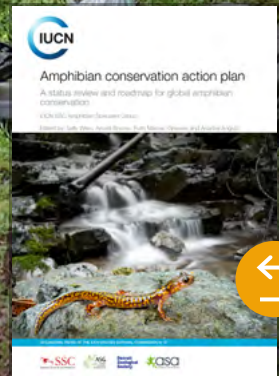




**Informing
decision-making**

Chapter 8



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During October 2022, the NGO Ranita de Darwin and ZSL delivered an amphibian-focused training session for park rangers from the national park Parque Nacional Alerce Costero and the private protected area Reserva Costera Valdiviana (RCV) in Chile. The RCV is implementing the first large-scale, amphibian-focused monitoring programme in Chile, which is being used as a model by other protected areas interested in setting up similar conservation monitoring efforts. © ONG Ranita de Darwin

Chapter 8

Communications and education for amphibian conservation

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Abstract

Most instances of detrimental environmental conditions are caused by human behaviour, and the amphibian decline crisis is not an exception. Although some species can be highly popular, amphibians are in general among the least preferred animals by people. This situation represents a source of direct and indirect threats to amphibians. In this chapter we review key research on the human dimensions of amphibian conservation. The first section looks at human attitudes and behaviours that act as threats to amphibians. The second section offers a review of the factors that have been identified as drivers of amphibian-focused human cognition. In the third section we provide an overview of different conservation education and outreach techniques that can be used to change human behaviours and improve public support for amphibians, as well as the role of communication in the co-production of usable science in amphibian conservation. We conclude this chapter by discussing some knowledge and methodological gaps that need to be addressed in order to better inform effective and strategic conservation education and communication actions to support amphibian conservation. Communications and education can increase stakeholder engagement and the success of amphibian conservation actions. Communicating the value of amphibian conservation using carefully designed messages, for instance by highlighting evidence about amphibians' relevance for ecosystem functioning and human well-being, or about the imperilled status of these animals, might provide a good starting point to increase the willingness to protect amphibians in decision makers and the public.

Introduction

Although some species can be highly popular, amphibians are in general among the least preferred animals by people (reviewed in Prokop & Randler, 2018). These animals can be associated with

negative values, emotions, and wrong perceptions, usually resulting from the direct interpretation of folklore and superstition (Ceríaco, 2012; Deutsch et al., 2021; Tarrant, Kruger & du Preez, 2016). This

situation represents a source of direct and indirect threats to amphibians. Most instances of detrimental environmental conditions are also caused by human behaviour (Schultz, 2011), and the amphibian decline crisis is not an exception. Think of a challenging conservation problem you have encountered in relation to amphibians - protecting a rare species, cleaning up a river, implementing disinfection points to decrease pathogen dispersal in a protected area, or winning support for legislation. Inevitably, people are part of the problem and public education and outreach must be part of the solution (Jacobson, McDuff & Monroe, 2015; Loyau & Schmitter, 2017). Good interpersonal relationships and communication among stakeholders are also necessary to produce usable science in amphibian conservation, to increase stakeholder engagement, and consequently, to boost the success of amphibian conservation actions (Wall, McNie & Garfin, 2017; Wright et al., 2020). Therefore, although generally neglected, communications and education are key to advance amphibian conservation science and practice.

Several authors have argued that efforts to promote biodiversity conservation must change human behaviours (Ehrlich & Kennedy, 2005; Schultz, 2011; Schultz & Kaiser, 2012). Education and communication strategies can play a central role in fostering conservation behaviours. Research has shown that appropriate education and outreach encourage sustainable behaviour, improve public support for conservation, reduce vandalism and poaching in protected areas, improve compliance with environmental regulations, increase recreation-carrying capacities, and influence policies and decisions that affect the environment and natural resources (e.g. Day & Monroe, 2000; Jacobson, 2009; Knudson, Cable & Beck, 2003). For instance, amphibian-focused outreach at institutions such as zoos and aquaria can be a crucial intervention to support amphibian conservation worldwide (Dos Santos et al., 2019).

In this chapter we review key research on the human dimensions of amphibian conservation. The first section looks at human attitudes and behaviours that act as direct or indirect threats to amphibians. The second section offers a review of the factors that

have been identified as drivers of amphibian-focused human cognition. In the third section we provide a brief overview of different conservation education and outreach techniques that can be used to change human behaviours and improve public support for amphibians, as well as the role of communication in the co-production of usable science in amphibian conservation. We conclude this chapter by discussing some knowledge gaps that need to be addressed to better inform effective and strategic conservation education and communication actions to support amphibian conservation.

