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The perception and cultural portrayal of animals

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It was back in 2008 that I noticed to my surprise that some of my fellow biology students did not know the difference between a jackdaw and a crow. This planted a seed in my head that years later would sprout and set me on a journey to explore people's perception of animal biodiversity in the Netherlands. The species represented on the cover of my dissertation are a few of the animals that participants had difficulty with identifying. To put these animals in the spotlight, they reappear elsewhere in this thesis with their actual everyday name.

Michiel Hooykaas

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The **common moorhen** (Nederlands: **waterhoentje**) is commonly found near freshwater in (sub)urban areas, where it feeds on aquatic plants and creatures.

Chapter 1

General Introduction

At a time when biodiversity is under pressure worldwide and we are at an increasing risk of losing our connection with nature, understanding people's perception of biodiversity has become increasingly important. In particular, people's awareness of animal species deserves our attention, as animals are accessible and effective agents for people to connect with biodiversity. The studies discussed in this dissertation are set in the Netherlands, one of the most densely populated countries in Europe. Through six research projects I have investigated which animals Dutch citizens do or do not know, I have studied cultural sources that may impact children's perceptions of animal diversity, and, from the perspective of biodiversity communicators, I have explored the potential to connect people with biodiversity in places that are becoming increasingly urbanized. Moreover, I introduce and discuss a new concept that highlights species as an accessible way to learn about biodiversity: species literacy. The research discussed in this thesis can be regarded as a step towards broadening people's perception of animal diversity, which can ultimately help expand the role of biodiversity in people's lives.

1.1 Values associated with animal biodiversity

Our world is home to an astounding diversity of animals. The animal kingdom comprises all shapes and sizes, from tiny pseudoscorpions that jump aboard large beetles for public transport, to giants like blue whales: the largest animals known to have ever existed. Animals display a multitude of different behaviors and they are present almost everywhere, from remote islands, rainforests, and deserts, to suburbs and city centers, and even on our bodies: unknowingly, most people offer a place of residence to microscopic follicle mites.

Animals play a significant part in our lives, whether we are aware of it or not. First, they hold an important ecological value. Worldwide, animals facilitate ecological processes such as biomass production, decomposition, and recycling (Danovaro et al., 2008; Hättenschwiler & Gasser, 2005), and provide ecosystem services such as pollination, seed dispersal, and waste removal (Ćirović et al., 2016; DeVault et al., 2003; Wenny et al., 2011; Winfree et al., 2018). Diverse communities in particular can aid in the persistence of resources and essential actions provided by ecosystems when conditions change (Boulton et al., 2008; National Research Council, 1999). For instance, a greater diversity of fish enhances reef fish biomass and buffers global fish biomass against the effects of climate change (Duffy et al., 2016). In line with this, biodiversity has been highlighted as an indicator for sustainable development (Blicharska et al., 2019; Niesenbaum, 2019; Schultz et al., 2016).

Secondly, although monetizing the natural world is problematic (Admiraal, 2016; Novacek, 2008), animals unquestionably hold an economic value. Animals are regarded as natural capital and contribute substantially to economies (National Research Council, 1999). Industries depend on animals for the production or development of goods and commodities such as food, biochemicals, and fuel, and sectors like (eco)tourism and hunting depend largely on animals as well (Curtin, 2009; National Research Council, 1999; Spalding et al., 2017). The animal kingdom also represents an inexhaustible source of inspiration for people that work in the arts, the entertainment business, and the fashion industry. Some of the best known and popular characters in films and animations are animals (Fukano et al., 2020; Yong et al., 2011), and images of animals are frequently incorporated in the design of commercial products that range from clothes to wall paper. Furthermore, animals are regularly featured in marketing and advertising strategies to help promote products or services (Berland, 2019; Burton & Collins,

2015; Feldhamer et al., 2002; Lerner & Kalof, 1999), and the large variety of species offers healthcare and pharmaceutical industries potential for new discoveries and for the development of new applications and products. For example, the market value of undiscovered anti-cancer drugs originating from marine organisms like sponges and mollusks was estimated to be between 563 billion and 5.69 trillion American dollars (Erwin et al., 2010).

Finally, and most importantly in relation to the theme of this thesis, people attach personal values to animals. Since the dawn of humankind animals have captivated us and have played important roles in human culture. Rock paintings of animals in the Caves of Lascaux and animal motifs on Egyptian mummies mirror the central role that animals played in ancient cultures (Herzog & Galvin, 1992; Hill, 2021). To this very day, animals are part of people's cultural identity and heritage (K. M. A. Chan et al., 2012), and may act as significant symbols in human society (Hill, 2021; Lerner & Kalof, 1999).

Animal biodiversity provides people with countless opportunities for educational, aesthetic, spiritual, or otherwise enriching experiences and activities. People may enjoy animals during leisure activities outdoors such as birding or they may marvel at the diversity of life through exposure to animals via cultural sources such as nature films, experiences that can kindle feelings of wonder and awe. Animals can also contribute to a *sense of place and belonging*: a grounded feeling that is associated with recognizing certain features of their environment, including the animals that reside there (Horwitz et al., 2001; Reid et al., 2005; Standish et al., 2013).

Research has demonstrated that people appreciate species richness and attach aesthetic values to biodiversity (Dallimer et al., 2013; Hedblom et al., 2014; Lindemann-Matthies et al., 2010; Southon et al., 2017). People may even value animals that they have had no direct experience with themselves (Mace et al., 2012), e.g. by taking pleasure in knowing that species such as tigers, elephants, and polar bears, exist, or by feeling satisfied when biodiversity is preserved for future generations (Novacek, 2008). It seems that exposure to biodiverse environments in particular contributes to people's psychological well-being (Clark et al., 2014; Curtin, 2009; Fuller et al., 2007; Luck et al., 2011; Sandifer et al., 2015). For instance, research suggests that people derive further pleasure when they watch a larger variety of birds (Cox & Gaston, 2015), and that exposure to a greater diversity of fish in an aquarium exhibit has greater calming effects (Cracknell et al., 2016).

1.2 Threats to animal biodiversity

Despite the values that it provides to people, animal biodiversity currently faces significant threats at both local and global scales; threats that are all caused by human needs and desires (Moss et al., 2017). The human population on our planet has grown to 7.9 billion and is projected to increase by almost one-third to around 10 billion in 2050 (Worldometers.info, 2021b). This brings with it large-scale modification of the environment. For instance, cities and towns are expanding rapidly, humans are extracting large amounts of water, timber, and other resources from the environment, and over half of all land surface is currently used for livestock or agriculture (H. Mooney et al., 2009). In addition to these land modifications, biodiversity is threatened by habitat destruction, overexploitation, pollution, invasive alien species, and climate change (European Commission, 2015). Together, these threats pose formidable challenges to the conservation of animal biodiversity.

While the impact of humans on the environment continues to take place, biodiversity continues to be lost rapidly, at a rate unprecedented in human history (De Vos et al., 2014; Díaz et al., 2019; Pimm et al., 2014). Extrapolations suggest that we are faced with an extinction crisis of the same magnitude as the end-Cretaceous extinction, when over 75% of existing species were lost, including non-bird dinosaurs (Palombo, 2021). Further imminent extinctions are indicated by the declining populations of many species. The most recent Living Planet Index showed that between 1970 and 2016 vertebrate populations suffered an average 68% decline (WWF, 2020). For instance, populations of iconic animals such as lions (Riggio et al., 2013), elephants (Chase et al., 2016), sharks (Pacoureau et al., 2021), cheetahs (Durant et al., 2017), and birds of prey (McClure et al., 2018) have plummeted in recent years. Moreover, steep population declines have been reported for invertebrates, such as terrestrial arthropods (Sánchez-Bayo & Wyckhuys, 2019; Seibold et al., 2019).

Especially in highly urbanized and industrialized parts of the world, pressure on biodiversity has been and still is significant. In Europe mammals such as bears and wisent were lost from areas inhabited by large numbers of humans (Chapron et al., 2014; Deinet et al., 2013) and a 17-19% decline in avifauna has been estimated since 1980: a loss of 560–620 million individual birds (Burns et al., 2021). For instance, house sparrows and starlings have disappeared at an alarming rate. In the Netherlands, the population of black-tailed godwits, the country's National

bird, has declined by 70 percent since the 1970's (Kentie et al., 2016).

Authors have referred to the ongoing loss of fauna as *defaunation* (Dirzo et al., 2014; Young et al., 2016) and *biological annihilation* (Ceballos et al., 2017). Currently, of over 80,000 animal species that have been assessed worldwide, nearly 16,000 species are listed as threatened according to the IUCN Red List criteria, meaning that these species are vulnerable, endangered or even critically endangered (IUCN, 2021).

1.3 The need for broad-based support

The ongoing decline in biodiversity is an urgent environmental issue that demands attention. In 2011 the United Nations declared 2011-2020 as the 'Decade on Biodiversity' and issued a framework for action to save biodiversity. To help avert further loss, broad-based support from society is vital, because conservation depends on the general public for funding and because a widely shared willingness of the general public to conserve biodiversity can encourage decision makers to implement policies. It is unlikely that governments or industries will change course when there is a lack of public concern about biodiversity (CBD, 2013; Novacek, 2008).

However, raising support for conservation is challenging these days. There are opposing interests at play (e.g. economic and ecological), and messages about biodiversity can be overshadowed by messages about other matters, including other environmental subjects. For instance, Novacek (2008) has stated that there has been a shift in attention to global warming and climate change away from issues such as biodiversity loss. The depressing nature of the continuing loss of biodiversity may further pose a barrier towards engagement, as people might get the idea that any efforts to conserve biodiversity will fail (Balmford & Cowling, 2006). People may feel hopeless or helpless (Allen, 2013; Moreno-Tarín et al., 2021) and may get the impression that money and effort invested in conservation is spent in vain (Miller, 2005). Finally, a big challenge is that simultaneously with the loss of biodiversity, there appears to be a widening gap between people and nature (Miller, 2005).

1.4 An extinction of experience

Throughout history, humans have shared an intimate relationship with the natural world, depending directly on their immediate surroundings for anything from food to shelter (Keniger et al., 2013). In contrast, most people nowadays are much less reliant on direct interaction with nature. More people than ever before are living in urban and suburban areas. While a mere 3% of the earth surface is taken up by cities, over half of the world's population resides there and the fraction of people living in cities will keep on growing in the following decades (United Nations, 2014; Wu, 2010). These changes have modified the ways in which people interact with biodiversity in their daily lives (Pett et al., 2016).

First, there seem to be reduced opportunities to experience nature directly. Many citizens live in neighborhoods where green space is sparse, access to wild habitats for outdoor activities is restricted, and biodiversity is impoverished (Cox et al., 2017; Miller, 2005; Turner et al., 2004). Reports show schools devote less time on fieldwork than before (Cheesman & Key, Roger, 2007; Scott et al., 2012, 2015), and there are indications that living organisms are used less frequently in classrooms (Barker & Slingsby, 1998; Reiss & Beaney, 1992), reducing opportunities for children to experience the natural world firsthand.

Secondly, people's orientation towards engaging with nature seems to be changing (Soga et al., 2018; Soga & Gaston, 2016). For instance, people nowadays tend to be less inclined to spend time on nature-based recreation (Pergams & Zaradic, 2006, 2008; Soga & Gaston, 2016), and an increasing number of children seem more drawn to indoor activities like gaming than to playing outside (Kimbell et al., 2009; Lucassen et al., 2020; Van den Boorn, 2007). Parents living in increasingly urbanized settings with lots of traffic may further be concerned about letting their children explore the outdoors (Malone, 2007).

As a result of these changes, people seem to have become isolated from experiences with biodiversity. There seems to be an *extinction of experience* (Pyle, 2011). Research suggests that compared to past generations children engage less with nature outdoors (Soga & Gaston, 2016). Langers (2018) reported that in the Netherlands primary school children's visits to forests, agricultural areas, and nature reserves declined between 2006 and 2015. Such restricted interaction with nature is likely to last into adulthood. Research findings show that adults who were exposed less frequently to nature during childhood visited green areas less (Hinds & Sparks, 2008; C. W. Thompson et al., 2008).

The gradual separation between people and nature also seems to manifest itself in cultural expressions, which suggests that opportunities to experience nature indirectly are also changing (Mccallum & Bury, 2013; Williams et al., 2012). References to nature have decreased since the 1950s in fiction books, song lyrics, and film storylines (Kesebir & Kesebir, 2017), and Disney films have become increasingly poor in species (Prévot-Julliard et al., 2015). When a new edition of the Oxford Junior Dictionary was published 2007, it had deleted animal names like adder, kingfisher, and otter, while words such as blog, chatroom, and cut-and-paste had been added (Macfarlane, 2015).

1.5 Potential impact on people's perception of biodiversity

The widening gap between people and nature is a big challenge for conservationists. Not only may billions of people lose opportunities to benefit from nature (Louv, 2005), the separation from nature could also diminish people's opportunities to become familiar with and connect with biodiversity (Turner et al., 2004). This could negatively affect conservation, as people tend to care about what they know (Balmford et al., 2002) and may not feel equipped to make informed decisions related to a subject that they are not knowledgeable about.

There are indeed indications that a growing distance between people and nature is affecting people's perceptions. For instance, it appears that nature vocabulary has been lost from societal and daily conversation (Barnett, 2019; Macfarlane, 2016, 2017; Morris & Macfarlane, 2017; Stibbe, 2012, 2014). Pilgrim et al. (2008) found that ecological knowledge was lower in communities independent of the local environment for subsistence, and Kai et al. (2014) concluded that in local communities in China, biodiversity decline was associated with a loss of ecological knowledge. This links to the *shifting baseline syndrome*, which can occur when people unaware of past conditions get used to baselines of lower biological and environmental quality and diversity (Kellert, 2002; Papworth et al., 2009; Pauly, 1995), and which may mute people's sense of urgency. The findings by Kai et al. (2014) also exemplify the process of *generational amnesia*, as older people were better skilled at identifying animals than young people (Kahn, 2002; Papworth et al., 2009).

Overall, it seems that nowadays laypeople's perception of biodiversity is narrow. People tend to struggle with accurately estimating species richness

(Dallimer et al., 2012; Lindemann-Matthies & Bose, 2008; Pett et al., 2016; Shwartz et al., 2014), which suggests that people have poor identification skills. In line with this, concern has been raised that people's knowledge about common, native species in particular is restricted (Balmford et al., 2002; Huxham et al., 2006). In this dissertation, we call this limited knowledge about species a lack of *species literacy*. Apart from restrictions in the number of species that people know, there are signs that laypeople's perception is biased towards domestic and exotic species (Ballouard et al., 2011; Genovart et al., 2013; Lindemann-Matthies, 2005). Such a skewed perception of biodiversity may result from reduced opportunities to experience nature directly, but may also stem from indirect experiences with animals, when people are exposed to cultural representations of the natural world.

