



Technische Universität München

Master's thesis to obtain the title "Master of Science"
at the Technical University of Munich, School of Life Sciences

**Bias in Conservation Attention:
the Example of Imperiled Freshwater Pearl Mussels
(*Margaritifera margaritifera*)**

**Die Einseitigkeit der Aufmerksamkeit im Naturschutz:
das Beispiel der gefährdeten Flussperlmuschel
(*Margaritifera margaritifera*)**

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Course of Study: Nature Conservation and Landscape Planning

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July 2022

“The love for all living creatures is the most noble attribute of man.”

Charles Darwin

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Abstract

The financial resources available for biodiversity conservation are relatively scarce considering the enormous need for action. To achieve maximum success and use funds in the most efficient way, prioritisation is urgently needed. There exists a number of approaches to select the taxa to be protected with the flagship species concept being one of the most common. Conservation flagships possess characteristic traits such as aesthetic attractiveness rendering them popular and suitable to arouse sympathy as well as concern and thus win public support. Large mammals like elephants, lions, tigers, bears or birds serve as prominent examples. The flagship species approach in conservation science is highly discussed. While for instance its benefits to general involvement and its function as approved fundraising tool are widely acknowledged, it is also linked to a number of negative impacts. The most striking argument against the use of charismatic flagship species seems to be the associated strong bias in conservation attention. One-sided conservancy programmes, media coverage and marketing lead to these appealing taxa receiving much greater protection efforts, even if mammal and bird species can overall be considered less at risk compared to many aquatic, particularly freshwater organisms. In this way, human preference for certain species based on their likeability or attractiveness may ultimately shape the future fauna on earth. The thesis at hand highlights the bias in conservation attention, its origin, related problems as well as possible solutions. It aims to show opportunities to reduce distortion. For this purpose, using the example of the imperiled freshwater pearl mussel *Margaritifera margaritifera*, different proposals and drafts for a possible awareness and marketing campaign are developed.

Zusammenfassung

Die für den Erhalt der biologischen Vielfalt zur Verfügung stehenden finanziellen Mittel sind angesichts des enormen Handlungsbedarfs knapp. Um maximalen Erfolg zu erzielen und die vorhandenen Mittel möglichst effizient einzusetzen, ist eine Prioritätensetzung dringend erforderlich. Bei der Auswahl der zu schützenden Taxa kann auf eine Reihe unterschiedlicher Ansätze zurückgegriffen werden. Eines der gängigsten Zielartenkonzepte ist dabei das der sogenannten Flaggschiffarten. Im Naturschutz eingesetzte Flaggschiffarten besitzen charakteristische Merkmale wie ästhetische Attraktivität, die wesentlich zu ihrer Beliebtheit beitragen. Dadurch eignen sich diese Arten, um Sympathie und Besorgnis zu erregen und so die Unterstützung der Öffentlichkeit zu gewinnen. Große Säugetiere wie Elefanten, Löwen, Tiger, Bären oder Vögel dienen an dieser Stelle als prominente Beispiele. Das Flaggschiffarten-Konzept wird in der Naturschutzwissenschaft viel diskutiert. Während beispielsweise der Nutzen in Hinblick auf das gesellschaftliche Engagement und die Eignung als Instrument zur Mittelbeschaffung weithin anerkannt werden, geht der Ansatz auch mit einer Reihe negativer Auswirkungen einher. Ein besonders schwerwiegendes Argument gegen die Verwendung charismatischer Flaggschiffarten dürfte die damit verbundene verzerrte Aufmerksamkeit im Naturschutz sein. Die Einseitigkeit von Schutzprogrammen, medialer Berichterstattung und Marketing führt dazu, dass diese attraktiven Taxa weitaus größere Schutzbemühungen erfahren, auch wenn Säugetier- und Vogelarten im Vergleich zu vielen aquatischen – insbesondere im Süßwasser lebenden – Organismen insgesamt als weniger gefährdet gelten. Auf diese Weise kann die Vorliebe des Menschen für bestimmte Arten aufgrund von Sympathie oder Attraktivität letztlich die zukünftige Fauna auf der Erde maßgeblich prägen. Die vorliegende Masterarbeit beleuchtet die Einseitigkeit der Aufmerksamkeit im Naturschutz, ihren Ursprung, daraus resultierende Probleme und denkbare Lösungen. Ziel ist es, Möglichkeiten zur Reduktion dieser Verzerrung aufzuzeigen. Hierzu werden am Beispiel der gefährdeten Flussperlmuschel *Margaritifera margaritifera* verschiedene Vorschläge und Entwürfe für eine mögliche Bewusstseins- bzw. Marketing-Kampagne entwickelt.

1 Introduction

We live in an era of “Anthropocene defaunation“ characterized by the exceptionally fast loss of wildlife species and populations as well as strong declines in local abundances (Dirzo et al. 2014). Human-induced pressures such as habitat loss, overexploitation and climate change are considered the major determinants of this biodiversity crisis (IPBES 2019; Liordos et al. 2017). Researchers suggest that current extinction rates are 1000 times higher than background levels and may even be up to 100 times greater in the future (Sitas et al. 2009). This is why the endangerment status of many species has been assessed and lots of biodiversity conservation programmes have been initiated worldwide (Liordos et al. 2017). However, in relation to the enormous need for action, the financial resources at hand are scarce (Lundberg et al. 2019). To achieve maximum success and use the available funds in the most efficient way, prioritisation is urgently needed. Researchers therefore try to identify appropriate areas and species of special conservation concern (Sitas et al. 2009). Protecting large geographic areas inhabited by a multitude of imperiled taxa seems a very plausible strategy (Kellert 1985) as the habitat can be considered the key to the survival of any species (Black et al. 2001). Single-species conservation strategies, opposed to this, are highly controversial. On the one hand, they are criticized for being too simplistic to acknowledge complex interactions within an ecosystem and rather following an animal protection approach than the ecological goal of biodiversity conservation (Ducarme et al. 2013). On the other hand, some of the most useful instruments for species protection are founded in single species rather than ecosystem conservation (Black et al. 2001). Some authors state that, when it comes to the perspective of the individual person, single-species approaches may even be an emotional and ethical necessity (Kellert 1985). Despite the disagreement about its effectiveness, this kind of approach is widely used in conservation programmes. There exists a number of concepts by which the taxa to be protected, also referred to as surrogate species, can be selected. The most prominent are indicator, keystone, umbrella and flagship species (Albert et al. 2018). Due to their ecological function, the former two types are of special importance as study tools (ibid.; Ducarme et al. 2013). Indicator species respond sensitively to changes in their natural surrounding and can therefore help to assess environmental parameters and habitat quality (Albert et al. 2018). Taxa crucial for

ecosystem structure and functioning are named keystone species (ibid.). Umbrella and flagship species are less important for research but are typically used as conservation tools (ibid.; Ducarme et al. 2013). Umbrella species often live in a large home range meaning that their protection automatically benefits other species sharing the same habitat (Albert et al. 2018). Flagship species are taxa suitable to raise public awareness and support for conservation goals reaching beyond the species specific requirements (Oberhauser & Guiney 2009).

The master's thesis at hand deals with the bias in conservation attention. It aims to explore its origin, point out the linked problems and identify possible solutions. Using the example of imperiled freshwater pearl mussels (*Margaritifera margaritifera*), it tries to show opportunities to reduce the distortion by designing an awareness and marketing campaign. In the following, the just mentioned flagship species approach, a prominent target species concept frequently applied in the public relations work of environmental non-governmental organizations (ENGOS), will be described in more detail. It is closely related to the societal view of species and therefore of particular interest in the thesis' context. In the third chapter, the focus is on the bias in conservation attention. The example of imperiled freshwater pearl mussels is treated in the fourth chapter. It provides important background information on *M. margaritifera* and describes the public attitudes towards freshwater mussels, later on the developed campaign ideas are presented. In the last chapter, a short conclusion is drawn from the new findings.

2 Flagship species in nature conservation

Flagship species can be defined as “popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action“ (Schlegel & Rupf 2010). This kind of species arouses interest, sympathy and concern in public (Ducarme et al. 2013; Albert et al. 2018) and can therefore be used to increase societal awareness (Albert et al. 2018), attract general support (Jarić et al. 2020) and promote conservation marketing activities such as fundraising (ibid.; Veríssimo et al. 2018; Lorimer 2007; Albert et al. 2018). By improving knowledge and funding, focussing campaigns on taxa with traits perceived as charismatic in public (Jarić et al. 2020) can ultimately help the implementation of nature conservation projects (Schlegel & Rupf 2010). This is the reason why ENGOs mostly select species appealing to humans for marketing purposes (Lundberg et al. 2019). They use flagship species for instance as emblems on their information brochures, conservation magazines, websites or printed on promotional gifts (Clucas et al. 2008).

Examples for such charismatic taxa receiving a lot of conservation attention are elephants, rhinos, orang-utans (Sitas et al. 2009), pandas, polar bears, wolves, tigers (Clucas et al. 2008), dolphins, whales and a variety of large African savanna mammals (Ducarme et al. 2013). The latter are regarded as the most popular group of flagship species (ibid.). This finding is consistent with the results of the study conducted by Albert et al. (2018). The researchers analysed data from direct and indirect sources (surveys, zoo websites, film posters) to identify the 20 most charismatic taxa as perceived by the general public in Western countries (ibid.). The species ranked as follows: tiger, lion, elephant, giraffe, leopard, panda, cheetah, polar bear, wolf, gorilla, chimpanzee, zebra, hippopotamus, great white shark, crocodile, dolphin, rhinoceros, brown bear, koala and blue whale (ibid.). Most of the mentioned species are large, terrestrial mammals, African species comprise more than half of the list (ibid.). However, the authors summarize that the identified species can not be described by just one specific profile as not all are rated based on their aesthetic appeal. Some species like the great white shark or the crocodile are rather chosen because of their frightening appearance (ibid.). Moreover, the researchers point out that many of the 20 rated species have been conservation targets in past or

current campaigns (ibid.). It remains uncertain how much a species' prior positive image determines its suitability for serving as conservation target and, vice versa, to what extent the media coverage leads to the species being viewed as appealing (ibid.).

2.1 Characteristic traits of flagships species

Although the just mentioned study results suggest that species charisma is not linked to one specific animal profile, conservation flagships usually possess characteristic traits perceived as particularly charismatic and appealing by humans. The first and most evident attribute which typically applies to these species is aesthetic attractiveness. In addition, rarity or endangerment, harmlessness and other aspects like utility or cultural importance may render certain taxa suitable as flagship species.

Aesthetic attractiveness

Human feelings of affection and public aid for conservation strongly depend on external characteristics (Gunnthorsdottir 2001) with the most striking one being aesthetics or rather perceived physical attractiveness of a species (Knight 2008; Kellert 1985; Schlegel & Rupf 2010). The more appealing a certain species' physique, the more support it receives (Liordos et al. 2017) or, with other words, the less attractive, the lower it features in the ranking (ibid; Kanagavel et al. 2014). The protection of species considered "cute" and/or "beautiful" just seems much easier to justify. Accordingly, ENGOs generally include pictures of visually pleasing animals in their conservation campaigns (Gunnthorsdottir 2001).

The perceived attractiveness in turn is affected by a species' similarity to humans (ibid.). Studies show that people prefer taxa that are rather closely related to *Homo sapiens*, feel greater empathy towards them and are more willing to support or contribute to their conservation (ibid.; Kellert 1985; Colléony et al. 2017; Tisdell et al. 2005). A species' degree of similarity to humans is reflected by its taxonomic order and the extent to which it is considered a "higher form of life" (Gunnthorsdottir 2001). This is why, speaking of classes, mammals and birds are advantaged compared to reptiles, amphibians, fish or invertebrates (Liordos et al. 2017; Tisdell et al. 2005). Especially mammal species possess "human-like" anthropomorphic traits like a flat

face or forward-facing eyes (Lundberg et al. 2019) which trigger concern and make them ideal conservation flagships (ibid.; Lorimer 2007). Apart from such physical attributes it is also a species' capacity to think, feel and experience pain that determines its charisma, perception and protection (Knight 2008; Kellert 1985). It seems like human beings have to individualise nonhumans before they can care about them (Lorimer 2007).

Another characteristic trait of flagship species closely related to public attitudes and protection efforts is an animal's physical body size (Knight 2008; Liordos et al. 2017; Clucas et al. 2008; Gunnthorsdottir 2001). It has been shown that people regardless of their cultural background tend to prefer large animal species (Liordos et al. 2017; Gunnthorsdottir 2001; Kellert 1985) and more likely support them rather than smaller taxa (Gunnthorsdottir 2001; Kellert 1985; Albert et al. 2018). Accordingly, the flagship species used as targets in conservation programmes by ENGOs are typically large in size (Albert et al. 2018; Clucas et al. 2008; Lundberg et al. 2019). In this respect, again mammals and birds but also fish are advantaged over other taxonomic groups (Liordos et al. 2017).

Apart from similarity to humans and size further aspects contributing to a species' aesthetic attractiveness and its suitability to serve as flagship species are warm and bright colours (Lundberg et al. 2019) as well as neotenic (juvenile) features (Liordos et al. 2017).

Rarity or endangerment

Preferences and affection for certain taxa are furthermore connected with their rareness (Schlegel & Rupf 2010; Tisdell et al. 2005). Thus, the endangerment level or IUCN status of species constitutes another crucial criterion when it comes to selecting suitable flagships for conservation (Clucas et al. 2008).

