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The Attractiveness of Freshwater Species Correlates Positively with Conservation Support

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ABSTRACT

The attractiveness of a species influences human perceptions and attitudes toward it, while flagship species play a significant role in shaping public conservation interests. This research investigated how humans perceive the attractiveness of and their willingness to protect vertebrate and invertebrate aquatic representatives. The study focused on endangered and invasive fish and crayfish species presented to the participants through pictures shared via an online questionnaire. Participants rated the attractiveness of the species and indicated their willingness to protect them using a 7-point scale. The analysis was conducted based on 118 responses from men and women whose backgrounds varied in terms of their age, education, and knowledge regarding biological invasions. The findings indicate that the perceived attractiveness of a species was the primary factor influencing the participants' willingness to protect the species: the more attractive a species was rated, the greater the willingness to protect it. Overall, endangered fish and crayfish species received higher willingness-to-protect scores than invasive species, with crayfish species being perceived as significantly more attractive than fish. Using attractive or flagship aquatic species, such as crayfish, in the conservation efforts of endangered freshwater taxa can enhance public, stakeholder, and policymaker awareness, thereby potentially contributing to the conservation and restoration of freshwater ecosystems and the protection of native biota.

KEYWORDS

Aquatic invasions; biological invasions; conservation; crayfish; fish; human–animal interaction

Global biodiversity is in strong decline and many species are becoming extinct or endangered (Pereira et al., 2010). These changes are mostly driven by humans, escalating to the sixth major extinction event in the history of life on Earth (Chapin et al., 2000; Pievani,

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2014). Humans have exploited the Earth's resources, modified habitats, and translocated animals and plants, changing the environment around them. In this process, some species become a necessity and others redundant. The reasons behind this lie partially in their usefulness and/or harmfulness to humans. In the modern era, humans have come to love or hate some species, and this relationship is partially explained through the perception of sympathy/attraction and the ability of humans to feel empathy for a nonhuman species (Signal & Taylor, 2007). Finally, these processes that are related to our view of nonhuman species are not only highly subjective and individual but are determined by cultural background and are also socially constructed (Backstorm et al., 2018). Myths and cultural backgrounds have been found to shape the way we perceive animals (Musila et al., 2018; Prokop et al., 2009a), including our attitudes toward them (Prokop et al., 2009b).

One of the major factors shaping the human perception of nonhuman species is the species' charisma. By the charisma of a species, we mean the species' attractiveness, appeal, or beauty (Jarić et al., 2020). The effects of the way humans perceive nonhuman species are multidimensional and have multiple implications (Dobson, 2007). While charismatic flagship species can stimulate public awareness and increase their conservation support, they can also become an obstacle in invasive species management as some invaders are perceived as attractive (Crowley et al., 2017; Novoa et al., 2018; Shackleton et al., 2019). Moreover, charismatic and attractive species of animals and plants can be favored and translocated by humans, inoculating new species to new regions largely without fully understood consequences (Jussila et al., 2021; Patoka et al., 2017; Vítková et al., 2017).

Aquatic ecosystems are particularly vulnerable, and invasive species along with human impacts are major threats to this environment on a global scale (Havel et al., 2015; Oberdorff, 2022; Su et al., 2021; Vörösmarty et al., 2010). We know that knowledge gaps can lead to misconceptions, ineffective management, an unhealthy perception of nonhuman species (Kochalski et al., 2018; Renault et al., 2021), and even myths (Prokop et al., 2009a). Numerous non-native and potentially invasive species have been introduced to new environments, culminating over time and changing native communities (Haubrock et al., 2021; Pereira et al., 2012; Su et al., 2021). On the other hand, some "unattractive" native species could fall short in the conservation efforts and be purposely overlooked (Colléony et al., 2017; Small, 2012). Studies on animal attractiveness and conservation support are largely carried out to focus on vertebrates, mainly mammalian and bird species (Albert et al., 2018; Frynta et al., 2010; Macdonald et al., 2017; Prokop et al., 2022), while fish, frogs, snakes, and invertebrates, in general, receive little or no attention (Prokop et al., 2022; Schlegel & Rupf, 2010; Small, 2012).

