annuus* (L.) Pers., *Impatiens glandulifera* Royle, *Fallopia japonica* (Houtt.) Ronse Decraene, *Solidago* sp., *A. altissima*, *P. americana* and *Robinia pseudoacacia* L.

Questions intentionally do not follow the order of sections written above to reduce the possibility of influencing respondents' answers. To ensure that answers were as reliable as possible, some questions were conditional, and only a certain answer made additional question(s) available to respondents (e.g. only respondents owning a residential or ornamental garden were asked about their garden waste disposal habits). In this manner, to respondents unfamiliar with the term IAS (IAPs), we introduced the term after the part addressing general knowledge about IAS (IAPs) to enable them to finish the survey.

Data analysis

We computed univariate descriptive statistics using frequencies and percentages for categorical data and means with standard deviations for continuous data.

We used binomial logistic regression (LR) models to examine associations between socio-demographic variables and spare time activities in nature (Table 1) with the dependent variables of interest (Table 2). Levels of the variable "Impact of IAS on local biodiversity" were grouped into two categories of respondents' opinion (low impact and strong impact) to examine differences in opinions among socio-demographic groups. In the models examining factors associated with garden waste disposal behaviour in forests and with the awareness of thus promoting invasion, we included respondents' knowledge of the term IAS and respondents' opinion about being sufficiently informed about IAS as the explanatory variable. Unanswered questions and those about respondents' "spare time spent in nature" and "most frequent activity in nature" were excluded from analysis because of identical answers. We confirmed an absence of multicollinearity among predictor variables by calculating the variance inflation factor (VIF < 2; Fox and Monette 1992). Potential predictors were assessed for significance at $P < 0.05$ within full models. To compare full *vs.* nested models with reduced set of predictors we calculated goodness of model fit and Akaike's Information Criterion (AIC) to rank alternative models, where models within 2 AIC units are commonly considered as alternatives. The optimal model according to AIC value was selected using the *dredge* function. Goodness of model fit was assessed based on Chi-square test (X^2)

statistics for significance at P < 0.05. Inputs to the X^2 test are the deviance of null model subtracted by the deviance of model fit (Δ deviance) and degrees of freedom of the null model subtracted by degrees of freedom of model fit. Statistics were performed in R, using the packages "MASS" (Venables and Ripley 2002), "car" (Fox and Weisber 2019) and "MuMIn" (Barton 2009).

Results

Response success and sociodemographic characteristics of respondents

The questionnaire reached 801 people; 428 of them only clicked on the invitation for participation heading, which included the theme of the survey; a further 102 people only opened the questionnaire. The questionnaire yielded 271 completions – a response rate of 34%. It showed a biased socio-demographic structure according to the gender and age of respondents: the highest rate of respondents were women between 21 and 40 years old with a tertiary-level education (Table 1). We were able to reach 216 GO (either vegetable, ornamental or both), representing 80% of respondents.

General knowledge about IAS

Results showed good knowledge of the term "invasive alien species" (IAS), even though 19% of respondents had never heard of IAS (17% of GO). The likelihood of a respondent being familiar with the term IAS was greater for older respondents and for respondents with higher education; however, these effects were not significant. On the other hand, the likelihood significantly increased if the respondent was a resident of western Slovenia (Model M1 in Table 3 and Supplementary material Table S1).

Among the respondents familiar with the term IAS, 70% (67% of GO) provided the correct definition of the term (including invasiveness and foreign origin of the species), while 25% (26% of GO) provided partly correct definitions. Most frequently, respondents did not take into account the foreign origin of the species or species invasiveness. Definitions considering only IAP were considered correct. Less than 5% of respondents (3% of GO) provided incorrect definitions. Women (LR; OR: 1.76, P = 0.13) or respondents with higher education (LR; OR: 1.16–5.90, P > 0.05) were more likely to provide the correct definition; however, neither the effects nor the model were significant (LR; data not shown).

Respondents perceived climate change, habitat loss along with degradation and pollution as stronger threats to local biodiversity than IAS; only 23% chose IAS. We found no difference in the socio-demographic structure of respondents according to their perception of IAS impact on local biodiversity.