Harmlessness

In their study, Liordos et al. (2017) demonstrated that, apart from one exception, the species receiving the most support at the same time were the ones rated as the least harmful. This suggests that more harmless taxa get more help compared to species perceived as fearsome and a potential threat (ibid.; Kanagavel et al. 2014).

Other attributes

Human attitudes towards species are additionally shaped by their utility (Schlegel & Rupf 2010). Beyond that, factors such as their cultural importance, historical familiarity (Gunnthorsdottir 2001), symbolism, intelligence, valor and singularity (Ducarme et al. 2013) contribute to their charisma.

For a long time, a species' physical appeal and visceral arguments have been viewed as the primary determinants in terms of public preferences (Czech et al. 1998; Kellert 1985; Lundberg et al. 2019; Martín-López et al. 2007). In contrast, some studies conclude that aesthetic reasons only play a minor role compared to arguments grounded in scientific value (Brady 2006), ecological importance, rarity (Czech et al. 1998) and the resulting conservation need (Lundberg et al. 2019; Tkac 1998; Tisdell et al. 2007). Besides, moral or ethical values as well as a species' intrinsic value and usefulness need to be taken into account (Tisdell et al. 2005). Consequently, one should definitely be cautious to consider an organism's appearance dominating human support to its conservation (ibid.). Nonetheless, it remains a fact that aesthetics and charisma strongly influence the public motivation for species preservation (Ceríaco 2012; Brady 2006). These interrelated aspects evidently hold an enormous importance in nature conservation that can and should not be ignored (Brady 2006; Ducarme et al. 2013). However, respondents of survey data analysed by Czech et al. (1998) indicate that according to the majority's opinion all species should be conserved. So maybe a shift in public attitudes is about to take place (ibid.). We reached a point where public understanding and appreciation of biodiversity are at an all-time high (ibid.) and with increasing awareness of environmental topics and the change in social attitudes towards nature that comes with it, moral aspects like the intrinsic values of species are of growing significance (Tisdell et al. 2005).

2.2 Underlying mechanisms determining public perception

Species with the above characteristics tend to be viewed positively by the larger part of society. Even if charisma, perceived attractiveness and emotional responses towards species can be regarded as subjective factors varying between individuals (Ducarme et al. 2013), there are some underlying mechanisms that could be used to explain general tendencies in human preferences. These mechanisms can be

divided into two different groups, biological-evolutionary aspects on the one and social parameters on the other hand.

The first include the biophilia and biophobia hypothesis, the similar principle theory as well as the baby schema. The so-called biophilia hypothesis goes back to sociobiologist Edward O. Wilson who stated that human beings show an inborn affinity towards other forms of life named biophilia (cited after Lorimer 2007). While biophilia is associated with approach behaviours (Liordos et al. 2017), biophobia, the negative manifestation of this affinity (Lorimer 2007) is related to negative learnings and avoidance (Liordos et al. 2017). Both biophilia and –phobia are triggered by certain species but also by different types of landscapes (Lorimer 2007). The fear of animals is among the best known, most common and persistent of human fears (Liordos et al. 2017; Schlegel & Rupf 2010). Phobias concern not only large predatory animals such as bears and wolves but also small ones like rats, mice, bats, cockroaches, snakes, snails, worms or spiders (Liordos et al. 2017). While the former are feared because of their association with injury and pain, the latter widely fill people with disgust due to their linkage to the spread of disease and infection, dirt or mucus (ibid.). As already mentioned, people favour the survival of mammals over that of birds or reptiles (Colléony et al. 2017), feeling greater empathy towards them (Tisdell et al. 2005) and being more willing to donate to more human-like species that are phylogenetically closer (Colléony et al. 2017)(see 2.1 Characteristic traits of flagship species). This common human preference for animal species resembling them was described by Plous' Similar Principle Theory (ibid.). The baby schema developed by Konrad Lorenz follows a similar approach. It suggests that people instinctively prefer organisms in possession of traits characteristic for human babies such as a relatively big head, flat face, large eyes or soft fur (Lorimer 2007).

Apart from these biological-evolutionary aspects, a person's perception of wildlife can be significantly shaped by social factors like culture (Gunnthorsdottir 2001). In this way, societal values and folklore strongly impact nature conservation (Ceríaco 2012). For instance, people are unlikely to support conservation efforts targeting species which are interpreted as bad omens in their cultural environment (slender loris and Travancore tortoise: Kanagavel et al. 2014). In the social context, media play a pivotal role, too. A lot of what we know about the world we are living in comes from media (Luhmann 1996: 9) like newspaper, television or the internet. Media can be

considered “real” in two senses: Not only are they real because of their factual existence but also due to their decisive influence on what people perceive as reality (Luhmann 1996: 12-15). Visual material like photographs for example can not be seen as a copy of reality as they substantially shape, if not even constitute, reality (Breckner 2008). Every published image is inevitably selective (Luhmann 1996: 56) as it shows just one perspective, the perspective of those involved in the production process, including the persons who release the shutter and edit the pictures later on (Kanter 2016: 1). By choosing, cutting and modulating photographs the editorial departments put their focus on what they consider most relevant (ibid.: no page). In this respect, every published picture reflects their world view and imposes their own personal interpretations to the recipients (ibid.: no page, 2). Images can thus be understood as socially designed products that have undergone several selection processes (ibid.: 2f). However, the selectivity and modification of the visual material are usually not taken into account (ibid.: no page). The same applies to images shown in the media as part of nature conservation campaigns. ENGOs considerably influence the citizens’ perception of species by focussing on certain taxa (Czech et al. 1998) and presenting them in a way that meets their strategic objectives.

The social construction of public attitudes towards species also becomes evident when looking at the portrayal of animal characters in popular (horror) movies and books, e.g. snakes (the Bible, Voldemort’s snake Nagini in “Harry Potter“), great white sharks (“Jaws“), bats (“Dracula“) or spiders (“Arachnophobia“, Shelob the spider in “Lord of the Rings“)(Liordos et al. 2017). This way of presentation helps to evoke or reinforce negative emotions and irrational fears (Knight 2008).

2.3 Strengths and weaknesses of the flagship species approach

After exploring flagship species, their characteristic traits as well as the underlying biological-evolutionary and social mechanisms contributing to their positive image among the general public, in the following the focus should be on the need, strengths and weaknesses of the concept. The flagship species approach in conservation science is highly discussed. On the one hand, there exist convincing arguments in favour of its necessity and use.

First of all, conservation flagships strongly help people to get involved and aid nature conservation (Ducarme et al. 2013; Liordos et al. 2017). As multiple studies have shown, public support is higher for the protection of aesthetically pleasing species than for less attractive ones (Liordos et al. 2017; Gunnthorsdottir 2001; Knight 2008). In this way, the utilization of charismatic flagship species benefits the general involvement but also the financial support of conservation projects (Schlegel & Rupf 2010). Overall, people are more willing to fund conservation programmes and donate for such species (Lundberg et al. 2019; Gunnthorsdottir 2001; Albert et al. 2018; Thomas-Walters & Raihani 2017; Veríssimo et al. 2018). This suggests that environmental organizations can effectively increase revenues by using conservation flagships as fundraising tools (Thomas-Walters & Raihani 2017).

Secondly, the protection of flagship species can be accompanied by positive local effects on other taxa within the same ecosystem and/or species as well as ecosystems worldwide. Ideally, the habitat requirements of flagship species coincide with other species' needs (Schlegel & Rupf 2010). In that case, the protection of appealing taxa would simultaneously benefit the survival of less charismatic, sympatric species, too (Lorimer 2007). This concept is commonly referred to as "umbrella species effect" in conservation literature (e.g. Schlegel & Rupf 2010). For example, the typically large flagship species oftentimes act as (top) predators, they depend on sufficient prey and overall intact food webs (Clucas et al. 2008) which makes them potential umbrella species. Some of the conservation flagships might be of such outstanding importance to species communities and ecosystem functioning that they can additionally be considered keystone species (ibid.). Ducarme et al. (2013) suggest that all of the charismatic, large predators at the same time are keystone species due to their ecological top-down effect on lower trophic levels. Furthermore, it is known that bioaccumulation processes lead to top predators showing the highest concentrations of pollutants. So the attractive, large predatory conservation flagships might serve as indicator species for environmental pollution as well (ibid.). The positive effects of conservation flagships are not limited to their ecosystems or the organisms they share habitats with. Flagship species can promote awareness, public support and funding for conservation goals far beyond the protection of a single species (Oberhauser & Guiney 2009). With the help of its iconic panda logo, the World Wide Fund For Nature (WWF) for example generates interest

and raises money not just for the conservation of this particular species but for nature and biodiversity globally (ibid.; Lorimer 2007). Among others, the organization also addresses general environmental problems such as climate change, deforestation and water pollution (Lorimer 2007).

On the other hand, apart from the mentioned strengths, the flagship species approach is also accompanied by a number of weaknesses. For instance, charismatic species with bright colours, special shape or symbolic value frequently get collected as souvenirs, to sell to tourists or on the international market which can ultimately result in local extinction (Ducarme et al. 2013). This holds true especially for sessile organisms like beautiful flowers, edible mushrooms, sea stars or shellfish (ibid.). Charismatic mammals such as dolphins can suffer from tourism and disturbance, too (ibid.).

Furthermore, repeated use of the same few standard flagship species might cause lower impact and effectiveness of protection measures as potential donors are likely to experience what is called “flagship fatigue”, a compassion fade due to overexposure (ibid.; Thomas-Walters & Raihani 2017).

Another aspect that should not be ignored is the fact that the most fund-earning conservation campaigns need not be the most efficacious (Ducarme et al. 2013). The success of protection measures heavily relies on the support of local communities (ibid.). Selecting flagship species perceived as charismatic among the occidental donors might be counter-productive if the animal is viewed as pest (ibid.) or possibly causes other damage to the detriment of local citizens (e.g. elephants)(Schlegel & Rupf 2010).

Besides, flagship species are not necessarily of vital importance for ecosystem functioning (Lorimer 2007). They do not automatically make good indicator species (Ducarme et al. 2013), their suitability as umbrella species is doubted (ibid.; Clucas et al. 2008) and their relevance as keystone species controversially discussed (Ducarme et al. 2013). As they are primarily chosen based on charisma, conservation flagships do not even need to be objectively assessed as endangered (ibid.; Lorimer 2007). The positive ecological effects of flagship species on other taxa within their ecosystem thus remain questionable.

However, the probably most meaningful counterargument lies in the drastic bias in global conservation communication and attention coming with the flagship species approach (Ducarme et al. 2013; Sitas et al. 2009). The selection of a small number of flagship species is regarded as problematic because the public gets exposed to a low percentage of conservation problems only (Clucas et al. 2008). As a consequence, other taxa – eventually of greater ecological value or conservation need – might receive less concern and resources as they are considered to be of lower priority or may even be overlooked completely (Thomas-Walters & Raihani 2017; Sitas et al. 2009). Sitas et al. (2009) note that the majority of endangered species experience either little or no protection efforts and that the few species that do receive well-planned measures, regular monitoring and updated conservation action are extremely distorted. The bias in literature, public attention and programmes clearly favours charismatic, well-studied species living in the developed world, especially big mammals (Clucas et al. 2008; Lorimer 2007; Ducarme et al. 2013; Sitas et al. 2009). On a global scale, many conservation related decisions are grounded in subjective attitudes or emotions rather than scientific considerations (Sitas et al. 2009; Ducarme et al. 2013). Conservation status, relative endangerment, rareness and distribution often seem to play a minor role compared to superficial criteria such as physical appearance, size, similarity to humans or likeability and utilitarian factors (Sitas et al. 2009; Martín-López et al. 2007; Gunnthorsdottir 2001; Tisdell & Wilson 2006).

To sum it up, the flagship species concept definitely has its justification as it draws public attention to nature conservation and helps to generate funds for protection measures. Nevertheless, it should be judged critically in terms of the ecological benefit. Most important, the associated bias in conservation attention that strongly favours aesthetically pleasing species is to be regarded as highly problematic.

3 Bias in conservation attention

In the previous chapter, the flagship species approach, a prominent target species concept in nature conservation, was highlighted. As shown by the final evaluation, the strategy is ambivalent and therefore justifiably controversially discussed. The problematic bias in conservation attention mentioned above applies in research, literature, protection programmes, media coverage as well as marketing. In this regard, it impacts public preference and perception of species (see 2.2 Underlying mechanisms determining public perception). It probably affects not only which taxa are perceived as attractive, but also which species are considered endangered by the general public – with severe consequences. For this reason, in the following the focus will be on the bias in conservation attention, the linked problems and possible solutions.

“Most people associate biodiversity decline with tropical rainforests. But as a matter of fact, if we look at the most endangered species, we can clearly see that these are mostly aquatic taxa occurring in freshwater habitats“ (Prof. Dr. Geist, personal communication¹).

As Geist (2016) states, the percentage of freshwater taxa like freshwater mussels, crayfish, stoneflies, fish and amphibians that falls under the categories of the IUCN Red List is particularly high at over 35%. At the same time, more prominent taxonomic groups such as mammals and birds whose protection receives much greater attention rank comparably low at 15% and 14% respectively and are overall less at risk than many of the aquatic organisms (ibid.).