Direct and indirect threats

Human behaviours as a direct threat to amphibians

The presence of negative values and emotions towards amphibians can lead to anti-conservation behaviours, such as torturing and killing amphibians, illegal consumption, or removing these animals from gardens (Fig 8.1; Deutsch et al., 2021; Pagani, Robustelli & Ascione, 2007; Tarrant et al., 2016). In general, little is known about the prevalence of these human behaviours and their consequences for amphibian populations. Persecution of amphibians based on negative values and emotions appears to be a non-significant threat in the Mediterranean basin (Cox, Chanson & Stuart, 2006). A cross-cultural study on high school students' tolerance of frogs conducted in Chile, Slovakia, South Africa, and Turkey revealed that a low proportion of students reported negative behaviours toward amphibians, such as actively killing frogs (6% of respondents), although 30% of the students reported moving frogs away from their home gardens (Prokop et al., 2016). Contrastingly, a study conducted in Slovakia found that around 26% of pond owners killed adult amphibians (Prokop & Fančovičová, 2012). In South Africa, Xhosa people associate amphibians with witchery and perceive these animals as dangerous and poisonous (Brom et al., 2020). The antidote to one of the many frog-related curses is to kill the animal, for instance, by sprinkling salt on its back (Brom et al., 2020). This salt sprinkling also occurs in Argentina, Brazil, and Uruguay with all toads (T. R. Kahn and G. Agostini,

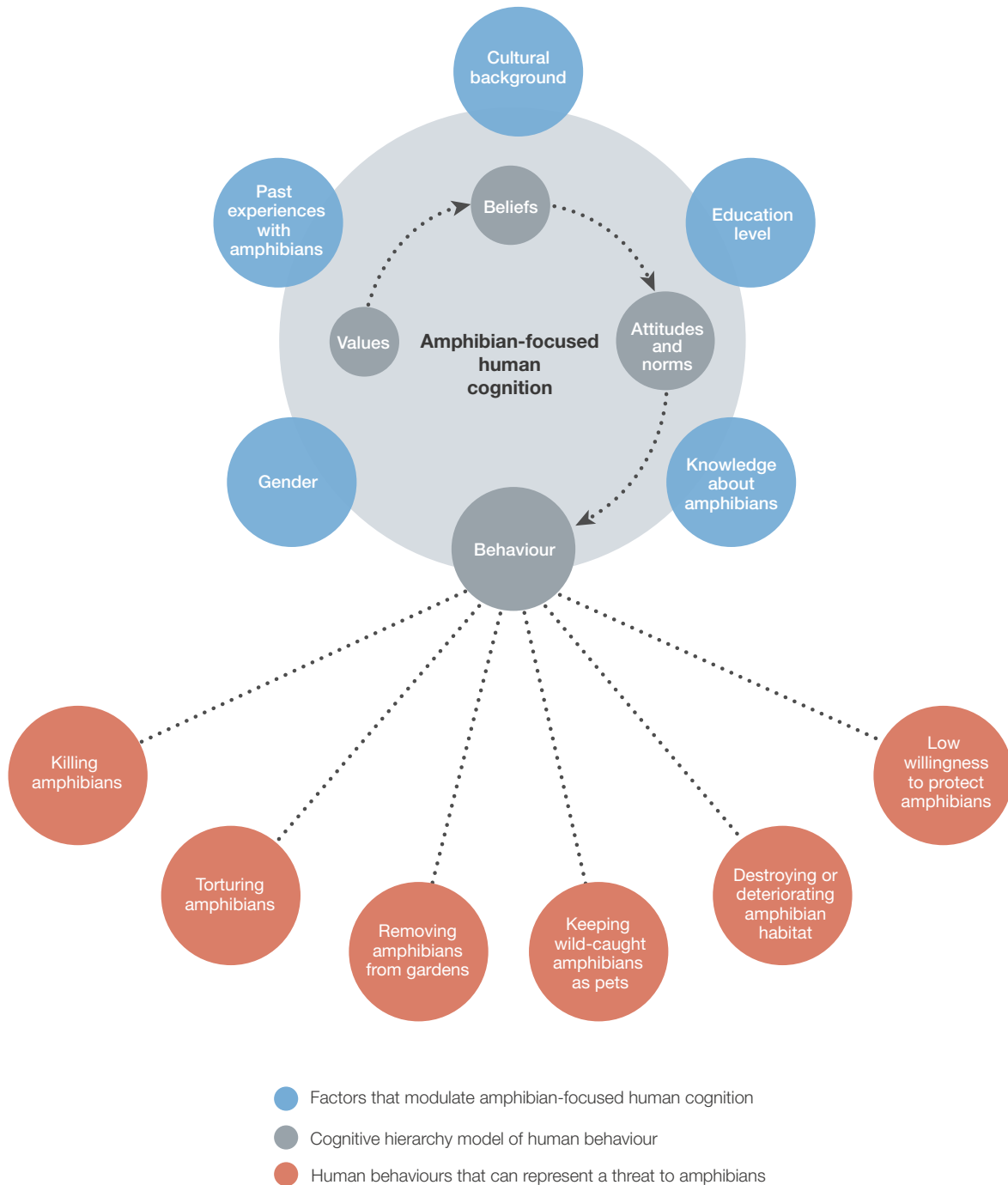


Figure 8.1: Factors that modulate amphibian-focused human cognition and human behaviours that can represent a threat to amphibians. Source: Developed by the authors.

personal observation), and is a practice recommended in other countries to keep amphibians away from gardens (e.g. <https://www.bobvila.com/articles/how-to-get-rid-of-frogs/>). In a study in Argentina, Brazil, and Uruguay, Deutsch et al. (2021) found that 45% of respondents have a strong aversion to the frog *Ceratophrys ornata*, a situation that led to the death of more than 350 individuals. Keeping

amphibians as pets could also represent a threat. For instance, Deutsch et al. (2021) revealed that 77% of the *C. ornata* individuals kept in captivity (=178 individuals in this study) were illegally caught from the wild. Due to overexploitation, spread of pathogens, and risk of invasions, the pet trade remains as an important threat to amphibians worldwide (Mohanty & Measey, 2019).

