Received: 10 October 2025 | Accepted: 20 April 2026

DOI: 10.1002/pan3.70344

People and Nature

RESEARCH ARTICLE

# When invasions go unnoticed: Public perception of the freshwater jellyfish *Craspedacusta sowerbii* in Europe

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**Funding information**
National Research, Development and Innovation Office, Hungary, Grant/Award Number: MEC_N:148923

**Handling Editor:** Joana Vicente

## Abstract

1. Biological invasions are a major driver of biodiversity loss, yet inconspicuous or "cryptic" species often escape detection and public awareness, limiting management responses.
2. We investigated the freshwater jellyfish *Craspedacusta sowerbii*, likely native to China and now present on six continents, through a 22-month multilingual online survey across 17 European countries ($n = 1388$), to assess public knowledge, perceptions and views on its management.
3. Results revealed low public awareness: over 80% of respondents did not know the scientific name, 49% misidentified its freshwater habitat as marine and only 33% recognized it as non-native.
4. Aesthetic perceptions were largely positive, but mass occurrences triggered caution and direct contact was rare and usually harmless.
5. Bayesian Network analysis showed that direct observation—rather than demographic factors or scientific knowledge—was the strongest predictor of concern and support for public discussion.
6. While *C. sowerbii* was not widely perceived as a local threat, many respondents acknowledged its potential ecological implications and supported greater public awareness and management actions.
7. Our findings highlight how visual subtlety and limited media coverage reduce detection and prioritization of cryptic invasive alien species (IAS), hindering early warning systems and policy development.
8. Leveraging citizen science and experiential engagement can improve recognition and reporting, complement formal monitoring and support more inclusive management strategies.

For affiliations refer to page 15.

9. We recommend integrating cryptic invasions like that of *C. sowerbii* into IAS frameworks and policies, emphasizing public participation and awareness to address overlooked, but potentially impactful species.

**KEYWORDS**
global change, hydrozoa, invasive freshwater species, perception, survey

## 1 | INTRODUCTION

Biological invasions are among the primary drivers of global biodiversity loss (Bellard et al., 2016). Following the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment, we distinguish here between alien species, that is those introduced outside their native range, and invasive alien species (IAS), defined as alien species whose establishment and spread threaten biodiversity, ecosystem services or human well-being. According to the IPBES Global Assessment Report (Roy et al., 2023), IAS are now recognized as the fifth main cause of species extinction, following changes in land and sea use, direct exploitation of organisms, climate change and pollution. The exponential increase in trade, globalization and international transport has significantly facilitated the introduction and establishment of species outside their native ranges. By 2023, the IPBES estimated that over 37,000 alien species had been introduced into new ecosystems, with at least 3500 classified as invasive, causing significant ecological, economic and health impacts (Pascual et al., 2023; Roy et al., 2023).

Nevertheless, not all biological invasions are perceived in the same way, whether by scientists, managers or the general public (Banha et al., 2022). Some IAS quickly attract attention due to their spectacular effects or direct impact on human activities, such as the Asian hornet (*Vespa velutina* Lepeletier, 1836) in Europe (Keeling et al., 2017) and the zebra mussel *Dreissena polymorpha* (Pallas, 1771) in North America (Strayer, 1991). Conversely, other invasions pass relatively unnoticed: their progress is silent, their effects less obvious, or their life cycle (or certain stages thereof) largely unobservable (Spear et al., 2021). These so-called cryptic invasions (Latombe et al., 2017) nonetheless make up a significant part of the current introduction dynamics, and their underestimation can be detrimental to the overall understanding of the ongoing ecological changes.

Public perception often differs from that of conservation managers, which can complicate management efforts and priorities for IAS (Banha et al., 2025; Gozlan et al., 2013), playing a critical role in shaping monitoring strategies, influencing policy decisions and guiding citizen science participation (Courchamp et al., 2018). Several studies have recently highlighted attention bias towards small aquatic IAS or those lacking an immediately identifiable economic impact (Seebens et al., 2017; Seebens et al., 2021; Essl et al., 2020). Species such as the bloody-red mysid *Hemimysis anomala* (G.O. Sars, 1907), a mysid shrimp native to the Caspian Sea, or the spiny water flea *Bythotrephes longimanus* (Leydig, 1860), a planktonic predator from the Great Lakes of North America, have long remained understudied despite their role as ecosystem engineers (Wittmann et al., 2016; Yan et al., 2011). Similarly, some ctenophores, such as *Mnemiopsis leidyi* (A. Agassiz, 1865), were only fully recognized as invasive several years after their introduction, despite contributing to fisheries collapse in the Black Sea (Shiganova, 2000). Yet, the growing involvement of the public in biodiversity monitoring highlights the potential of the 'power of many': when well-informed and adequately supported, collective observation efforts can counteract attention biases and enhance early detection of inconspicuous or understudied species. Public participation not only helps fill critical data gaps but also fosters more inclusive and responsive monitoring systems capable of detecting subtle ecological signals that might otherwise go unnoticed by conventional surveillance (Dickinson et al., 2010; Pocock et al., 2017).

In recent years, public participation in biodiversity monitoring has become an increasingly valuable tool for detecting or tracking biological invasions. However, its effectiveness largely depends on public awareness and the recognizability of species, which remain major challenges for organisms that are unknown or difficult to observe (Ricciardi et al., 2017; Tricarico, 2022).

*Craspedacusta sowerbii*, the world's most widespread freshwater jellyfish, exemplifies this type of discreet invasion. Likely native to the Yangtze River basin in China (Fritz et al., 2007), this hydrozoan was first described outside its native range in 1880, in an ornamental pond in London (Lankester, 1880). Since then, it has been reported on six continents through the involuntary transport of propagules (polyp or podocyst stages) associated with aquatic plants or submerged substrates (Dumont, 1994; Lüskow et al., 2024; Marchessaux, Lüskow, et al., 2022). In Europe, its presence is now well-documented in many countries, including the Czech Republic, Finland, France, Germany, Greece, Italy and Spain, though its distribution remains highly uneven across the regions (Karaouzas et al., 2015; Lüskow et al., 2025; Marchessaux et al., 2021).

Despite its wide distribution, *C. sowerbii* remains surprisingly understudied (Lüskow et al., 2024). Most publications focus on occurrence records or descriptive studies of its life cycle, which alternates between a tiny benthic polyp and a planktonic medusa visible only at certain times of the year (Lüskow et al., 2024). Its actual ecological impact is still poorly understood, although some studies suggest it may disrupt pelagic food webs, notably by competing with fish larvae or macroinvertebrates (Dodson & Cooper, 1983; Schachtl et al., 2026; Thomas, 1950). In addition, the species often escapes traditional detection (Moore et al., 2025): its appearance is sporadic,

localized and sometimes limited to a few days per year, making it very difficult to monitor. Given this biological and media invisibility, it is legitimate to question whether the invasion of *C. sowerbii* is perceived and recognized as such by the general public, particularly in Europe, where awareness of IAS varies considerably depending on geographical and cultural contexts.

Hence, the aim of the study was to assess, using survey data and citizen observations, the level of public knowledge and perception of *C. sowerbii* in 17 European countries to better understand the societal and cognitive factors influencing the visibility of a biological invasion. This study hypothesized that *C. sowerbii* is poorly known to the public and that its ecological implications go largely unnoticed. Findings from this study can inform targeted public engagement and monitoring strategies, improve the design of citizen science platforms, and contribute to a broader understanding of how societal factors mediate the detectability of biological invasions, particularly those that are inconspicuous yet ecologically significant (Groom et al., 2019). Enhancing public awareness of cryptic IAS such as *C. sowerbii* could support earlier detection and more effective management responses, thereby reinforcing prevention strategies and biodiversity conservation policies.

## 2 | MATERIALS AND METHODS

### 2.1 | Ethics

An online questionnaire survey (in Google Form format) was carried out to assess public awareness about the invasion of freshwater jellyfish *C. sowerbii* across 17 European countries (see the questionnaire in the Figure S1). No formal ethics committee approval was required for this study because it was based solely on an anonymous, voluntary online questionnaire that did not collect any sensitive personal data (e.g. no information about the respondents' last name, first name or home address was requested). All participants were informed about the purpose of the research, the nature of their participation and their right to withdraw at any time before starting the questionnaire, and their explicit consent was obtained before participation. The survey design and data handling strictly complied with European data protection regulations (GDPR) and followed accepted ethical standards for social science research involving human participants.