1.6 Cultural representations

Despite the growing distance between humans and nature in modern society, people remain exposed to cultural representations of the natural world, in particular portrayals of animals. Animals are regularly featured in the media, fashion, and design, and they are frequently represented as toys, mascots, and tattoos. Together, such portrayals reflect how society perceives and appropriates animals, but they also provide unprecedented access to biodiversity (Kellert, 2002). For instance, people may readily come across portrayals of species that are found only in small numbers in the wild or that are seldom seen outdoors due to their reclusive lifestyles (Berland, 2019; Courchamp et al., 2018). Representations of animals reach very large audiences, including groups that lack time and interest to actively educate themselves about biodiversity (Small, 2016). This raises the interesting question if portrayal of animals compensates for the loss of direct experience with nature.

Repeated exposure to images of animals, even when this exposure is subtle and accidental rather than purposefully organized for educational purposes, impacts people's perceptions (Bornstein & D'Agostino, 1992; Burton & Collins, 2015; Kaikati & Kaikati, 2004; Kalof et al., 2015; Roy & Chattopadhyay, 2010; Zajonc, 1968). Past research has demonstrated that cultural representations of animals shape people's awareness of species; e.g. portrayals may influence what species people know (Alves et al., 2014; Ballouard et al., 2011; Dixon et al., 2005).

Exposure to animal portrayals may further trigger interest and engagement, and can help build positive attitudes towards animals (Kalof et al., 2015; Pearson et al., 2011). It was found that the animated films *Madagascar*, *Finding Dory*, and *Rio*, and the nature film *Planet Earth*, led to substantial increases in online searches for animals featured in these movies (Fernández-Bellon & Kane, 2019; Silk et al., 2018). Similarly, Fukano et al. (2020) demonstrated that the Japanese animated television program *Kemono Friends* promoted public interest in threatened animals; the TV show even led to increased donations for conservation.

However, portrayals of animals will not necessarily help people with developing a broad and balanced view on biodiversity. First, cultural sources may represent only part of the animal kingdom; e.g. nature film makers have been accused of mainly portraying charismatic megafauna from overseas (Ballouard et al., 2011). Such biases may lead people to adopt a narrow and biased perception of animal diversity (Celis-Diez et al., 2016). Secondly, the way in which animals are portrayed may detract from the learning potential of cultural sources. Portrayals may be unspecified (e.g. when a prototypical butterfly is displayed instead of a peacock butterfly), which will not help expand people's perception of different species. Similarly, distorted and artistic depictions of species that therefore are hardly recognizable and unspecific references to species (e.g. when a mallard is referred to as 'duck') will make it hard for people to search for information about specific species and learn more about them (Fernández-Bellon & Kane, 2019). Research has demonstrated that young children are less likely to link cultural references to real objects when the perceptual similarity is lower (Ganea et al., 2008). When animals are portrayed in an anthropomorphized fashion, this may not only obscure the link with the species that they represent, but this may also induce misconceptions about their natural behavior (Ganea et al., 2014; Geerdts, Van De Walle, et al., 2016; Waxman et al., 2014).

As urbanization continues, cultural representations of animals will play an increasing part in shaping people's perception of biodiversity (Gerbner, 1969; Kellert, 2002; Kesebir & Kesebir, 2017; Potter, 2014; Prévot-Julliard et al., 2015; Soga, Gaston, Yamaura, et al., 2016). This makes it important to understand what image of animal biodiversity cultural sources present to the public, especially products targeted at children, as childhood is considered to be a critical period for developing a lasting connection with the natural world.

1.7 The importance of biodiversity communication

While cultural sources usually provide subtle exposure to animal biodiversity, people who communicate biodiversity to lay audiences could offer a more direct route to connect people with biodiversity. In line with this, international agendas feature communication as a good starting point towards raising biodiversity awareness and broad-based support for conservation (CBD, 2013). Communicators can promote broader awareness and deeper understanding of the diversity of life, which can help people make choices and well-informed decisions. For example, people will only be able to make a weighted judgement about the importance of halting biodiversity loss, when they are aware of biodiversity in the first place. Becoming aware of local flora and fauna may further help people living in highly urbanized settings realize that biodiversity is relevant for them, too.

However, communicating biodiversity can be challenging, as people vary widely in their knowledge base and attitudes, and this diversity affects outcomes (J. H. Falk & Adelman, 2003; Scheufele, 2018). Laypeople can differ considerably from professionals in their understanding, expectations, and the language they use, potentially hampering communication (Bullock et al., 2019; Venhuizen et al., 2019). For instance, one significant challenge in biodiversity communication constitutes the concept of biodiversity itself. Since its inception by Walter Rosen of the National Research Council in 1986 (Sarkar, 2002), the term biodiversity is most commonly used by biologists, environmentalists and conservationists worldwide (Elder et al., 1998). For laypeople the concept remains quite abstract, and its technical and multidimensional character makes the concept difficult to understand (Novacek, 2008; Wals & Weelie, 1997). In fact, many people do not recognize and comprehend the term (Fischer & Young, 2007; Lindemann-Matthies & Bose, 2008; Moss et al., 2014; Turner-Erfort, 1997). A survey showed that in 2015 only 59% of Dutch lay respondents had heard of the concept of biodiversity and a mere 27% could correctly define it, suggesting that messages about biodiversity may currently not be understood by society at large (European Commission, 2013; UEBT, 2018).

Although it may be strategic for communicators to use simpler alternatives such as species to represent biodiversity and communicate it in an accessible way, challenges in communication may present themselves here as well. As mentioned before, there are indications that laypeople lack knowledge about species, i.e. that their level of species literacy is low. This can impact their response

to messages too. A picture of a nonvenomous snake species at an entrance board of a nature trail may scare people who misidentify it as a venomous species, and species names that people are unfamiliar with may act as jargon. This illustrates that it is valuable for communicators to be aware of knowledge levels within their target groups, and to have a clear picture of the knowledge level that they strive for in their audiences. For example, being aware of current levels of species literacy would enable communicators to connect to people's existing understandings and could provide clarity about steps needed to expand people's perception of biodiversity.

1.8 The Netherlands: An urbanized country as a test-case

As biodiversity loss continues and people are at an increasing risk of losing touch with nature, it is increasingly important to understand people's perception of animal biodiversity and to explore current practices in biodiversity communication. This may ultimately help expand the role of biodiversity in laypeople's lives. As more and more people grow up in industrialized and urbanized environments, and global conservation will increasingly depend on the ability of urbanites to maintain a connection with nature, it is especially important to study people's perceptions in areas that have become or are becoming increasingly urbanized.

The studies comprised in this thesis are all set in in the small and densely populated Netherlands (national population of 17.6 million people; 522 people/km^2 (CBS, 2021) where over 90% of the population is urban (Worldometers.info, 2021a). As such, the country can serve as a model and test-case for assessing the connection (or lack thereof) between people and nature in a rapidly urbanizing world. In this dissertation we use species literacy as a *pars pro toto* to study biodiversity awareness. In addition to establishing current levels of species literacy and factors that drive these levels, the thesis aims to explore species literacy levels in laypeople as estimated and desired by biodiversity communicators, and to find out what picture of animal biodiversity is portrayed by cultural sources targeted at children. Finally, this thesis aims to determine opportunities for and challenges to expand the role of biodiversity in laypeople's lives. Based on these research goals, the following research questions arise:

Part I: Species literacy

1) What is the level of species literacy in Dutch laypeople? (Chapters 2 + 3)
2) What are drivers for species literacy in Dutch laypeople? (Chapter 2)
3) To what extent are two important components of species literacy – species identification and in-depth species knowledge – associated with each other? (Chapter 3)

Part II: Cultural sources

4) Which taxa and types of animals (exotic or native, and domestic or non-domestic) are portrayed as cultural representations targeted at children? (Chapters 4 + 5)
5) To what extent are animals in cultural representations targeted at children specified or anthropomorphized? (Chapters 4 + 5)

Part III: Perspective from communicators

6) How do biodiversity communicators perceive the current role of biodiversity, including the current level of species literacy, in Dutch laypeople? (Chapters 6 + 7)
7) What importance do biodiversity communicators place on species literacy in laypeople and what is the desired level? (Chapters 6 + 7)
8) What potential do biodiversity communicators see in the Netherlands for expanding the role of biodiversity in laypeople's lives? (Chapter 7)

1.9 Outline

This thesis comprises eight chapters: a general introduction, six empirical research chapters based on studies situated in the Netherlands, and finally a general discussion.

Part I: Species literacy

The first part of this dissertation focuses on the current perception of animal biodiversity, by introducing and exploring the new concept of species literacy. It explains what species literacy is, and explores the different dimensions of species literacy: which components it comprises and how they are interconnected.

Chapter 2 elaborates on the concept of species literacy and describes why it can be valuable for people to be knowledgeable about species. Furthermore this

chapter reports the findings of a quantitative research project that established the level of species literacy in biodiversity professionals, primary school children, and the general public, using an animal species identification test. Insight is provided into biodiversity awareness, and information is obtained about the possible connection or lack thereof between Dutch citizens and the natural world. In addition, possible determinants for species literacy are explored, using correlation and regression analyses. Implications of these findings for conservation and communication are discussed.

Chapter 3 investigates whether species literacy can be accurately measured via species identification tests, i.e. if species identification skills are suitable indicators for in-depth knowledge about species. This is valuable information for researchers and communicators who may wish to use identification tests to assess knowledge levels in their target groups. To this purpose, an animal knowledge test was distributed among a large sample of online participants. The chapter shows to what extent accurate species identifications predict knowledge about the origin of species, their habitat, diet, and behavior, and reveals knowledge gaps and misconceptions about animals in Dutch adults. Reflecting on the findings, the value of species identification tests is discussed.

Part II: Cultural sources

The second part of the dissertation zooms in on cultural representations of animals, as they may reflect and affect people's perception of animal biodiversity. This section is based on two separate research projects that used quantitative content analyses to explore the image of animal biodiversity that is conveyed by two product categories made for young children. Chapter 4 reports the findings of a study on representations of animals in children's clothes, while Chapter 5 discusses the portrayal of animal biodiversity in children's picture books. Coding a sample of around 800 animals portrayed on clothes, and over 2,000 animals depicted in picture books, we report what taxa and types of animals are represented, how they are portrayed, furthering our understanding of how animal biodiversity is currently appropriated by the fashion and entertainment industry. Moreover, we note and discuss opportunities to specify and diversify the portrayal of animal biodiversity in picture books and clothing.

Part III: Perspective of communicators

The third part of this thesis explores opportunities and barriers in expanding people's perception of biodiversity. It focuses on the perspective of Dutch biodiversity communicators. As more and more people grow up in an urban environment, it is important to find out if urban environments offer sufficient opportunities for human-nature interaction to unfold, and what role communicators can play.

Based on the idea that it is important for communicators to know their target audience, Chapter 6 presents findings of a quantitative study that investigated whether biodiversity communicators are aware of the average level of species literacy in primary school children, and if and why they think knowledge about species is important. Moreover, the chapter reports what level of species literacy communicators deem desirable in children, which ultimately can help set educational goals. The value of assessments to bridge the gap between expected and actual knowledge levels in target audiences is discussed.

Chapter 7 presents the results of a qualitative research project with biodiversity professionals that explored motivations, opportunities and challenges to expand the role of biodiversity in people's lives in an increasingly urban world. Semi-structured interviews were carried out with 12 professionals, and their perception and experience were analyzed. The chapter reflects on possible routes to connect people to biodiversity, and provides an overview of best practices that professionals operating in urban contexts could use to reach out to their respective audiences regarding biodiversity. As such, the findings described in this chapter may empower and encourage professionals in urbanizing parts of the world who communicate about biodiversity, and may ultimately help grow biodiversity awareness and broad-based support for conservation.

Part IV: Reflection and future directions

Chapter 8, the final part of the dissertation, reflects on the work presented here in this thesis and makes connections to relevant literature. Major outcomes of the research are highlighted and put into perspective. A framework for species literacy is presented, and promising avenues for raising species literacy and connecting people to biodiversity are distilled. Additionally, directions for further research are provided, as interesting opportunities exist for future studies on species literacy.

Part I:

Species Literacy

The **red admiral** (Nederlands: **atalanta**) performs an annual migration cycle: those that fly to the south eventually give rise to new generations that travel north again. The red admiral flies at high altitudes, where the wind carries it forward.

Chapter 2

Identification Skills in Biodiversity Professionals and Laypeople: A Gap in Species Literacy

This chapter is based on:

Hooykaas, M. J. D., Schilthuizen, M., Aten, C., Hemelaar, E. M., Albers, C. J., & Smeets, I. (2019). Identification skills in biodiversity professionals and laypeople: A gap in species literacy. *Biological Conservation*, *238*, 108202. https://doi.org/10.1016/j.biocon.2019.108202

Abstract

Biodiversity is in worldwide decline and it is becoming increasingly important to expand biodiversity awareness and achieve broad-based support for conservation. We introduce the concept of species literacy, as knowledge about species can be a good starting point for engaging people in biodiversity. However, concern has been raised about a general lack of knowledge about native species. We explored species literacy via a species identification test in the Netherlands, and we investigated potential drivers of it. The dataset included 3,210 general public participants, 602 primary school children aged 9/10, and 938 biodiversity professionals.

A considerable gap in species literacy was found between professionals and laypeople. Knowledge about common, native animals was particularly low in children, who on average identified only 35% of the species correctly. Mammals received relatively high identification scores as compared to birds. Laypeople's species literacy increased with age and educational level, and was associated with positive attitudes towards nature and animals, media exposure and having a garden.

The results indicate that a considerable part of the Dutch lay public is disconnected from native biodiversity. This points to a separation between people and nature that could hinder future efforts to preserve biodiversity. Our assessment can help bridge the gap between laypeople and professionals, as it can help set up communication and education strategies about native biodiversity that fit prior knowledge.

2.1 Introduction

Biodiversity is declining at a high rate as a consequence of human activities, such as habitat destruction, overexploitation of natural resources and pollution (Barrett et al., 2018; Ceballos et al., 2015, 2017; Dirzo et al., 2014). As a result, people are losing opportunities to experience biodiversity and to develop a personal connection with it (Pyle, 2011; Soga, Gaston, Koyanagi, et al., 2016; Soga & Gaston, 2016). The public might therefore become estranged from nature, resulting in a society that is uninformed and unconcerned about its degradation (Celis-Diez et al., 2017; Kai et al., 2014; Miller, 2005; Rozzi, 2013). While conservation of biodiversity has become an urgent environmental topic, reaching out to the public about biodiversity is becoming increasingly important.