Additionally, 78% of respondents (76% of GO) believed they are insufficiently informed about IAS (Model M2 in Table 3 and Table S1).

Table 3. Comparison of alternative multivariate logistic regression models M1–M5 within 2 AIC units. Models with the lowest AIC value are considered as optimal and shown in detail in Table S1. Sign + indicates that the variable is included in the model.

Intercept	Education	Garden owner	Gender	Residence	Age	Already heard about the term IAS	Being insufficiently informed about IAS	df	AIC	delta
M1: Already heard about the term IAS										
−0.56	+			+	+			8	247.8	0
−0.59	+	+		+	+			9	248.2	0.42
−0.82	+		+	+	+			9	249.3	1.47
−0.89	+	+	+	+	+			10	249.5	1.74
M2: Insufficiently informed about IAS										
0.82		+	+	+				4	275.9	0
0.94			+	+				3	276.4	0.52
−0.13	+	+	+	+				7	276.7	0.84
−0.05	+		+	+				6	277.0	1.15
M3: Ability to recall IAP(s)										
0.19			+	+	+			6	257.6	0
0.28		+	+	+	+			7	257.8	0.18
−0.39				+	+			5	258.5	0.95
−0.34		+		+	+			6	259.0	1.47
0.55			+		+			5	259.5	1.96
M4: Disposal of garden waste in forest										
−2.19						+		2	159.5	0
−2.71			+			+		3	160.6	1.07
−1.99								1	160.8	1.34
−2.75					+	+		5	160.9	1.38
−2.11				+		+		3	161.4	1.87
M5: Perceiving deposition of garden waste in forest as risk of invasion										
−3.15			+	+		+	+	7	229.0	0
−2.71			+	+		+		6	229.7	0.61
−3.10			+	+			+	6	230.3	1.29
−3.35		+	+	+		+	+	8	230.8	1.81
−3.17	+		+	+		+	+	8	230.9	1.85
−2.52			+			+	+	4	231.0	1.96
−3.04			+	+	+	+		7	231.0	1.96

Women between 21 and 40 years old with high school education represented a group very likely to express such an opinion (LR; data not shown), as well as respondents from eastern Slovenia.

Knowledge of and perceptions about the IAPs

Most respondents (58%; 61% of GO) were able to recall at least one IAP from the region they lived. The likelihood of recalling at least one IAP was greater for residents of western Slovenia. Moreover, the likelihood also increased with age (Model M3 in Table 3 and Table S1).