### 2.2 | Survey strategies

The questionnaire was accessible for 22 months starting in March 2023. We used the 'snowball' method to collect responses to the questionnaires, beginning with previously identified networks such as Facebook groups oriented towards citizen sciences (e.g. photography, hiking, excursions), major institutions in natural sciences (e.g. IUCN), nature managers, university mailing lists and personal networks of co-authors. Participants were also encouraged to share the questionnaire within their respective networks to help reach a broader panel of respondents. Additional outreach was achieved by sharing the questionnaire online via press and TV communication (Marchessaux et al., 2023, 2024), as well as through dissemination via project mailing lists and stakeholder databases managed by co-authors.

The questionnaire was created based on a review of the available literature on public perception of IAS (Cerveira et al., 2022; Huth et al., 2016; Marchessaux et al., 2024; Vandendriessche et al., 2016; Varble & Secchi, 2013) and was further refined by the co-authors to address country-specific aspects. The questionnaire was translated into multiple languages by native-speaking co-authors with expertise in invasion and jellyfish ecology and environmental sciences. While the co-authors' team collaborated to harmonize terminology and ensure conceptual consistency, the process did not employ a formal cross-cultural validation protocol, such as independent back-translation. Consequently, subtle linguistic or cultural variations in the interpretation of terms such as 'invasive', 'non-native' or 'problematic' may exist, a factor that should be considered when discussing cross-country comparisons.

To broaden the study's geographical coverage, 40 researchers across Europe were contacted, identified through published work on freshwater ecology and biological invasions and invited to disseminate the survey within their national networks. However, several researchers did not respond or declined collaboration, resulting in uneven geographic representation. Variability in response rates and local engagement resulted in an uneven geographic representation; thus, a number of countries where *C. sowerbii* is known to occur (e.g. Belgium, the Netherlands and Ireland) are absent from the dataset. As a result, data from 17 countries were collected: Bosnia and Herzegovina, Denmark, France, Georgia, Germany, Hungary, Italy, Norway, Poland, Portugal, Romania, Russia, Slovakia, Spain, Türkiye, Ukraine and the United Kingdom.

The questionnaire was designed for an average completion time of 10–12 min to maximize participation (Figure S1) and was administered anonymously and voluntarily to minimize response bias. The survey was structured into six thematic sections:

1. *Demographics*: Basic data were collected, including gender, age and city of residence. To prevent survey fatigue, we omitted variables such as education level and professional background, prioritizing accessibility over exhaustive socio-demographic profiling.
2. *Interactions*: Familiarity with the species name (*C. sowerbii*) and personal observations.
3. *Aesthetics & physical impact*: Exploring the aesthetic perceptions of the species, including its physical appearance and whether respondents had ever been stung by *C. sowerbii*.
4. *Origin perception*: Assessment of whether respondents considered *C. sowerbii* native or introduced.
5. *Ecology and management*: Aimed to assess public knowledge of the species' ecology and views on its management and prioritization, respectively.

To avoid influencing responses, we chose never to explicitly name the species in focus (in this case, *C. sowerbii*), even at the end of the questionnaire, but a panel of pictures of the species was given to the respondents in the questionnaire (Figure S1). Similarly, in all communications promoting the survey, we simply specified that this study concerned an emerging ecological phenomenon in Europe, without ever mentioning what it was.

### 2.3 | Data analysis

Given the noteworthy difference in the number of responses collected per country (minimum: one for Ukraine, likely due to the ongoing war during the survey period; maximum: 247 for Slovakia), we chose to process all responses collectively to reflect European citizens' perception of the *C. sowerbii* invasion. Accordingly, all country-level data were aggregated into a data matrix comprising all responses. The data were processed in alignment with the 6-panel structure of the questionnaire, allowing us to monitor its organization and the evolution of responses according to the various categories. For the first panel, we created a map presenting the countries included in the study. Using the QGIS software (version 3.40.1), we highlighted and colour-coded each country based on the number of responses received. The frequency distributions of respondent age and gender were calculated and then visualized using a histogram and a pie chart created with SIGMAPLOT 12.5. Responses for the remaining categories were converted to percentages and plotted accordingly. The figure formats were selected to best represent the trends observed in the collected data. To support our theory that the invasion of *C. sowerbii* is poorly understood, we highlighted the proportion of 'I don't know' responses in dark grey across all graphs.

To contextualize the species invasion of each country and the number of replies, we have plotted the number of *C. sowerbii* occurrences and the total number of replies per country, and we performed a generalized linear model (GLM) analysis using the R Studio software (version 2024.12.0).

To explore the interdependence of individual responses and detect any demographic, geographic or independent effects related to respondent characteristics, a Bayesian Network (BN) was constructed to model the conditional dependencies among the measured variables. A BN is a graphical probabilistic model in which each node represents a random variable, and each directed arc encodes a conditional dependency relationship between two variables (Pearl, 1988). The structure of the network was learned using the hill-climbing (hc) algorithm, which optimizes a log-likelihood score by exploring possible structures under the constraint of graph acyclicity (Koller & Friedman, 2009). The entire process was carried out using the '*bnlearn*' package (Scutari et al., 2015) in R Studio. After learning the structure of the directed acyclic graph (DAG), the conditional parameters of the network were estimated using a frequentist approach (bn.fit), which allowed for defining the conditional distributions of each variable given its parents in the graph (Spirtes et al., 2000). Conditional inference was performed using the likelihood weighting method via the 'cpquery' function of the '*bnlearn*' package (Scutari et al., 2015). This method relies on weighted simulations from the learned network. The number of simulated samples was set to 10,000 to ensure sufficient convergence. The network visualization was carried out using the '*Rgraphviz*', '*igraph*' and '*visNetwork*' packages within an interactive Shiny interface. The resulting DAG illustrates the structure of conditional dependencies among the variables, where each node represents a variable, and each arrow indicates a direct influence in the joint factorization of the model.