Engaging the public in biodiversity can help build broad-based support for its protection. Support is needed for conservation to be successful, as conservation strategies and practices depend on persistent funding, membership and acceptance (Home et al., 2009). A widely shared willingness of the public to conserve biodiversity could encourage decision makers to implement policies that grant protection, yet when there is a lack of concern about biodiversity, governments or industries will unlikely change course (Novacek, 2008; Shwartz et al., 2014).

In order to engage people in biodiversity conservation and achieve public support, increasing awareness of biodiversity has been acknowledged as a good starting point. Deeper understanding can empower people to take well-informed decisions about their own lives or the world they would like themselves or their children to live in (Mankin et al., 1999). Furthermore, people care about what they know (Balmford et al., 2002). Even familiarity as a result of mere exposure has been correlated to positive changes in attitudes and preferences, which has been termed the 'mere-exposure effect' (Bornstein & D'Agostino, 1992; Zajonc, 1968). In line with this, broader biodiversity awareness has been set as a target in international agendas, demonstrating that communication to the general public about biodiversity is becoming increasingly important (CBD, 2013).

Biodiversity, however, is a challenging concept to convey to the public. It is rather abstract and can be interpreted in different ways (Van Weelie & Wals, 2002). The Convention on Biological Diversity (CBD) defines biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are

part; this includes diversity within species, between species and of ecosystems" (United Nations, 1992). However, in addition to the scientific and organizational dimensions referred to in this definition, biodiversity also has ethical, economic and social dimensions that imply interrelations (Gayford, 2000; Wals & Weelie, 1997). The concept thus has a multi-dimensional character, which makes it difficult for the public to grasp its meaning. Moreover, the biodiversity concept is value-laden or normative and this might lead to biased conceptualizations (Dreyfus et al., 1999; Fiebelkorn & Menzel, 2013). For instance, for some people the term biodiversity has a negative connotation, as it can be used as a political argument for land management policies that some may not agree with (Buijs et al., 2008). These reasons make it difficult to transmit the concept biodiversity to the public (Elder et al., 1998; Navarro-Perez & Tidball, 2012).

Several studies have indeed concluded that people have poor recognition and comprehension of the term 'biodiversity' (Fischer & Young, 2007; Lindemann-Matthies & Bose, 2008; Turner-Erfort, 1997). For instance, when over 6,000 visitors to zoos and aquariums worldwide were surveyed, it appeared that 30% was not even aware that biodiversity was related to biological issues (Moss et al., 2014). Understanding of biodiversity also differs between countries (European Commission, 2013). For instance, the Union for Ethical BioTrade (UEBT, 2018) reported that in Peru 94% of participants had heard of the term 'biodiversity' and 72% could provide a correct definition, yet only 59% of respondents in the Netherlands had heard of the concept and just 27% could correctly define it. This suggests that in at least some countries messages about biodiversity will not be understood correctly by the general public and it demonstrates that there is room for improvement.

2.1.1 The species literacy concept

Instead of relying on the technical concept of biodiversity, communicators can use simpler alternatives to represent biodiversity and communicate it in an accessible way. Species are highly suitable, as they are easy to relate to, they conjure up real images and may remind people of past experiences with them (Verboom et al., 2004). Species can further provoke widespread curiosity and can serve as examples to highlight problems posed to biodiversity. Conservation agencies and NGOs regularly use widely recognized and charismatic animal species as 'flagships' to capture people's attention, raise support for conservation

or educate the public about environmental threats (Clucas et al., 2008; Home et al., 2009; Senzaki et al., 2017). Hence, by getting to know species, people can take an important step towards awareness about biodiversity and conservation.

To emphasize the value and potential of knowledge about species, we introduce the concept of *Species Literacy*. Species literacy comprises broad as well as in-depth knowledge about species. Broad knowledge about species involves basic awareness: knowing the name and characteristics of species. For this a basic understanding of the species concept is required (Aldhebiani, 2018). As people expand their broad knowledge about species literacy, they become aware of an increasing number of species that they will be able to distinguish and identify. In-depth knowledge about species involves background information about a species: knowing its position in the ecological food chain (trophic level) and diet, its natural living environment (habitat), information about its life cycle (e.g. egg – larva - adult) and how it behaves. This includes awareness of the origin of a species (e.g. whether it is native) and insight into its abundance and rarity. When people grow their in-depth knowledge about species, they become increasingly knowledgeable about a particular species.

Species literacy goes beyond naming species and concerns different learning domains. It involves knowledge of facts, basic awareness and understanding, but also competences and skills, in particular species identification skills.

2.1.2 The potential of species literacy

Species literacy underpins comprehension of biodiversity and issues related to it. For instance, species knowledge is fundamental to understanding the relationships between species and the environment (Magntorn & Helldén, 2006; Somaweera et al., 2010). Species literacy can further ease communication and education about biodiversity and can be regarded as an important aspect of ecological and environmental literacy (Barker & Slingsby, 1998; Orr, 2005; Roth, 1992).

Moreover, knowledge about species can stimulate people's interest, in biodiversity but also the environment and sustainability (Palmberg et al., 2015). Getting to know species may help foster a connection with the environment (M. Clarke, 2013; Cox & Gaston, 2015) and species can provide people with a 'sense of place and belonging', indicating that species add to the authenticity of localities and can contribute to the attachment of people to their living environment

(Horwitz et al., 2001; Standish et al., 2013). In contrast, low knowledge about the local environment might point to a lack of a relationship with it (Louv, 2005).

In line with this, greater knowledge about species has been associated with positive attitudes towards them (Lindemann-Matthies, 2005). In fact, it has been argued that when people can identify a species, their relationship with it becomes more respectful and intensive (Mohneke et al., 2016). Schlegel & Rupf (2010) indeed demonstrated that animal species that could be identified and named, received higher affinity levels from participants. This is consistent with the idea that knowledge about species can enable people to better enjoy and appreciate them (Wilson & Tisdell, 2005).

Finally, species literacy has potential to help people make judgements and informed decisions. For instance, accurate perception of species richness allows people to recognize biodiverse areas (Junge et al., 2009; Shwartz et al., 2014) and notice changes (Weilbacher, 1993). Furthermore, Wilson & Tisdell (2005) reported that knowledge about vulnerable species can stimulate people to hypothetically allocate money to them, which suggests that raising species literacy offers opportunities for conservation. To conserve biodiversity, it is thus vital that not only conservationists, but all segments of society have knowledge about species.

2.1.3 Past research related to species literacy

Although species literacy is important, previous studies have reported a lack of species knowledge in the lay public. For example, it has been concluded that people have widely inaccurate ideas about the number of species in their country or worldwide (Lindemann-Matthies & Bose, 2008), and that although laypeople appreciate species richness, they do not accurately perceive it in local greenspace (Dallimer et al., 2012; Shwartz et al., 2014). Furthermore, people have been shown to be unaware of population declines (Courchamp et al., 2018; Penn et al., 2018) and misconceptions have been uncovered in the public concerning the diet, behavior or habitat of species (Kubiatko & Prokop, 2007; Prokop et al., 2007, 2008; Torkar, 2016; Yli-Panula & Matikainen, 2014).

In particular, concern has been raised about laypeople's limited knowledge about common, native species. Perceptions seem to be directed more towards exotic and domesticated species (Ballouard et al., 2011; Genovart et al., 2013). In line with this, studies have reported that the ability to identify native animals is meager in children (Balmford et al., 2002; Huxham et al., 2006; Prokop & Rodák,

2009; Randler et al., 2005), and adults (Vázquez-Plass & Wunderle, 2010). Moreover, when in Switzerland more than 6,000 participants aged between 8 and 18 were asked to list organisms in the local environment, on average they named only six animals and five plants (Lindemann-Matthies, 2002; Lindemann-Matthies & Bose, 2008).

Furthermore, studies have examined factors associated with species knowledge. For instance, species identification skills have been linked to an interest in nature (Palmberg et al., 2015) and to animal-related activities such as zoo visits or watching wildlife (Randler, 2010), suggesting that direct exposure to biodiversity drives species literacy. In line with this, in Brazil rural students performed better at identifying snakes than urbanites (Alves et al., 2014) and in Germany park visitors achieved higher identification scores than people who had not visited the park in the previous years (Randler et al., 2007).

However, factors such as education and media exposure may occasionally outweigh the impact of direct experiences on species literacy. For instance, in Puerto Rico people living in rural communities were found to be less knowledgeable about birds predominant in rural areas than urban residents, who were reported to have higher education levels (Vázquez-Plass & Wunderle, 2010). Media may drive people's perceptions of biodiversity as well, as studies have reported that they regularly focus on exotic and charismatic species, and taxa such as mammals (Ballouard et al., 2011; Huxham et al., 2006). Yet, species that live in close proximity to humans also tend to be represented (Correia et al., 2016) and searched for (Schuetz et al., 2015) more on the internet, indicating that feedback loops between direct and indirect experiences with biodiversity may further influence knowledge levels in the public.

The effects of age and gender on species knowledge have also been investigated. Age was found to be positively correlated with species identification skills (Randler, 2010; Randler et al., 2007), although in some studies the increase did not follow a linear pattern (Huxham et al., 2006; Randler, 2008a). Gender gaps have been uncovered as well, with studies generally reporting boys and adult men exhibiting greater knowledge about wildlife than females (Huxham et al., 2006; Nyhus et al., 2003; Peterson et al., 2008, 2017). However, a few studies have also reported opposite patterns, with girls (Schlegel & Rupf, 2010) or adult women (Nates Jimenez & Lindemann-Matthies, 2015a) achieving higher identification rates.

2.1.4 Aim of the study and research questions

Although several studies investigating species knowledge have been conducted, some important questions remain. First of all, studies have tended to overlook people who do work related to biodiversity and who may or may not have a raised species literacy (Lewinsohn et al., 2014). Therefore it is not yet clear how species literacy levels of different segments of the lay public compare to levels in professionals.

Furthermore, while it is apparent that knowledge about species varies between locations, very little information is available in the Netherlands. Yet, research is needed, as Dutch residents' familiarity with the biodiversity concept was found to be low (UEBT, 2018). The country is also highly urbanized, and although urbanization has been linked to a widening gap between people and nature and loss of ecological knowledge, previous studies have mostly been conducted in less densely populated countries (Miller, 2005; Pilgrim et al., 2008).

Finally, although studies have investigated potential determinants of species knowledge, further research is required to elucidate their relative importance. Moreover, if an association can be found between people's identification skills and attitudes towards nature and animals, this would imply that recognition of species can be regarded an indicator of people's attitudes to nature. This would offer conservationists possibilities to use species identification tests not only to obtain information on biodiversity awareness but also about the (dis)connection between people and nature.

In this study we explored species literacy in Dutch laypeople and professionals, using a species identification test. We used participants' ability to identify native animal species as a proxy for species literacy. Two groups of laypeople were included in the study: the general public, as well as primary school children. We specifically targeted primary school children, because children of that age are susceptible for information about nature, and assessing knowledge levels in this particular group could help set up educational strategies about biodiversity (Bjerke & Østdahl, 2004; Eshach & Fried, 2005; Magntorn & Helldén, 2006; Rivas & Owens, 1999).

We further aimed to determine positive and negative drivers for species literacy in laypeople, as they can eventually help bridge the potential gap between professionals and the lay public. For instance, we investigated variables

such as attitudes (towards nature and animals, and towards species identification), exposure to biodiversity and the socio-demographic factors age, gender and education level.

The following research questions were investigated:

1) What is the level of native animal species literacy in Dutch biodiversity professionals, primary school children and the general public?
2) What are positive or negative determinants for native animal species literacy in Dutch laypeople?

2.2 Methods

We designed a survey (Online Supplementary Materials: S_Ch2_Questionnaire) targeted at Dutch biodiversity professionals and laypeople. We regarded biodiversity professionals as people who do voluntary or paid work related to nature, biodiversity or animals, and laypeople as persons who do not do such work. Two groups of laypeople were targeted: the general public (aged 12 or older), as well as primary school children at fourth grade level (aged 9/10). Each survey was anonymous, taking into account privacy regulations and avoiding social desirability or 'prestige bias' in the answers (Streiner, David et al., 2015).

The questionnaire was similar for the different target groups; each included the same species identification test to assess species literacy. The survey targeted at laypeople also included potential determinants of species literacy. We assessed attitudes (towards nature and animals, and towards species identification), for which we used scales of five-point Likert scale questions (e.g. 1 = very boring, 5 = highly interesting). We also asked participants whether they had a garden at home and assessed media exposure and exposure to the outdoors by asking whether they had participated in certain animal-related activities in the past seven days (e.g. watching animals on television, or spending recreational time outdoors). For each of these questions an 'I do not know' option was included. Demographics were also included (e.g. gender). General public participants were asked for their age on a 10-point scale and educational level on a 6-point scale.

We started by piloting the study among colleagues in the field of Science Communication to detect possible errors and assess content validity. Subsequently, we tested the adjusted survey on people from the different

target groups, among which a class of 27 primary school children. As a result, we clarified several questions and a few questions were dropped. We found, for instance, that the identification test took too long with 40 species, but 25 to 30 would be suitable.

2.2.1 The species identification test

The species identification test consisted of 27 animal species native to the Netherlands: 13 birds, 9 mammals, 1 amphibian and 4 invertebrates. Participants were asked to identify each depicted animal by providing the name of the species as precise as possible (at the lowest taxonomic level). The African Lion- *Panthera leo* was used as an example to illustrate the instructions.

We selected species frequently encountered in Dutch (sub)urban areas according to collective counting days (e.g. www.tuinvogeltelling.nl: the Dutch version of the Big Garden Birdwatch citizen science program where people count garden birds), supplemented by a few species found mostly outside urban areas. For example, we selected the black-tailed godwit *(Limosa limosa)*, as this rural species was pronounced the 'Dutch National Bird' in 2015. The 27 native species were supplemented by 3 charismatic, exotic species in the survey targeted at laypeople (e.g. polar bear - *Ursus maritimus*), to keep participants motivated.

In the identification test, each species was represented by one color picture, downloaded from the website https://pixabay.com/. In order to make valid comparisons, the same images were used in the same order for the different target groups. We selected pictures of adults or imagines (e.g. butterfly instead of caterpillar) and made sure that pictures displayed species-specific morphological characteristics. For those species with clear male-female dimorphism an image of a male as well as a female was provided (e.g. blackbird - *Turdus merula* – see Figure 2.1).