Low conservation attention as an indirect threat to amphibians

Unfortunately, the comparatively low likeability of a species can translate into low conservation efforts, indicating that human predispositions and attitudes toward animals determine conservation agendas (Prokop & Randler, 2018). For instance, Bellon (2019) found that federal funding allocated under the Endangered Species Act to vertebrate species in the US during 2013 was significantly influenced by species' charisma and not by the federal priority assigned by the Fish and Wildlife Service. Although amphibians are among the most threatened vertebrates on Earth, they receive less conservation funding and research attention than mammals and birds (Dos Santos, 2018; Tapley et al., 2017; Tarrant et al., 2016; *also see* Resourcing amphibian conservation section in [Chapter 2](#)). For example, Troudet et al. (2017) found that amphibian species have a small number of occurrence data in the GBIF database in comparison with other vertebrates, a situation that has not changed over time. Most of these data were specimen-based occurrences (e.g. from museum collections) rather than observation-based occurrences, which reflects a low number of records from enthusiasts (e.g. citizen scientists) compared to other vertebrate groups. Amphibians are also highly under-represented among the flagship species featured on covers of US conservation and nature magazines (Clucas, McHugh & Caro, 2008). Meredith, Van Buren and Antwis (2016) argued that a poor representation of amphibians in education and outreach initiatives leads to little public engagement in the conservation of these animals.

Public acceptance and compliance of conservation measures

Amphibian-focused human cognition is also expected to affect the support and compliance of conservation measures, although this subject has been little explored. Prokop and Fančovičová (2012) found a high willingness to protect amphibians (similar to values received by birds and mammals) in participants attending five randomly selected primary

and secondary schools in Slovakia. In the Pyrenees Mountains, Loyau and Schmeller (2017) found that all but one conservation measure (pay entrance fees) used to mitigate amphibian chytridiomycosis was well accepted by the public. Public willingness to support amphibian-focused conservation actions increased when people heard about the amphibian extinction crisis (Espinosa-Molina, Rodriguez-Jorquera & Beckmann, 2021; Loyau & Schmeller, 2017) or became aware of the benefits that amphibians provide to human society (Tyler, Wassersug & Smith, 2007).

Factors influencing attitudes and behaviours toward amphibians

Cultural variation in amphibian-focused human cognition

People of different cultural backgrounds perceive and relate to amphibians in very different ways (Das, 2011). Contemporary local folklore associated with negative attitudes and behaviours towards amphibians has been found in several regions worldwide, including Argentina (Deutsch et al., 2021), Ethiopia (Kassie, 2020), Portugal (Ceríaco, 2012), and South Africa (Brom et al., 2020). For instance, in Argentina, Deutsch et al. (2021) reported that a third of the respondents that encountered the frog *Ceratophrys ornata* killed the animal. This behaviour was associated with myths and tales telling the danger and evil of this species (Deutsch et al., 2021). In contrast, in other places, amphibians are perceived as beneficial to humans (Jimenez & Lindemann-Matthies, 2015a). For example, in Southeast China, most people found toads and frogs beautiful and considered them important for pest control, medicinal purposes, and consumption (Jimenez & Lindemann-Matthies, 2015b). For some indigenous cultures amphibians are sacred (Beebee, 1996; Valiente et al., 2010), thus, there is a cultural and spiritual connection that involves responsibility for amphibian welfare and conservation for future generations (Cisternas et al., 2019). It is worth noting that local folklore and the related human behaviours toward amphibians can exhibit considerable differences even among groups of people inhabiting the same geographical area,

as it is the case of South Africa between Xhosa-speaking and English-speaking people in their dislike towards amphibians (67% vs 6%, respectively) (Brom et al., 2020).

Intrapopulation variation in amphibian-focused human cognition

Research about the intrapopulation variation in attitudes and behaviours towards amphibians has highlighted that the interaction between intra- and interpopulation factors is common. For instance, gender is one of the main factors driving intrapopulation variation in attitudes and behaviours towards amphibians (Ceríaco, 2012; Deutsch et al., 2021; Prokop et al., 2016; Tarrant et al., 2016), but whether women or men show more positive or negative attitudes or behaviours depends on the human population under scrutiny. For instance, in China, Jimenez and Lindemann-Matthies (2015b) found that women considered frogs more beautiful while the opposite was found in Colombia by the same authors (Jimenez & Lindemann-Matthies, 2015a). Some studies suggest that the effect of gender might depend on the level of the cognitive hierarchy model that is evaluated (Prokop et al., 2016). For example, Ceríaco (2012) reported that women dislike amphibians more than men, but men are more likely to persecute these animals. Some personality traits such as pathogen disgust (which in turn can be associated with gender and/or personality traits such as neuroticism) are associated with amphibian-focused human cognition (Prokop et al., 2016). For instance, in Chile, Slovakia, South Africa and Turkey, Prokop et al. (2016) found that pathogen disgust negatively correlates with frog tolerance in respondents.