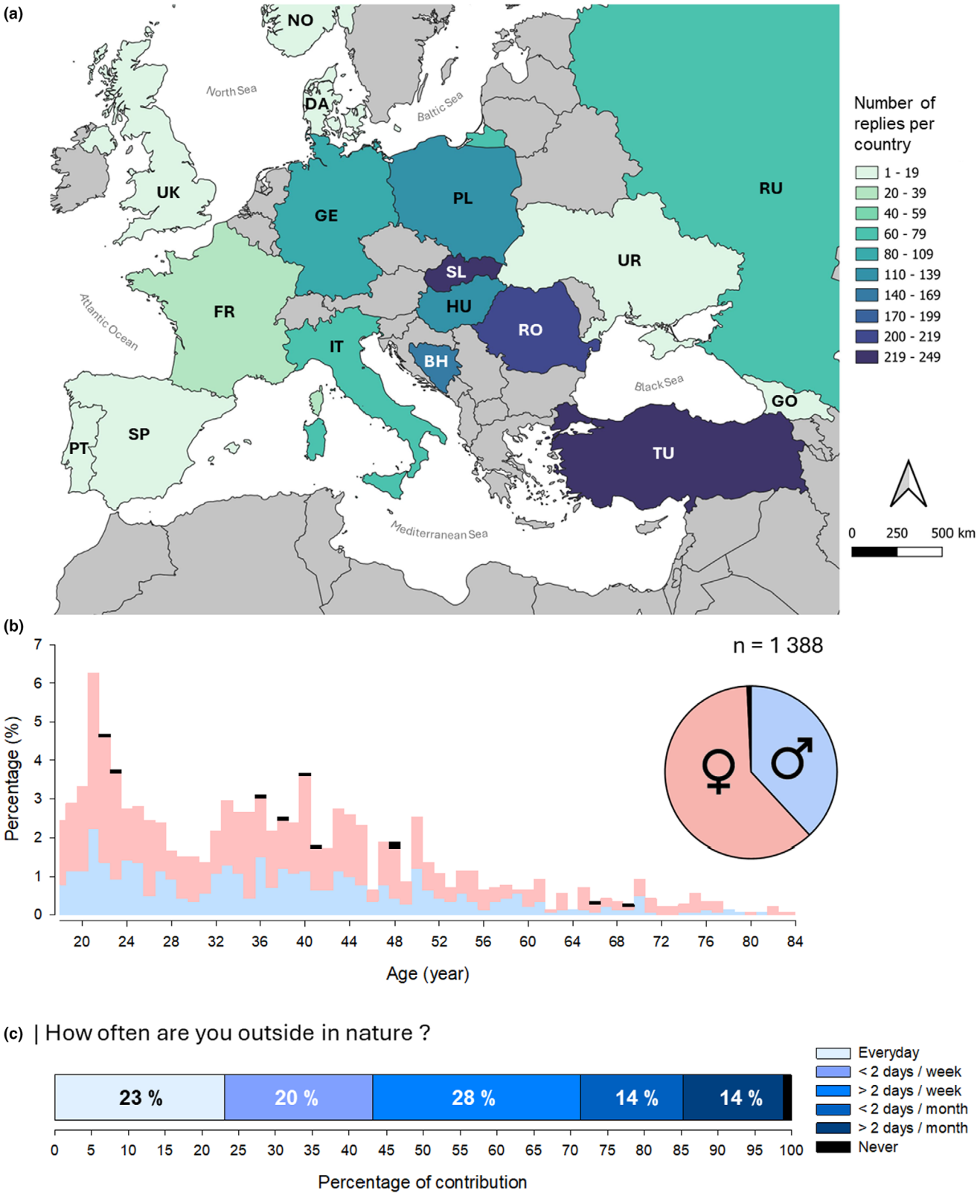
## 3 | RESULTS

A total of 1388 questionnaires were completed between 3 March 2023 and 31 December 2024 (Figure 1a). The spatial distribution of respondents shows broad coverage across all countries included in the study (Figure 1a), with the number of responses ranging from 1 (in Ukraine) to 247 (in Slovakia). The sample consisted of 38% male respondents, 61% female and 1% who did not specify their gender. Respondents were between 18 and 84 years, with a majority (64%) falling within the 18–40 age group (Figure 1b). Regarding the relationship between the number of replies per country and the number of reported occurrences of *C. sowerbii* (Figure S2), notable discrepancies emerged from the GLM Poisson model ($\beta = -0.0049 \pm 0.00076$ SE, $z = -6.43$, $p < 0.001$; AICc = 121.92; Figure S2). For instance, countries such as France and Germany reported numerous occurrences despite fewer responses, whereas others, such as Slovakia and Türkiye, contributed many responses, but reported few or no occurrences (Figure S2). We observed that 23% of respondents report going outdoors into nature every day, while 14% never do so (Figure 1c).

Regarding the species visibility (Figure 2a), 48% of respondents reported having seen it, while 52% stated they had never observed it. When asked to identify the organism (Figure 2b), 83% recognized it as a jellyfish, whereas 14% did not know what it was. Common misidentifications included comb jellies, tunicates and fish. When asked about the scientific name of the species (Figure 2c), 81% indicated they did not know it, and only 10% correctly identified *C. sowerbii*. Confusion with marine species such as *Aurelia aurita* and *M. leidyi* was common. The reported locations of observation revealed

**FIGURE 1** (a) The number of responses collected from the 17 countries included in the study. (b) Distribution of the respondents by age and gender. (c) Frequency of respondents' habit of being outside in nature. In panel (a), the abbreviations correspond to the countries' names: BH, Bosnia and Herzegovina; DA, Denmark; FR, France; GE, Germany; GO, Georgia; HU, Hungary; IT, Italy; NO, Norway; PO, Poland; PT, Portugal; RO, Romania; RU, Russia; SL, Slovakia; SP, Spain; TU, Türkiye; UK, United Kingdom; and UR, Ukraine.

# Respondents metrics



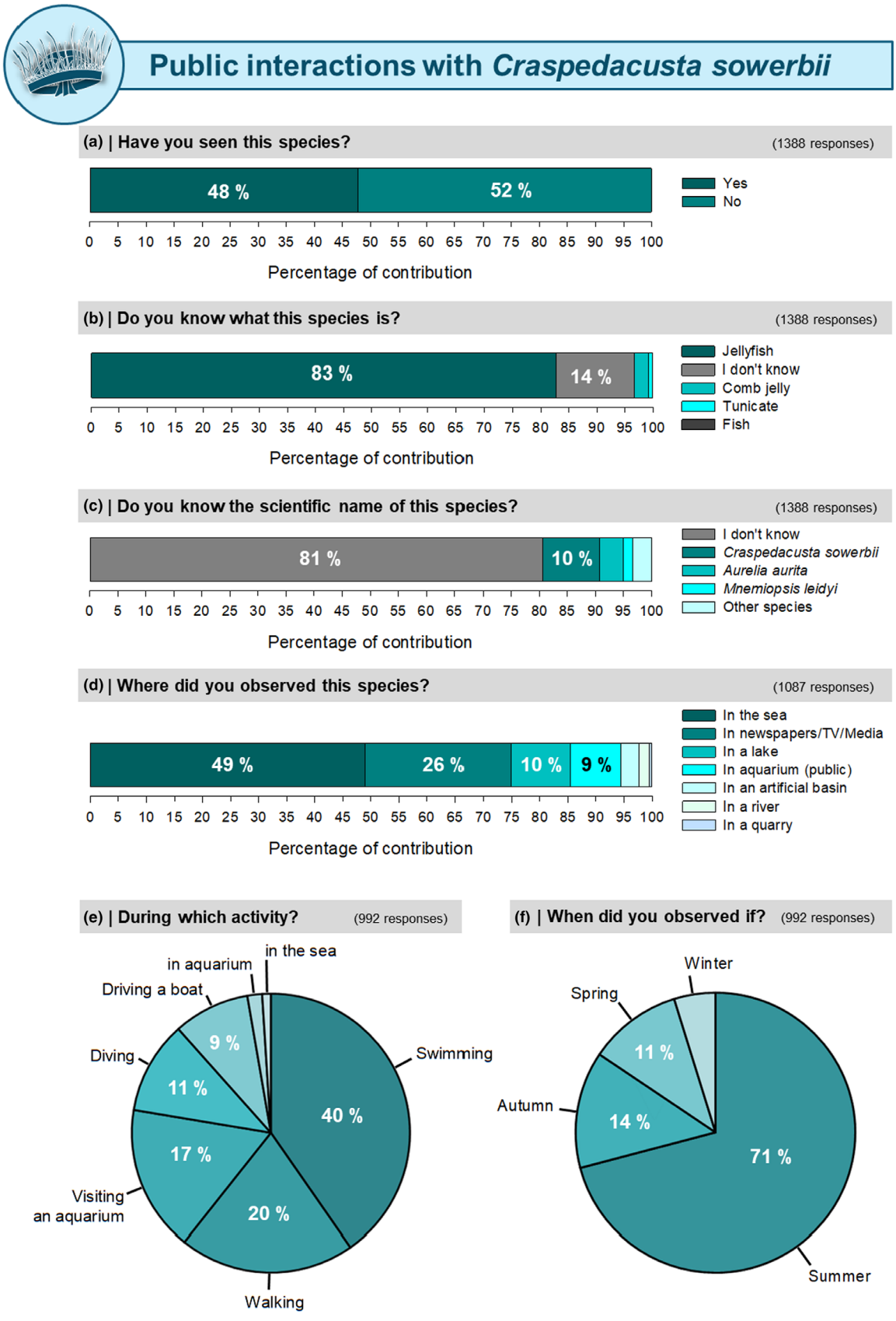



FIGURE 2 Public perception of *Craspedacusta sowerbii* (Panel 2 of the questionnaire): (a) 'Have you seen this species?', (b) 'Do you know what the species is?', (c) 'Do you know the scientific name of this species?', (d) 'Where did you observe this species?', (e) 'During which activity?', (f) 'When did you observe this species?'.

significant misconceptions: 49% of respondents claimed to have seen the species in the sea, which is incorrect as *C. sowerbii* is strictly freshwater (Figure 2d). Furthermore, 26% saw it through media (TV, newspapers), 10% in a lake and 9% in a public aquarium—environments more consistent with the species' ecology. Observations in artificial basins, rivers or quarries were less frequent. The activities during which the species was observed varied broadly: the majority (40%) observed it while swimming, 20% while walking, 17% during aquarium visits, 11% while diving and 9% while boating (Figure 2e). Very few respondents reported sightings in private aquariums or at sea. Finally, the seasonal distribution of observations showed that most sightings occurred in summer (71%), followed by autumn (14%), spring (11%) and only a small proportion (4%) in winter (Figure 2f).