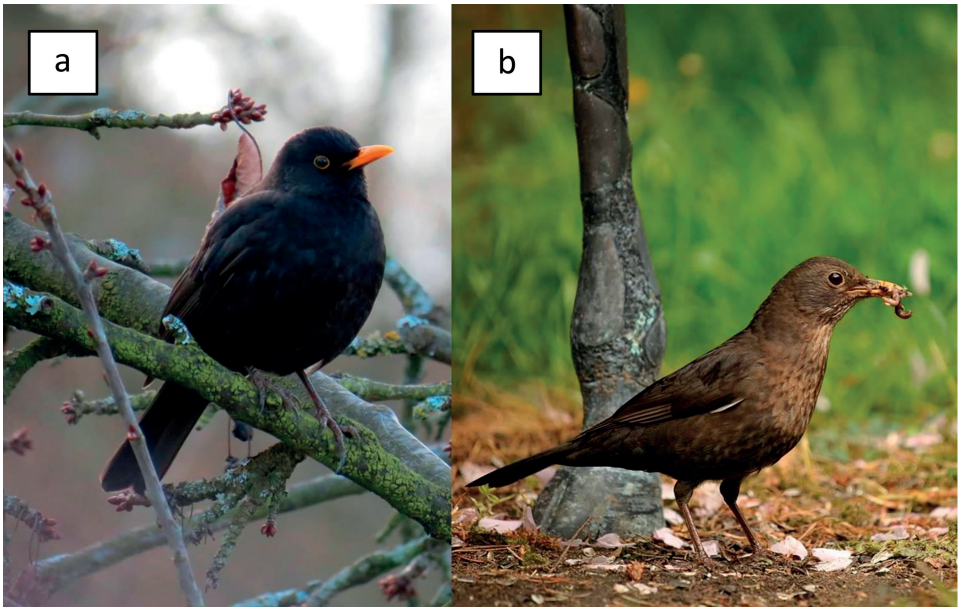


Figure 2.1 Male (a) and female (b) blackbird (*Turdus merula*; Dutch: merel); photo credits a. Manfred Richter b. Susan Mielke

2.2.2 Data collection

The surveys aimed at biodiversity professionals and the general public were made in Qualtrics (https://www.qualtrics.com) and distributed online. We targeted biodiversity professionals via e-mail, by contacting a large number of Dutch organizations and institutions involved with nature and biodiversity, such as nature conservancy organizations, zoos, and natural history museums. Data were collected between May and July 2018. The general public was targeted by distributing the survey via social media network websites between the 26th of June and 3rd of July 2018.

The survey was further administered at 17 primary schools spread across the Netherlands. We selected schools purposively, to include a variation of different school types, geographical locations as well as urbanity-levels (moderately urbanized to very highly urbanized – as determined via www.cbsinuwbuurt.nl). At some schools more than one class was visited and 27 classes were included in this study. Children were tested during normal teaching hours between April and July 2018. Beforehand, a passive permission request was sent by the teachers

to the children's parents, in which the objectives of the visit were explained and contact information was included. Schools were visited by one researcher with educational experience. First, the research was briefly explained and the children received an answer sheet, after which the test (referred to as a 'quiz') was carried out via Powerpoint. To limit pressure, the children were assured that they would not be graded. The average time of the survey was 45 min.

2.2.3 Processing of the answers to the identification test

The answers were checked manually and coded binomially: a correct species identification was awarded one point, incorrect identifications received zero points. A coding scheme was set to score the provided answers consistently – see Figure 2.2 and Appendix 2.1; more detailed guidelines can be found in the Online Supplementary Materials (S_Ch2_Scoring_Guide).

Some answers proved to be difficult to score. For example, auto-correct functions on digital devices can change input of online respondents. When needed, answers were discussed by three researchers until they agreed on the scoring.

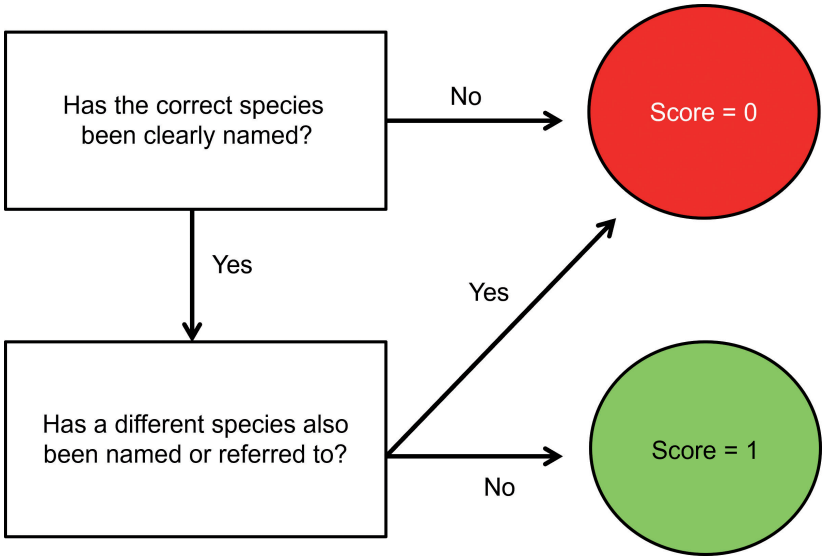


Figure 2.2 Basic coding scheme used for scoring the answers provided during the identification test.

2.2.4 Analyses and statistical procedures

Data were analyzed with R-3.4.1 (https://www.r-project.org). Levels of species literacy were determined by calculating the identification score per participant: the number of correct identifications. Moreover, identification rates were calculated for each species. The species literacy distributions and identification rates were subsequently compared between laypeople and professionals.

To identify possible drivers for species literacy in laypeople, we carried out correlation analyses by assessing the bivariate relationship between potential determinants and the species literacy level. Subsequently, we carried out a multiple regression analysis, to test the contributory effects of the different variables to species literacy. Linear regression models were constructed for primary school children and the general public separately.

2.3 Results

2.3.1 Descriptive statistics

In total, the data of 4,750 people were analyzed (Online Supplementary Materials: S_Ch2_Datasheet). The final dataset included 602 primary school children at fourth grade educational level (50% boys and 50% girls, average age of 9.6 years old (SD = 0.70)), 938 biodiversity professionals (e.g. conservationists, nature guides, communicators in zoos, and park rangers) and 3,210 participants from the general public. An examination of the demographic characteristics of the general public revealed that the obtained sample was diverse. However, when compared to the 2018 demographic census by Statistics Netherlands (CBS, https://opendata.cbs.nl), the dataset was strongly skewed towards highly educated citizens (86.6% had achieved higher professional or scientific education against 29.5% of Dutch residents (CBS). Furthermore, the sample underrepresented people under 25 and above 54, and overrepresented women (58% against 50.4% of Dutch residents).

2.3.2 Species identification rates

Identification rates for the 27 native animal species differed between target groups, and generally they were much higher in professionals than in laypeople – see Table 2.1. For each species primary school children showed the lowest identification rates. Only six species were identified by at least three quarters of the children. Eleven species, most of which can be easily found in gardens or city parks (e.g. blue tit, moorhen and jackdaw) were identified by fewer than 1 in 10 pupils. In contrast, all species but one were correctly identified by over 75% of the professionals. Participants from the general public generally showed intermediate identification rates.

In general, mammals received relatively high scores. Within each target group the red fox, red squirrel, hedgehog and wolf were identified correctly by over 90% of the participants; the hare and wild boar were successfully identified by over 75% of the participants. The bias towards mammals was most pronounced in primary school children, where the ten most identified species were predominantly mammal species. Relatively low identification rates in each target group were also found for the two species of butterfly.

Some species frequently identified by professionals were virtually unknown by laypeople. For instance, the long-tailed tit was identified by 78% of the professionals, compared to 17.7% of the general public and less than 1% of the children. Moreover, whereas 80.3% of professionals recognized the black-tailed godwit, only 42.5% of the general public and just 2.0% of the children identified this bird correctly. Common birds such as the blue tit, moorhen and chaffinch were identified by fewer than 5% of the pupils and by less than 40% of the general public.

Finally, some species were well-known by the general public and professionals, yet knowledge was lacking in primary school children. For instance, the magpie, kingfisher, blackbird and house sparrow were identified by less than 25% of the children, whereas over 85% of the general public and professionals correctly identified these species. Children also hardly recognized the roe (8.1%) and jackdaw (6%), whereas about half of the general public and over 90% of the professionals correctly identified these species.

Table 2.1 Idzentification rates for the 27 native animal species in primary school children, general public and biodiversity professionals (profs). Values denote the percentage of participants providing a correct answer (green = 75% or higher, yellow = 25–75%, red = below 25%).

	Species	Primary school children	General public	Profs
Vulpes vulpes	Red fox	97.2%	99.2%	99.7%
Sciurus vulgaris	Red squirrel	96.0%	99.5%	99.9%
Erinaceus europaeus	Hedgehog	92.0%	99.6%	99.5%
Canis lupus	Wolf	90.2%	98.4%	98.8%
Lepus europaeus	European hare	84.7%	95.2%	96.8%
Sus scrofa	Wild boar	76.6%	99.8%	97.2%
Porcellio scaber	Rough woodlouse	69.1%	92.5%	96.8%
Lutra lutra	Eurasian otter	61.3%	85.9%	85.5%
Bufo bufo	Common toad	50.8%	94.7%	97.1%
Meles meles	Badger	45.5%	85.5%	97.2%
Erithacus rubecula	Robin	39.7%	91.7%	98.1%
Araneus diadematus	Cross spider	37.2%	55.3%	77.9%
Pica pica	Eurasian magpie	23.3%	88.1%	98.6%
Alcedo atthis	Common kingfisher	20.9%	83.7%	98.9%
Turdus merula	Common blackbird	18.3%	86.0%	98.4%
Passer domesticus	House sparrow	15.9%	86.0%	94.1%
Capreolus capreolus	Roe deer	8.1%	53.6%	90.6%
Coloeus monedula	Jackdaw	6.0%	59.0%	91.0%
Podiceps cristatus	Great crested grebe	4.7%	63.5%	88.4%
Cyanistes caeruleus	Blue tit	2.3%	36.4%	84.4%
Limosa limosa	Black-tailed godwit	2.0%	42.5%	80.3%
Fringilla coelebs	Common chaffinch	1.8%	39.8%	86.6%
Gallinula chloropus	Common moorhen	0.8%	35.2%	80.0%
Chloris chloris	Greenfinch	0.5%	25.5%	80.0%
Vanessa atalanta	Red admiral	0.5%	25.8%	77.1%
Aglais urticae	Small tortoiseshell	0.5%	11.2%	55.2%
Aegithalos caudatus	Long-tailed tit	0.2%	17.7%	78.0%

2.3.4 Levels of species literacy

A gap in species literacy was found between professionals and laypeople – see Figure 2.3. The ability to identify species was high in professionals. On average they identified 89.9% of the species correctly and 48.7% even succeeded in identifying all or all but one species. In total, 88.0% of the professionals correctly identified over 75% of the species.

In contrast, species literacy was found to be low in primary school children aged 9/10. On average they identified only 35.0% of the species correctly. The majority (86.9%) recognized less than half of the species and 20.8% identified just 0 to 6 species correctly. Out of the 602 pupils only 2 identified over 75% of the species.

Species literacy was found to be higher in the general public than in the children, yet lower than in professionals. The general public on average identified 68.6% of the species correctly. Two in three participants (67.4%) failed at identifying over 75% of the species.

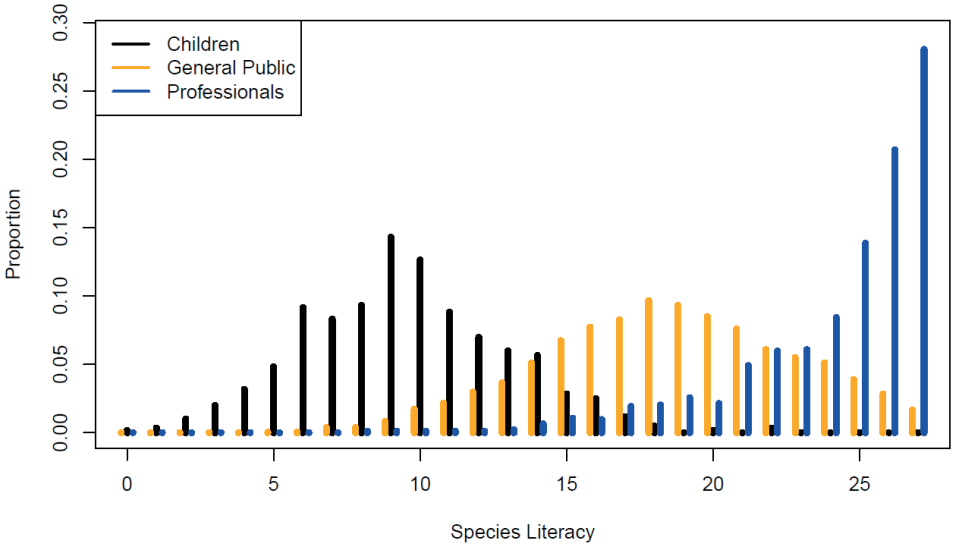


Figure 2.3 Distribution of species literacy in the three target groups (i.e. the proportion of each target group achieving a certain identification score)

2.3.5 Species literacy determinants in laypeople

Before identifying potential drivers for species literacy in laypeople, we checked validity for the different scales by calculating Cronbach's alphas. The attitudes towards nature and animals scale (8 items) and the media exposure scale (4 items) were acceptable in children (α = .83 and .69) as well as the general public (α = .84 and .52). The attitudes towards species identification scale (2 items in children; 3 in the general public) was also reliable (respectively α = .73 and .77).

As a next step correlation analyses were conducted, by assessing the relationship between potential determinants and species literacy – see Table 2.2. In both primary school children and the general public species literacy was not significantly correlated to gender, yet positive correlations were found between species literacy and attitudes towards nature and animals, exposure to the outdoors, media exposure, and having a garden at home. In addition, a positive correlation was found between species literacy and attitudes towards species identification in the general public, but not in children. Finally, in the general public species literacy was correlated positively to age and educational level.

Table 2.2 Pearson correlation coefficients (r) between species literacy and potential determinants in primary school children and the general public. For coding gender we used 1 = male, 2 = female; a negative r-value indicates males achieving higher scores. *p*-Values in bold indicate significance at a level of < 0.05.