There is a positive correlation between direct past experiences with amphibians and positive attitudes and behaviours towards these animals (Schlegel & Rupf, 2010; Tomažič, 2008; Tomažič, 2011b, 2011a; Tomažič & Šorgo, 2017). For instance, in Indiana, Reimer et al. (2014) reported that respondents more familiar with hellbenders have more positive attitudes towards this salamander. Even human-wildlife interactions that can be considered as a threat (e.g. hunting for consumption) can be associated with positive attitudes

towards amphibians (Jimenez & Lindemann-Matthies, 2015b; Nicholson et al., 2020). One important remark is the critical role that parental figures and other role models play in the experience that children might have with amphibians; children that were discouraged from playing with, observing, or going near amphibians in early childhood, retained their fear as adults, while those who were encouraged or facilitated by their parents, showed affinity for these animals (Brom et al., 2020). In the cross-cultural study conducted by Prokop et al. (2016), the tolerance of frogs reported in parents or other family members positively influences the tolerance of frogs in high school students.

Finally, knowledge about amphibians (Brom et al., 2020; Espinosa-Molina et al., 2021; Jimenez & Lindemann-Matthies, 2015a, 2015b; Rommel, Crump & Packard, 2016; Tarrant et al., 2016) and educational level in general (Deutsch et al., 2021; Kassie, 2020; Prokop & Fančovičová, 2012; Tarrant et al., 2016, but see Ceríaco 2012) can increase positive attitudes and behaviours in relation to these animals. For example, in Indiana, providing respondents with a small amount of information about the rarity and endemism of hellbenders increased their positive attitudes towards this species (Reimer et al., 2014). The perceived importance of amphibians also positively correlates with peoples' emotions, attitudes, and behaviours in relation to these animals (Jimenez & Lindemann-Matthies, 2015a, 2015b; Prokop & Fančovičová, 2012).

The importance of amphibian morphological traits

Amphibian traits can influence how people perceive these animals. Some groups such as tree frogs (Schlegel & Rupf, 2010) or Darwin's frogs (Azat et al., 2021; A. Valenzuela-Sánchez, unpublished data) can be highly charismatic. Differences among amphibian species in their likeability can relate to aesthetic factors and anthropomorphic relatability (Brom et al., 2020; Prokop & Fančovičová, 2013). For instance, in the Czech Republic, Frynta et al. (2019) found that worm-like, legless, and small-eyed amphibians, such as caecilians, were less preferred by people. Morphological analyses also revealed that anuran species with a round body shape, short forelegs, small

eyes, warts, pink and grey colouration, or dark and dull colouration were perceived as disgusting or ugly (Frynta et al., 2019).

Strategic education and communication actions

Education programmes

The need for improved education and outreach about amphibians is growing as these animals continue to decline. Careful planning and evaluation are critical

for success. Thus, the development of education and outreach programmes should follow a systematic framework: planning-implementation-evaluation (PIE) process (Jacobson et al., 2015). Planning involves identifying goals and objectives, audiences, and educational strategies. Implementation concerns the operation of activities. Monitoring and evaluation of the results help identify successful activities as well as components in need of improvement (Table 8.1). This interactive process-PIE-leads to an education and outreach programme that avoids common problems, like targeting the wrong audience or using

Table 8.1: Data collection methods for programme evaluation

Methods	Overall purpose
Interviews	To fully understand someone’s impressions or experiences or learn more about their answers to questionnaires.
Focus groups	To explore a topic in depth through group discussion, e.g. reactions to an experience or suggestion, understanding common beliefs, etc.
Questionnaires and surveys	To quickly and/or easily get a lot of information from people in a non-threatening way.
Observation	To gather accurate information about how a project operates, particularly about processes.
Literature review	To gather information on the audience and/or the issue. To identify what previous investigations have found about the state of the knowledge, skills, behaviours, or attitudes of the intended audience with relation to the issue.
Tests	To determine the audience’s current state of knowledge or skill regarding the issue.
Concept or cognitive maps	To gather information about someone’s understanding of and attitudes toward a complex subject or topic.
Document or product review	To gather information on how the project operates without interrupting the project.
Case studies or peer review	To fully understand or depict experiences of end-users in a project and conduct comprehensive examination through cross-comparison of cases.

Source: Ernst, Monroe and Simmons (2009)