In terms of aesthetic perception and emotional responses to mass encounters and stinging experiences, people commonly described the species as 'beautiful' (21%), 'sublime' (18%) and 'delicate' (18%; Figure 3a). Additional terms such as 'fragile' (15%) and 'aesthetic' (14%) further underscore a generally positive perception. Respondents' emotional responses to encountering large numbers of specimens showed a tendency towards caution: 65% reported feeling 'careful', while 54% 'nervous' and 51% felt 'scared', though these feelings varied in intensity (split between 'a little' and 'yes'; Figure 3b). More positive emotions, such as feeling 'relaxed', 'confident' or 'calm', were less commonly reported. Specifically, 49% did not feel relaxed, 45% did not feel confident, and 40% did not feel calm in such situations (Figure 3b). Regarding direct contact, the vast majority of respondents (92%) had reported never having been stung by *C. sowerbii*. Among those who had, over half (56%) reported no pain at all (Score 0), 14% reported moderate pain (Score 3) and 13% mild pain (Score 2; Figure 3c). Other pain levels were rare, with very mild (6%), severe (8%) and very severe (3%) pain (Figure 3c). Overall, the data suggest that *C. sowerbii* is perceived positively in terms of appearance, but mass encounters may provoke caution or apprehension. Direct contact is rare, and when it occurs, it typically results in minimal or no pain.

The analysis highlights a general lack of public knowledge regarding the geographical origins of *C. sowerbii* and its status in Europe (Figure 4). When asked to identify the species' country of origin, the most common response was 'I don't know' (13%). Among those who provided an answer, China was the most frequently cited (11%), correctly corresponding to the species' most likely native range in the freshwater systems of the Yangtze River basin. However, a range of other countries were mentioned across all continents, including Türkiye, Australia, the United States, Croatia and Greece. Responses were highly scattered, also citing countries such as South Africa, Brazil, Germany, India and Madagascar, reflecting widespread uncertainty and misinformation (Figure 4a). In a follow-up question about whether the species is native or non-native to Europe, 51% of respondents indicated that they did not know, 33% correctly identified *C. sowerbii* as non-native and IAS, while 16% incorrectly believed it to be native (Figure 4b). These results reveal a clear gap in public understanding of the species' biogeography.

The evaluation of public knowledge about the main vector of introduction of *C. sowerbii* showed that the most frequent response was 'I don't know' (26%; Figure 5a), followed closely by boats (25%), a widely recognized pathway for aquatic IAS. Regarding factors driving the species' proliferation, global change was the most commonly referenced (28%), followed by overfishing and predator removal (16%), and IAS vectors (13%). Twelve percent of respondents answered that they did not know, while others mentioned pollution (8%), natural evolution (6%), ocean acidification (5.9%), eutrophication (5.7%) and rarity of predators (5.4%), suggesting an awareness of complex ecological pressures, albeit with varying levels of scientific accuracy (Figure 5b). On the question of feeding habits, 34% of respondents correctly identified zooplankton as the primary food source, followed by phytoplankton (29%). Sixteen percent responded with 'I don't know', while smaller proportions incorrectly selected fish (7%), jellyfish (6%), molluscs (5%) and insects (3%), reflecting a partial understanding of the species' trophic role (Figure 5c). Overall, the results pointed to fragmented, but occasionally accurate, public perceptions of *C. sowerbii*'s ecology.

The analysis of public perceptions concerning the management and societal relevance of *C. sowerbii* as a potentially IAS highlights a diversity of opinions across local, global and ecological contexts (Figure 6). When asked whether the species is perceived as problematic, 36% of respondents did not consider it a local issue ('0 [no]'), while others rated its importance with increasing concern: 18% ('1 [a little]'), 29% ('2 [middle]'), 11% ('3 [a lot]') and 6% ('4 [very much]'), indicating a predominantly low perception of a local threat (Figure 6A.a). However, views shifted slightly when considering its global impact: 14% stated it is not a problem at all, but 30% rated it as a moderate concern ('2 [middle]'), and 23% viewed it as a significant global issue ('3 [a lot]') (Figure 6A.b). Similarly, when framed as a minor problem, 38% still rated it at '0 (no)', though 30% gave it a relatively high concern ('2 [middle]'), and 22% scored it ('3 [a lot]'), revealing nuanced views on the severity of its presence (Figure 6A.c). Regarding personal or ecological concern, 28% reported no concern at all, while 30% rated their concern at a moderate level ('2 [middle]'), suggesting a degree of ambivalence (Figure 6B.a). Nonetheless, many respondents found the species interesting, with 30% assigning it a mid-level score ('2 [middle]'), and another 30% placing it in higher interest categories ('3 [a lot]' and '4 [very much]' combined) (Figure 6B.b). Ecological concern appeared more pronounced, with 31% ranking it at the highest level ('4 [very much]'), indicating a growing recognition of its environmental relevance (Figure 6B.c). Finally, when asked whether the species warrants greater public discourse and institutional attention, 30% supported increased discussion and 28% rated its importance at '3 (a lot)' (Figure 6C.a). Public education was also favoured, with 33% calling for broader awareness ('2 [middle]') and another 28% ('3 [a lot]') assigning it high importance (Figure 6C.b). Twenty-seven percent of participants believed regional governments should reinforce management efforts ('2 [middle]'), while an additional 26% ('3 [a lot]') and 24% ('4 [very much]') emphasized the need for moderate to strong policy actions (Figure 6C.c). Overall, this section reflects a thoughtful yet varied public perspective: *C. sowerbii* is not broadly