For these reasons, prominent freshwater fish and crayfish invaders of different groups, body shapes, and features were chosen and compared with their endangered counterparts in our current research. The present work aimed to evaluate how the public rates their attractiveness and how this perception is linked to conservation attitudes. Responders were recruited in the Republic of Serbia, an emerging hotspot for invasive species, but also a location rich in species diversity. We hypothesized that a higher attractiveness score of a species results in a higher willingness to protect (WTP) that species, independently of whether a species is invasive or endangered. Our research is among the first to evaluate the attractiveness of the indigenous/endangered and introduced/invasive freshwater species (vertebrate fish and invertebrate crayfish species) of different groups in one study. Our study is also the first to evaluate the relationships between attractiveness and the willingness to protect these freshwater species.

Methods

Ethics Statement

As the questionnaire was administered for educational purposes and participation was voluntary and anonymous, ethical approval was not needed. All participants provided informed consent before completing the survey.

Procedure

Participants from the Republic of Serbia were recruited via social media (Meta) by sharing the questionnaire on the personal pages (profiles) of the co-authors (B.L., K.Z., and M.P.) and their colleagues, who forwarded the questionnaire further to their peers. The authors were blind to the extent and directions in which the survey expanded. The participants were asked to fill out the questionnaire, for which a link was posted along with the message/posts. The questionnaire was shared for about four months, from November 2021 to March 2022.

Questionnaire

For this study, an online questionnaire was created on the platform Google Forms. It was anonymous, and all participants were blind to the research hypotheses. All responders were informed that the output of the research would be published in a scientific paper and were provided with references to the previously published work. The questionnaire was prepared in the Serbian language and divided into four sections (the full questionnaire is available in the online supplemental material). In the first part, the responders were asked about their sex (male/female), age (0–22, 23–45, 46–68, 69–110 years) and the highest level of education achieved (primary education, secondary education, higher secondary education, BSc or BA, MSc or MA, PhD).

In the second section, we aimed to investigate general knowledge as regards biological invasions. The following questions were put forward: (i) Are you familiar with the issue of biological invasions? (ii) Do you know that biological invasions are occurring in your country? (iii) Do you think that biological invasions pose a serious threat to indigenous biodiversity? (iv) Do you think that there are some measures needed to avoid biological invasions and conserve nature? The participants rated each question on a 7-point scale, ranging from 1 (absolutely not) to 7 (absolutely yes), according to Prokop and Fančovičová (2013). The reliability of this section of the questionnaire was high (Cronbach $\alpha = 0.87$).

In the third section, we evaluated the attractiveness of the species. For this purpose, we selected 12 different species (8 fish and 4 crayfish species), out of which half are considered invasive and the other half endangered (Table 1). The used illustrations (except the illustration of European mudminnow (*Umbra krameri*) and European sea sturgeon (*Acipenser sturio*)) are in the possession of the University of South Bohemia in České Budějovice, Czech Republic, and drawn by the MgA. Radka Bošková. Species from both groups are present in Serbia and in accordance with their status (invasive/endangered). The selected species in both groups have different traits and shapes to reduce the bias in favoring one or the other group. The participants rated each of the twelve species on a 7-point scale, ranging from 1 (unattractive) to 7 (attractive). Overall, the reliability of the attractiveness ratings was high (Cronbach $\alpha = 0.89$).

Table 1. List of species used in the questionnaire.