Respondents listed 32 different IAPs, with most of them listing up to 5 species (Figure 1A, B). The most frequent was *A. artemisiifolia*, followed by *Solidago* sp. and *Fallopia* sp. (Figure 1A). The majority of respondents (97%) thought that the most widespread IAP from their domestic surroundings has a negative impact on the environment; 3% chose the answer that the IAP does not have an impact, while only 1% thought that the impact of IAP is positive. Moreover, respondents were asked to report the negative consequences caused by IAPs already present in their domestic environment or which could be expected in the near future. When
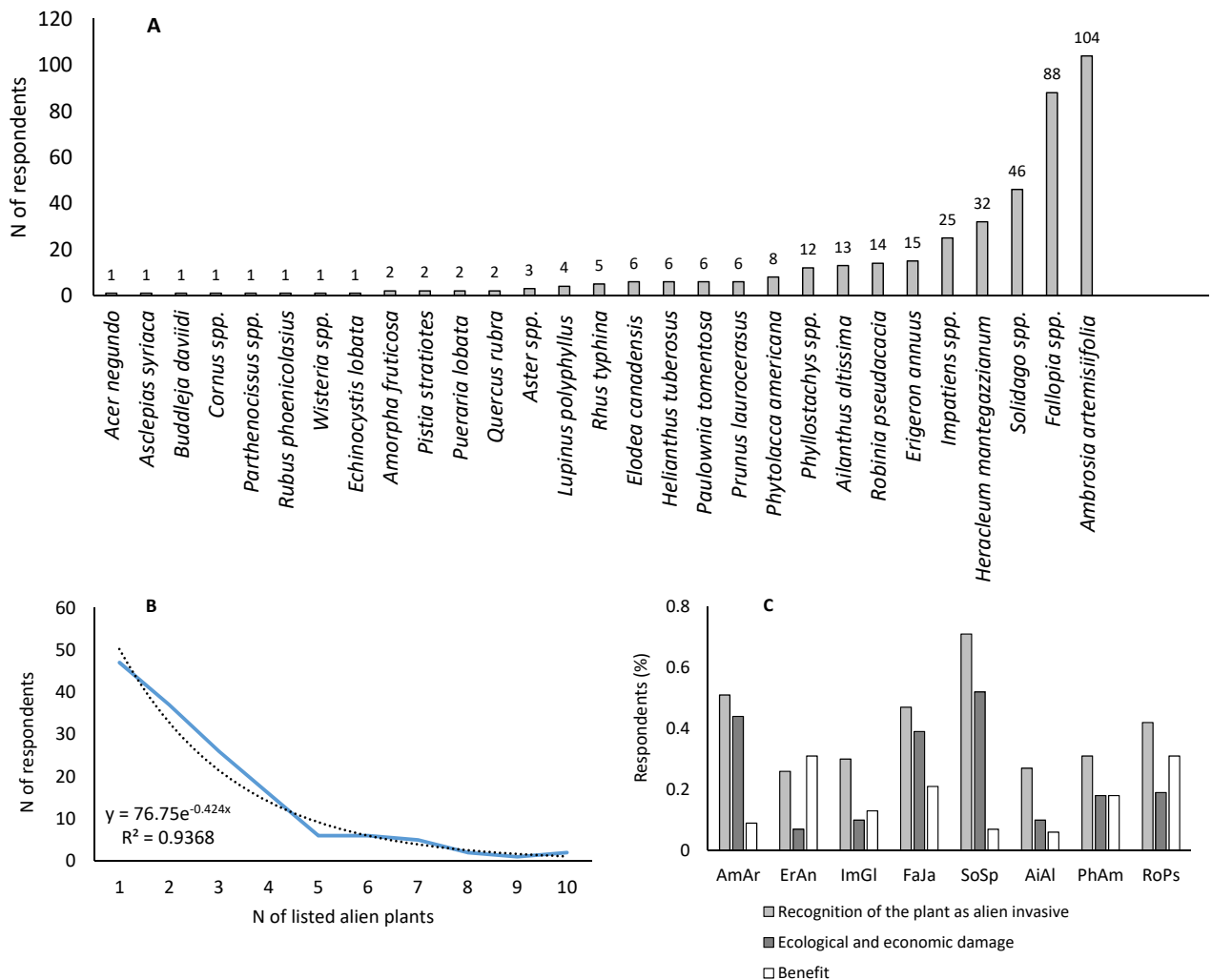
Figure 1. (A) Frequency of listed IAPs by respondents. *Impatiens glandulifera* and *I. parviflora* were combined under *Impatiens* spp., *Fallopia sachalinensis*, *F. japonica* and *F. × bohemica* were combined under *Fallopia* spp., (B) the number of respondents who listed more than one IAP is in exponential decline. The pointed curve represents fitted exponential function with equation and R^2 and (C) respondents' recognition of IAPs and their opinion about the damage and benefits provided by IAPs. AmAr – *Ambrosia artemisiifolia*, ErAn – *Erigeron annuus*, ImGl – *Impatiens glandulifera*, FaJa – *Fallopia japonica*, SoSp – *Solidago* spp., AiAl – *Ailanthus altissima,* PhAm – *Phytolacca americana* and RoPs – *Robinia pseudoacacia.*

they were asked to report evident negative consequences caused by the IAPs in their home range, most respondents (92%, N = 231) chose the extinction of indigenous species; 58% chose the negative influence on public health, and 28% chose economic damage. Socio-demographic characteristics had no significant effect on their opinions (LR; data not shown).

At least one given IAP illustrated by photographs in the questionnaire was recognized as an invasive species by more than 26% of respondents (Figure 1C). Moreover, 71% of respondents recognized a photograph of *Solidago* spp., while only 26% recognized *E. annuus*. The most frequently listed IAP from their home range, *A. artemisiifolia*, was recognized by 51%. The opinion of 52% of respondents was that *Solidago* spp. caused the greatest ecological and economic damage, followed by *A. artemisiifolia* with 44% and *Fallopia* spp. with 39%. Surprisingly, all IAPs presented in

the photographs were perceived as beneficial to humans to some extent, even the highly allergenic *A. artemisiifolia* by 9% of respondents (Figure 1C).