In Europe, several of the most threatened species groups either live in freshwater ecosystems or depend on them at some point of their life cycle (Fig. 1). The same holds true in the United States and the Canadian context (Nash 2004; Auerswald et al. 2019). Mean future extinction rates of freshwater fauna are projected to be five times higher than those for terrestrial animal species (Ricciardi & Rasmussen 1999). The estimated depletion rates for freshwater biota are comparable to the ones predicted for species living in tropical rainforests (1-8% loss per decade; ibid.) which are commonly considered the most imperiled habitats worldwide. Looking at the

¹ as part of the lecture “Aquatic Ecology and Conservation“, summer semester 2020, TU Munich

freshwater taxa it is clearly invertebrate species that are at highest risk of extinction (Geist 2011). Neubauer et al. (2021) for example found that the current loss of freshwater gastropod species happens at a pace even faster than during the Cretaceous-Paleogene mass extinction in Europe. According to their analysis, 75% of all European freshwater gastropod species might get lost within the next centuries. Another alarming example is that of freshwater mussels. Ricciardi and Rasmussen (1999) projected that at least 127 of the endangered North American freshwater bivalve species will get extinct within the coming 100 years if no effective action is taken.

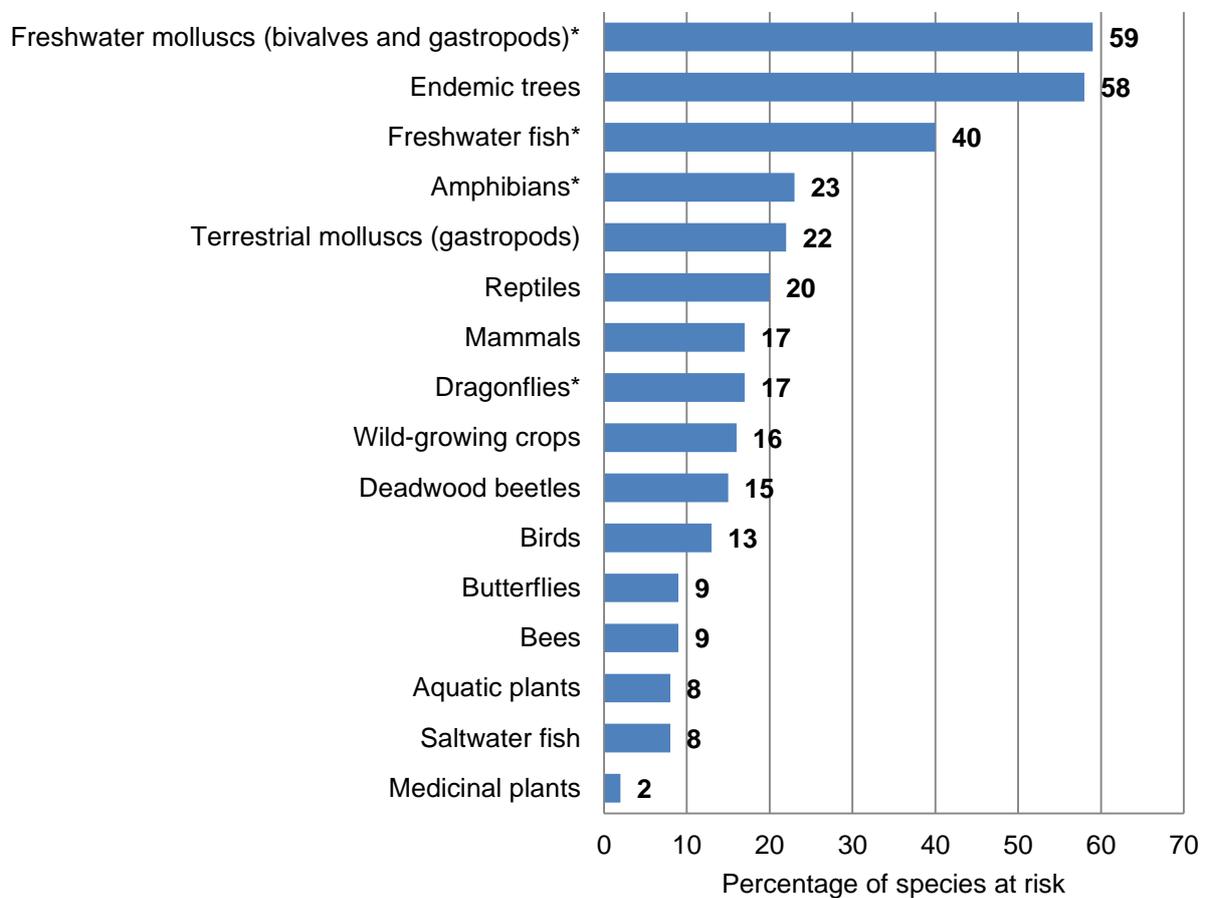


Fig. 1: Taxa particularly at risk in Europe. Species groups that require freshwater ecosystems during at least part of their life cycle are marked with *. (Own figure based on European Parliament 2020)

Thus, there appears to be a significant discrepancy between the most threatened taxa and those perceived to be the most threatened by the general public. This phenomenon can very likely be explained by one-sided media coverage in favour of charismatic species such as mammals and birds (Prof. Dr. Geist, personal

communication²)(see 2 Flagship species in nature conservation). However, despite the urgent need for addressing the bias in conservation, there are no studies available on which species are perceived as endangered. This is where further research could and should be undertaken in the future.

3.1 Problems

The described bias in conservation attention is accompanied by serious consequences. Studies found that European children have greater knowledge about African than European animal species (Ducarme et al. 2013). The preference for exotic, charismatic animals lasts until adulthood and accordingly impacts the behaviour of potential donors, researchers or conservationists. “Selective preferences for certain animals are therefore likely to shape the future fauna of our planet“ and our whole natural surrounding (Gunnthorsdottir 2001) by granting or denying species the right to survive based on their likeability (Ducarme et al. 2013) or attractiveness (Tisdell et al. 2005). In other words: “An animal’s external characteristics may seal its fate“ (Gunnthorsdottir 2001). This gets particularly evident when looking at the IUCN Red List of Threatened Species: Of the 134,425 species assessed in total from 1996 to 2020, as much as 54,807 (41%) are vertebrate taxa (IUCN 2021)(Fig. 2). The percentage of invertebrates is comparably low at only 19% (25,051 species)(ibd.)(Fig. 2) even though it is commonly acknowledged that they comprise more than 90% of the world’s animal species (Kellert 1993).

² as part of the lecture “Aquatic Ecology and Conservation“, summer semester 2020, TU Munich

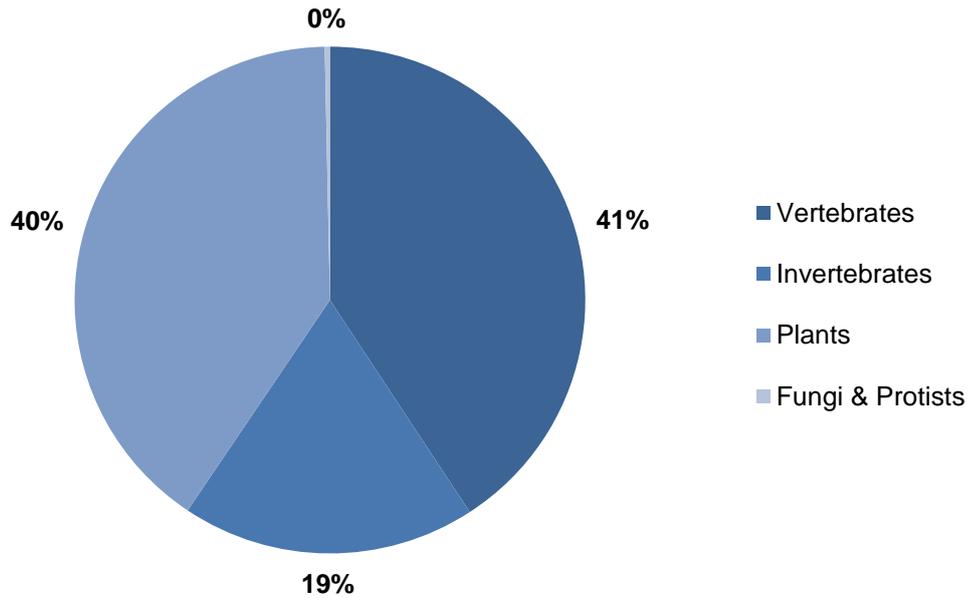


Fig. 2: The bias in conservation attention gets particularly evident when looking at the IUCN Red List of Threatened Species: Of the 134,425 species assessed in total from 1996 to 2020, as much as 54,807 (41%) are vertebrate taxa, the percentage of invertebrates is comparably low at only 19% (25,051 species). (Own figure based on IUCN 2021)

3.2 Possible solutions

The problematic bias in conservation attention can be addressed in several different ways. Three approaches are described in further detail below: Research, education and information as well as media and marketing. For the sake of clarity, the fields are presented separately. In practice, however, the areas are highly interdependent.

Research

Research oftentimes focuses on vertebrates rather than on invertebrate taxa (Bentlage 2015). As indicated above, the same holds true for red listing. That is why a first important strategy should be to improve research, starting in the field of taxonomy and systematics. It is estimated that only one out of 30 invertebrate species have been scientifically described so far (Kellert 1993). Increasing this percentage could remarkably help to improve the representativity of species in Red Lists as only well-known taxa can be assessed, catalogued and potentially be classified as “endangered” (Ducarme et al. 2013; Black et al. 2001). Furthermore,

research can contribute to a better understanding of species' habitat needs allowing for more efficient habitat protection (Black et al. 2001).

Education and information

A second approach lies in education which provides an opportunity to influence the way people perceive species. Studies show that attitudes towards certain species not solely rely on their characteristics but also on several other factors, especially on the type of educational institution a person attended (Schlegel & Rupf 2010). Higher education levels, more information and better knowledge are closely linked to positive attitudes towards fauna as well as greater esteem (ibid.; Martín-López et al. 2007) and in this way correlate with the individual willingness to allocate funds for wildlife and species conservation, too (Tisdell & Wilson 2006; Veríssimo et al. 2018; Lundberg et al. 2019; Martín-López et al. 2007). Well-informed people are not just more likely to support conservation programmes, they also take into account ecological-scientific considerations like endangerment rather than affective aspects when it comes to choosing species (Martín-López et al. 2007; Tisdell et al. 2007; Tisdell & Wilson 2006). For nature conservation practice, this means that by providing appropriate information, one can actively increase people's willingness to donate for species they used to be unfamiliar with (Tisdell & Wilson 2006). Another education related aspect strongly shaping the perception of wildlife seems to be a person's closeness to nature. For example, people with more childhood experiences in rural surroundings were shown to choose less charismatic species (Colléony et al. 2017). The importance of childhood in this context is confirmed by the project "Nature on the Way to School" (by the Swiss nature conservation organization "Schweizerischer Bund für Naturschutz") concluding that 8-16 year old children perceived local species as more attractive when being able to identify and name them (Schlegel & Rupf 2010). Apparently, if the aim is to help less charismatic, unpopular species to be perceived more positively, providing relevant information and encouraging children to get into contact with nature should be of high priority.

Media and marketing

Thirdly, media and marketing offer further opportunities to tackle the problem. A species' perceived charisma is closely interrelated with conservation communication and its representation in media (Jarić et al. 2020). The extent of media exposure, the

specific point of view, the way an organism is portrayed, all these aspects can influence public attitudes towards certain species positively or negatively (ibid.). For this reason, promotional campaigns can undoubtedly be used as a means of artificially enhancing or constructing species charisma (Lorimer 2007; Ducarme et al. 2013). However, conservationists can not magnify or manipulate charisma at will as it remains constrained by the species biological attributes (Lorimer 2007).

When it comes to improving the image and protection of less charismatic taxa, two strategies seem promising. The first consists in stressing the values and services provided by uncharismatic species. As Kellert (1985) points out, “a major deficiency in most endangered species protection efforts is an insufficient appreciation of people’s perceptions of endangered wildlife, and an inadequate evaluation of the benefits society derives from these species“. Efficiently communicating and emphasizing the various aesthetic, utilitarian, ecological and outdoor recreational values of taxa and their extraordinary contributions to human economy and well-being therefore is an absolute necessity, especially in regard of invertebrate conservation (ibid.; Kellert 1993; Black et al. 2001). It can help to mitigate existing negative attitudes towards these organisms (Kellert 1993), appreciation based on scientific understanding may even bring positive aesthetic evaluation of species previously considered unattractive (Brady 2006). The second advisable strategy is to highlight the endangerment of uncharismatic species. Providing information about a species’ conservation status alters people’s willingness to contribute to its protection (Tisdell 2006; Tkac 1998; Gunnthorsdottir 2001). On average, for endangered species, greater knowledge of their conservation status means more funding (Tisdell 2006). That means stressing the plight of species helps raising donations for their cause regardless of their charisma (Lundberg et al. 2019). Studies indicate that, similar to the effect of improved scientific understanding, focusing campaigns on unattractive animals and presenting them as threatened even enhances their perceived aesthetic appeal (Gunnthorsdottir 2001).

4 The example of imperiled freshwater pearl mussels

As demonstrated in the previous chapter, freshwater organisms are among the most threatened taxa in the world. This holds true especially for invertebrates such as bivalves, including the freshwater pearl mussel *Margaritifera margaritifera* which is discussed in more detail below. The species can be considered highly endangered and rather uncharismatic at the same time. Using it as example, ways of reducing bias in conservation attention by skillful marketing should be shown (see 3.2 Possible solutions). For this purpose, an awareness campaign is to be developed. But first, background information on the species is provided to illustrate its ecological value and the urgent need for conservation action.