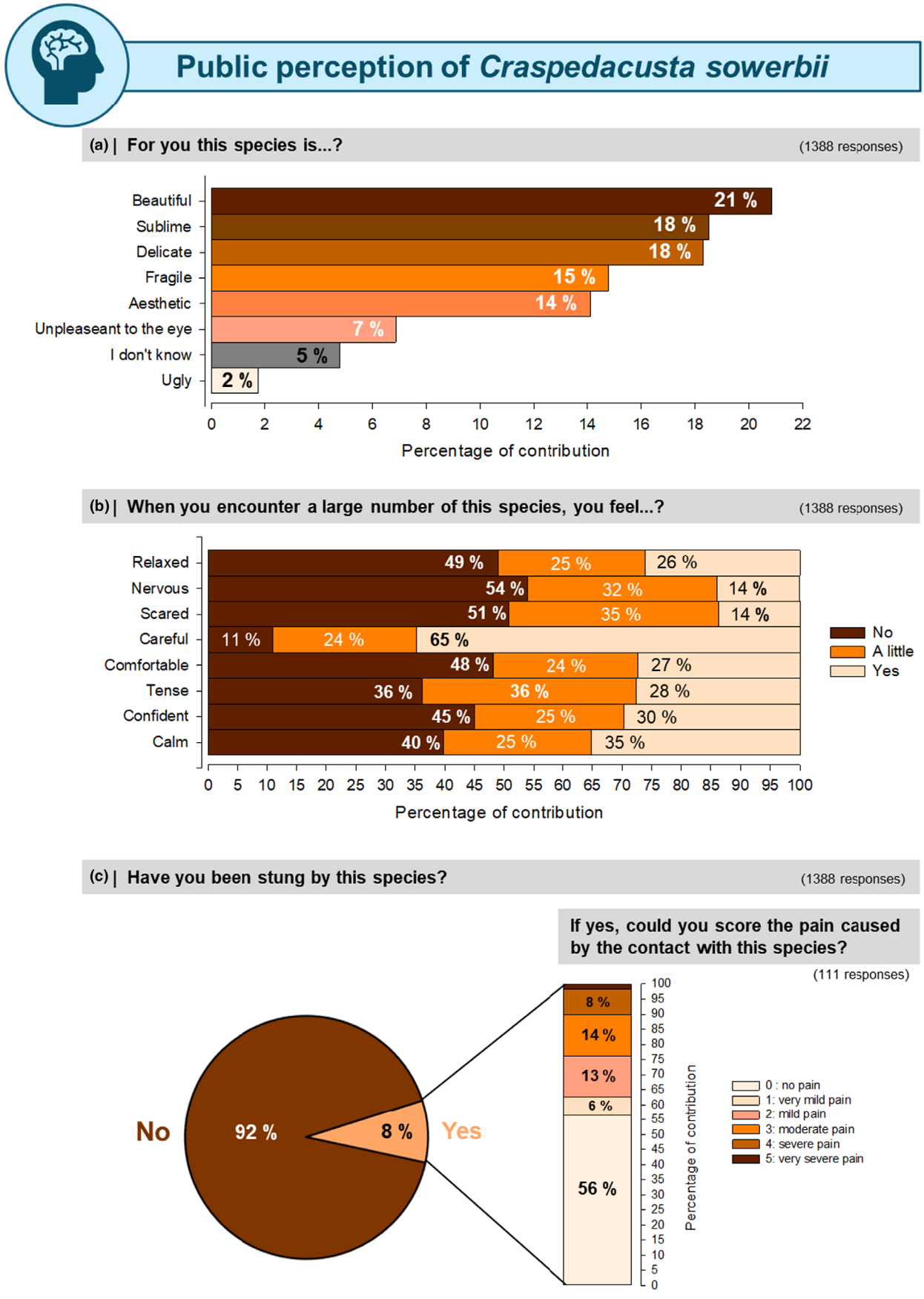



FIGURE 3 Public perception of *Craspedacusta sowerbii* (Panel 3 of the questionnaire): (a) 'For you, this species is', (b) 'When you encounter a large number of this species, you feel', (c) 'Have you been stung by this species?'.

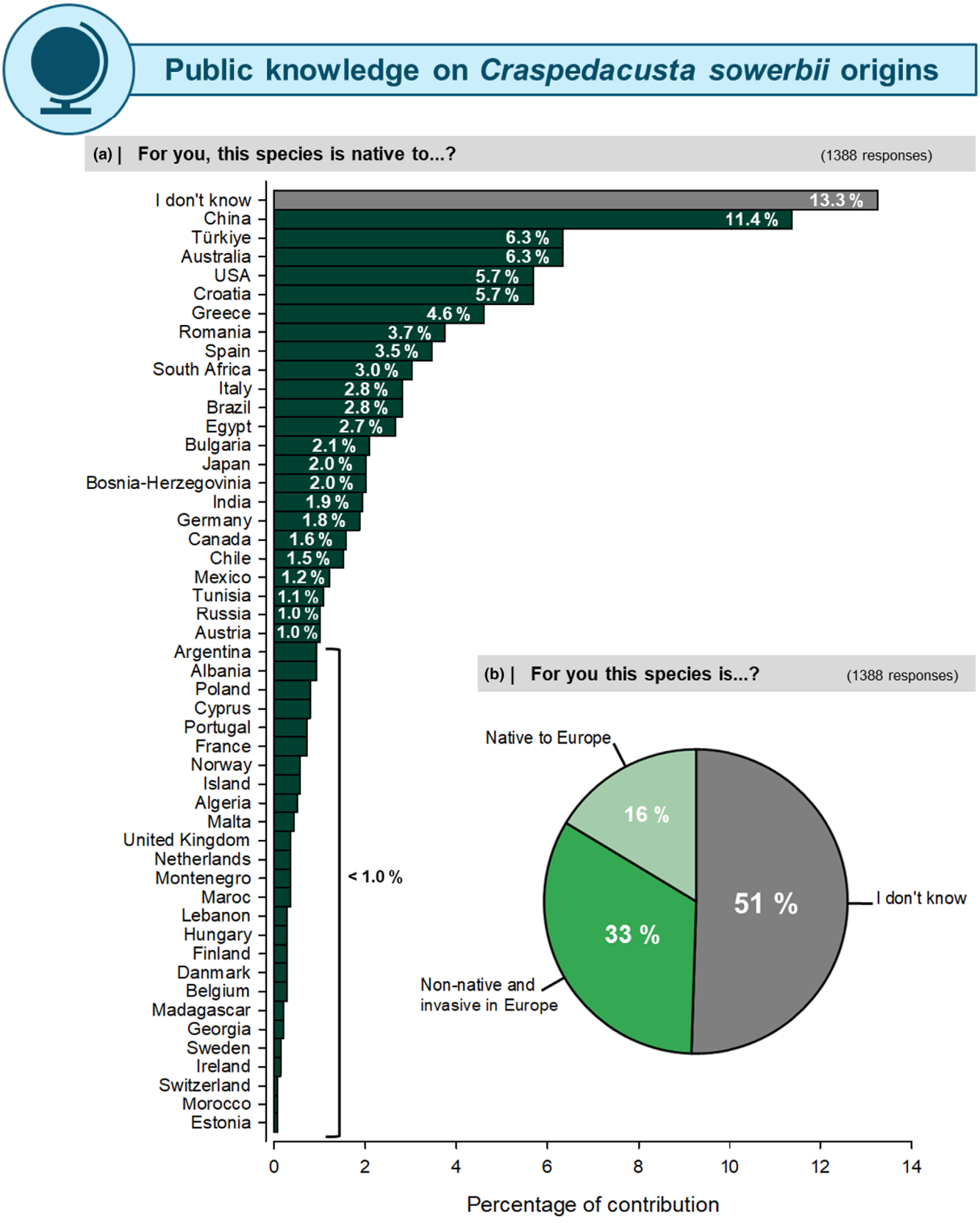



FIGURE 4 Public knowledge of *Craspedacusta sowerbii* origins (Panel 4 of the questionnaire): (a) 'For you, this species is native to?', (b) 'For you, this species is?'.