	Primary School Children			General Public		
	r	**df**	***t-value***	***r***	**df**	***t-value***
Attitudes towards nature and animals	0.24	481	4.27***	0.42	3163	26.30***
Attitudes towards species identification	0.03	560	0.62	0.44	3193	27.76***
Exposure to the outdoors	0.12	574	2.97**	0.07	3189	3.98***
Media exposure	0.11	398	2.26*	0.21	3038	11.93***
Garden at home	0.26	587	6.48***	0.15	3208	9.35***
Gender	0.05	597	1.34	-0.02	3184	-1.17
Age				0.30	3208	17.58***
Educational level				0.07	3188	3.87***

* = $p < .05$, ** = $p < .01$., *** = $p < .001$.

After investigating correlations, multiple regression analysis was conducted to determine to what extent the different factors contributed to species literacy. For the school children, the predictors included in the model were the attitudes towards nature and animals, attitudes towards species identification, exposure to the outdoors, media exposure, garden, and gender. For the general public, the same predictors plus age and educational level were used. For both models, we visually checked the assumptions of normally distributed homoscedastic residuals and found no evidence against these assumptions.

In the regression model for primary school children (Table 2.3), significant contributors to the model were possession of a garden ($B = 2.93$, $p < .001$) and attitudes towards nature and animals ($B = 0.18$, $p < .001$). The results indicated that these two variables explained 14.9 % of the variance in species literacy (Adj. $R^2 = .149$, $F(6,289) = 9.62$, $p < .001$). Other variables, including gender, did not contribute significantly to the model.

In the model for the general public (Table 2.3), significant contributors to the model were in particular attitudes towards nature and animals ($B = 0.21$, $p < .001$), attitudes towards species identification ($B = 0.63$, $p < .001$), and age ($B = 0.61$, $p < .001$). In addition, species literacy was significantly predicted by gender, with males achieving slightly higher scores than females ($B = -0.42$, $p < .01$), educational level ($B = 0.27$, $p < .001$) and media exposure ($B = 0.20$, $p < .01$). Having a garden at home ($B = 0.73$, $p < .001$) further contributed significantly to the model, yet exposure to the outdoors did not predict species literacy. The regression accounted for 29.12% of the variance in species literacy (Adj. $R^2 = .291$, $F(11,291) = 123.60$, $p < .001$).

Table 2.3 Regression analysis of potential drivers of species literacy in primary school children and the general public. For coding gender we used 1 = male, 2 = female; a negative (Std.)*B*-value indicates males achieving higher scores. *p*-Values in bold indicate significance at a level of < 0.05.

	Primary School Children				General Public			
	B	**Std. Error**	**Std. *B***	***t*-value**	***B***	**Std. Error**	**Std. *B***	***t*-value**
Attitudes towards nature and animals	0.18	0.05	0.25	3.43***	0.21	0.02	0.19	8.93***
Attitudes towards species identification	-0.03	0.14	-0.02	-0.23	0.63	0.04	0.30	15.05***
Exposure to the outdoors	1.07	0.90	0.07	1.19	-0.26	0.14	-0.03	-1.84
Media exposure	0.03	0.15	0.01	0.16	0.20	0.06	0.05	3.14**
Garden at home	2.93	0.52	0.31	5.60***	0.73	0.15	0.08	4.92***
Gender	0.44	0.39	0.06	1.12	-0.42	0.13	-0.05	-3.19**
Age					0.61	0.05	0.19	11.89***
Educational level					0.27	0.08	0.06	3.55***

* = $p < .05$, ** = $p < .01$., *** = $p < .001$.

2.4 Discussion

2.4.1 Species literacy in professionals and laypeople

We introduced the concept of species literacy, which involves broad as well as in-depth knowledge about species. An important component of species literacy is species identification skills, which we regarded as a proxy for species literacy in this study. As data on species knowledge in the Netherlands were limited yet important in light of low levels of biodiversity awareness (UEBT, 2018), we explored species literacy in Dutch laypeople and biodiversity professionals. For this, we used a species identification test comprising 27 native animal species. Moreover, we investigated potential determinants of species literacy

Although we argue that species literacy is important for professionals as well as laypeople, a considerable gap was found between these target groups in the ability to identify native animals. Whereas biodiversity professionals correctly identified on average 89.9% of the native animal species, knowledge levels

were much lower in laypeople. Two in three general public participants failed at identifying 75% or more of the species. Primary school children aged 9/10 showed the lowest identification rate for each animal and demonstrated a general lack of species recognition. On average children only identified 35% of the species correctly. The results thereby confirm earlier studies that have suggested that native species are hardly in laypeople's minds (Ballouard et al., 2011; Genovart et al., 2013; Huxham et al., 2006).

In addition to the gap in species literacy, we found a biased perception towards mammals within each target group. This taxonomic bias is in line with previous studies reporting perceptions directed mostly to mammals (Huxham et al., 2006; Lindemann-Matthies, 2005; Patrick et al., 2013). Differences in identification ability between professionals and laypeople concerned bird species in particular. While professionals accurately distinguished and identified many birds, laypeople performed much worse and regularly failed at recognizing common species such as moorhen, chaffinch and blue tit.

Finally, we found that some species were well-known by professionals as well as the general public, yet knowledge was lacking in primary school children. For instance, whereas over 85% of the general public and professionals correctly identified the blackbird and the house sparrow, more than 80% of the children failed to identify these conspicuous species, again pointing to a limited species literacy.

2.4.2 Implications of the gap in species literacy

The high levels of species literacy in professionals are reassuring, yet the low levels in the lay public raise concern. The results imply that laypeople may face difficulties in learning about biodiversity, nature, and the environment. Whether the knowledge levels found in our study are adequate for achieving ecological and environmental literacy is questionable (Barker & Slingsby, 1998; Cutter-Mackenzie & Smith, 2003; Roth, 1992). In addition the gap in knowledge presents barriers when biodiversity is communicated in conservation campaigns or in educational projects. For instance, lack of knowledge about native species will make it harder to discuss biodiversity in a way that is locally relevant (Magntorn & Helldén, 2005).

The results further suggest that Dutch laypeople, especially primary school children, are currently disconnected from the local environment, as they had

poor knowledge of species that can be readily encountered. This is worrisome, as separation from nature may prevent people from building a personal relationship with it, leading to estrangement (Louv, 2005; Miller, 2005). Moreover, people tend to care about what they know and are less likely to protect species they lack knowledge about (Balmford et al., 2002; Schlegel & Rupf, 2010). Even though we did not assess attitudes towards specific species, this raises concern for vulnerable species that received low identification rates, such as the black-tailed godwit, a bird for which the Netherlands constitutes important breeding habitat (Kentie et al., 2016). In line with this, it has been argued that schoolchildren may be more prone to protect well-known exotic species rather than local species (Ballouard et al., 2011).

Finally the results show that a significant part of the Dutch public lacks the required skills to perceive native biodiversity accurately. As a result, people may overlook changes and underestimate species richness in their surroundings (Shwartz et al., 2014; Weilbacher, 1993). This could lead people to undervalue biodiverse, native habitats and could prevent them from making informed-decisions about the local environment. Dutch citizens might get the impression that nature is found only outside of the Netherlands and conclude that conservation should focus on other parts of the world (Verboom et al., 2004). In this light we mention that while it was not the aim of the study to investigate people's attitudes towards animals and nature in depth, we did notice that children's interest in foreign animals was higher than their interest in animals that occur in the Netherlands. Ultimately, the limited knowledge uncovered in laypeople could make it harder to build broad-based support for biodiversity conservation.

2.4.3 Drivers of species literacy in laypeople

Species literacy was found to be associated with various factors. Knowledge increased with age and educational level, in line with our expectations based on the literature. It seems that people in the Netherlands derive knowledge about species partly from education, and that they learn about species over the course of their lives. However, we do note that the higher level of knowledge in older participants also fits with the phenomenon of generational amnesia (Kahn, 2002; Papworth et al., 2009), a process of knowledge loss that can occur when younger generations get used to lower baselines of biodiversity. In the general public, male

participants further achieved slightly higher knowledge levels than females, yet gender did not seem to modulate the relationship with native animals in primary school children. While several previous studies have reported boys to outperform girls, our results therefore suggest that Dutch school girls might currently not experience the same gender socialization processes that have been put forward to explain lower knowledge levels in girls in other countries (Huxham et al., 2006; Kellert & Berry, 1987; Peterson et al., 2017).

In both groups of laypeople species literacy was associated with positive attitudes towards nature and animals. This is in line with the idea that knowledge about species may stimulate people's interest and may help foster affinities towards them (Palmberg et al., 2015; Schlegel & Rupf, 2010). However, our results do not demonstrate a causal relationship and positive attitudes towards animals may also motivate people to seek information and learning about them. This is in accordance with the association found between attitudes towards species identification and species literacy in the general public. Regardless of the direction of the relationship between species literacy and attitudes towards nature and animals, the findings indicate that species identification tests can provide information about people's connection to nature.

Furthermore, species literacy was associated with exposure to biodiversity through direct or indirect experiences. Although exposure to the outdoors did not predict species literacy, participants with a garden achieved higher species literacy scores, suggesting that people learn about native biodiversity close to their homes (e.g. watching birds at bird feeders (Cox & Gaston, 2015)). However, we cannot rule out confounding factors (e.g. highly educated people might not only be more knowledgeable but also be more likely to have a garden). Media exposure was also positively correlated with species literacy, yet it only contributed significantly to it in the general public. Taking into account the species identification rates, it seems that Dutch laypeople are currently exposed to media and other sources portraying biodiversity that outweigh the effect of direct experiences. While previous studies have reported abundant and highly visible animals to be correctly identified most often (Kai et al., 2014; Randler et al., 2007), Dutch participants had biased perceptions towards charismatic species not likely to be encountered, such as the red fox and the common kingfisher, while conspicuous and abundant birds and butterflies were poorly recognized. This pattern is in line with the predominance of charismatic species in children's

books, school books and the internet (Ballouard et al., 2011; Celis-Diez et al., 2016; Huxham et al., 2006).

2.4.4 Limitations of the study

It is important to note that the gap in species literacy that we report between professionals and laypeople is a conservative estimate. In the identification test, partial names (e.g. 'sparrow' instead of 'house sparrow') were evaluated as being correct, even though they potentially signal a misidentification (e.g. referring to other sparrow species). Under stricter evaluation procedures the gap in species literacy would have increased further, as laypeople more often than professionals provided partial names. Our sample of the general public was further strongly skewed towards highly educated people, and those with an interest in nature and animals will have been more likely to participate in the study. As species literacy was positively correlated to education and attitudes towards animals and nature, we expect species literacy of a truly random selection of the Dutch general public to be lower than the level found in our sample. Concerning children, previous research has indicated that species knowledge peaks at age 9 (Huxham et al., 2006) and that the affective appraisal of wildlife is relatively high in 9 and 10-years-olds as compared to 12–15-year-olds (Bjerke & Østdahl, 2004). The species literacy level we report here for the children will therefore probably be lower in pupils a few years younger or older.

Concerning determinants of laypeople's species literacy we used a scale to assess them. However, exposure to the outdoors was measured by only one item, and we acknowledge that the questionnaire may not have been sensitive enough to fully measure this potential driver. This may explain why this variable was not found to drive species literacy, even though previous studies have reported links between use of greenspace and knowledge about biodiversity (Coldwell & Evans, 2017; Randler, 2010; Randler et al., 2007). Moreover, the regression models accounted for only part of the variance in species literacy, which suggests that there are drivers for species literacy that have yet to be explored.

Lastly we emphasize that we regarded species identification skills as a proxy for species literacy. We argue that people who can correctly identify a species will be more likely to have in-depth knowledge about it. For instance, participants that in the current study misidentified the common kingfisher as a woodpecker, will not likely be aware of this birds' piscivorous diet. Further research is recommended to

establish how identification skills compare to other components of the species literacy framework. For instance, research by Courchamp et al. (2018) suggests that identification skills may not be indicative of insight into the conservation status of species.

2.5 Conclusion

This study is the first to explore species literacy in the Netherlands. We gathered data from a large sample of participants, and included biodiversity professionals to evaluate findings in the lay public more meaningfully. By demonstrating a considerable gap between Dutch professionals and laypeople in the ability to identify species, our study contributes to a growing body of international research showing that knowledge about biodiversity in the lay public is mediocre to poor. Ultimately this lack of knowledge may hinder future efforts to preserve biodiversity at local and global levels.

Our study suggests that a significant part of the Dutch lay public is 'species illiterate'. As laypeople regularly failed at identifying common and conspicuous animals, such as birds and butterflies, our study further points to a disconnection from the local environment and native biodiversity. The general lack of species recognition in children may even point to an increasing separation between people and nature. To investigate this further, we recommend that species literacy assessments are conducted every few years.

The low knowledge levels in the lay public pose challenges to conservationists, biodiversity communicators as well as educators. Our research indicates that for the majority of the Dutch public a small number of mainly mammal species stand out, as they connect to people's prior knowledge and recognition. Currently, these species will be better suited than others as flagship species in conservation campaigns or in educational strategies. However, this paper also signals the potential of raising awareness of species that are currently hardly known by laypeople.

Pathways aimed at fostering species literacy could tap into variables associated with it. For instance, opportunities could be created for people to experience native species in the immediate environment, at schools and via other sources, such as the media. Projects could feature species that are hardly known, yet occur close to where people live and work, such as birds and butterflies (Cosquer et

al., 2012; Cox & Gaston, 2015). Such species exist even in highly urbanized areas. Resources (e.g. apps) that provide people with ways to discern and distinguish species in the local environment could also raise interest and in turn, curiosity might stimulate people to learn more. We argue that primary school children especially are a suitable target group, as we found that there is much room for improvement in this group, and because childhood is considered to be a key period for connecting to and learning about nature (Eshach & Fried, 2005; Magntorn & Helldén, 2006; Rivas & Owens, 1999). Via children others can be reached too, such as family members (Diris & Lambrix, 2010).

Fostering knowledge about species should not be regarded as the sole route in combatting the widening gap between people and nature, yet it could make a valuable contribution. If people get to know local species, this may raise interest in their surroundings and encourage them to explore. In turn, this may offer people new ways to connect with nature. In the end, an increase in species literacy may help achieve a society that is aware of and connected to biodiversity, and that appreciates the diversity of species in the local environment. As a result, both biodiversity as well as the public will then benefit from the increased interactions.

The **grass snake** (Nederlands: **ringslang**) is a strong swimmer that mainly eats amphibians. It is a non-venomous snake that may feign death to escape predators.