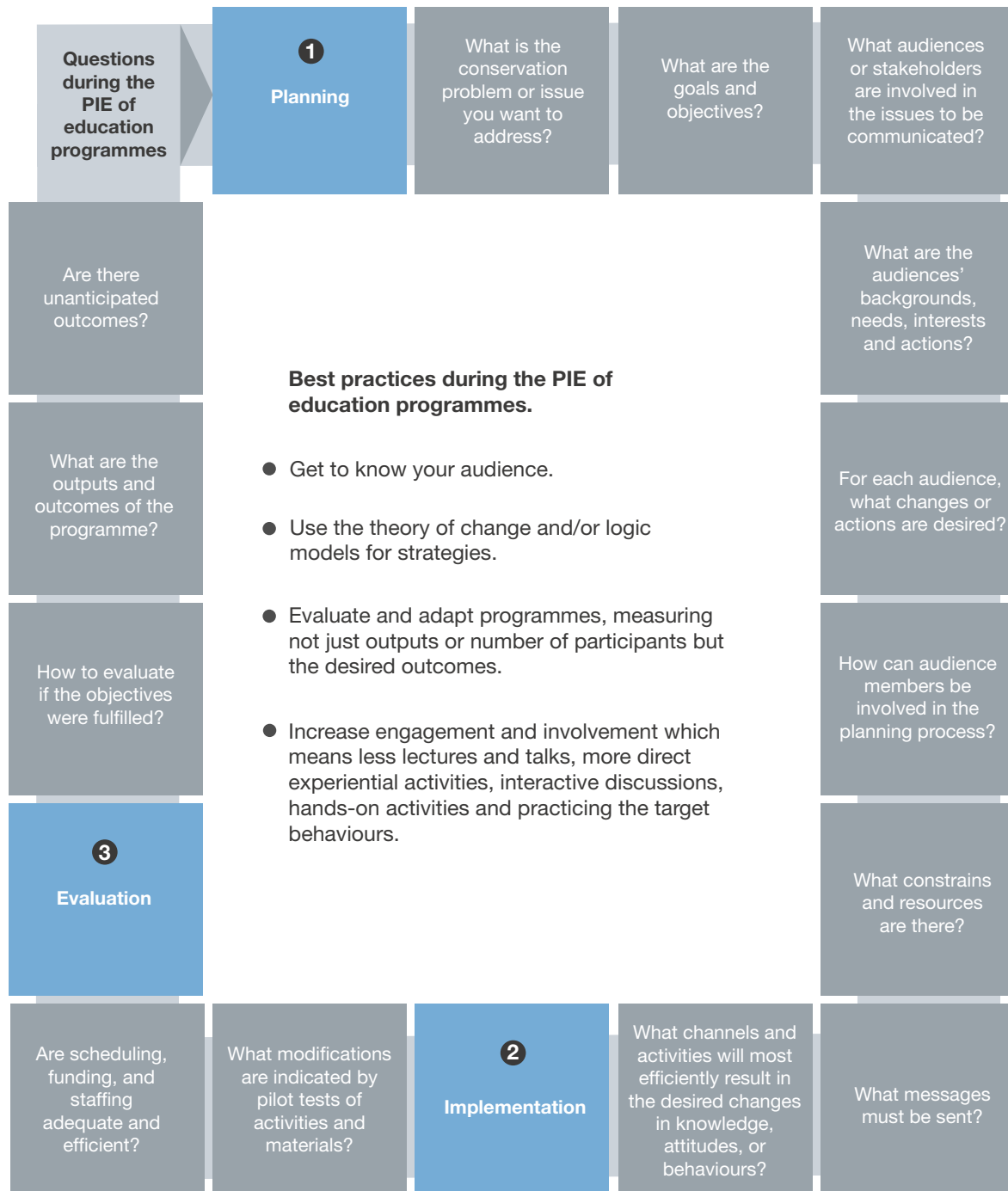


Figure 8.2: Best practices and questions during the planning-implementation-evaluation (PIE) of education programmes. Source: Adapted from Jacobson et al. (2015).

an inappropriate message or medium (Jacobson et al., 2015). In [Figure 8.2](#) we propose some questions and best practices that amphibian conservationists can use to guide the planning, implementation, and evaluation of their education and outreach programmes.

The success of any education and communication strategy should be measurable. But what do we know

about programme evaluation for amphibian conservation education? We found few studies that have evaluated the short and long-term impacts of amphibian-focused education activities. For instance, in a multi-partner educator workshop for the threatened Houston toad (*Anaxyrus houstonensis*), Rommel et al. (2016) reported significant increases in awareness/knowledge and values regarding general amphibian

declines and the focal species. The workshop significantly increased participants' belief that they had the necessary resources to teach about the Houston toad. Ninety-nine percent of participants agreed that they cared more about wild toads after meeting live “ambassador” toads. Post-workshop, the authors observed a 33% increase in use of amphibians or Houston toads in participant learning settings.

An evaluation of public understanding of the amphibian decline crisis carried out at 15 zoos in Brazil, New Zealand, and the United Kingdom, found that visitors in the three countries had relatively little understanding of amphibians and the global amphibian crisis (Dos Santos et al., 2019). The study also found that zoo visitors in Brazil knew less about amphibian conservation than those in New Zealand or the United Kingdom. There was less amphibian-focused content in educational materials in zoos in Brazil than in the United Kingdom. An evaluation of an amphibian conservation education programme for middle schoolers in southern Chile showed increased knowledge but to a lesser extent, increased awareness (Soto, 2015). This study used pre- and post-test measures, as well as a control group.

Some authors have discussed the best type of learning experiences aimed at increasing knowledge and positive attitudes toward amphibians. In Slovenia, primary school students with prior direct experiences with amphibians were more willing to study animals and exhibited more positive attitudes towards them (Tomažič, 2008; Tomažič, 2011a). In Germany, Randler, Ilg and Kern (2005) compared two types of learning experiences with 3rd and 4th graders (indoor-only vs. additional outdoor conservation action). They found that students who participated in the outdoor conservation action performed significantly better on achievement tests. Therefore, it seems that direct experiential activities (i.e. first-hand experiences) perform better than indirect experiences, such as classroom activities. There is a lack of information about the use and effectiveness of other education techniques in amphibian-focused contexts. In [Figure 8.3](#) we show some examples of amphibian focused education and outreach interventions.

Communications and audience mobilisation

Strategic planning for amphibian conservation can use conservation psychology and behaviour change theories to connect actions to the threats amphibians face (Maynard et al., 2020). In [Figure 8.3](#) we present a classification of conservation behaviours that can be used to guide strategic planning frameworks (Maynard et al., 2020). By promoting these behaviours, organisations can mobilise their audiences and enable the public to take action for amphibian conservation, increasing their reach and potential impact (Maynard et al., 2020; Salafsky et al., 2008).