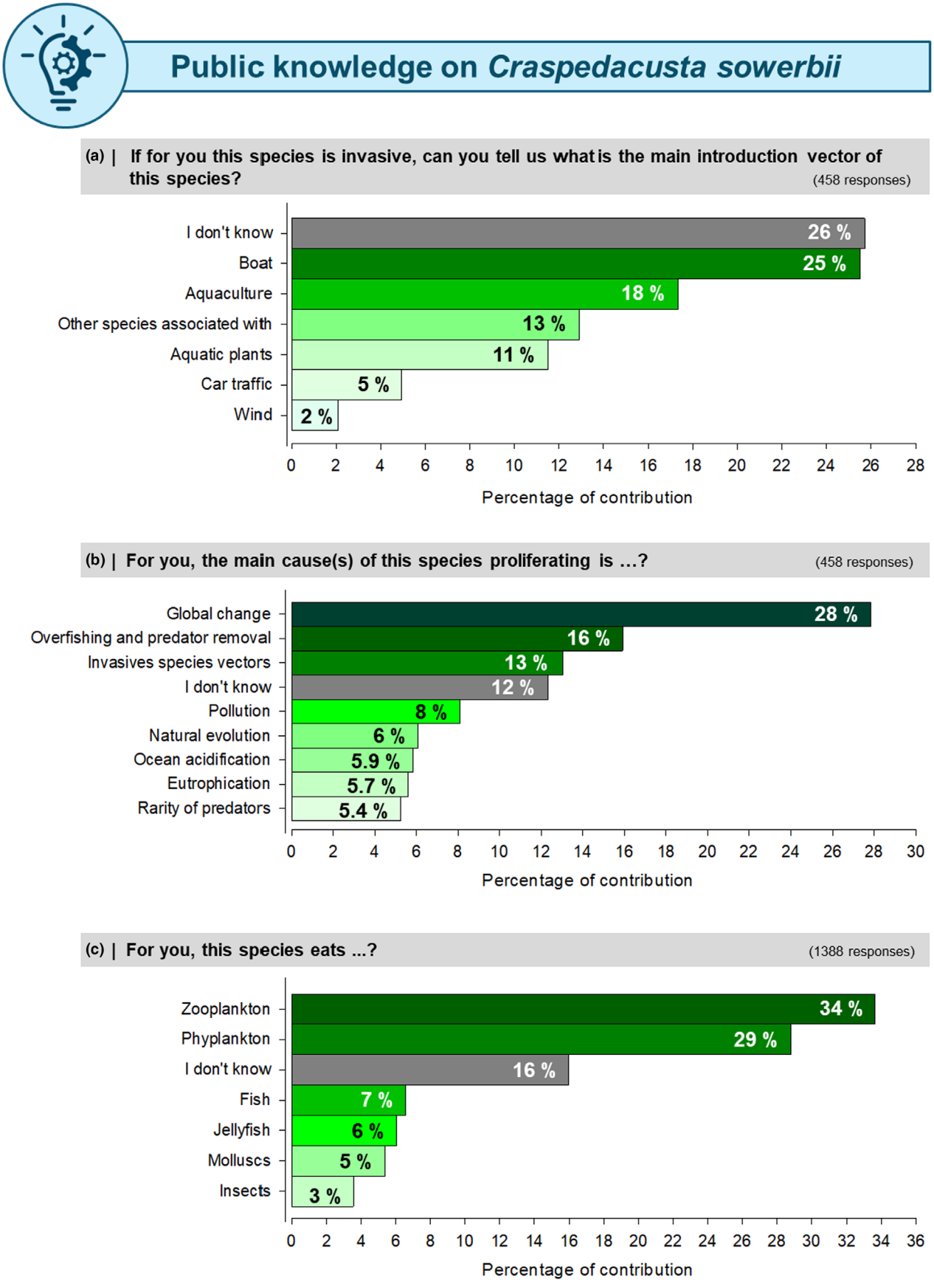



FIGURE 5 Public knowledge of *Craspedacusta sowerbii* (Panel 5 of the questionnaire): (a) 'If for you this species is invasive, can you tell us what the main introduction vector of this species is?', (b) 'For you, the main cause(s) of this species proliferating is/are?', (c) 'For you, this species eats'.

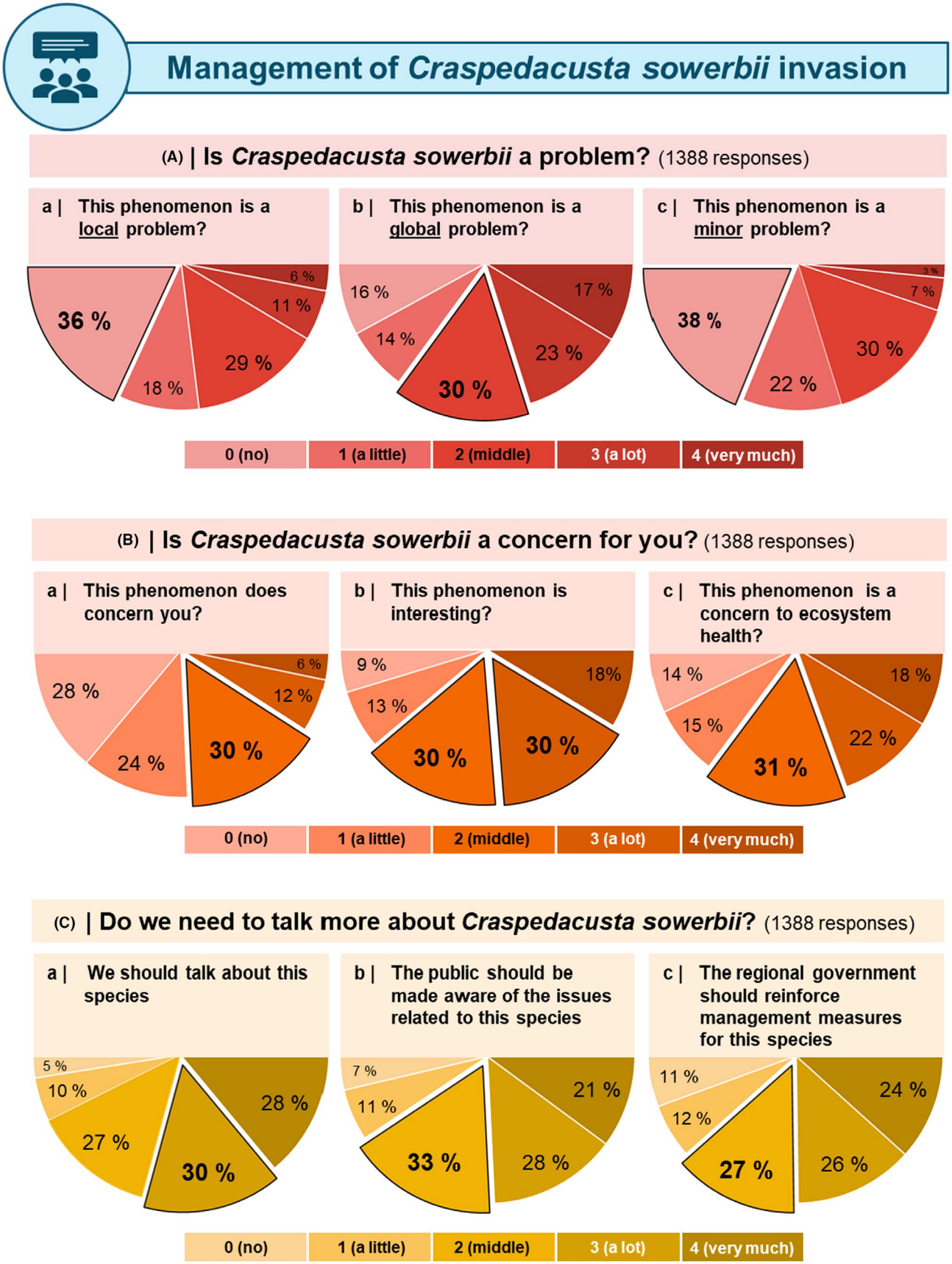
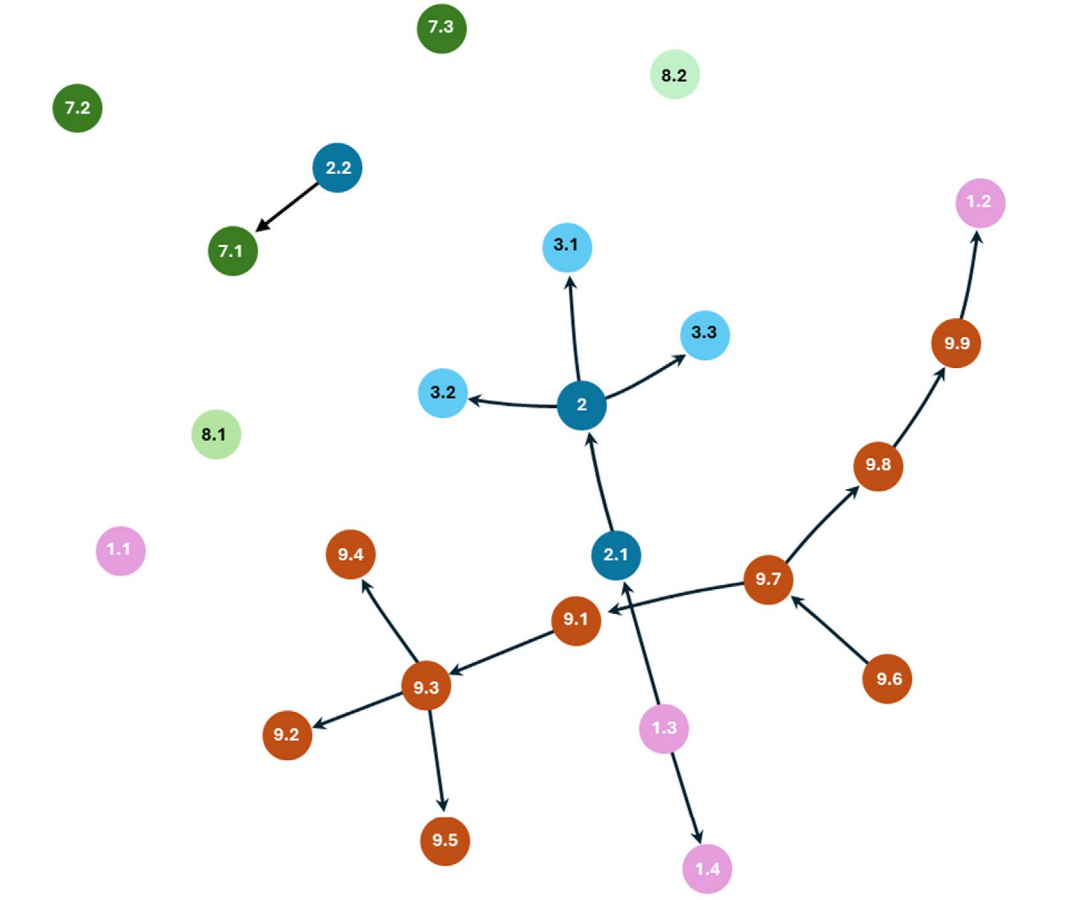