4.1 Biology, endangerment and conservation

M. margaritifera occurs in cool running waters within the Holarctic region (Geist 2010) ranging from the arctic and temperate regions of western Russia westwards to Europe and the northeastern coast of the North American continent (ibid.). Apart from few exceptions, the species can only be found in oligotrophic streams (ibid.; Boon et al. 2019). Freshwater mussels like *M. margaritifera* can account for more than 90% of a river's benthic biomass and provide various essential ecosystem functions and services (Lopes-Lima et al. 2017). Among others, the mussel beds act as important substrate for other species like juvenile salmonids or the invertebrates they feed on (ibid.; Geist 2010). Another crucial aspect is the filter-feeding strategy of these organisms. A single mussel is able to filter approximately 40 liters of water per day (Lopes-Lima et al. 2017). The associated transfer of matter and energy from the water to the benthos is closely related to primary and secondary production, biogeochemical processes, sedimentation and water clarity (ibid.).

Due to the enormous amounts of water they filter and the linked effects on the entire habitat, freshwater mussels are considered keystone species (Geist 2016) as well as indicators for clean water and intact freshwater ecosystems (ibid.; Bentlage 2015). Additionally, as the freshwater pearl mussel reacts sensitively to processes going on in the water column and its surrounding, it can also be referred to as umbrella species (Geist 2010, 2016)(for keystone, indicator and umbrella species see also 1

Introduction). Despite *M. margaritifera* being rare and endangered respectively as well as harmless – both characteristic traits of flagship species (see 2.1 Characteristic traits of flagship species) – it seems unsuitable as such due to its inconspicuous appearance (Fig. 3).



Fig. 3: A group of freshwater pearl mussels (*M. margaritifera*) on a stream bed.
(https://commons.wikimedia.org/wiki/File:Group_of_Margaritifera_margaritifera.jpg)

4.1.1 Life cycle

In order to better understand the threats the species is exposed to, it is essential to first have a closer look at its life cycle. Freshwater pearl mussels are extraordinarily long-lived organisms, they often attain ages of more than 100 years (Geist 2010; Lopes-Lima et al. 2017; Boon et al. 2019). Their lifespans strongly vary depending on growth rates and geographic location (Geist 2010; Boon et al. 2019). While specimens in southern Europe only reach ages of 35 years (Geist 2010), the ones in Scandinavia can exceed ages of more than 2 centuries (ibid.; Boon et al. 2019).

Like all unionoid mussels, *M. margaritifera* has a complex life cycle (Boon et al. 2019; Geist 2010)(Fig. 4). A main characteristic of the species' reproductive strategy

consists in the high fertility of females (Geist 2010). They brood their eggs in the so-called marsupium and absorb the male's sperm via their gills in the course of their filtering activity (Lopes-Lima et al. 2017). The fertilized eggs later develop into glochidia larvae (ibid.) of which a single female pearl mussel can produce several million per year (Geist 2010). The glochidia are released to the water column in mid to late summer and must be inhaled by a host fish on whichs gills they live as parasites for up to 10 months (ibid.). What makes this point of the larval stage so sensitive is the limited infectiveness (few days), mobility (ibid.) and host fish suitability. The pearl mussel glochidia exclusively grow on salmonid fish (Boon et al. 2019), in Europe only three species (sea trout *Salmo trutta f. trutta*, brown trout *Salmo trutta f. fario* and Atlantic salmon *Salmo salar*) make a complete metamorphosis of the larvae possible (Geist 2010, 2016). The glochidia profit from their host fish in terms of dispersal and nutrition (Lopes-Lima et al. 2017) until they drop off the next spring or summer (Boon et al. 2019). After the parasitical phase the juvenile freshwater pearl mussels bury themselves in the sediments of the river bed where they stay for about five years (Geist 2010, 2016). During that life stage the young mussels highly depend on well-oxygenated, good quality substrate that allows adequate exchange between interstitial water and the rest of the water column (Geist 2010). Researchers agree that this post-parasitical phase poses the most delicate and critical stage in *M. margaritifera's* life cycle (ibid.) as it determines juvenile mussel recruitment (Boon et al. 2019). After the glochidia have developed into sexually mature mussels they return to the surface of the stream bed (ibid.). The adult specimens can actively move by pumping haemolymph into their foot but can still be considered rather sessile organisms (Geist 2010).

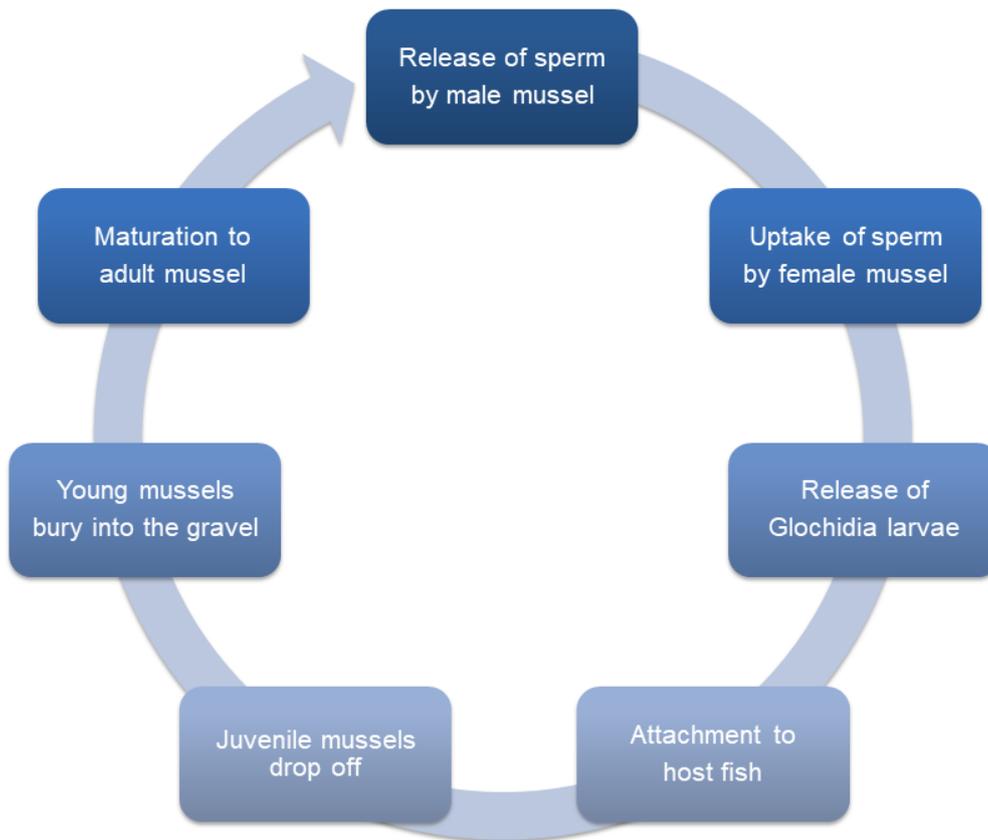


Fig. 4: Life cycle of the freshwater pearl mussel *M. margaritifera*. (Own figure)

4.1.2 Threats

Freshwater pearl mussels are exposed to a large number of pressures (e.g. Boon et al. 2019). The most important threats are described in detail below.

Biological traits

Mussels possess a number of biological traits that make them particularly vulnerable to changes in their natural surrounding (Bentlage 2015). First of all, their way of locomotion is very limited (Geist 2010). Even if they are able to slowly move across the river bed, they are not mobile enough to adapt their local position to rapid environmental changes (Bentlage 2015). Second, they are filter-feeders and therefore very susceptible to variation in water quality like increased concentrations of pollutants or sediments (Bentlage et al. 2019). Third, their complex reproduction cycle (see 4.1.1 Life cycle) depends on several variables like sufficient numbers of female and male specimens in physical proximity or the availability of high quality sediment substrate (Bentlage 2015). A lack or decline of suitable host fish poses an additional threat to the survival of freshwater mussel populations, especially if they

are limited to few host species like *M. margaritifera* (Geist 2010; Lopes-Lima et al. 2017).

Habitat alteration: degradation and fragmentation

A main pressure to healthy mussel populations are human-made alterations to aquatic ecosystems including the degradation and fragmentation of freshwater habitats (Bentlage 2015; Geist 2010). This kind of anthropogenic changes include several aspects: Pollution, agricultural run-off and eutrophication, structural modification as well as siltation and colmation of stream beds.

Increasing levels of pollutants contribute to declining species range and abundances (Black et al. 2001; Boon et al. 2019). When it comes to the type of contamination, diffuse sources seem to be of greater importance than point-source pollution (Lopes-Lima et al. 2017). For instance, higher concentrations of de-icing salt used on roads may affect filtering behaviour and negatively influence the attachment success of glochidia larvae to their host fish (ibid.). Environmental pollutants like the insecticide DDT as well as its metabolite DDE and the heavy metal Cadmium have been found to cause thinner, less calcified mussel shells in *M. margaritifera* specimens (ibid.). The survival and reproduction of freshwater mussels may also depend on other substances such as pharmaceutical compounds, dioxins or brominated flame retardants (ibid.).

Agricultural run-off represents another significant threat to freshwater mussel populations (ibid.). It can be considered a special form of pollution as it causes the introduction of fine sediment as well as nutrients like nitrogen and phosphorus into aquatic ecosystems (ibid.). The latter might ultimately lead to the eutrophication of rivers and streams (Bentlage 2015) which are no longer suitable habitats for the freshwater pearl mussel. Apart from sediments and nutrients, other substances such as pesticides might reach the water columns via run-off as well (ibid.). These may be poisonous to mussels and microorganisms (ibid.).

Structural modifications pose *M. margaritifera* at even higher risk. The majority of European rivers and streams are heavily altered in respect of their physical characteristics. For example, there exist approximately 7000 large dams (>15m) (Lopes-Lima et al. 2017). River engineering and the associated habitat fragmentation constitute another severe threat to freshwater organisms like *M. margaritifera* (Black

et al. 2001; Boon et al. 2019; Geist 2016). Dams can disrupt the structure of meta-populations by reducing gene flow (Lopes-Lima et al. 2017). They also act as a barrier to the migration of host fish carrying glochidia which makes the dispersal of larvae and the recolonization of sites after disturbances such as drought more difficult or even impossible (ibid.). Moreover, structural modifications like dams cause changes in temperature, flow and sediment regime that negatively influence freshwater mussel habitats (ibid.). Alterations of thermal regimes can have strong impacts on fish communities, the mussels' reproductive ability and timing as well as the successful development of glochidia larvae on their host fishes (ibid.). Releasing water from dams can lead to both atypically high and low flow velocities (ibid.). Higher flow rates may disturb freshwater mussel recruitment while low flow can result in reduced reproduction but also abnormally high mussel mortality due to stranding, desiccation and low levels of dissolved oxygen (ibid.; Bentlage 2015).

Apart from the just mentioned negative impacts, structural modifications are also problematic in another respect. Dam construction and the linked reduction of flow rates – just like agricultural run-off – increase the amount of fine sediment and silt accumulated on the stream beds and thus pose a major threat particularly to specialized rheophilic species like *M. margaritifera* (Bentlage 2015; Lopes-Lima et al. 2017). Changes in sedimentation processes affect the survival of mussel populations indirectly and directly (Bentlage 2015): Indirectly by reducing the hatching success of their salmonid hosts (ibid.; Lopes-Lima et al. 2017) and directly by increasing the mortality of juvenile pearl mussels (Lopes-Lima et al. 2017) that highly depend on a well-oxygenated stream bed (see 4.1.1 Life cycle). The clogging of interstitial pore space due to excess sedimentation and siltation is considered the main bottleneck for the survival and recruitment of freshwater mussel populations (Geist & Hawkins 2016; Geist 2016; Bentlage 2015).

Overexploitation/Overharvesting

Other harmful human activities include overharvesting and illegal exploitation of native mussel species (Bentlage 2015; Boon et al. 2019). Historically, mussels were gathered for personal use as food (Bentlage 2015; Lopes-Lima et al. 2017) and for commercial purposes (Bentlage 2015). Until the late 19th century mussels were intensively harvested for the button production (ibid.), in some European regions this development even continued until the 1990s (Lopes-Lima et al. 2017). In the case of

M. margaritifera, another obvious reason for the removal of specimens from their aquatic habitats lies in their precious pearls (ibid.). Not only the pearls themselves were extracted but also the mussel shells were purchased and used as “bead nuclei” to create cultured pearls especially in Asian countries (Bentlage 2015). Biologists agree that the overexploitation in previous centuries has contributed to the decrease of population numbers (ibid.). However, the effects of direct threats such as pearl harvesting are spatially limited and not sufficient to explain the global decline in *M. margaritifera* (Geist 2010).

Invasive species

Human activities are also linked to the introduction of non-native molluscs. In Europe, *Corbicula fluminea*, *Corbicula fluminalis*, *Dreissena rostriformis bugensis*, *Dreissena polymorpha* and *Sinanodonta woodiana* are considered invasive bivalve species (Lopes-Lima et al. 2017). These introduced species – particularly the quagga mussel *D. bugensis* and the zebra mussel *D. polymorpha* – represent an additional threat to native Unionida mussels (ibid.; Black et al. 2001; Geist 2016; Bentlage 2015) as they directly compete for food (Lopes-Lima et al. 2017). Beyond that, dreissenid mussels can attach to the shells of the local specimens with their byssus threads (ibid.). *D. polymorpha* does not benefit from this kind of overlay but the covered mussels suffer from it (Bentlage 2015). Not only do the invasive zebra mussels impose a restriction to their ability to actively burrow through the sediments, they also limit valve movements and therefore vital processes such as filter feeding, respiration and reproduction of the underlying mussel (ibid.; Lopes-Lima et al. 2017). The additional weight might ultimately result in the lower Unionida mussel getting buried in the river bed substrate (Lopes-Lima et al. 2017).