Invasive species	Endangered species
Fish	
Ameiurus nebulosus	*Anguilla anguilla*
Carassius gibelio	*Alburnoides bipunctatus*
Neogobius melanostomus	*Umbra krameri*
Lepomis gibbosus	*Acipenser sturio*
Crayfish	
Procambarus virginalis	*Astacus astacus*
Procambarus clarkii	*Austropotamobius torrentium*

In the fourth section, we evaluated the willingness to protect these species (the same as in the previous section). The same set of species, placed in the same order, was used. The responders rated the willingness to protect the selected species on a 7-point scale, ranging from 1 (would not consider it for conservation) to 7 (would definitely consider it for conservation). The overall reliability of the willingness-to-protect ratings was high (Cronbach $\alpha = 0.91$).

Statistical Analysis

Data were not normally distributed (Shapiro–Wilk test) and the sample sizes were limited. Therefore, we used a conservative statistical approach. We compared median scores among the species using the median test if the data were independent (e.g., gender). Friedman ANOVA was used for dependent samples. A subsequent post-hoc comparison was performed with Durbin-Conover using a free and open statistical platform from the jamovi project (2021). For correlations, the Spearman rank-order correlation coefficient was calculated. A p-value of < 0.05 was considered statistically significant.

Results

Participants

A total of 118 responders participated in the study, of which 78 were female (66.1%) and 40 were male (33.9%). The age of most of the responders ranged between 23 and 45 years (76.3%), while 9 (7.6%) and 19 responders (16.1%) were between 0–22 and 46–68 years, respectively; 26 (22%) had secondary education, 8 (6.8%) higher secondary education, and 84 (71.2%) a university degree (with 20 (16.9%) holding a BSc or BA, 33 (28%) with an MSc or MA, and 31 (26.3%) with a PhD). Participants with only primary education did not participate in the study.

The Willingness to Protect

Perceived attractiveness was the main predictor of the WTP. The more attractive the species, the greater the observed WTP (Table 2). Knowledge regarding biological invasions produced an inverse effect, and better knowledge was associated with a lower WTP (all but one Spearman correlation showed negative directions and ranged between –0.40 and 0.19, and p-values ranged between < 0.001 and 0.61). The WTP was significantly lower as the level of education increased (all but one Spearman correlation

Table 2. Descriptive statistics and correlations (Spearman's rank-order correlation coefficient) for perceived attractiveness and willingness to protect (WTP) particular fish and crayfish species.

	Attractiveness		WTP			
	Median	95% CI	Median	95% CI	*r*	*p*
Invasive fish						
Ameiurus nebulosus	5	4.18, 4.86	5	3.94, 4.85	0.40	< 0.001
Carassius gibelio	5	4.46, 5.10	6	4.74, 5.55	0.57	< 0.001
Neogobius melanostomus	6	4.69, 5.46	6	4.59, 5.41	0.49	< 0.001
Lepomis gibbosus	6	4.95, 5.61	5	4.0, 4.94	0.40	< 0.001
Endangered fish						
Anguilla anguilla	5	4.39, 5.08	7	5.37, 6.04	0.44	< 0.001
Alburnoides bipunctatus	5	4.64, 5.28	6.5	5.18, 5.84	0.58	< 0.001
Umbra krameri	6	5.04, 5.62	7	5.51, 6.07	0.50	< 0.001
Acipenser sturio	7	5.76, 6.35	7	6.10, 6.63	0.45	< 0.001
Invasive crayfish						
Procambarus virginalis	6	4.96, 5.57	6	4.77, 5.55	0.36	< 0.001
Procambarus clarkii	6	5.35, 5.95	6	4.44, 5.30	0.22	0.016
Endangered crayfish						
Astacus astacus	6	5.18, 5.78	7	5.26, 5.94	0.38	< 0.001
Austropotamobius torrentium	6	5.07, 5.68	7	5.17, 5.85	0.24	0.01

showed negative directions and ranged between –035 and 0.01, *p*-values ranged between < 0.001 and 0.91). Gender differences were not significant (median tests, all *p*-values > 0.17). There were significant differences in median WTP scores among the species (Friedman ANOVA, $\chi^2 = 130$, $df = 11$, $p < 0.001$). Endangered fish received generally higher WTP scores than invasive fish, but there were no significant differences in the WTP of invasive and endangered crayfish (Table 3). Notably, endangered *Acipenser sturio* outperformed all invasive fish.