Organisations and individuals interested in mobilising their audiences for amphibians should consider the range of communication strategies for their programmes ([Figure 8.4](#)). Strategic communications tools include:

- 1) Mass media, such as social media, press kits, and advertisements.
- 2) Interpretive and educational media, such as exhibits, kiosks, publications, mail, social media, and clubs.
- 3) Events - such as presentations, workshops, tours, field trips, community running (e.g. Das et al., 2014), meetings, and contests.
- 4) Community or citizen science, such as the iNaturalist “Global Amphibian BioBlitz” or the FrogWatch USA programme promoted across the Association of Zoos and Aquariums (AZA, 2021).

A powerful communication and outreach technique to consider for amphibians is community-based social marketing (Green et al., 2019; McKenzie-Mohr, 2011). By assessing the needs, motivations, and interests of the target audience, as well as any barriers hindering conservation actions, your communications programme can inspire behaviour change. Other conservation psychology theories suggest additional communications techniques, such as the Elaboration Likelihood Model which highlights

Conservation behaviour change strategies for organisation audiences



Figure 8.3: Classification of behaviours that can be promoted to mobilise organisation audiences for amphibian conservation. Source: Adapted from Maynard et al. (2020).

how reminders, cues, or celebrity spokespersons can spark interest in your audience (Petty & Cacioppo, 1986), or the Theory of Planned Behaviour that integrated social norms with behavioural intention to act (Ajzen, 1985). An example social marketing campaign for amphibians that used such strategies is the Amphibian Report Card, which created clear messages, a framework relatable to all people, and direct connections between the threats amphibian species face and the suggested actions to help them (“Amphibian Report Card”, 2018).

The importance of stakeholder and community engagement

When creating impactful communication and education programmes, stakeholder engagement and community involvement are key factors to consider in order to align the local context with the proposed conservation actions (Bennett et al., 2017; Lin et al., 2008). For example, Kanagavel et al. (2020) found that to develop amphibian-based community conservation initiatives in the Western Ghats of



Figure 8.4: Examples of amphibian-focused education and outreach interventions. **a), b)** Education activities. **a)** Classroom sessions about the mountain chicken frog to school children in Dominica (credit: Benjamin Tapley). **b)** Children from Chilean Patagonia collaborate with ONG Ranita de Darwin members during the monitoring of Darwin’s frog populations at the Reserva Elemental Melimoyu (credit: Daniel Casado). **c), d)** Training workshops. **c)** Training workshops for amphibian monitoring with tangata whenua (local indigenous communities in New Zealand) (credit: Phil Bishop). **d)** A workshop in the Hoang Lien National Park, Viet Nam, encouraged porters and guides to adopt amphibian friendly behaviours (credit: Luan Thanh Nguyen). **e), f)** Outreach activities. **e)** Children paint frog watercolours at a zoo in central Chile. This outreach intervention also included a photo exhibition and infographics about amphibian ecology and conservation (credit: ONG Ranita de Darwin). **f)** “Día de los anfibios” in the central square of Valdivia (southern Chile), a festival that gathered conservation organisations and the public to celebrate amphibians (credit: Felipe Rabanal).

India, frog conservation must be linked within a wider concept of forest protection since a significant proportion of community livelihoods depend on the presence of forests. Similarly, Cisternas et al. (2019) proposed that for achieving the feasibility of biocultural partnerships in New Zealand, building a relationship between participants would be the

best way to optimise communication and validate the incorporation of different perspectives on frog conservation. A partnership between rural farmers and scientists in Mexico allowed the creation of a restoration programme focused on improving axolotl (*Ambystoma mexicanum*) habitat while maintaining traditional agricultural practices (Valiente et al., 2010).

Long-term partnerships between private landowners and conservationists have also allowed protection of amphibian habitat in the USA (Kuyper, 2011; Milmo, 2008; Symonds, 2008), United Kingdom (Pond Conservation: The Water Habitats Trust, 2012), and Chile (NGO Ranita de Darwin, 2021) (Figure 8.5). In Romania, Hartel et al., (2020) concluded that lack of engagement from a broad range of local stakeholders was crucial for the failure of maintaining amphibian conservation initiatives within a protected area that changed its custodian. Therefore, amphibian conservation initiatives that focus on the broader cultural-socio-economic context would benefit from public support and long-term impact. Partnerships could also help to produce actionable science in amphibian conservation.

Communication and collaboration for actionable science in amphibian conservation

The need for actionable science in amphibian conservation is urgent, although generally there is a disconnection between research and practice (Grant et al., 2019). This knowledge-implementation gap means that much of the amphibian scientific evidence available is not useful for end users, such as managers or decision makers (Schmidt et al. 2019). A way to address this problem is to communicate research in a way that can be directly used by end

users (Schmidt, Brenneisen & Zumbach, 2020). For instance, Indermaur and Schmidt (2011) quantified the requirements for wood deposits for populations of common toads (*Bufo bufo*) and European green toads (*Bufo viridis*). These authors reported their findings in a way that managers can easily determine the amount of woody deposits per hectare that are required to sustain a population of any size (Indermaur & Schmidt, 2011). The Conservation Evidence project is another good example of knowledge communication that can be directly used in conservation policy and management decisions. This project currently summarises evidence about the effectiveness of 129 amphibian conservation actions, mostly from North America, Europe, and Australia (Christie et al., 2021).