Climate change

Last but not least, freshwater mussels like *M. margaritifera* belong to the many species severely affected by human-induced climate change. The inter-annual variability in precipitation and consequently also in river flows are likely to increase (ibid.). The same holds true for the frequency as well as the intensity of climatic extreme events (ibid.). Droughts and floods raise freshwater mussel mortality (ibid.). As *M. margaritifera* reacts sensitively to changes in temperature regime too, even

small differences can strongly influence their metamorphosis and larval development (ibid.).

4.1.3 Endangerment status

As the list above indicates, freshwater mussels in general and the freshwater pearl mussel in particular are exposed to a multitude of different threats. The fact that these stressors act simultaneously and interact with each other puts the species at even higher risk (Lopes-Lima et al. 2017). The current situation of freshwater bivalve molluscs is reflected in their endangerment status.

Freshwater mussels are considered one of the most imperiled animal groups worldwide (Geist 2010). In 2015, 224 of the 511 globally existing freshwater mussel species (44%) were categorized as “near threatened” or “threatened” in the IUCN Red List of Threatened Species (Lopes-Lima et al. 2017). On smaller geographic scales, the picture can be even more striking. In Europe 12 of the 16 present species (75%) fall under one of these two IUCN categories (ibid.). Freshwater mussels are also considered to be one of the most (or even the most) endangered fauna in North America (ibid.; Black et al. 2001). About half of the native mussel species are either extinct or listed as “endangered”, “threatened” or “of special concern” (Bentlage 2015; Black et al. 2001).

The freshwater pearl mussel *M. margaritifera* in turn is regarded as one of the most critically endangered freshwater bivalves worldwide (Boon et al. 2019; Geist 2010). Originally, the species was widely spread in Europe (Geist 2010). Only about a century ago, the pearl mussels occurred in such high densities that they were frequently found to cover river beds in several layers (ibid.). Since the beginning of the 20th century, the number of *M. margaritifera* populations diminished significantly (Boon et al. 2019). Bauer (1988) estimated a decline in known European populations of more than 90% (cited after Geist 2010) and the negative trend has continued or maybe even increased (Geist 2010). By now, most of the remaining populations are not only extremely overaged (ibid.), strongly reduced and fragmented, often they can also be considered “functionally extinct” due to the lack of juvenile recruitment and low genetic diversity (ibid.; Boon et al. 2019). As a consequence of this alarming development *M. margaritifera* is protected on national and international scales (Boon et al. 2019). In Europe, the species is classified as “critically endangered” by the

International Union for Conservation of Nature (ibid.) and listed in the Annexes II and V of the European Habitats & Species Directive (Geist 2010). Besides, the freshwater pearl mussel has been set as priority species in numerous European Biodiversity Action plans (ibid.).

4.1.4 Conservation

As the worrying endangerment status of *M. margaritifera* indicates, there is enormous need for protection measures. In general, there exist two different approaches to freshwater mussel conservation: the restoration of their aquatic habitats on the one hand and artificial mussel culturing and reproduction techniques on the other (Lopes-Lima et al. 2017). The latter include a variety of strategies. If mussel recruitment is limited by the availability of suitable host fish populations, artificially infecting autochthonous host fish may be a useful conservation measure (Geist 2010). Infecting host fish in hatcheries and releasing them right before the glochidia drop-off or artificially infecting farm-reared host fish and then directly release the juvenile mussels provide other possibilities to increase mussel reproduction rates (ibid.). Regarding the low substrate quality in many freshwater ecosystems, culturing of the juvenile mussels in cages or constructed bypass-channels with good sediment quality can help to reduce mortality in the highly delicate post-parasitical life stage (ibid.). It is important to note that the mentioned (semi-) artificial management tools can be applied to just a small percentage of populations, that is why they can be seen as an essential but only temporary emergency action (ibid.). To achieve desirable, long-term results a combination of habitat restoration and culturing strategies is therefore highly recommended (Lopes-Lima et al. 2017). Both approaches require further research (Geist 2010) to better understand the mussels' life history as well as the population dynamics and genetic structure (ibid.). The development of a holistic concept that integrates aspects of conservation genetics and ecology as well as different spatial scales (from individual specimens and populations up to global strategies) should be a top priority in the conservation of freshwater pearl mussels (ibid.). To reach this goal, greater international collaboration is imperative when it comes to the monitoring of mussel distributions, densities and recruitment rates or suitable management methods (Lopes-Lima et al. 2017). In this respect, the standardized protocol for monitoring published by the European Committee for

Standardization (CEN) may be an important step in the right direction (Boon et al. 2019).

Overall, freshwater mussel conservation faces a number of obstacles starting with the sum of money spent on protection measures (Bentlage 2015). As Biber (2002) has shown for North America, in terms of funding there is a large divergence between freshwater mussel species and all the other species listed (cited after Bentlage 2015). He also states that a considerable gap exists regarding the success of recovery plans: While almost 25% of all species plans have reached more than one fourth of their goals, only 3% of mussel recovery plans could achieve the same (ibid.). This lack of success can possibly be put down to the bias in research favouring vertebrate species over invertebrates (Bentlage 2015). It leads to little being known about the effects of specific threats on freshwater mussels and consequently ineffective protection (ibid.). In Europe, the success of taken conservation measures remains largely uncertain. In the course of policies like the Water Framework Directive and the Habitats Directive, the conservation and restoration of riverbed quality was put high on the agenda (Geist & Hawkins 2016). Oftentimes, these restoration efforts not necessarily follow an evidence-based and systematic approach (ibid.). Even if river restoration has become a commonly used practice, the extent to which the projects achieve the aim of improving structure and function of freshwater habitats has not been adequately evaluated (ibid.). However, despite these obstacles, there are positive aspects to freshwater mussel conservation, too. The longevity of *M. margaritifera* in combination with the species' high reproductive potential for instance provide a good basis for population recovery (Geist 2010).

4.2 Public attitudes towards endangered freshwater mussels

As the success of conservation efforts strongly depends on the support provided by involved stakeholders (see also 2.3 Strengths and weaknesses of the flagship species approach), understanding the way they perceive the species of concern is crucial when it comes to planning effective measures (Bentlage 2015). Nevertheless, conservation literature lacks scientific publications regarding the public perception of uncharismatic taxa like invertebrates (ibid.). Many people have negativistic or even fearful attitudes towards these kind of species, often viewing them as less precious

and hence less worth protecting (ibid.). This seems to be only partially true in the case of imperiled freshwater mussels. Bentlage (2015) found that in general, attitudes of landowners along the Tippecanoe River towards the protected bivalve molluscs were mostly neutral or even positive. The freshwater organisms might be mistaken for rocks or marine species but they possess some advantageous attributes that are likely to be beneficial in terms of public attitudes and conservation (ibid.). For instance, unlike other invertebrates, freshwater mussels are not associated with agricultural pests, predation or disease (ibid.). The same study showed that despite their great ecological value and critical endangerment many citizens (like recreational users, etc.) were not familiar with the native freshwater mussel species (ibid.). Apparently, the major issue in public perception of freshwater mussels is not a negative attitude towards these species but rather a general lack of awareness.

4.3 Designing a freshwater pearl mussel awareness/marketing campaign

To extend public awareness of the existence and imperilment of freshwater mussels, Bentlage decided to develop an outreach and education campaign (Bentlage 2015; Bentlage et al. 2019). For the implementation of this project, landowners, anglers, children and visitors to the Tippecanoe river were defined as four target groups (Bentlage et al. 2019). The campaign proved to be a success: Awareness in respect to the existence of endangered freshwater mussels increased significantly just as the reported sightings of specimens and knowledge about the illegality of taking mussels out of their natural habitat (ibid.). As this example shows, freshwater mussel awareness campaigns are not only a necessity but also a promising conservation tool.

In the following, ideas for a freshwater mussel campaign with the focus on *M. margaritifera* will be presented. The developed designs are intended to fulfil two functions, namely to raise awareness as well as funds for the imperiled species. They are supposed to address the general population with no subject-specific background or expertise, that means adolescents and adults of all ages. When it comes to content especially for children, the booklet “Margarete – Königin der Flussperlmuscheln“ by the author Gudrun Opladen is highly recommended (available

online as free download in German language: https://naturpark-steinwald.de/wp-content/uploads/2020/10/flupemu_steinwald_web.pdf). The campaign designs developed for this thesis relate to Europe as reference area but could theoretically be applied in other regions within the species' home range (see 4.1 Biology, endangerment and conservation), too. Since this thesis is written at a German university, the drafts are not only provided in English but also in German. Not all of the following ideas specifically target the freshwater pearl mussel but all of them promote freshwater mussel conservation which in turn includes *M. margaritifera*. The elaborated awareness and marketing campaign is based on a visual approach.

Visual information and communication constitute an integral part of our daily life. More than 90% of the everyday information processed by the brain is derived from visual receptors (Pavel 2014; Manic 2015). When it comes to modern communication through social media and messaging services, it gets clear that visual content in the form of images, videos, GIFs, emojis and alike can be regarded as the "internet's new language" (Pavel 2014), increasingly replacing written words. People see and recognize before they can speak (ibid.) which makes visual communication a very intuitive way of information transfer. Pictures are more vivid, more interesting, more attractive (Ping 2020) and more eye-catching (ibid.; Manic 2015) compared to text. Furthermore, images are clearer (Ping 2020) and easier to comprehend, usually within seconds and often even beyond cultural or linguistic boundaries (Manic 2015). While written language is deciphered in a linear, successive manner, graphics are decoded simultaneously (Pavel 2014). This allows the brain much faster processing of pictures which proves advantageous considering the very short attention span of individuals and, at the same time, the enormous amount of information available today (Manic 2015; Pavel 2014). Images not only require less effort and time to understand, they are remembered more easily as well (ibid.). Another essential characteristic of visual material is its ability to affect human emotions quickly and directly, thus influencing people's decision-making more effectively than words (ibid.). All these mentioned features render visual content a valuable information tool in modern communication (Manic 2015) and therefore suitable for the purpose of a freshwater mussel awareness and marketing campaign.

Due to limited technical opportunities, a professional graphical implementation of the following ideas was not feasible. The presented designs should therefore not be

regarded as finished products but rather as a collection of drafts that might be brought in again in a different context at a later stage. They could be conceivable to utilize as large-format posters in highly frequented public places (such as bus stops, railway stations) or as advertisement, e.g. in (online) newspapers or magazines. The developed campaign ideas follow three different approaches or strategies. The first consists in stressing the values and services provided by freshwater mussels, the second aims to highlight the endangerment of these species (see 3.2 Possible solutions). The third approach is about promoting the bivalves by emphasizing their disregard in conservation. Each of the designs presented below addresses at least one of these strategies. Those that could be listed among several are assigned to the category that best corresponds to the main message.

4.3.1 Stressing values and services provided by freshwater mussels

Raising awareness about the values and services derived from uncharismatic taxa can increase people's appreciation, sympathy and willingness to get involved in their protection. The first two drafts focus on the value of the freshwater pearl mussel in a double sense. On the first glance, the developed designs draw attention to *M. margaritifera*'s precious pearls and accordingly the organism's material worth. Additionally, they point out the species' ecological value and importance for intact streams. In this way, they illustrate the enormous value *M. margaritifera* holds far beyond the aesthetically pleasing pearl. To get across the message, two different motifs are chosen: a golden necklace with a pearl charm (Fig. 5a, b) as a symbol for preciousness and beauty as well as J. R. R. Tolkien's world-famous character "Gollum" from "The Lord of the Rings" (Fig. 6a, b). The latter is closely associated with the mighty One Ring he calls "my precious" (in German: "Mein Schatz"). For the campaign, instead of the ring, he holds a freshwater pearl mussel as his treasure. It looks like he tries to hide and protect his precious mussel from anyone else. Thus, he transports the message that *M. margaritifera* is valuable and worth protecting.