FIGURE 6 Management of *Craspedacusta sowerbii* (Panel 6 of the questionnaire): (A) 'Is *C. sowerbii* a problem?', (B) 'Is *C. sowerbii* a concern for you?', (C) 'Do we need to talk more about *C. sowerbii*?'.




**Respondents' metrics**

- 1.1 Gender
- 1.2 Age
- 1.3 Country
- 1.4 How often are you outside in the nature?

**People's interactions with *C. sowerbii***

- 2 Have you seen this species?
- 2.1 Do you know what this species is?
- 2.2 Do you know the scientific name of this species?
- 3.1 Where did you observed this species?
- 3.2 During which activity?
- 3.3 When did you observed this species?

**People's knowledge on *C. sowerbii* origins**

- 7.1 For you, this species is...
- 7.2 Specifically, for you this species in native from
- 7.3 What is the main introduction vector of this species?

**People's knowledge on *C. sowerbii***

- 8.1 The main cause(s) of this species proliferating is/are ...
- 8.2 For you, this species eats

**Management of *C. sowerbii***

- 9.1 This phenomenon does concern you
- 9.2 This phenomenon is a local problem
- 9.3 This phenomenon is a global problem
- 9.4 This phenomenon is a minor problem
- 9.5 This phenomenon is a concern to ecosystem health
- 9.6 This phenomenon is interesting
- 9.7 We should talk about this species
- 9.8 The public should be made aware of the issues
- 9.9 The regional government should reinforce management measures for this species

**FIGURE 7** Directed acyclic graph (DAG) representing the conditional dependencies among respondents' answers in the survey on the hydrozoan species *Craspedacusta sowerbii*. Each node corresponds to a specific survey question, grouped into five thematic categories: Respondent characteristics (purple), interactions with *C. sowerbii* (blue), knowledge about the species' origins (dark green), ecological knowledge of the species (light green), and perceptions and management of the phenomenon (orange). Arrows indicate conditional dependencies between variables, inferred from the data using the hill-climbing structure learning algorithm under an acyclicity constraint. This model supports the identification of potential demographic or geographic effects on responses, as well as dependency chains between knowledge, experience and perception of issues related to *C. sowerbii*.

seen as an immediate or personal threat; there is clear recognition of its ecological significance and strong support for increased public engagement and governance.

The BN diagram illustrates the interrelationships among respondents' perceptions, knowledge and interactions with *C. sowerbii*, as well as their views on its management (Figure 7). The central node (2), corresponding to whether individuals have seen the species, is closely linked to questions about situational context (e.g. where, when, and during which activity the species was observed), suggesting that direct experience with *C. sowerbii* significantly shapes broader attitudes. Node 2.1 (knowledge of the species) appears as a critical bridge between observation and perceptions of the phenomenon's seriousness (e.g. Nodes 9.1, 9.7), implying that familiarity influences both concern and perceived threat (Figure 7). The right-hand cluster of brown nodes (nodes with the n° 9) represents a detailed structure of opinions on management, ranging from personal concern (9.1) to recommendations for public awareness and governmental action (9.8, 9.9), reflecting a progression from individual impact to societal-level responses (Figure 7). Peripheral nodes related to species knowledge (nodes with the n° 7, and n° 8.) are less connected, indicating that while such knowledge is collected, it may play a secondary role compared to direct interactions in shaping opinions. The respondents' country of origin (node 1.3) plays a secondary role, acting as a modulator of species knowledge and the perceived importance of communication. Overall, the graph reveals that management perceptions are more strongly influenced by personal experience and recognition of the species than by scientific or origin-based knowledge (Figure 7).

## 4 | DISCUSSION

The results of our study confirm a worrying issue: *C. sowerbii*, although widespread on six continents (with only Antarctica remaining uncolonized), remains virtually unknown to the general public in Europe. Over 80% of respondents did not know the species' scientific name, and almost half were unaware of the type of environment in which it thrives, with frequent confusion between this freshwater jellyfish and marine species noted in our survey. This confusion represents a major interpretative limitation. Management-related responses and risk perceptions may, therefore, partly reflect generalized attitudes toward marine jellyfish rather than specific knowledge of *C. sowerbii*. Nevertheless, this taxonomic confusion itself underscores the species' low recognizability and the broader challenges of detecting cryptic freshwater invasions. The high proportion of respondents reporting marine observations likely reflects confusion with common coastal jellyfish species frequently portrayed in media and public discourse. This pattern suggests that visual familiarity with marine jellyfish may override ecological specificity, leading to misattribution of habitat. Media exposure, rather than direct ecological knowledge, may, therefore, play a central role in shaping species recognition. This misidentification itself constitutes an important finding, highlighting low taxonomic literacy and the difficulty of detecting freshwater IAS. These figures illustrate a profound lack of recognition of a well-established invasion (Lüskow et al., 2024; Marchessaux et al., 2021). This lack of awareness may reflect a bias in public and media attention toward large-bodied, charismatic, or economically impactful IAS, while small, visually inconspicuous IAS tend to receive comparatively less attention. While emblematic species attract considerable scientific, media, and political attention because of their direct or spectacular impact, others go unnoticed, not because of their lack of impact, but because of their ecological subtlety or visual discretion (Latombe et al., 2017; Seebens et al., 2021). These species, known as 'cryptic invasions', represent a significant proportion of currently expanding IAS, but whose trajectories remain underestimated (Essl et al., 2020). This imbalance is well-documented in the literature. Many aquatic species, such as *H. anomala* or *B. longimanus*, have long been ignored despite their role in the ecosystem's services (Wittmann et al., 2016; Yan et al., 2011). However, some visually inconspicuous IAS, such as the small freshwater snail *Potamopyrgus antipodarum* (J. E. Gray, 1843), require close monitoring despite their limited public visibility (Aksu et al., 2024). This differentiated attention, often linked to the visibility or immediate economic impact of species, distorts our overall understanding of invasion processes.

Our study also highlights that *C. sowerbii* is not just a natural curiosity, but an unknown IAS whose global spread could be amplified by climate change (Lüskow et al., 2024; Marchessaux et al., 2021; Marchessaux, Lüskow, et al., 2022). Recent studies show that rising temperatures not only favour the polyp-medusa transition (Winata et al., 2024) but also facilitate the geographic expansion of the species into more temperate zones (Marchessaux, Lüskow, et al., 2022). This phenomenon raises concerns about the future acceleration of its spread, especially since the species often escapes detection by conventional traditional monitoring protocols (Moore et al., 2025). The seasonal appearance of the medusa form, its morphological subtlety and its brief visibility window make it extremely difficult to detect, posing a challenge for biomonitoring networks. In this

context, a citizen-based survey represents a valuable tool to assess public perception and awareness of *C. sowerbii* and to complement existing knowledge on its temporal and spatial presence. However, it is important to clarify that such an approach cannot reliably inform on ecological impact, species spread, or broader ecological patterns. To avoid any ambiguity, we emphasize that this type of data should not be considered a substitute for ecological monitoring or formal impact assessments but rather as a complementary source of information, particularly useful for generating hypotheses and guiding further scientific investigation.