Chapter 3

Species Identification Skills Predict In-depth Knowledge About Species

This chapter is based on:

Hooykaas, M. J. D., Schilthuizen, M., Albers, C. J., & Smeets, I. (2022). Species identification skills predict in-depth knowledge about species. *PLoS ONE*, *17*(4), e0266972. https://doi.org/10.1371/journal.pone.0266972

Abstract

To engage people effectively with biodiversity, communicators should be aware of knowledge levels in their audiences. Species identification skills have been used in the past as a measure of what people know about species, yet it is not known whether they serve as good indicators. To study the link between species identification and in-depth species knowledge, we presented an animal knowledge test to an online audience of over 7,000 Dutch adults, and used correlation and regression analyses to determine the extent to which species identification predicts in-depth knowledge about species' origin, habitat, diet, and behavior. We found that in-depth knowledge was higher in those who correctly identified species as compared with those who did not correctly identify species, for all four types of in-depth knowledge. Moreover, as compared to alternative variables (work, age, gender, and educational level), species identification was by far the best predictor for in-depth knowledge about species. However, species identification levels were generally higher than levels of in-depth knowledge, and knowledge gaps and misconceptions were uncovered. The results confirm the value of species identification tests, but also highlight limitations and challenges that should be taken into account when establishing knowledge levels and communicating biodiversity.

3.1 Introduction

Communication plays a vital role in building biodiversity awareness and public support for conservation. To do this effectively, biodiversity communicators should be aware of knowledge levels in their target groups. Prior knowledge influences the way in which audiences respond (Buijs et al., 2008; Hailikari et al., 2008; R. A. Thompson & Zamboanga, 2003), and materials can then be crafted according to existing knowledge gaps and misconceptions. However, research has shown that while people may be aware of their own level of knowledge (Mortimer et al., 2019), it is generally quite difficult to estimate knowledge levels (Dickens et al., 2013; Hooykaas et al., 2021, Chapter 6; Kelly & Haidet, 2007; Perrenet, 2010). In different fields, professionals struggle with making accurate judgements, even when they are confident about their estimation and prediction skills (Burgman, 2016; Tetlock & Gardner, 2015). This makes effective ways of assessing prior knowledge in the public highly important. Species identification tests have regularly been used to measure people's knowledge about species (Ballouard et al., 2011; Dixon et al., 2005; Gerl et al., 2021; Hooykaas et al., 2019, Chapter 2; Mohneke et al., 2016; Nyhus et al., 2003; Peterson et al., 2008; Randler, 2008a; Randler & Wieland, 2010; Remmele & Lindemann-Matthies, 2018; Vázquez-Plass & Wunderle, 2010), and to establish levels of ecological knowledge (Kai et al., 2014; Pilgrim et al., 2007) and knowledge about nature in general (Balmford et al., 2002). However, empirical proof that identification skills are good indicators of in-depth understanding is lacking.

Species identification skills are an important component of species literacy (Hooykaas et al., 2019; Chapter 2), which combines both 'broad knowledge about species' (notably knowledge that enables a person to identify, i.e. recognize and name species) and 'in-depth knowledge about species' (e.g. knowledge about where species occur, what they eat, and how they behave). Species literacy is regarded as a starting point towards awareness about biodiversity (Elder et al., 1998), which is crucial for building broad-based support in society for conservation (Greene, 2005; Novacek, 2008; Wilson & Tisdell, 2005).

Although levels of both species identification (Gerl et al., 2021; Hooykaas et al., 2019, Chapter 2) and in-depth species knowledge (Kubiatko & Prokop, 2007; Torkar, 2016; Yli-Panula & Matikainen, 2014) have been reported in the past, few studies have explored broad and in-depth species knowledge simultaneously, and when they did (Almeida et al., 2020; Huxham et al., 2006), it was not reported

how these were associated with each other. While it is often assumed that when people identify species correctly this also reflects their in-depth knowledge about those species, it is not known whether this is indeed the case. On the one hand an association between identification skills and in-depth knowledge is plausible, as recognition and naming can lead people to learn more about a species (Barker & Slingsby, 1998; Leather & Quicke, 2009). Moreover, even though authors have argued that people mainly use anatomical features to identify species (Tunnicliffe & Reiss, 1999), people use environmental and behavioral clues too. For example, an elephant on the African savannah will be recognized as an African elephant; a lizard may commonly be distinguished from a newt by noting that the animal is basking in the sun, not swimming underwater. Even names themselves may reveal a species' origin (e.g. Malayan tapir), habitat (e.g. forest thrush), diet (e.g. giant anteater), and behavior (e.g. splash tetra).

However, there are also signs that identification skills and in-depth knowledge may not be tightly linked. For instance, it has been suggested that children's ecological knowledge about species continues to rise throughout their primary years while their ability to correctly identify species peaks and then decreases (Huxham et al., 2006). Moreover, even though people may learn about species from brief exposure via the media or outdoors, such knowledge may remain fragmentary. For instance, a person may encounter a bird in a conifer forest and conclude that the species resides there, without knowing its name, or may recognize an animal that is frequently depicted in cultural sources (e.g. European robin or reindeer on Christmas cards) without knowing its way of life. In line with this, Yli-Panula & Matikainen (2014) found that respondents could name native animals, yet they did not link them to the indigenous fen ecosystem where they occurred, and Almeida et al. (2020) reported that children placed some well-known animals from the African savannah, zebras and giraffes, in Europe too. If species identification and in-depth species knowledge are not tightly linked, demographic variables such as people's age and educational level might be more suited for estimating in-depth knowledge, as they are easier to assess and have been reported to correlate with species identification skills (Hooykaas et al., 2019, Chapter 2; Randler, 2010; Randler et al., 2007).

To determine whether identification skills are suitable proxies for in-depth knowledge about species, we explored these two important components of species literacy simultaneously via an online questionnaire distributed among

Dutch adults. The questionnaire largely consisted of an animal knowledge test that assessed people's identification skills and their in-depth knowledge about species' origin, habitat, diet, and behavior. Subsequently, we compared people's species identification skills with their in-depth species knowledge, and we determined knowledge gaps and misconceptions. We calculated correlations and odds ratios for in-depth species knowledge and species identification, and we used univariate logistic regression analyses to determine the magnitude of association. As knowledge levels can differ markedly between laypeople and professionals who do work related to biodiversity, and between people of different ages, genders, and educational levels (Hooykaas et al., 2019, Chapter 2), we adjusted for these variables in our exploration of possible associations between the two types of knowledge. Our study provides valuable insights for people who study biodiversity awareness and those who communicate biodiversity, whether in education, research, or conservation, who may wish to use species identification tests in the future to estimate knowledge levels in their target groups.

We investigated the following research questions:

1) How do species identification skills in Dutch adults compare to their level of in-depth knowledge about species per theme (origin, habitat, diet, and behavior) and for themes combined?
2) To what extent does species identification reflect in-depth knowledge about species and how does this compare to alternative predictors (age, gender, educational level, and work)?

3.2 Methods

3.2.1 Survey design

We designed a questionnaire targeted at Dutch adults, aged 18 years and older (Online Supplementary Materials: S_Ch3_Questionnaire). The questionnaire consisted largely of an animal knowledge test, presented to participants as an 'animal quiz', that covered four themes: origin, habitat, diet, and behavior. To prevent the test from taking too long, each respondent was tested on two randomly selected themes.

Every theme included 15 different vertebrate animal species, making a total of 60: 29 mammals, 24 birds, 3 reptiles, 3 bony fish, and 1 amphibian. Half of the animals were native to the Netherlands, half were exotic. Based on a small pilot study we selected suitable species: we did not include animals with names that would automatically lead respondents to the right answer to the in-depth knowledge question and animals for which multiple answers would be correct (e.g. for theme origin we did not select the Asian elephant or species with a worldwide distribution).

The animals were shown successively, one by one, each represented by one color picture that displayed species-specific morphological characteristics, downloaded from the website https://pixabay.com/. We made sure that pictures did not provide clues to what the correct answer to the in-depth knowledge question might be; if needed we edited the pictures, e.g. by erasing the environmental background – see Figure 3.1. Per animal, two questions were presented: the respondent had to identify the species, and – depending on the theme – answer an in-depth knowledge question about the origin, habitat, diet, or behavior of the species. Both questions were four-answer multiple-choice questions, to avoid difficulties with determining when an answer would be correct; e.g. because of possible spelling mistakes. Careful crafting of the incorrect answer options ensured that respondents would not correctly identify the animal from physical clues in the name (e.g. for the green woodpecker, we included 'olive woodpecker' as an incorrect answer).

In addition to the animal quiz, demographic questions were included to assess gender, age (on a 7-point scale), and highest achieved education level (on a 4-point scale). Moreover, we asked participants whether they did voluntary or paid work related to nature, biodiversity, or wild animals; if so, respondents were identified as biodiversity professionals, otherwise as laypeople. The Ethics Review Committee of the Faculty of Science of Leiden University approved this study.

Figure 3.1 Picture of a common kingfisher (*Alcedo atthis*; Dutch: ijsvogel) used for theme diet; photo credits Lydia Simmons. We did not use a picture with water in the background, as this would have provided a clue about the birds' piscivorous diet.

3.2.2 Data collection and analyses

The questionnaire was constructed in Qualtrics (https://www.qualtrics.com) and distributed online via social media between the 27th of May and 10th of June 2021. After downloading the data from Qualtrics and compiling them in Microsoft Excel 365, we performed descriptive and statistical analysis in IBM SPSS Statistics (version 25.0).

First, the percentages of correct identifications and correct answers to the in-depth knowledge questions were calculated per theme and in total. In addition, identification rates and in-depth species knowledge rates were calculated per species, to uncover knowledge gaps and misconceptions. Next, we used paired *t*-tests to compare per theme the average levels of the two components of species literacy: species identification and in-depth species knowledge, and we compared the species literacy distributions between laypeople and professionals using Welch' independent samples *t*-tests.

Subsequently, we investigated the possible association between species identification and in-depth knowledge about species. First, we performed Pearson correlation analyses by assessing the bivariate relationship between species identification and in-depth species knowledge. Then we established the odds ratios (ORs) for in-depth species knowledge among people who did or did not correctly identify species. For this purpose, we determined how frequently both, either, or neither of the identification and corresponding in-depth knowledge question had been answered correctly – see Figure 3.2. We calculated odds ratios with 95% confidence intervals (CIs) for each theme and for all themes combined.

	In-depth species knowledge incorrect	**In-depth species knowledge correct**
Species identification incorrect	A	B
Species identification correct	C	D

Figure 3.2 Odds ratios were calculated using the frequency counts in a 2 by 2 contingency table via the following formula: (A*D)/(B*C). Frequency counts of A, B, C, and D were determined per theme and in total.

Finally, we conducted univariate regression analysis to determine the extent to which species identification contributed to in-depth knowledge about species, as compared to alternative factors: age, gender, educational level, and work. By including these variables in the model we controlled for biases in the sample of the target group.

3.3 Results

3.3.1 Descriptive statistics

Of the 8,954 respondents who had opened the questionnaire, 1,705 were excluded, e.g. because they did not provide consent to participate in the study or because they did not finish the animal knowledge test. The final dataset (Online Supplementary Materials: S_Ch3_Datasheet) comprised data from 7,249 participants; 1,909 indicated that they were professionals (26.3%), and 5,259 were identified as laypeople (72.5%). Compared to the 2021 demographic census by Statistics Netherlands (CBS, https://opendata.cbs.nl), the sample was biased towards highly educated citizens (70.8% had achieved higher professional or scientific education against 34.4% of Dutch residents). Moreover, the dataset overrepresented adults under 45 (61.8% against 41.6% of Dutch residents) and women (56.7% against 50.6% of Dutch residents).

3.3.2 Species literacy levels

On average, participants identified 68.5% of the species correctly. Concerning in-depth knowledge, respondents achieved lower scores (55.0%), particularly for knowledge about species' diet (49.3%) and behavior (48.8%) – see Table 3.1. Still, these percentages are considerably higher than the guessing percentage of 25%, indicating that part of the participants knew the correct answers.

Table 3.1 Paired *t*-tests comparing average levels of two components of species literacy: species identification and in-depth knowledge about species (subdivided into four themes). Each respondent was tested on two themes.

	N	Species identification (Mean)	In-depth species knowledge (Mean)	*t*	df	*p*
Origin	3,494	69.8%	59.7%	41.69	3493	<0.001
Habitat	3,680	69.7%	62.3%	36.66	3679	<0.001
Diet	3,675	67.8%	49.3%	90.10	3674	<0.001
Behavior	3,649	66.6%	48.8%	78.31	3648	<0.001
Total	7,249	68.5%	55.0%	113.51	7248	<0.001

Knowledge levels were significantly higher in professionals than in laypeople – see Table 3.2. Professionals performed better both at identifying species and at answering in-depth species knowledge questions.

	Laypeople		Professionals				
	N	Mean	N	Mean	*t*	df	*p*
Species identification (Total)	5,259	64.9%	1,909	78.4%	34.59	3271.39	<0.001
In-depth species knowledge (Total)	5,259	51.1%	1,909	65.7%	31.64	2915.39	<0.001
In-depth species knowledge (Origin)	2,543	55.9%	920	70.0%	18.51	1527.82	<0.001
In-depth species knowledge (Habitat)	2,650	58.5%	985	72.2%	22.68	1590.69	<0.001
In-depth species knowledge (Diet)	2,681	45.1%	956	61.1%	22.91	1441.32	<0.001
In-depth species knowledge (Behavior)	2,644	45.0%	957	59.4%	19.30	1448.71	<0.001

Table 3.2 Welch' independent samples *t*-tests comparing species literacy levels in laypeople and biodiversity professionals. Two components of species literacy were tested: species identification and in-depth knowledge about species (subdivided into four themes).

3.3.3 Knowledge gaps and misconceptions

Some animals were identified correctly much more frequently than others (Appendix 3.1). For instance, while over 95% of the respondents correctly identified exotic species such as the giant panda, polar bear, and koala, and species native to the Netherlands such as the European mole and robin, less than half of the respondents identified the native grass snake and red-backed shrike, and the exotic leopard seal and black-tailed prairie dog. Hardly anyone correctly identified the gelada, which was often mistaken for the hamadryas baboon even by professionals.

Considering in-depth knowledge, the same pattern was revealed. The origin, habitat, diet, and behavior were shown to be well-known for some species yet largely unknown for others. For example, while most people knew that giant

pandas eat bamboo and that white storks make sounds through bill-clattering, a minority of the respondents – including those who correctly identified the animals – knew that black-footed penguins originate from Africa, that okapis reside in rainforests (instead of savannahs), that bearded vultures predominantly eat bones, and that warthogs sleep underground in burrows. Misconceptions about native species were revealed too. Many people were unaware that the European green woodpecker has a diet that mostly consists of ants and instead thought that it mainly eats beetle larvae. Moreover, many respondents wrongly assumed that hares sleep in burrows like rabbits, while they usually do in a shallow depression in the ground, and that shelducks make floating nests, while they usually nest in burrows or cavities.