Table 3. Pairwise comparisons (Durbin–Conover) of the attractiveness of endangered and invasive fish and crayfish species and willingness to protect (WTP) scores followed by the Friedman ANOVA.

		Attractiveness		WTP	
		Statistic	*p*	Statistic	*p*
Endangered fish	**Invasive fish**				
Anguilla anguilla	*Ameiurus nebulosus*	1.13	0.26	5.77	< 0.001
	Carassius gibelio	0.08	0.94	1.72	0.062
	Neogobius melanostomus	3.18	< 0.001	2.18	0.003
	Lepomis gibbosus	3.26	< 0.001	4.91	< 0.001
Alburnoides bipunctatus	*Ameiurus nebulosus*	1.6	0.047	5.10	< 0.001
	Carassius gibelio	0.78	0.43	1.16	0.247
	Neogobius melanostomus	2.62	0.02	2.35	0.024
	Lepomis gibbosus	2.68	0.004	4.09	< 0.001
Umbra krameri	*Ameiurus nebulosus*	4.28	< 0.001	6.00	< 0.001
	Carassius gibelio	3.58	< 0.001	2.96	0.014
	Neogobius melanostomus	0.57	0.57	3.41	< 0.001
	Lepomis gibbosus	0.00	1.0	5.15	< 0.001
Acipenser sturio	*Ameiurus nebulosus*	9.03	< 0.001	9.22	< 0.001
	Carassius gibelio	8.33	< 0.001	5.18	< 0.001
	Neogobius melanostomus	5.17	< 0.001	6.64	< 0.001
	Lepomis gibbosus	4.75	< 0.001	8.37	< 0.001
Endangered crayfish	**Invasive crayfish**				
Astacus astacus	*Procambarus virginalis*	1.78	0.10	1.54	0.102
	Procambarus clarkii	1.6	0.17	2.24	0.014
Austropotamobius torrentium	*Procambarus virginalis*	0.91	0.36	1.06	0.291
	Procambarus clarkii	2.12	0.03	1.30	0.059

Species Attractiveness

A Friedman ANOVA was performed to examine the species' perceived attractiveness differences. Differences were significant ($\chi^2 = 148$, $df = 11$, $p < 0.001$) (Table 3). Native fish received, in most cases, higher attractiveness scores than invasive fish (Table 3). Again, endangered *A. sturio* outperformed all invasive fish. In contrast, differences between native and invasive crayfish attractiveness scores were minimal (Table 3).

Concerning the influence of other variables on species attractiveness scores, females (median = 6.5) rated *L. gibbosus* as significantly more attractive than males (median = 4.5; median test, $p = 0.003$), but other gender differences were not significant (all $p > 0.20$, data not shown). Knowledge regarding biological invasions showed very inconsistent associations with the perceived attractiveness of fish species; there were positive (*Anguilla anguilla, A. sturio*, $r = 0.33$ and 0.41, both $p < 0.001$, respectively), negative (*Alburnoides bipunctatus*, *Carassius gibelio*, $r = -0.21$ and -0.29, $p < 0.05$ and < 0.01, respectively) and no correlations (all remaining species, data not shown) with fish attractiveness. The level of education did not correlate with fish attractiveness (all correlations ranged between −0.09 and 0.13, all $p > 0.15$). Interestingly, however, crayfish species attractiveness consistently and positively correlated with the knowledge about biological invasions and the level of education (r ranged between 0.18 and 0.24, all $p < 0.05$).