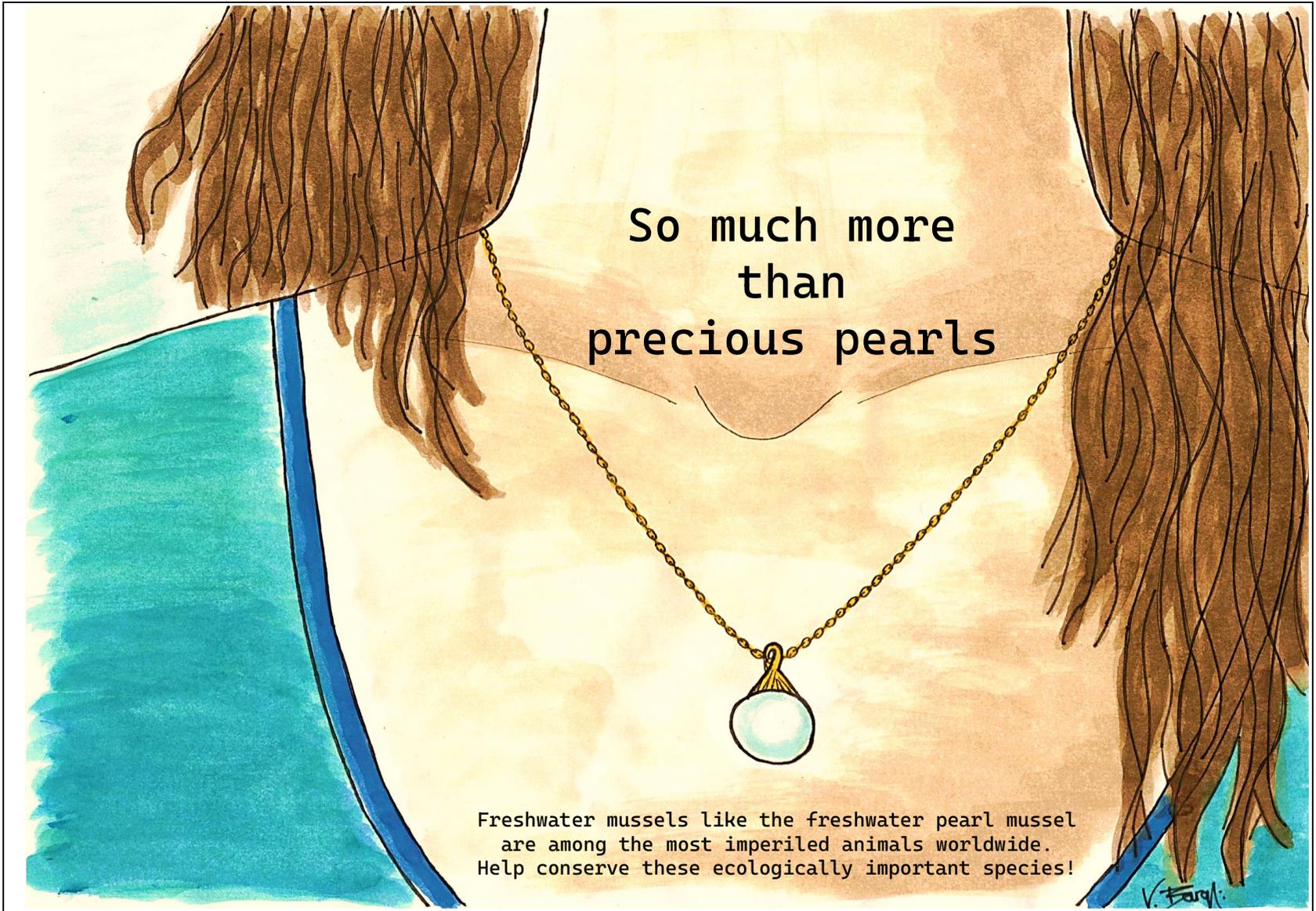


Fig. 5a: Design "Necklace - So much more than precious pearls" (English)



Fig. 5b: Design "Necklace - So much more than precious pearls" (German)

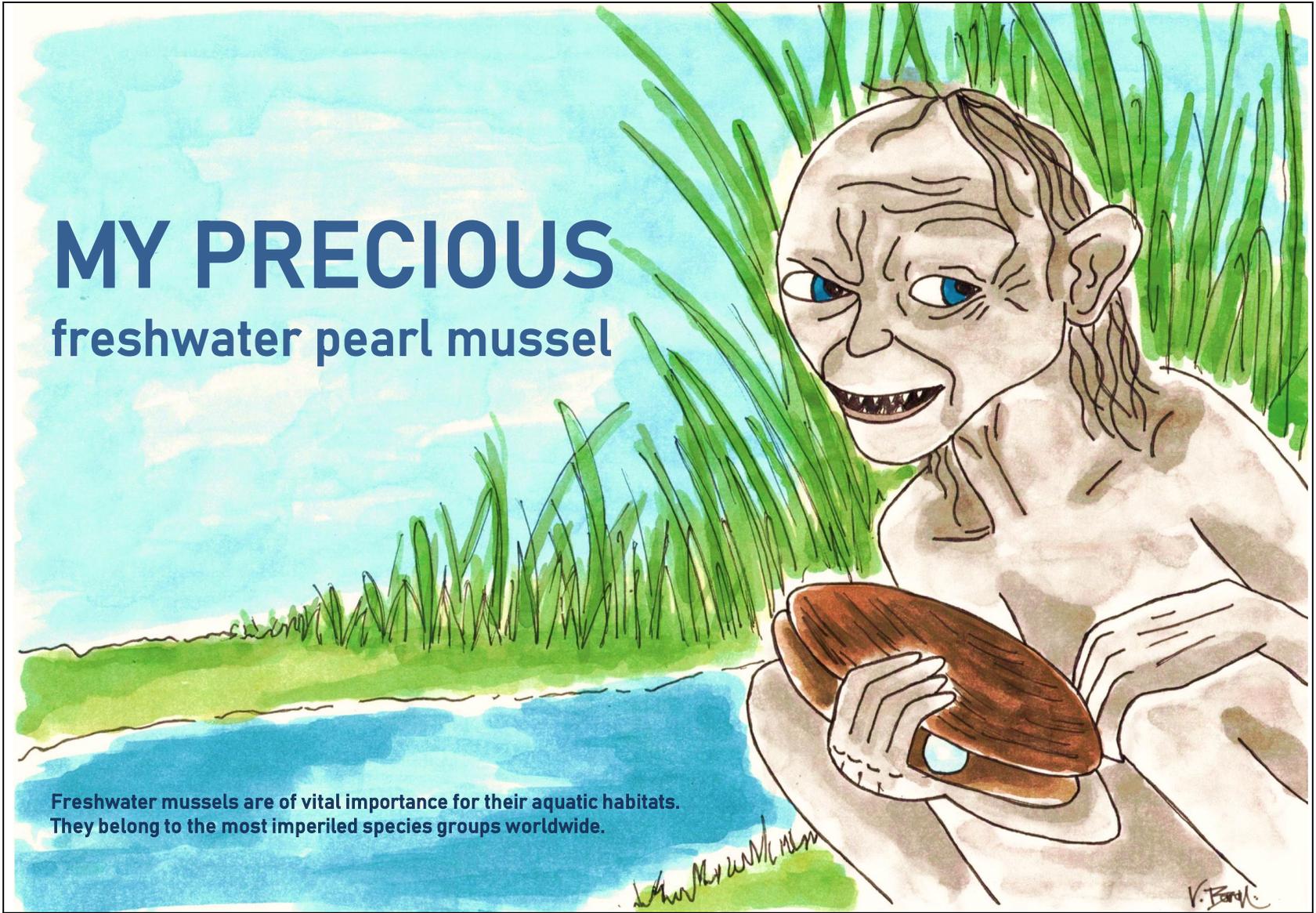


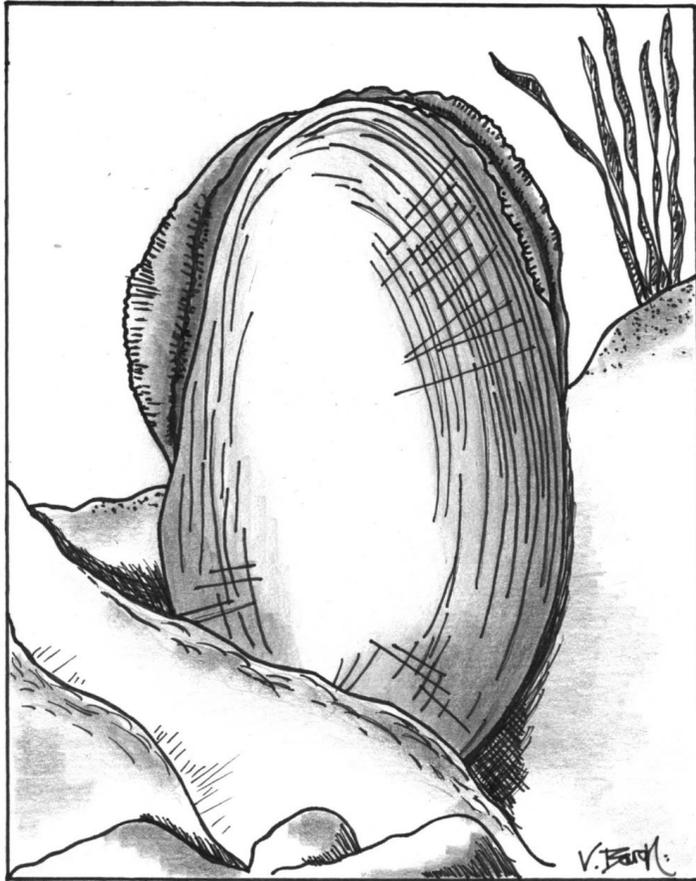
Fig. 6a: Design "Gollum – My precious freshwater pearl mussel" (English)



Fig. 6b: Design “Gollum – My precious freshwater mussel” (German)

4.3.2 Highlighting endangerment of freshwater mussels

Informing the public about the critical endangerment of uncharismatic species can help to increase acceptance and readiness to act, too. That is why the next four drafts aim to highlight the freshwater mussels' imperilment. The first consists in an obituary (Fig. 7a, b) which can be interpreted as a symbol for the threatening extinction of aquatic taxa. The death notice indicates the freshwater mussel's longevity, its filterfeeding lifestyle as well as its importance for intact stream habitats. It also concretely calls for donations and provides specific bank details. The layout of the second design resembles that of an online shop (Fig. 8a, b). Analogously, it displays the species' name, the star ratings and a description of the freshwater organism. Many online merchants try to encourage customers to buy their products by accentuating that only few more items are available. This design uses the same strategy. It points out that only few more of these valuable freshwater organisms are left. In this case, stressing the rarity should not encourage people to buy but to donate for the species' conservation. The third idea falling into this category of highlighting the endangerment of freshwater mussels is a rather simple, clean, black-and-white design (Fig. 9a, b). It shows a group of *M. margaritifera* in a river bed at the top and a question ("Did you know that some of the world's most endangered animal species live right on our door step?") as well as a request for conservation action ("Save the freshwater mussels!") at the bottom. The question is intended to address the viewer directly and create closeness, affinity and compassion by pointing out the physical proximity to these organisms. Another way to stress the imperilment of these valuable aquatic organisms could be the presented cartoon-like design of a freshwater mussel in a shop selling beds and mattresses (Fig. 10a, b). The mussel asks for a high-quality stream bed. It therefore gives a hint in regard of the main cause for the species' decline, human-made degradation of its freshwater habitats (see 4.1.2 Threats).



Full of sadness we bid farewell to

Milli Mussel

* 18.06.1837 † 23.05.2022

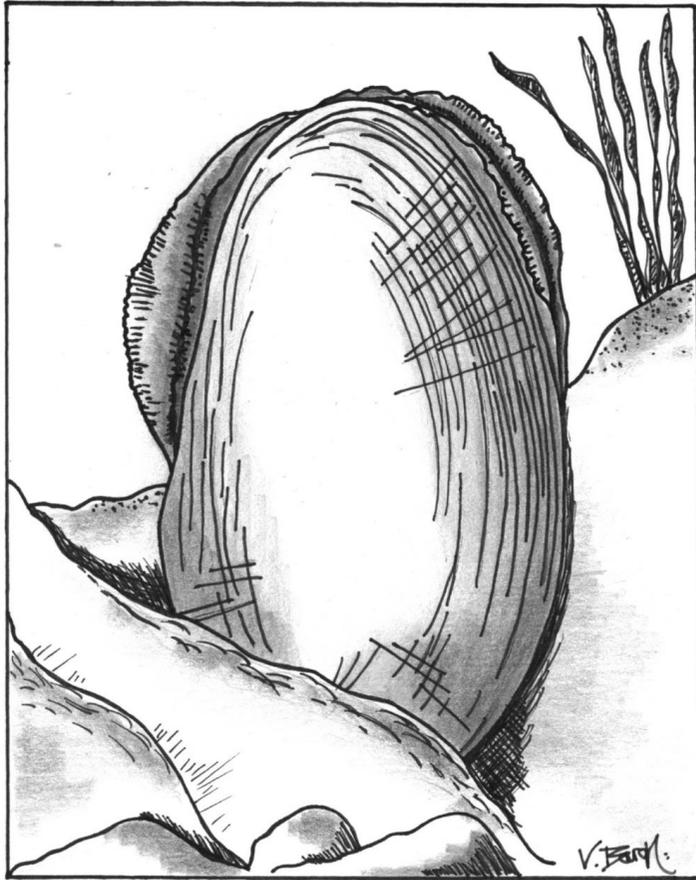
As a diligent filter feeder, she has cleaned many thousands of liters of water in the course of her long life.

We all owe her a debt of gratitude for her tireless commitment to intact freshwaters!

On behalf of the whole mussel bank
Wilfred Mussel

Instead of flowers, we ask in the spirit of the deceased for a donation in favor of the campaign "freshwater mussel", IBAN DE12 4853 9700 0057 1238 24, keyword "mussel".

Fig. 7a: Design "Obituary Milli Mussel" (English)



Voller Trauer nehmen wir Abschied von

Milli Muschel

*** 18.06.1837 † 23.05.2022**

Als fleißige FiltriererIn hat sie im Laufe ihres langen Lebens viele Tausend Liter Wasser gereinigt.
Ihrem unermüdlichen Einsatz für intakte Fließgewässer gebührt unser aller Dank!

Im Namen der ganzen Muschelbank
Wilfried Muschel

Anstelle von Blumen bitten wir im Sinne der Verstorbenen um eine Spende zugunsten der Aktion „Süßwassermuschel“, IBAN DE12 4853 9700 0057 1238 24, Stichwort „Muschel“.

Fig. 7b: Design "Obituary Milli Mussel" (German)



Home > Invertebrates > Molluscs > Bivalves > Freshwater Pearl Mussel



Freshwater Pearl Mussel

Margaritifera margaritifera

★★★★★ 6523 ratings

Species description:

- Long lived organism (up to 200+ years)
- Typically occurs in oligotrophic streams
- Filter feeder with a complex life cycle
- Provides essential ecosystem services (e.g. water purification)
- Major threats: habitat degradation/fragmentation, overexploitation, invasive species, climate change

Only few more left!