3.3.4 Association between in-depth knowledge and species identification

To investigate whether species identification skills are a suitable indicator for in-depth species knowledge, first Venn diagrams were constructed, which showed much overlap between correct species identifications and accurate in-depth species knowledge, especially in professionals – see Figure 3.3.

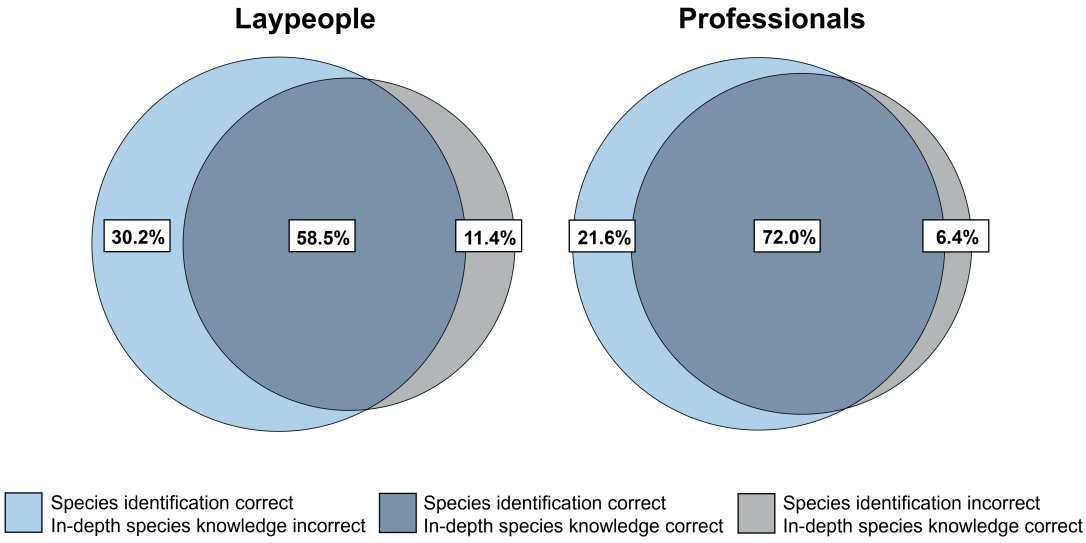


Figure 3.3 Venn diagrams showing the overlap in species identification and in-depth knowledge in both laypeople and professionals for the four themes combined.

Subsequently, we calculated correlations and odds ratios, and found that in-depth knowledge about species was positively associated with correct identification of those species for the four themes combined (OR: 7.18, 95% CI: 7.04–7.33; $r = 0.81$, $p < .01$). In other words, the odds of someone being aware of the origin, habitat, diet, or behavior of an animal were over 7 times larger if the person correctly identified the species. Moreover, an association was found for each theme separately, for knowledge about species' origin (OR: 5.75, 95% CI: 5.52–5.99; $r = 0.72$, $p < .01$), habitat (OR: 5.72, 95% CI: 5.50–5.95; $r = 0.71$, $p < .01$), diet (OR: 15.05, 95% CI: 14.31–15.82; $r = 0.76$, $p < .01$), and behavior (OR: 6.75, 95% CI: 6.48–7.04; $r = 0.73$, $p < .01$), both for professionals and laypeople (Appendix 3.2).

As a next step we conducted univariate regression analysis to determine to what extent species identification contributed to in-depth knowledge about species, as compared to alternative factors: age, gender, educational level, and work related to nature, biodiversity, or wild animals (hereafter: 'work'). Regression models were constructed for each theme of in-depth species knowledge separately and for all themes combined. Species identification was included as a predictor in the model, while age, gender, educational level, and work were added as fixed factors. The assumptions of normally distributed homoscedastic residuals were checked visually; no evidence against these assumptions was found. The percentages reported below are based on the adjusted *R*-squared values.

Species identification and work were significant contributors to the model for each theme and for all themes combined; age, gender and educational level contributed significantly to the models of only some themes – see Table 3.3. Out of all predictor variables, species identification clearly was the most important predictor, explaining in itself 44.2% (origin), 43.5% (habitat), 50,3% (diet), 46.6% (behavior), and 59.7% (themes combined) of the variance in in-depth knowledge about species.

Table 3.3 Regression analyses of predictors of people's in-depth knowledge about species (subdivided into four themes).

Theme & Variables	Type III	df	Mean	*F*	*p*	Partial Eta
Origin						
Species identification	11,129.87	1	11,129.87	2,668.64	<0.001	0.442
Work	293.42	1	293.42	70.35	<0.001	0.020
Gender	462.03	1	462.03	110.78	<0.001	0.032
Age	149.14	6	24.86	5.96	<0.001	0.011
Educational level	125.34	3	41.78	10.02	<0.001	0.009
R-squared = 0.542 (Adjusted *R*-squared = 0.540)						
Habitat						
Species identification	7,718.44	1	7,718.44	2,719.40	<0.001	0.435
Work	306.31	1	306.31	107.92	<0.001	0.030
Gender	283.89	1	283.89	100.02	<0.001	0.028
Age	16.33	6	2.72	0.96	0.452	0.002
Educational level	21.58	3	7.19	2.54	0.055	0.002
R-squared = 0.534 (Adjusted *R*-squared = 0.532)						
Diet						
Species identification	9,959.56	1	9,959.56	3,586.56	<0.001	0.503
Work	117.47	1	117.47	42.30	<0.001	0.040
Gender	7.64	1	7.64	2.75	0.097	0.037
Age	146.74	6	24.46	8.81	<0.001	0.012
Educational level	13.39	3	4.46	1.61	0.185	0.000
R-squared = 0.584 (Adjusted *R*-squared = 0.582)						
Behavior						
Species identification	10,624.70	1	10,624.70	3,057.02	<0.001	0.466
Work	418.43	1	418.43	120.40	<0.001	0.033
Gender	99.99	1	99.99	28.77	<0.001	0.008
Age	888.53	6	148.09	42.61	<0.001	0.068
Educational level	18.43	3	6.14	1.77	0.151	0.002
R-squared = 0.575 (Adjusted *R*-squared = 0.573)						
Themes combined						
Species identification	86,784.91	1	86,784.91	10,331.57	<0.001	0.597
Work	1,445.83	1	1,445.83	172.12	<0.001	0.024
Gender	1,773.53	1	1,773.53	211.14	<0.001	0.029
Age	950.99	6	158.50	18.87	<0.001	0.016
Educational level	163.60	3	54.53	6.49	<0.001	0.003
R-squared = 0.681 (Adjusted *R*-squared = 0.680)						

3.4 Discussion

Species identification tests have regularly been used to measure people's knowledge about species in general, yet without empirical proof that species identification is a good indicator of in-depth knowledge about species. To fill this research gap, we studied the expected link between these two important components of species literacy: species identification skills and in-depth species knowledge, by presenting an animal knowledge test to a large online audience of over 7,000 adult participants.

3.4.1 Levels of species literacy and misconceptions

We found that people were more likely to correctly identify species than to exhibit in-depth knowledge about them. In particular, knowledge about species' diet and behavior was relatively low. As expected, knowledge levels were significantly higher in professionals than in laypeople. Only a few species, such as the giant panda, polar bear, and robin, were well-known by both professional and lay participants, which links to previous studies that have concluded that people's perceptions are directed to only a minority of the species that exist (Ballouard et al., 2011; Davies et al., 2018; Lindemann-Matthies, 2005). The animals that were identified by most and for which the origin, habitat, diet, or behavior was generally answered correctly can be regarded as charismatic species; they feature frequently in society as cultural representations (Albert et al., 2018; Courchamp et al., 2018).

We also uncovered misconceptions, some of which seem to stem from generalizations where people extrapolate traits of species' relatives. For example, many people probably assume incorrectly that all vultures feed on meat from dead animals and that penguins are restricted in range to polar regions. Moreover, we noticed that some animals were frequently confused with a specific other species, which led to in-depth knowledge questions being answered incorrectly; e.g. the jaguar was often misidentified as a leopard and linked to Africa. Similarly, while virtually all respondents who recognized the cuckoo knew that the bird lays her eggs in the nest of another bird, those who misidentified the bird hardly ever chose the correct answer.

Misconceptions and misidentifications can have serious implications, e.g. when venomous and nonvenomous species are confused. In our study, people who misidentified the native nonvenomous grass snake as an adder or as a black

mamba usually assumed that the snake was venomous, which links to Corbett et al. (2005), who reported that participants tended to believe that many of the nonvenomous snakes presented to them were venomous. From a conservation perspective, this is unfortunate, as species that are deemed to be a risk to people's health may experience persecution. Furthermore, as laypeople were unaware of the way of life of certain animals, notably common, native species such as hares, green woodpeckers, and shelducks, they miss out on opportunities to enrich their lives, e.g. by growing a sense of place (Horwitz et al., 2001). The results demonstrate that there is plenty of room for educators to broaden people's perceptions.

3.4.2 Association between species identification and in-depth knowledge

As noted above, people were more likely to correctly identify species than to exhibit in-depth knowledge about them. For a considerable number of species (e.g. warthog, common eider, coconut lorikeet), only a minority of respondents who correctly identified them answered the in-depth knowledge question correctly, in line with studies that reported a lack of deeper understanding about animals that could be named (Almeida et al., 2020; Yli-Panula & Matikainen, 2014). This could be an indication that often people become familiar with the name or physical characteristics of an animal first, enabling them to accurately identify it, after which in-depth knowledge may or may not follow. Furthermore, people may learn isolated facts about species from brief exposure (e.g. via the media) and this knowledge may remain fragmentary, which may also explain that species identification did not mirror in-depth species knowledge perfectly.

Still, identification skills do not have to be perfect reflections of in-depth knowledge about species in order to serve as proxies. Thus, using correlation and regression analyses, we investigated to what extent species identification skills reflect in-depth knowledge about species. The odds for having in-depth knowledge about species were considerably higher for those who correctly identified species as compared with those who did not correctly identify species, both for knowledge about species' origin, habitat, diet, and behavior. Moreover, species identification was by far the best predictor for in-depth species knowledge in comparison to other factors (work, age, gender, and educational level). Although our respondents were all from the Netherlands, we have no reason to doubt that our results have international applicability, as species identification tests have revealed similar knowledge patterns in different countries.

3.5 Conclusion

In conclusion, we provide evidence that species identification skills are associated with in-depth knowledge about species. Species identification can predict in-depth species knowledge reasonably well, and a lot better than demographic characteristics such as age and highest achieved educational level, which underscores the value of using species identification tests to assess what people know about animals. However, as people tended to experience more difficulty with the in-depth knowledge questions than with the identification of the species, and as misconceptions were uncovered about species that were correctly identified, researchers and communicators should take into account that such tests hold limitations. Such restrictions may depend on the animal group that is included in a test and the type of in-depth knowledge that is assessed, something which future research could elucidate. Moreover, future studies could determine whether the association between identification and in-depth knowledge also applies to taxa such as plants and fungi.

Communicators could use a variety of short quizzes to address different knowledge components in their target audiences. A mix of such assessments could help them in becoming aware of current knowledge levels and existing misconceptions. By adjusting their communication accordingly, they will be able to engage the public more effectively on the topic of biodiversity. Moreover, we recommend educators who aim to expand species literacy in their audiences to embed species in context, e.g. by sharing information about how they can be identified and combining this with fun facts and background information about their living environment, diet, or behavior. This can connect people with the vast diversity of life that exists worldwide and in the local environment, which can ultimately help build broad-based public support for conservation.

Part II:

Cultural Sources

The **jackdaw** (Nederlands: **kauw**) pair-bonds for life. Pairs stay together within flocks and nest in cavities.

Chapter 4

Animals in Fashion: Portrayal of Animal Biodiversity on Children's Clothing

This chapter is based on a paper that has been accepted in July 2021 for publication in Society & Animals

Abstract

While cultural products such as clothes are usually not designed with an educational goal in mind, they may still raise biodiversity awareness. This study explored the portrayal of animal biodiversity on children's clothing marketed by three major clothing retailers in the Netherlands. Findings showed that although nonhuman animals were a common theme, diversity was quite low. The portrayal was centered on mammals, in particular exotic and domestic species, and a gender binary was uncovered, restricting animals such as dinosaurs to boys' clothes and butterflies to girls' clothes. Moreover, portrayals were often highly simplified and anthropomorphic, which reduced recognizability. The results show that children's clothes currently do not offer a balanced and iconic depiction of animal biodiversity needed for broadening people's perceptions. In order to achieve a more extensive representation that can help connect people with biodiversity, a shift in ideas will be required of what animals are suitable to portray.

4.1 Introduction

While the human population grows and the world becomes increasingly urbanized, many non-human animals are rapidly dropping in numbers (Ceballos et al., 2017; Dirzo et al., 2014). To halt the decline, it is vital that the public is aware of animal diversity. However, previous studies have concluded that laypeople's perceptions of biodiversity are limited. For instance, many children are only aware of a small number of domestic and exotic species that they also show affinities towards, while they experience difficulty with identifying native animals (Ballouard et al., 2011; Celis-Diez et al., 2017; Genovart et al., 2013; Hooykaas et al., 2019, Chapter 2; Lindemann-Matthies, 2005). This limited and biased perception may prevent children from building lasting connections to biodiversity (Cox & Gaston, 2015), and could negatively affect future support for conservation (Kim et al., 2014; Wilson & Tisdell, 2005).

Previous authors have linked the low levels of awareness about biodiversity to a decline in direct exposure. This "extinction of experience" may inhibit people from learning about animal biodiversity (Kai et al., 2014; Pilgrim et al., 2007, 2008), and could lead to an increasing, emotional separation of people from nature (Miller, 2005; Soga & Gaston, 2016). However, people learn about animals not only through direct encounters with real animals, but also through exposure to cultural representations of animals. Representations of animals are found in society in many shapes and forms, in the media, architecture, art, and in cultural products that range from toys to clothes. Together, these cultural sources reflect how society relates to animals, but more importantly in this context they also make biodiversity accessible to the general public in new ways (Kellert, 2002). For instance, people are far more likely to encounter vulnerable, reclusive, or exotic species vicariously than in real life outdoors (Courchamp et al., 2018).