Garden waste disposal and the awareness of promoting invasions

Most respondents (75%) were composting garden waste in their gardens, and 30% were using waste bins collected by municipal waste services. Alarmingly, 12% of respondents (N = 216) were discarding garden waste in nearby forests. Among other ways of disposal, listed in low percentages, were burning, discarding as manure, dumping at the garden edge, or even on one occasion, in a nearby river.

Our model (Model M4 in Table 3 and Table S1) reveal that likelihood of dumping garden waste in forests significantly increase for respondents not familiar with the term IAS (IAP). Further, the odds of disposing garden waste in nearby forests were in favor of female respondents between 21 and 60 years old, resident in the eastern part of Slovenia (LR; data not shown).

Respondents expressed their opinion that the activity most likely to increase the risk of invasions was the planting of alien ornamental plants in domestic gardens and hedges (59%), or planting of alien ornamental plants in parks (14%). Only 21% of respondents recognized disposal of garden waste in forests as posing the greatest risk for new invasions. Respondents who were more likely to perceive garden waste disposal as increasing the risk of new invasion belong to one of the following groups: younger than 40, older than 60, resident in western Slovenia, unfamiliar with the term IAS and those who perceived themselves to be insufficiently informed about IAS. However, only residence in eastern or western Slovenia had a significant effect (Model M5 in Table 3 and Table S1).

Discussion

Disposal of garden waste in natural habitats represents numerous threats (e.g. pollution with nutrients, chemicals (e.g. pesticides), and disease transfer), particularly facilitating the spread of IAS (Bar-Massada et al. 2014). According to our previous observations in the field, which confirmed the frequent presence of garden waste in forest fragments, and the results of this survey, we need to stress that the importance of appropriate garden waste disposal is not sufficiently recognized among our respondents.

The population part, participating in an online survey, can differ from the average population in a higher education level and a lower rate of older respondents (Windle and Rolfe 2011; Lindhjem and Navrud 2011; Saloniki et al. 2019). However, survey results about biodiversity protection plans were not different to those from the face-to-face approach (Lindhjem and Navrud 2011). In our survey, most respondents were middle-aged women with tertiary level education. The sample included 216 (80%) garden owners. We expected that overrepresentation of women could result in an overestimated familiarity with IAS; however, gender bias would not influence

the answers about managing garden waste, since GOs of the same garden manage it in the same way.

Our results support findings by Japelj et al. (2019) that general knowledge about the IAS in Slovenia was good, similar to the Netherlands, as reported by Verbrugge et al. (2013). Most respondents were familiar with the term IAS and understood it at least partly correctly. Similar to the Netherlands (Verbrugge et al. 2013), 58% of respondents were able to name at least one IAP. The number of respondents able to list more declined rapidly (Figure 1b), nevertheless resulting in a remarkable list of IAPs. As expected, the most frequently listed IAPs were the most common ones in the natural environment. Among these, were species with high levels of media attention (Japelj et al. 2019) like *A. artemisiifolia* because of its highly allergenic pollen and legally required eradication. However, 27% of respondents (28% of GO), who listed *A. artemisiifolia*, have not recognized it in a photograph in further questioning and 2% even perceived it as beneficial. This indicates gaps in knowledge and inconsistent opinions about IAPs. Moreover, inconsistent opinion was shown by answers that the most common IAPs from respondents' neighborhoods were perceived to have a negative impact on the environment; however, when they had to select several environmental issues with an impact on local biodiversity, IASs were never perceived as the most threatening factor. Our results are similar to those from the Eurobarometer survey (European Commission 2019, N = 27643), showing that pollution, habitat loss and climate change are the biggest threats perceived.