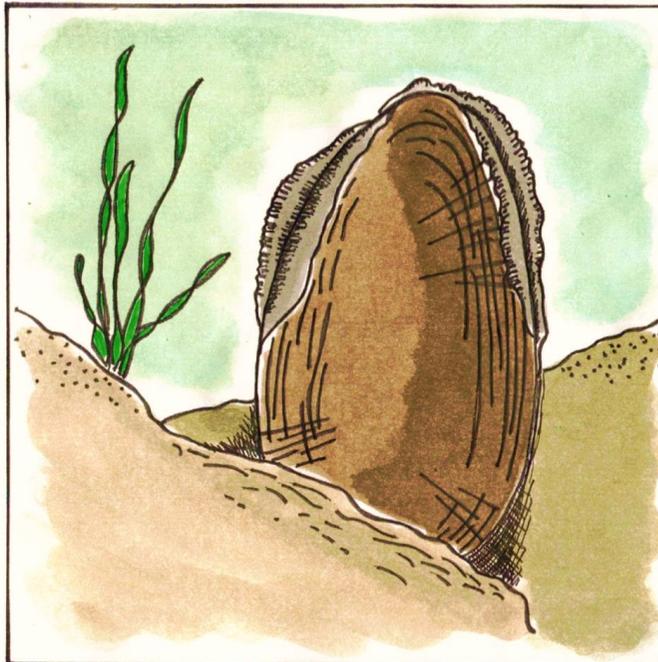
Donate now

V. Eason

Fig. 8a: Design "Online shop – Only few more left!" (English)



Home > Invertebraten > Mollusken > Bivalvia > Flussperlmuschel



Die Flussperlmuschel

Margaritifera margaritifera



6523 Sternebewertungen

Artenbeschreibung:

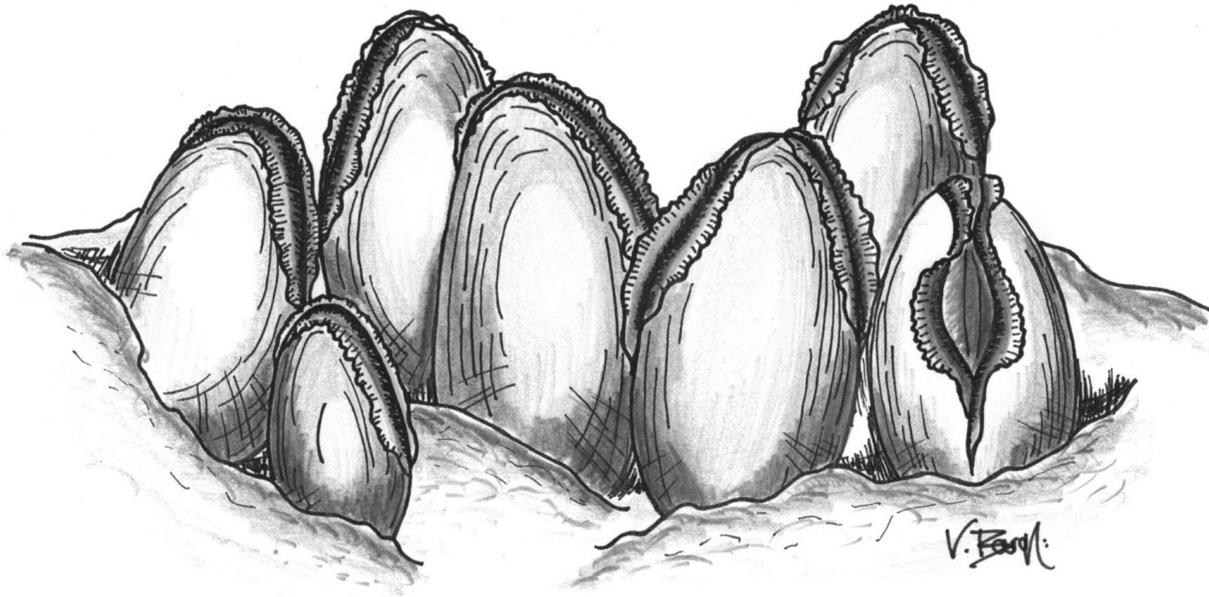
- Langlebiger Organismus (bis zu 200+ Jahren)
- Vorkommen typischerweise in oligotrophen Flüssen
- Filtrierer mit komplexem Lebenszyklus
- Bereitstellung wichtiger Ökosystemleistungen (u.a. Wasserreinigung)
- Gefährdungsfaktoren: Degradierung/Fragmentierung des Lebensraums, Übernutzung, invasive Arten, Klimawandel

Nur noch wenige Exemplare verfügbar!

Jetzt spenden

V. Ferry

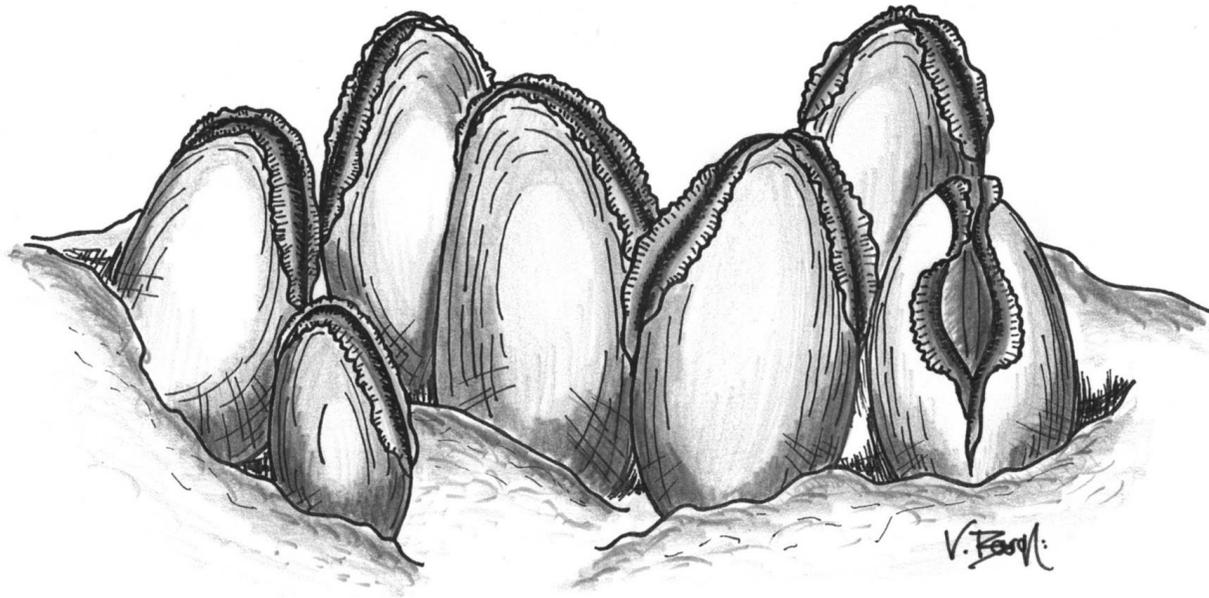
Fig. 8b: Design "Online shop – Only few more left!" (German)



Did you know that
some of the world's most endangered animal species
live right on our door step?

Save the freshwater mussels!

Fig. 9a: Design "Right on our door step" (English)



Wusstest Du, dass
einige der weltweit am stärksten bedrohten Tierarten
direkt vor unserer Haustür leben?

Rettet die Süßwassermuscheln!

Fig. 9b: Design "Right on our door step" (German)

Freshwater mussels are among the most imperiled animals worldwide.
The main cause is human-induced degradation of their river habitats.



Fig. 10a: Design "Stream bed" (English)

Süßwassermuscheln zählen zu den bedrohtesten Tierarten weltweit.
Hauptursache ist die Degradierung ihrer Habitate durch den Menschen.

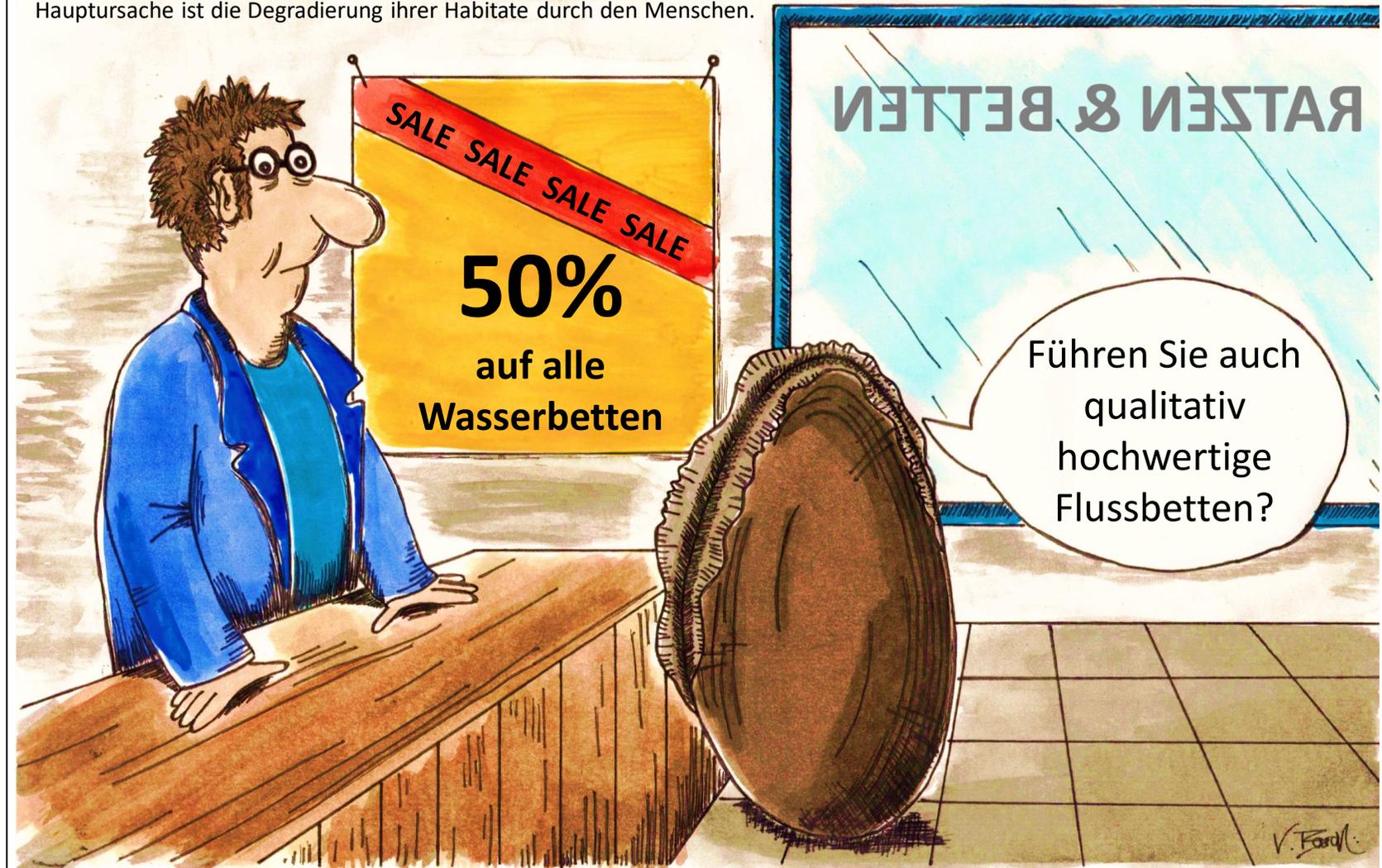


Fig. 10b: Design "Stream bed" (German)

4.3.3 Emphasizing the freshwater mussels' disregard in conservation

Apart from the two above strategies, another possibility to enhance awareness of the freshwater mussels' imperilment and willingness to donate for their conservation could be emphasizing their disregard in terms of protection efforts. By comparing them to popular, charismatic taxa frequently used in conservation campaigns, people should be encouraged to question the way they perceive and evaluate certain species. The idea is to demonstrate that a species' value is not determined by its appearance. In this respect, the third strategy appeals to the viewers' ethical principles and morals. For this purpose, two designs are developed. The first shows a group of freshwater mussels in the setting of an African savanna (Fig. 11a, b). In this context, one would rather expect to see the large, exotic mammals typically shown in conservation campaigns, e.g. elephants (see 2 Flagship species in nature conservation). At first glance, the dark brown freshwater mussels blend well into their surrounding, at second glance they seem really out of place. The fact that the picture's message becomes clear only when looking closely and reading the title makes the image more interesting. The same holds true for the second design which shows a black-and-white drawing of a group of freshwater mussels in a snowy landscape (Fig. 12a, b). They are slightly modified by adding a yellow beak so that they might be taken for a penguin family in Antarctica. The message is the same as for the previous design: These organisms are not the charismatic animals you associated them with at first glance but they are still worth protecting.