When thinking about communicating research to inform practice, one should ask what format(s) should be used to meet the needs of multiple end users (Wall et al., 2017). These formats can include websites, scientific and outreach articles, policy briefs, guidelines, smartphone apps, seminars, or hands-on workshops. It is likely that in most situations more than one format will be required. For instance, Schmidt et al. (2020) used a comparative effectiveness study to evaluate the effect of underpasses for amphibians (toad tunnels) and its physical characteristics on nearby amphibian populations in Switzerland. These authors decided to publish the key conclusions of this study in two outreach articles



Figure 8.5: Examples of community engagement in amphibian conservation. **a)** Citizen conservationists (“toad patrollers”) set up a fence in canton Basel-Landschaft, Switzerland, to make sure that migrating amphibians are not killed on the road (credit: Benedikt Schmidt). **b)** Landowners from southern Chile sign long-term conservation agreements with a local amphibian conservation organisation to protect and monitor amphibians and related habitat in their land (credit: ONG Ranita de Darwin).

in two languages well before the scientific article was published (Schmidt et al., 2020).

Carefully thinking about how to communicate research findings does not guarantee that these findings will be relevant for solving amphibian conservation problems. If research is designed, implemented, and communicated only considering the scientist's perspective and knowledge of a conservation problem, there is the risk of failing to provide the information that is required by those who make policy and management decisions (Enquist et al., 2017; Wall et al., 2017). Most amphibian conservation problems require changing this unidirectional flow of information paradigm to a multidirectional one. Communication between scientists, managers, decision makers, and other stakeholders can improve the chances that research makes a true positive impact for amphibian conservation. There is a robust body of literature concerning collaborative production of knowledge in several scientific and medical fields, including conservation, which can be consulted by readers interested in the subject (e.g. Wall et al., 2017 and references therein). For example, translational ecology is "an approach that embodies intentional processes by which ecologists, stakeholders, and decision makers work collaboratively to develop and deliver ecological research that, ideally, results in improved environment-related decision making" (Enquist et al., 2017). A translational ecology approach, ideally guided by decision support frameworks (e.g. Wright et al., 2020), is an effective way to co-produce scientific evidence that informs conservation action (Wall et al., 2017).

It is important to consider that actionable science does not guarantee conservation success, as institutional barriers can play a significant role in the success of any conservation project (Wright et al., 2020). Institutional barriers can include conservation not being a political priority, amphibians not being preferred by the primary decision makers, and deficient engagement and communication between scientists and decision makers (Rose et al., 2019). For instance, Wright et al. (2020) evaluated 12 amphibian conservation case studies from Australia, Canada, Italy, and USA that used decision science to

plan and implement conservation actions. Although all these case studies provided usable science by identifying optimal actions, less than 25% of the studies achieved conservation success. Most of the barriers for success were institutional barriers related to the complexity of the governance structures for a given decision problem, which led to over half of the studies failing, at least partially, at securing funding and implementing the actions (Wright et al., 2020). Therefore, communication among, and engagement of the different individuals and organisations involved in a project, is critical. A conservation project that uses a translational ecological approach should explicitly consider since its inception by what means, how frequently, and at what depth of engagement (e.g. presential or online workshops, emails, etc.) the researchers, end users, and other stakeholders are expected to communicate (Wall et al., 2017). Key leadership needs to be engaged to transcend organisational structures, which might require the involvement of multiple actors across time and space (Wright et al., 2020). This highly collaborative work can be an extenuating process, so careful consideration of "soft skills" such as listening, communicating, mediating, negotiating, and sharing, is very important for success (Enquist et al., 2017; Wall et al., 2017). It is also important for researchers to acknowledge that effective communication may require the participation of boundary-spanning organisations or professionals that can be better prepared to facilitate the collaboration across multiple disciplines and sectors (Wall et al., 2017; Wright et al., 2020).

Discussion

In this chapter we reviewed a representative body of literature to assist those researchers and practitioners who may undertake research and/or actions for amphibian conservation. We acknowledge a taxonomic and geographical bias in the evidence reported here. For instance, most studies about amphibian-centred human cognition were focused on anurans and conducted in Europe, South America, and South Africa. Additionally, there was an evident methodological bias towards an interpretivism research approach, and the application

of questionnaires was the predominant data collection tool. Based on examples of community and stakeholder empowerment with conservation (e.g. Charles, 2021; Lyver et al., 2019), amphibian researchers might also be interested in exploring innovative research methods that allow a bottom-up approach to knowledge construction, such as participatory action research or biocultural approaches. Several factors have been identified as modulators of human attitudes and behaviours towards amphibians. These factors highlight different cultural and psychological sources of variation that need to be considered when designing conservation education and communication programmes. Two important remarks are worth discussing. First, most studies have focused on factors associated with intermediate levels in the cognitive hierarchy model of human behaviour (Fig 8.1; Fulton, Manfredo & Lipscomb, 1996), such as beliefs, attitudes, and norms. How these intermediate levels translate into behavioural intentions and behaviours affecting amphibians is largely unknown. The prevalence and impact of human behaviours that might threaten amphibians also remain poorly understood. Second, most studies on this topic have focused on the lay public, while much less is known about factors influencing behaviour towards amphibians among private landowners, farmers, producers and entrepreneurs, conservation professionals, educators, natural resources managers, and policymakers (but see Pontes-Da-Silva et al., 2016; Prokop & Fančovičová, 2012; Rommel et al., 2016 for exceptions).