It is widely acknowledged that private GOs unintentionally promote invasions by planting alien ornamental plants in gardens and hedges (Verbrugge et al. 2014; van Kleunen et al. 2018), and almost 60% of our respondents agreed. Garden waste disposal in nearby forests is one such promotion that can be frequently observed; however, data about people doing it is scarce. One reason might be clandestine dumping (Dewaelheyns et al. 2013). In New South Wales, Australia, this was reported by 24% of respondents (12% of them on a monthly basis; Hu and Gill 2015). The high representation of GOs suggested that the majority of our respondents would be well informed about the IAS and that they would recognize activities promoting IAP in nature. That was true for their knowledge about IAS; however, only about 21% of our respondents (19% of GO) agreed that disposal in natural habitats of garden waste containing alien plant propagules promoted invasions, even though this is also widely acknowledged (Rusterholz et al. 2012). Those 21% of respondents who agreed were less likely to dump garden waste in forests. Our results showed that 12% of GOs throw garden waste into nearby forests, and those who were unfamiliar with the term IAS were twice as likely to dispose of garden waste in such a way. On many occasions, this behavior results from the misunderstanding that it is non-harmful or even good for the environment (Hu and Gill 2015). Further reasons are the respect for living plants, aesthetics

and the ease of plant dumping (Verbrugge et al. 2014) or insufficient capacity of bins (Hu and Gill 2015). It seems that non-recognition of the threat of IAP by most respondents could be related to the prevailing opinion that each IAP is in some way beneficial. Interestingly, respondents unfamiliar with the term IAS were more likely to recognize disposal of garden waste in nature as a possibility enabling invasions. Similarly, a survey of Swiss horticulturalists suggested that, if a plant was perceived as familiar, this had a mitigating effect on risk perception (Humair et al. 2014). Additionally, we believe that media reports about IAP (at least in Slovenia) are over-focused on atypical IAPs (e.g. *Heracleum mantegazzianum* Sommier & Levier or *Pueraria* DC.), and we can expect that once people recognize *E. annuus* as the most frequent IAP (in Slovenia), they would perceive the general harmfulness of IAP to a lesser extent. Our results are an indication that merely familiarizing the public with which species are invasive would be insufficient and might even reduce concern about IAPs. Therefore, additional information about the threat each IAP presents in nature should be communicated in a carefully planned way to promote a consistent opinion toward IAS.

What is more, in most answers we found a significant difference in knowledge and perceptions between respondents resident in the western and eastern parts of Slovenia (Table S1). Respondents from the western region were almost three times more likely to be familiar with the term IAS; they also showed better knowledge of and awareness about the invasion risk of garden waste dumping. Residents of eastern Slovenia were more likely to discard garden waste in forests. Results mirror the division of the country into two cohesive regions: the less developed eastern part and a western part that is developed to a level above the European average. Additional causes for such results can be attributed to uneven awareness-raising campaigns across the country (e.g. lectures, IAP elimination campaigns and exhibitions). According to the Ministry of the Environment and Spatial Planning, since 2010, 80% of all activities implemented across the country were conducted in the western region. However, in the last three years the number of activities for raising public awareness about IAS also increased slightly in the eastern region, an area which should remain in focus or even become priority region for further activities.

From the answers of our respondents, we can imply that women, younger respondents, or those with lower education levels think that they have insufficient knowledge about the IAS. This opinion was shared with respondents who already had some knowledge and was significant for residents of eastern Slovenia. We expect that their self-critical opinion expresses an interest in and willingness to learn more about IAS issues. Therefore, we estimate that an awareness raising program would be beneficial in changing perceptions about IAPs in general and in encouraging the abandonment of or at least minimization of inappropriate

garden waste disposal. Specifically for Slovenia, more effort towards awareness-raising activities should be addressed to the eastern region. It is crucial to involve the public (Shrestha et al. 2019) and to collect preliminary information about people's values and knowledge (Shackleton and Shackleton 2016) to design adequate communication strategies. According to our results, people with some knowledge about IAPs should be approached differently from those with no or less knowledge. We additionally suggest targeted awareness campaigns for private GOs behaviour, with the main objective of highlighting the role of horticulture in alien plant invasion.

Acknowledgements

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Supplementary material

The following supplementary material is available for this article:

Table S1. Results of multivariate logistic regression analysis: already heard about the term IAS; insufficiently informed about IAS; the ability to recall IAP(s) from own environment; disposal of garden waste in forests and perceiving deposition of garden waste in forests as risk of new invasions according to demographic factors.

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