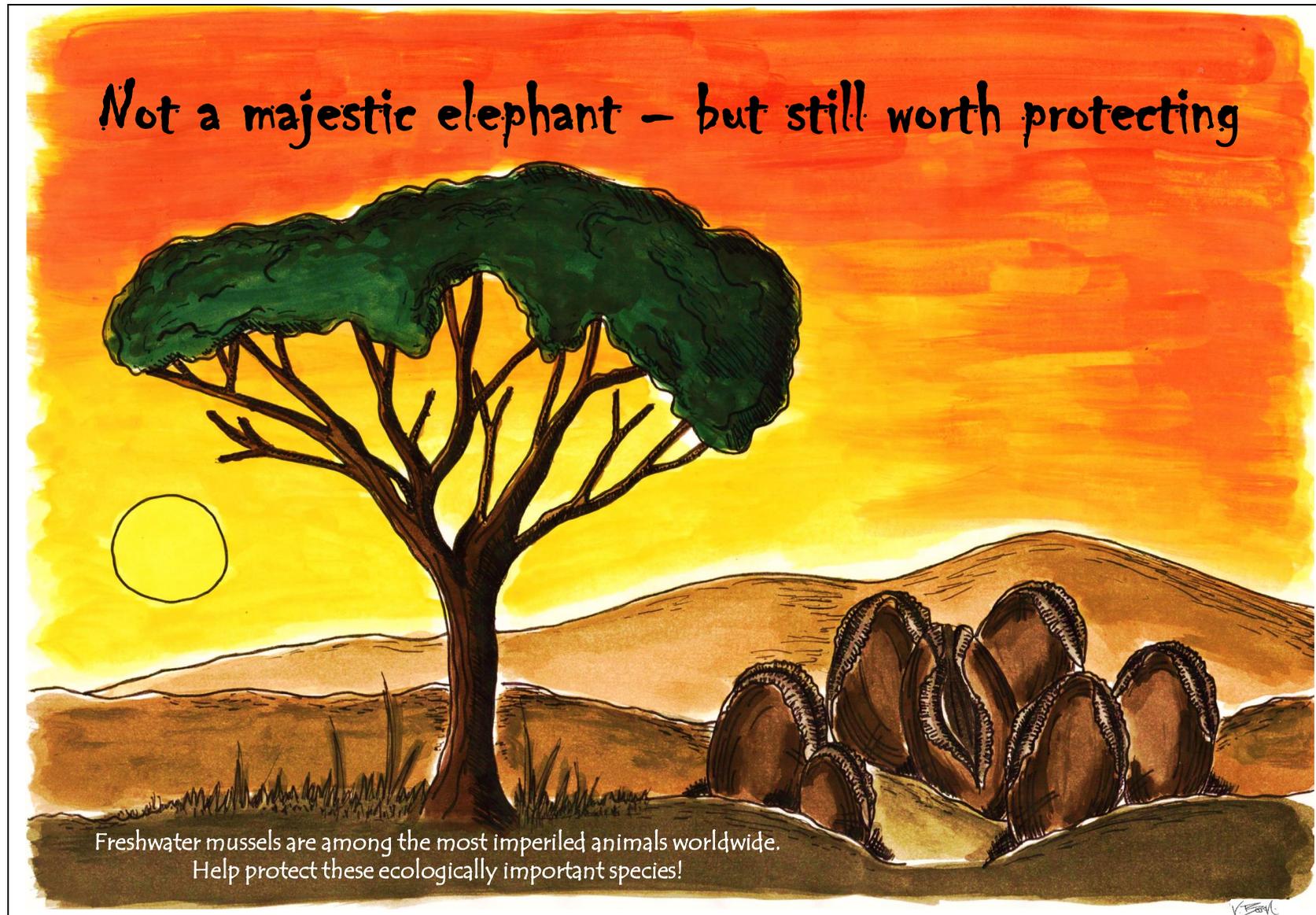
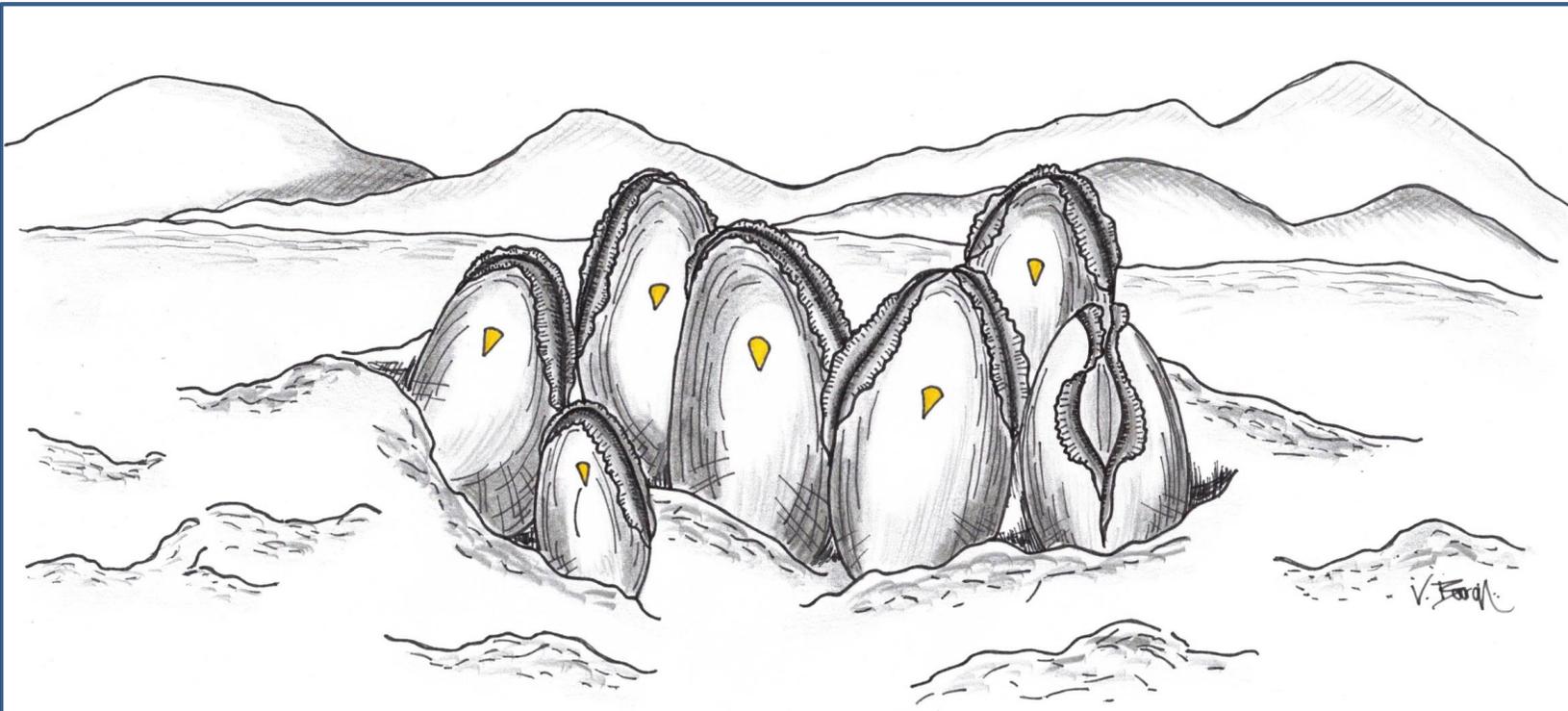


Fig. 11a: Design "Not a majestic elephant" (English)



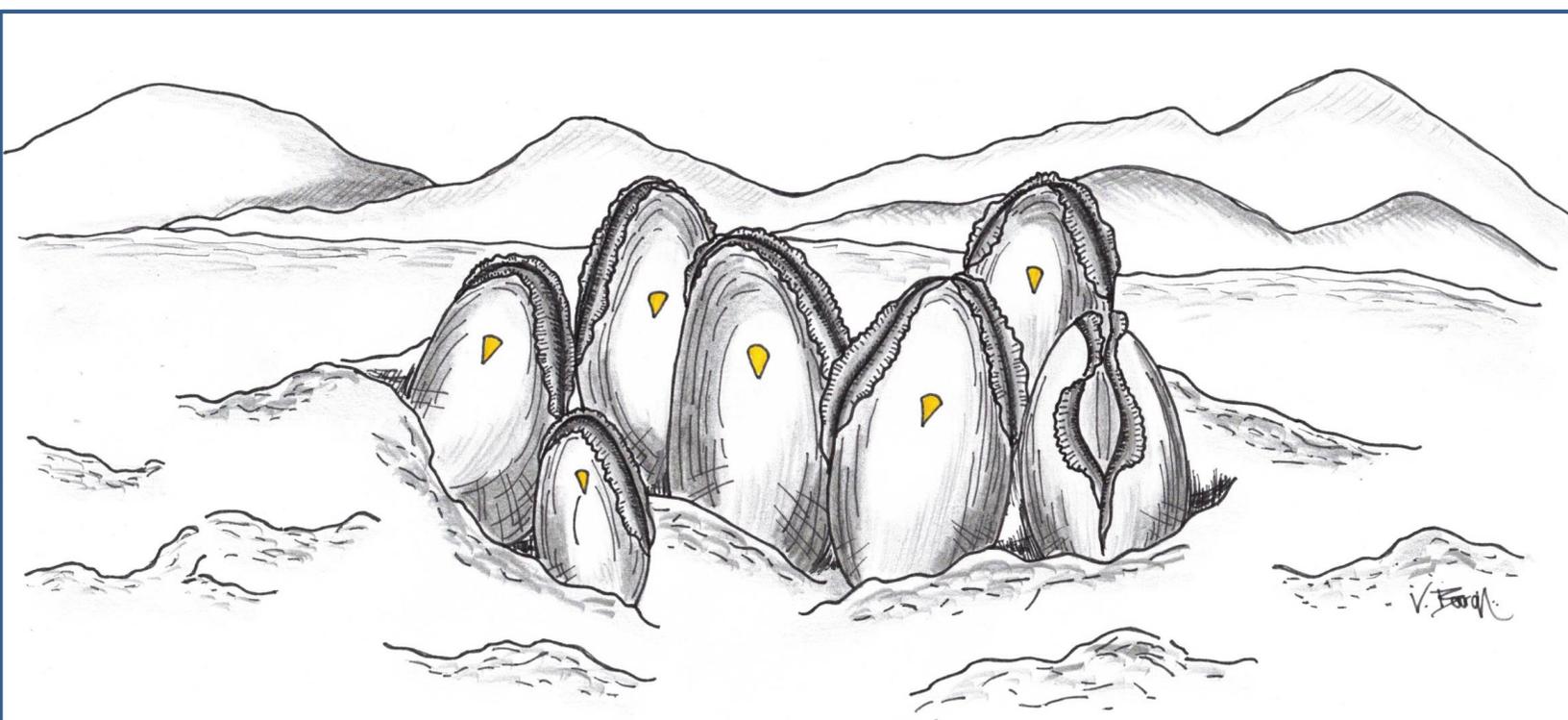
Fig. 11b: Design "Not a majestic elephant" (German)



Not a penguin family – but still worth protecting

Freshwater mussels are among the most imperiled animals worldwide.
Help conserve these ecologically important species!

Fig. 12a: Design “Not a penguin family” (English)



Keine Pinguinfamilie – aber trotzdem schützenswert

Süßwassermuscheln gehören zu den bedrohtesten Tieren weltweit.
Hilf, diese ökologisch bedeutsamen Arten zu schützen!

Fig. 12b: Design “Not a penguin family” (German)

5 Conclusion

As explored in detail in the second and third chapter, there is clear evidence for a strong bias in conservation attention. It favours the charismatic taxa while the less aesthetically appealing species are disadvantaged in terms of protection efforts. However, despite the drastic consequences for endangered species and ecosystem functioning, the topic does not seem to get adequate attention in science and research. For example, there are no studies available on which species are actually perceived as threatened by the general public. Such publications would be urgently required to prove the gap between perceived and real endangerment of species and demonstrate the necessity of action. In addition, there is further need for research with regard to freshwater bivalve taxa, too. Bentlage (2015) assessed public attitudes towards these imperiled molluscs in North America. Even if the results can be assumed to be transferable, conducting similar studies in the European context would be highly recommendable. Within the scope of this master's thesis, scientific background information was provided and drafts for a freshwater mussel awareness/marketing campaign were developed and presented. Given more time and resources, it would have been interesting to realize some of the ideas and measure the campaign's success by carrying out before-and-after surveys. Apart from the need for further research, the work at hand also discusses ways to help reduce the problematic bias in conservation attention. Especially the three fields of research, education and information as well as media and marketing can be considered helpful in this respect. Visual approaches hold a great potential when it comes to science communication in general and conservation communication or marketing in particular. For campaigns to achieve maximum success, conservation and the fields of art or design should definitely be thought together. In practice, for the work of ENGOs, conservation agencies, institutes and associations, that means attaching great importance to an interdisciplinary strategy combining science and art can be quite promising. Including specialists with expertise in both sectors in their teams is likely to be very beneficial for their public relations work, the societal support they receive and, ultimately, the impact they make in protecting our planet's flora and fauna.

Acknowledgements

First of all, I would like to express my sincere thanks to the supervisor of this thesis, Dr. Tina Heger, for her time and commitment as well as her helpful feedback, ideas and suggestions. I am very grateful for the positive cooperation.

Many thanks be to Prof. Dr. Jürgen Geist, whose lectures sparked my interest in aquatic ecosystems and their conservation. In his courses, he has pointed out the divergence between endangered species and species perceived as endangered by the general public, which has served as crucial inspiration for the present work.

Last but not least, my greatest gratitude goes to my parents, without whose manifold and generous support my studies would not have been possible in this way.

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Affirmation in lieu of an oath

I hereby confirm that I authored the master's thesis "Bias in Conservation Attention: the Example of Imperiled Freshwater Pearl Mussels (*Margaritifera margaritifera*)" independently and that I have not used other than the declared sources. Literal or content-related quotations are marked as such. The work has not been previously presented in the same or a similar form elsewhere.

Hauenstein, 09.07.2022

Vera S. Baron