Discussion

The four questions regarding knowledge about biological invasions reflect the relative awareness of invasive species in freshwaters, their negative impacts, and management needs. It indicates a relatively strong awareness of the issue in the public, which could be something that one should draw on in management and conservation planning. This result is encouraging as biological invasions pose a serious threat to native biodiversity, not only from a local perspective but also from a global one (Bellard et al., 2016; Pereira et al., 2010), and awareness of the public on the subject plays a key role in the prevention of further introductions of potential freshwater invaders present, for example, in the aquarium pet trade (Lipták et al., 2023b; Lipták & Vitázková, 2015; Patoka et al., 2018). These results could, however, be influenced by the high proportion of participants with a high school education (71.2%) and by the younger individuals (23–45 years of age, 76.3%) who participated in the study (cf. Verbrugge et al., 2021). A fair share of the sample was found to be well-informed, active, and engaged with nature. The small (118), young, educated sample is a limitation of the study.

Endangered species received higher conservation support than invasive species from both male and female responders. This relationship is as expected, related to the degree of achieved education/experience, previous engagement with nature, and age of the participants (Barrows et al., 2022; Lipták et al., 2023a). This result suggests that the public, as represented by the sample, favors endangered species over invasive counterparts and acknowledges their protection. There were no statistically significant differences between genders in general knowledge regarding biological invasions, the perceived attractiveness of the species, and the willingness to protect them. These results are in agreement with the results on the related subject of environmental attitudes that show

no differences between genders (Hayes, 2001); however, other research reports women as being more pro-environmental than men (Milfont & Sible, 2016). One exception was *L. gibbosus,* which received a higher attractiveness score from females than males. We hypothesize that the bright red or orange spots in this species could underly a higher aesthetic judgment by females, ultimately motivated by preferences for ripe fruits (Hurlbert & Ling, 2007; Prokop & Fančovičová, 2012).

There were also no significant differences on the issue of biological invasions in general when comparing different age groups. Although age is considered a significant factor in terms of general experience, in terms of pro-environmental attitudes and interests, the most significant factor is contact with nature, regardless of age (Rosa et al., 2018). Younger individuals tend to be more active than older individuals and engage with nature more often, leading to pro-environmental behavior that develops from childhood to adulthood (Soga et al., 2016; Soga & Gaston, 2016). Our results are thus in accordance with the prediction that education and age play a key role in nature conservation, sustainable development, and even in the management of invasive species (Banha et al., 2022; Dobson, 2007; Ladrera et al., 2020; Morar & Peterlicean, 2012; Schelly et al., 2012).

There were relatively small differences in perceived attractiveness and WTP scores among endangered and invasive crayfish species. Crayfish species are less likely to be correctly discriminated than fish (Lipták et al., 2023b) and are generally considered an "indicator of a healthy environment" and tend to be automatically considered for protection (despite being harmful to the environment when introduced outside their native area). Future research could adopt choice experiments (CE), frequently used in the field of WTP nature (Can & Alp, 2012; Cerda et al., 2013; Nie et al., 2019). CE with background information about the ecological consequences of invasive species on native crayfish species would produce more polarized responses from participants on their choices of crayfish species. The same method can be applied to fish as well.

It is thought that empathy underlies the relationship of humans with nonhuman species (Signal & Taylor, 2007). Previous research examined the links between empathy and attitudes toward interactions with animals, which is different from the attitudes of humans based on the perceived attractiveness of the nonhuman species and their protection, as did the current research. For instance, Lišková and Frynta (2013) showed a significantly higher perception of the attractiveness of species that are colorful and found that human preferences for species (birds in their case) were affected by the species' body shape (morphology), which provides a hint as to why crayfish species were perceived as more attractive than fish species in our study. These results are important for the conservation of crayfish species and their use as umbrella species for the conservation of freshwater ecosystems (Roberge & Angelstam, 2004). Other factors that shape our perceptions of crayfish could also be adhered to in the general discourse that crayfish are valuable components of the ecosystems that serve as bioindicators of high-quality environments, including water quality (Kuklina et al., 2013; Reynolds et al., 2013).