Our analysis provides an exploratory overview of the conditional relationships between respondents' characteristics, direct experience with the species, and perceptions of its management. Using a BN approach, we identified patterns suggesting that visual recognition and personal observation are more strongly associated with concern and engagement than socio-demographic variables or formal ecological knowledge. However, given the uneven distribution of responses across countries and the self-selected nature of the sample, these findings should be interpreted cautiously. The BN analysis is intended as a hypothesis-generating tool rather than a definitive causal model. Future studies using probabilistic sampling designs and standardized cross-cultural validation procedures will be necessary to confirm and refine these patterns. Thanks to our transnational participatory survey (over 1300 respondents in 17 European countries), we were able to identify conditional interdependencies between individual characteristics, direct experience with the species, and perception of its management. The BN reveals that visual recognition and direct observation are the primary factors influencing both interest in the species and willingness to engage in further discussion about it. Socio-demographic variables (age, country, gender) have a marginal effect, while biological or taxonomic knowledge plays a secondary role. These results confirm that, in the case of a little-publicized species, personal experience overrules scientific information in shaping public opinion—a finding in line with Varble and Secchi (2013) and Vandendriessche et al. (2016) on marine invasions. The perception of jellyfish varies greatly depending on cultural context and personal experience, oscillating between aesthetic fascination and aversion linked to fear or disgust (Vandendriessche et al., 2016). In our study, however, the majority of people found *C. sowerbii* beautiful and fascinating. Despite their generally poor reputation, some jellyfish species are increasingly appreciated for their beauty, strangeness and ecological importance (Marchessaux, Thibault, & Claeys, 2022; Vandendriessche et al., 2016). Nevertheless, with regard to the blue crab invasion in the Mediterranean, a species that received a lot of media coverage, public perception was negative. The species was poorly perceived, likely because people had access to abundant information about its ecological impact (Marchessaux et al., 2023, 2024). This approach opens new perspectives for integrating cryptic or visually discrete species into awareness-raising and management strategies. Rather than seeking to pass on biological data alone, it may be more effective to leverage field experiences, citizen observations and contextual encounters. This implies a paradigm shift in scientific communication, where visual and sensory pedagogy can complement traditional science outreach methods.

Several methodological limitations should be acknowledged. First, although the questionnaire was translated by native-speaking researchers and internally harmonized, it did not undergo a formal back-translation procedure or independent cross-cultural validation (e.g. Banha et al., 2022). Differences in semantic interpretation across languages may therefore have influenced responses, particularly for value-laden or policy-related terms such as 'invasive species' or 'problem'. Cross-cultural survey research has shown that linguistic framing can affect risk perception and environmental attitudes. Consequently, part of the observed variation may reflect subtle interpretative differences rather than purely perceptual divergence among respondents. Future research would benefit from standardized translation protocols, including independent back-translation and pilot testing in each language. In addition, the snowball sampling strategy and uneven distribution of responses across countries limit the representativeness of the dataset. The results, therefore, reflect trends within a self-selected sample rather than nationally representative perceptions. The absence of variables such as education level and professional background may also limit interpretation, as ecological literacy is likely influenced by socio-professional context. These limitations reinforce the need for cautious interpretation and prevent overgeneralization regarding public perception of IAS across Europe.

Few examples in the current literature illustrate how IAS can go unnoticed, while still being ecologically significant. This lack of attention from both the general public and scientists is likely due to a shortage of 'stories, images, and striking symbols' (Nixon, 2011), which diminishes the visibility of progressive environmental issues, such as biodiversity loss, climate change and chemical pollution, in the cultural imagination and on political agendas (Nixon, 2011). Lidström et al. (2016) build on Rob Nixon's idea of 'slow violence', arguing that we also need to examine its converse: how complex and multifaceted environmental phenomena are often reduced to quick, simple, evocative and pervasive narratives that permeate science, legislation, public policy, and civic action and to study how these narratives can stifle, rather than open up, possibilities for new socio-ecological engagements. While earlier invasion narratives often framed IAS within a simplified 'good versus evil' dichotomy, contemporary invasion science increasingly emphasizes biological invasions as complex socio-ecological processes driven by human activities, globalization and environmental change. This shift promotes more nuanced, process-based understandings that move beyond moralized species labelling and encourage proactive and systemic management approaches (Lidström et al., 2016). The authors call for a representative balance by promoting complex, relational narratives that allow for more diverse solutions, broadened management practices and strengthened innovative socio-ecological commitments (Lidström et al., 2016).

In this vein, our study advocates for a more systematic consideration of cryptic and visually discrete species in policies aimed at combating IAS. The current focus on emblematic species—often

marine, terrestrial or charismatic—leads us to underestimate invasive dynamics that are silent, but potentially structuring for ecosystems (Ricciardi et al., 2017). Criteria such as 'small size', 'visual rarity' or 'not directly dangerous' should not exclude a species from watch lists (Marchessaux, Thibault, & Claeys, 2022). *Craspedacusta sowerbii* is a typical example: a widely distributed and potentially impactful species that is overlooked by conventional assessment grids (Moore et al., 2025) and often understudied by scientists (Lüskow et al., 2024). The citizen science approach employed in our study highlighted these aspects. Engaging citizens in participatory science can also aid in detecting species whose invasions are silent, as seen in the case of the ladybird *Harmonia axyridis* (Pallas, 1773) in Central America (Hiller & Haelewaters, 2019).

In conclusion, our study has shown that one of the world's most widespread IAS is poorly known and largely overlooked by the public, who lack access to adequate information and awareness-raising efforts. Therefore, we urge management authorities, environmental non-governmental organizations (NGOs), and researchers to integrate these invisible species into their action plans, mainly because we do not know whether this species (in its polyp or medusa form) hurts the native biodiversity of the invaded sites. Importantly, while *C. sowerbii* is clearly an alien species in Europe, its classification as an IAS sensu IPBES depends on demonstrated ecological impact. Our study, therefore, focusses on the perception of an alien species with potential invasive characteristics rather than assuming confirmed invasive status. Behind their apparent discretion lie weak signals of global change, which, if ignored today, could escalate into ecological emergencies shortly.

## AUTHOR CONTRIBUTIONS

Guillaume Marchessaux and Florian Lüskow (equal) contributed to the study conception and design. Material preparation and data collection were performed by all authors. The first draft of the manuscript was written by Guillaume Marchessaux and Florian Lüskow, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Conceptualization: Guillaume Marchessaux, Florian Lüskow (equal); Methodology: Guillaume Marchessaux, Florian Lüskow (equal); Formal analysis and investigation: Guillaume Marchessaux, Florian Lüskow (equal); Writing—original draft preparation: Guillaume Marchessaux, Florian Lüskow (equal); Writing—review and editing: all authors; Supervision: Guillaume Marchessaux and Florian Lüskow (equal).

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## ACKNOWLEDGEMENTS

The authors would like to thank all the partners in this study who shared the questionnaire in each country, and we would also like to thank all the respondents who took the time to contribute to this study. Work of AA and ÁB was funded by the National Research, Development and Innovation Office, Hungary (project MEC_N:148923). We acknowledge the thoughtful and constructive comments provided by the lead and associate editors, as well as two anonymous reviewers, on an earlier version of the manuscript.

## CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## DATA AVAILABILITY STATEMENT

The data presented in this study are all available in the figures.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**Figure S1.** English version of the survey questionnaire performed to collect the people's perceptions on *Craspedacusta sowerbii* in the 17 European countries considered.

**Figure S2.** Generalized linear model (GLM) showing the trend between the number of *Craspedacusta sowerbii* occurrences (extracted from Marchessaux et al. (2021)) and the total number of responses for each country studied.

**How to cite this article:** Marchessaux, G., Slovák Švolíková, K., Ševove, B., Tarkan, A. S., Giannetto, D., Preda, C., Kalamujić Stroil, B., Mańko, M. K., Abonyi, A., Becz, Á., Morpurgo, M., Pakhomov, E. A., Mumladze, L., Bosch-Belmar, M., Hosia, A., Ventura, P., Javidpour, J., & Lüskow, F. (2026). When invasions go unnoticed: Public perception of the freshwater jellyfish *Craspedacusta sowerbii* in Europe. *People and Nature*, *00*, 1–17. https://doi.org/10.1002/pan3.70344