Conservation education and outreach techniques can be used to change human behaviour and improve public support for biodiversity conservation. Specifically for amphibian conservation education, we found that although some methods have produced positive results, programme evaluation is still rare. Evaluation is critical to assess and improve the effectiveness of any conservation intervention, and therefore to ensure that limited funds go as far as possible in achieving conservation outcomes (Ferraro & Pattanayak, 2006). Most of the evaluation research that has been done focuses on classroom/experiential activities with pre- or middle-schoolers, and uses surveys or interviews

to measure knowledge and attitudes. Thus, there is very limited evidence about the effectiveness of conservation education programmes on changing human behaviours and improving public support for amphibian conservation. We strongly suggest expanding the range of evaluation designs and methods traditionally used (Table 8.1) and assess other target audiences and conservation education techniques that could be used for amphibians (e.g. citizen science, storytelling, visual arts, interactive web sites, see Jacobson et al., 2015 for more examples). This information is crucial to inform effective and strategic conservation education and communication actions. For instance, citizen science could be a useful tool to engage stakeholders and communities in amphibian conservation (Bonney et al., 2014; Lee et al., 2021). Participants of citizen science benefit from the experiential hands-on and field-based activities as well as gain confidence from the mastery of concepts and associated skills required for their participation (e.g. Cisternas et al., 2017; Lee et al., 2021). Citizen scientists or citizen conservationists (e.g. “toad patrollers”) might also directly benefit declining amphibian populations, for instance, by reducing road mortality of pond-breeding amphibians (Fig 8.5; Sterrett et al., 2019).

Communications and education can increase stakeholder engagement and the success of amphibian conservation actions. Increasing conservation attention towards amphibians could lead to a virtuous circle promoting career development of amphibian conservationists. For instance, media such as television, internet, and magazines ranked as the most important career motivations for natural resources students in Florida (Haynes & Jacobson, 2015). Increasing the presence of amphibians in such media could increase students’ interest in pursuing an amphibian-focused career. Improving positive attitudes toward amphibians in high-level decision makers (such as politicians, CEOs, board of directors, dean of colleges, or funders) should also be a high priority in the amphibian conservation community. Working with a species that is not preferred by the administration of your research institution or conservation organisation, or that receives less funding compared to other more charismatic species, can be

a barrier difficult to sort in the career pipeline of an amphibian conservationist. Communicating the value of amphibian conservation using carefully designed messages, for instance, by highlighting evidence about amphibians' relevance for ecosystem functioning and human well-being, or about the imperilled status of these animals, might provide a good starting point to increase concern about amphibians in decision makers and the public.

Priority actions and knowledge gaps

- » Most studies about amphibian-focused human cognition have focused on factors associated with intermediate levels in the cognitive hierarchy model of human behaviour. How these levels translate into behaviours affecting amphibians remains poorly understood.
- » Knowledge about amphibians can increase positive human attitudes and behaviours in relation to these animals. Unfortunately, evaluation in amphibian-focused outreach and education programmes seems to be rare. Evaluation is

critical to assess and improve the effectiveness of any outreach or education intervention.

- » We need more actionable science in amphibian conservation. This should include communicating research in a way that can be directly used by end users and considering multidirectional and collaborative production of knowledge.
- » Conservation success requires overcoming institutional barriers. In collaborative projects, key leadership often needs to be engaged to transcend organisational structures. Also, careful consideration of “soft skills” (e.g. listening, mediating) and incorporation of boundary-spanning organisations or professionals can be very important for success.
- » Despite these knowledge gaps and barriers, our chapter highlights a considerable body of research on amphibian-focused communications and education that can be used to inform conservation practice. Iterative processes of planning, implementation, and evaluation will allow refining knowledge without delaying urgent action.

Box 8.1: Glossary

Actionable science: “data, analyses, projections, or tools that can support decisions in natural resource management; it includes not only information but also guidance on the appropriate use of that information” (Enquist et al., 2017).

Biocultural partnerships: an association of persons joined as partners to develop conservation actions that sustain the biophysical and sociocultural components of dynamic, interacting, and interdependent social-ecological systems.

Citizen science: broadly defined as the involvement of non-expert volunteers in scientific research.

Community involvement: the action of welcoming and integrating local people and communities into conservation decisions and implementation to effectively mobilise their action and reduce conflicts.

Folklore: traditional description of local beliefs and customs of a people often expressed in stories, myths, legends, and other artistic representations.

Stakeholders: include any community member, organisation, or individual with a stake in the conservation issue or location of a conservation project.

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Many people living alongside the Chinese giant salamander (*Andrias* spp.) do not know how threatened it is or may even exploit it. Here, a group of schoolchildren from a rural school located within the distribution of this species are participating in a community outreach activity. They have learned about the uniqueness of the species and why it is threatened. It is hoped that these children will not only influence the wider community but also become better custodians of Chinese giant salamanders. © Benjamin Tapley