Our perception of crayfish is also shaped culturally through stories and myths, where crayfish often play significant roles. These findings can also partially explain the rich history of human–crayfish relationship development (Clavero, 2022; Patoka et al., 2016). Alternatively, crayfish have conspicuous claws, sharp objects that have been harmful to humans throughout our evolutionary history (Bar & Neta, 2006). Similarly, like sharp

thorns on plants (Fančovičová et al., 2022), crayfish claws have attracted attention that has contributed to the perceived attractiveness scores. This argument can also explain the exceptionally high attractiveness and WTP scores of *A. sturio*, which has sharp bony scales on its body. The high attractiveness scores of crayfish in this research show that these species can be used as flagship species in conservation campaigns, but it should be noted that a relatively high attractiveness and willingness to protect the species was also found for invasive counterparts, leading to a potentially reduced willingness to manage invasive crayfish, even contributing to their introductions and dispersal (Chucholl & Wendler, 2017; Lipták & Vitázková, 2015). This hypothesis is supported by the fact that many invasive crayfish species have been introduced and translocated (Bláha et al., 2022; Kouba et al., 2014). This could be closely associated with a high cuddliness factor that is typical for mammals and birds, which can be applied to fish and crayfish species alike (Bertolino & Genovesi, 2003; Verbrugge et al., 2013). But evolutionary aspects are not so straightforward, as phylogenetically distant species like invertebrates receive less empathy from humans than phylogenetically closer species like mammals (Miralles et al., 2019; Prokop et al., 2021).

The evaluation of animal beauty is thus highly subjective and linked to sociodemographic factors such as education, age, gender, experiences with animals, and culture (Davey, 2006). For example, an increased perception of the attractiveness of animals is correlated with conservation support, as shown in various studies of zoo-kept animals (Landová et al., 2018; Swanagan, 2000). Our results agree with these studies, providing additional support for the hypothesis that the degree of attractiveness of nonhuman species is positively correlated with the willingness to protect these species and, thus, with general conservation. The attractiveness of a species acts in the light of conservation as a double-edged sword (Frynta et al., 2010). For example, attractive species can come under high pressure because of overexploitation and be driven to extinction or become favored at the expense of other species (Marková et al., 2020; Militz & Foale, 2017; Tella & Hiraldo, 2014).

Enlarging the biology syllabus with issues of conservation incorporating practical aspects such as fieldworks is a promising strategy for pro-environmental attitudes and thereby sustainable management of not only freshwater ecosystems in the young population (Soga et al., 2016; Soga & Gaston, 2016). Educational activities, presentations, and live involvement in current conservation problems are important in shaping the real consequences of invasive species and the perceived harm from these species to biodiversity and the environment (Verbrugge et al., 2013). As regards crayfish species, minimal engagement at an early school age significantly raises the level of awareness and knowledge on the given topic (Marković et al., 2022).

Public participation in studies on biodiversity protection, environmental monitoring, or some of its other components has increased significantly in recent years. The potential of citizen science has become increasingly apparent, with numerous scientific publications and projects dealing exclusively with this issue (Chandler et al., 2017; Giovos et al., 2019; Howard et al., 2022; Perdikaris et al., 2017; Soroye et al., 2018; Trichkova et al., 2021); however, only some have evaluated potential mechanisms, such as human perception of species and attitudes toward them. Using attractive species could raise public involvement in conservation and management issues. Raising

awareness through education and communication can lead to effective management of invasive species that could link the public, specialists, and managers, and are highly recommended (Leandro & Jay-Robert, 2019; Woods, 2000). Using attractive or flagship species in the conservation of endangered freshwater taxa (Frynta et al., 2010), such as crayfish or sturgeons, can bring conservation advantages to other less attractive (even commonly unknown) species and contribute to the conservation and restoration of freshwater ecosystems.

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