Especially in highly urbanized countries, cultural representations play an increasing part in shaping people's perceptions of biodiversity (Prévot-Julliard et al., 2015; Soga, Gaston, Yamaura, et al., 2016). By offering indirect ways of experiencing animal diversity, these portrayals may compensate for a reduction in direct experiences. This links to cultivation theory, which highlights the impact of vicarious experience on people's perceptions (Gerbner, 1969; Potter, 2014). Indeed, there are indications that exposure to animal portrayals in cultural sources such as the media triggers interest and engagement (Fernández-Bellon & Kane, 2019; Fukano et al., 2020; Soga, Gaston, Yamaura, et al., 2016), fosters species

literacy (Alves et al., 2014; Ballouard et al., 2011; Dixon et al., 2005; Hooykaas et al., 2019, Chapter 2), and may help build positive attitudes towards animals (Barbas et al., 2009; Barney et al., 2005; Fukano et al., 2020; Kalof et al., 2015). In line with this, the International Union for Conservation of Nature partnered up with fashion brand Lacoste in 2018 for a campaign in which the usual crocodile emblem on Lacoste polos was replaced for ten endangered animal species, in an effort to increase awareness of and support for these species.

While some cultural products are purposefully designed to educate people about animals, the majority of them are not. However, by portraying animals the latter do influence people's connections with biodiversity, as it is known that subtle and repeated exposure can induce positive changes in attitudes and preferences (Bornstein & D'Agostino, 1992; Kaikati & Kaikati, 2004; Kalof et al., 2015; Roy & Chattopadhyay, 2010; Zajonc, 1968). Interest in cultural representations of animals has increased in recent decades, although some cultural products have received more attention than others. Most studies have explored the portrayal of animal diversity on the internet (Ballouard et al., 2011; Berland, 2019; Correia et al., 2016; Roberge, 2014; Roll et al., 2016; Schuetz et al., 2015) and in print media (Celis-Diez et al., 2016; Clucas et al., 2008; Genovart et al., 2013; Marriott, 2002; Sousa et al., 2017). One cultural product that has received little attention in studies on animal representations is clothing.

4.1.2 The role of the fashion industry

There has been no extensive study on how the fashion industry portrays and appropriates biodiversity. However, clothes do portray animals, especially those marketed towards young children, who are at a suitable age to learn about animals and whose knowledge levels and affinities towards animals have been shown to affect future perceptions and pro-conservation behaviors in adults (Hinds & Sparks, 2008; Kahn, 2002; Kellert, 1985, 2002; Pilgrim et al., 2007). Moreover, although they are usually not designed to raise awareness about biodiversity, clothes are used in daily life and therefore constitute a frequent public display (Feinberg et al., 1992). As such, children's fashion offers subtle and repeated exposure (Bornstein & D'Agostino, 1992; Roy & Chattopadhyay, 2010), which we regard as a potential route to subtly raise awareness about biodiversity.

However, several factors may compromise opportunities to raise biodiversity awareness through clothes. First, biases in the portrayal could expose people

to animals that they are already familiar with. It has been reported that in other cultural products vertebrates outnumber invertebrates, and that birds, and mammals in particular, predominate over fish, amphibians, and reptiles (Fernández-Bellon & Kane, 2019; Nemésio et al., 2013; Sousa et al., 2017). Exotic and domestic species also seem to be featured relatively often as compared to their native, and wild counterparts (Ballouard et al., 2011; Celis-Diez et al., 2016; Huxham et al., 2006). Such biases are expected in children's fashion too and may stem from deliberate choices by designers based on what animals they expect to appeal to consumers, or from limited and biased perceptions of biodiversity that they hold themselves. The tight link between the fashion, media, and entertainment industry is also likely to influence what animals are portrayed, as cartoon characters are expected to be popular choices to portray. Rather than expand, skewed representations would reinforce biases in people's perceptions of biodiversity.

Secondly, clothing designers use artistic freedom in their designs, which may result in low specificity of portrayals. Whereas realistic or iconic depictions allow for precise identification ("a blackbird"), an animal that is depicted in an artistic or abstract way is likely to be identified at a higher taxonomic level ("a bird"). Designers may even purposefully transform animals into cute and marketable commodities to appeal to consumers (Cole & Stewart, 2016). For instance, anthropomorphism is a widely used stylistic device when portraying animals in cultural products, that may make animals relatable for people (A. A. Y.-H. Chan, 2012; Geerdts, 2016; Root-Bernstein et al., 2013), yet may also reduce recognizability by misrepresenting the true character of a species (Ganea et al., 2014; Geerdts, Van De Walle, et al., 2016; Marriott, 2002). Moreover, a preference for anthropomorphic animals may create a biased inclusion of animals that are more easily anthropomorphized (Huxham et al., 2006), mammals in particular.

4.1.2 Aims of the study

We studied the portrayal of animal biodiversity in childrenswear offered by fashion retailers in the Netherlands, a highly urbanized country in Western Europe, where vicarious sources are expected to play a relatively large part in shaping people's perceptions of biodiversity (Prévot-Julliard et al., 2015), and where biodiversity awareness was found to be low, especially in children (Hooykaas et al., 2019, Chapter 2). By exploring the range of animals featured on

children's clothing we aim to shed light on the species that children encounter in their daily lives, and to determine both the current learning potential and room for improvement.

We determined which taxonomic groups and types of animals were portrayed, to what level the animals were specified, and whether the animals were anthropomorphized. As some animals seem to be culturally associated with either the male or female gender (Lash & Polyson, 1988), and clothes can be an expression of gender identity (Dodd et al., 2000; Goodman et al., 2007), we also investigated possible differences in portrayal between clothes marketed towards different genders.

We formulated the following research questions:

1) Which taxa and types of animals (exotic or native, and domestic or non-domestic) are portrayed?
2) To what taxonomic rank are the portrayed animals specified?
3) What proportion of the portrayed animals are anthropomorphized?
4) How does the portrayal of animal biodiversity differ between clothes marketed towards different genders?

4.2 Methods

We conducted a quantitative content analysis of the animals portrayed on clothes marketed online towards children aged 2-10 by three major clothing retailers in the Netherlands: Zalando, H&M, and C&A. By including these three retailers, we accounted for variation in pricing and target groups, and provided a robust sample of the clothing supply for children offered to Dutch customers.

4.2.1 Data collection

Data were collected on three consecutive days at the beginning of November 2019. Clothes were sampled digitally: for each of the three online stores, we scanned the first 500 newest clothing items offered on their respective websites for boys and girls aged 2-10 (sizes 92-140), making a total of 3,000. Web cookies were deleted between rounds of data collection to increase reliability. We excluded shoes, bags, jewelry, badges, undergarments, and nightwear from the selection. Pictures of clothing items that portrayed animal biodiversity were downloaded

for further processing. Clothing item duplicates marketed both towards boys and girls were regarded as "unisex" and included only once.

4.2.2 Coding of the animals

A codebook was designed to code the animals depicted on the clothes (Online Supplementary Materials: S_Ch4_Codebook). Per clothing item, a maximum of five animal species was coded, scanning the garment horizontally from the top left to the bottom right. Depictions of both extant and extinct animals were included; fantasy creatures (e.g., unicorns) and biodiversity elements such as feathers, footprints, and skin patterns were excluded.

First, each animal was identified at the lowest possible taxonomic level, drawing from the literature and professional experience. Subsequently, the taxonomic affiliation was noted using the English Wikipedia (species, family, order, and class, and whether the animal was an invertebrate or vertebrate). We treated dinosaurs as a taxonomic class, to separate them from other reptiles and birds. In addition, we coded the type of animal (native or exotic, and domestic or non-domestic), using lists of animal species native to the Netherlands and a list of domestic animals.

To explore the level of distortion in the portrayal and recognizability, we finally noted for each animal the lowest taxonomic rank at which it could be identified, and its depiction state (anthropomorphized or not). Animals were coded as anthropomorphic when they showed one or more of the following characteristics: wearing clothes or accessories, human behavior (including human posture), and human facial features – see Figure 4.1.

4.2.3 Intercoder reliability

Coding was performed by two researchers, including the lead author, who checked all data entries. For anthropomorphism, intercoder reliability was calculated by comparing the independent coding of a randomly chosen quarter of the animals. Intercoder reliability was high (percent agreement = 95.2%, Cohen's Kappa = .90), indicating a strong level of agreement between the two coders (McHugh, 2012). The cases where there was disagreement between the two coders were resolved through discussion.

Figure 4.1 Different forms of anthropomorphism. Wearing clothing: a dog wearing a winter hat (a); human behavior: a skiing polar bear (b); human facial expressions: happy dinosaurs (c). These examples from clothing items marketed by C&A (a and b) and Zalando (c) were not part of the final dataset, yet feature portrayals similar to those coded during the project.

4.2.4 Data analysis

A descriptive and statistical analysis of the data was performed in SPSS Statistics (version 25.0). First, we made frequency tables for the taxonomic groups, specificity of the identification, and anthropomorphism, and subsequently we used two-tailed chi-square tests of independence with a significance level of $p \leq 0.05$ to analyze relationships between the categorical variables. To determine differences in portrayal of taxonomic groups per gender, we compared the five most frequently featured classes, and the twelve most frequently featured orders, families, and species. To account for multiple testing, a strict Bonferroni adjustment was applied when making multiple comparisons.

4.3 Results

Of the 3,000 clothing items that were sampled, 18.3% portrayed one or more animals. The clothes constituted mostly sweaters, t-shirts, and trousers, and due to the season hats and mittens were regularly encountered as well. The final dataset (Online Supplementary Materials: S_Ch4_Datasheet) comprised 549 clothing items (H&M: 201, C&A: 217, and Zalando: 131) depicting 827 animals in

total (H&M: 341, C&A: 316, and Zalando: 170). Clothes marketed towards boys (331) featured animals more often than clothes marketed towards girls (215); only three clothing items were unisex.

4.3.1 Taxonomic representation

The vast majority (90.9%) of the animals portrayed on the children's clothing represented vertebrates. Mammals were the most featured class (54.3%), followed by dinosaurs (27.7%), birds (7.5%), insects (7.4%), and arachnids (1.5%). Other classes, whether vertebrate or invertebrate, were present in the dataset only a few times or were lacking altogether, such as amphibians – see Table 4.1.

From the 827 animals, most could be assigned to a taxonomic order (98.3%) and a taxonomic family (84.9%). In total, animals from 34 orders and 74 families were found. Many orders and families were featured only once or twice, yet a few were highly prevalent – see Tables 4.2 and 4.3.

Carnivores were the most common order, representing in particular canids, felids, and bears. Other mammalian orders that were portrayed often included even-toed ungulates and cetaceans, mainly due to a high number of deer, and rodents, due to the prevalence of mice.

Saurischian dinosaurs (e.g., tyrannosaurids) and Ornithischian dinosaurs (mainly ceratopsids and stegosaurids) were portrayed often too, as were butterflies, of which a considerable number concerned brush-footed butterflies. Considering birds, songbirds and "waterfowl" (anseriforms, represented by ducks and swans), were most prevalent.

Only 51.1% of the animals could be identified at the species level. In total, 71 different animal species were encountered, yet only a few, particularly domestic and exotic mammals, were portrayed frequently times – see Table 4.4.

Table 4.1 Frequency of nonhuman animals portrayed on clothes marketed towards boys, girls, and total (including unisex), per taxonomic class.

Class		Boys	Girls	Total	
	Mammals	250	194	449	54.3%
	Dinosaurs	229	0	229	27.7%
	Birds	23	39	62	7.5%
	Insects	0	61	61	7.4%
	Arachnids	12	0	12	1.5%
	Bony fish	5	1	6	0.7%
	Reptiles	4	1	5	0.6%
	Cartilaginous fish	1	0	1	0.1%
	Crustaceans	1	0	1	0.1%
	Snails and slugs	1	0	1	0.1%

Note: The total number of animals was 827 (526 for boys and 296 for girls). The unisex clothing items portrayed five mammals.

Table 4.2 The 12 most featured nonhuman animal orders portrayed on clothes marketed towards boys, girls, and total (including unisex), and their frequency of occurrence.

	Order	Boys	Girls	Total	
	Carnivores	155	65	224	27.1%
	Saurischian dinosaurs	135	0	135	16.3%
	Even-toed ungulates and cetaceans	51	43	95	11.5%
	Rodents	28	50	78	9.4%
	Ornithischian dinosaurs	73	0	73	8.8%
	Butterflies and moths	0	59	59	7.1%
	Rabbits, hares, and pikas	1	19	20	2.4%
	Songbirds	3	16	19	2.3%
	Pterosaurs	15	0	15	1.8%
	Odd-toed ungulates	6	8	14	1.7%
	Anseriforms ("waterfowl")	6	7	13	1.6%
	Spiders	12	0	12	1.5%

Note: The total number of animals was 827 (526 for boys and 296 for girls). The unisex clothing items portrayed one deer (Cetartiodactyla), two bears (Carnivora), and two foxes (Carnivora). The animal icons in black, dark gray, and light gray represent mammals, dinosaurs, and other animals, respectively.

Table 4.3 The 12 most featured families of nonhuman animals on clothes marketed towards boys, girls, and total (including unisex), and their frequency of occurrence.

Family + example(s)		Boys	Girls	Total	
	Canids	67	12	81	9.8%
	Felids	36	40	76	9.2%
	Deer	41	33	75	9.1%
	Mice	23	46	69	8.3%
	Tyrannosaurids	56	0	56	6.8%
	Bears	38	9	49	5.9%
	Ceratopsids	29	0	29	3.5%
	Stegosaurids	28	0	28	3.4%
	Rabbits and hares	1	19	20	2.4%
	Brush-footed butterflies	0	18	18	2.2%
	Pteranodontids	15	0	15	1.8%
	Ducks, geese, and swans	6	7	13	1.6%

Note: The total number of animals was 827 (526 for boys and 296 for girls). The unisex clothing items portrayed one deer (Cervidae), two bears (Ursidae), and two foxes (Canidae). The animal icons in black, dark gray, and light gray represent mammals, dinosaurs, and other animals, respectively.

Table 4.4 The 12 most featured nonhuman animal species on clothes marketed towards boys, girls, and total, and their frequency of occurrence.

Class		Boys	Girls	Total	
	House mouse	23	46	69	8.3%
	Dog	54	6	60	7.3%
	Brown bear	23	1	24	2.9%
	Cougar	13	10	23	2.8%
	Moose	15	8	23	2.8%
	Domestic cat	3	18	21	2.5%
	Reindeer	13	6	19	2.3%
	Tiger	16	1	17	2.1%
	T.rex	14	0	14	1.7%
	Raccoon	10	2	12	1.5%
	Red fox	7	5	12	1.5%
	Horse	4	5	9	1.1%

Note: The total number of animals was 827 (526 for boys and 296 for girls). Only 51.1% of the animals were identified as a distinct species. The unisex clothing items did not portray animals specified at the species level. The animal icons in black and dark gray represent mammals and dinosaurs, respectively.

4.3.2 Type of animals

Most animals (72.3%) that were portrayed were extant, while the remainder were dinosaurs and thus (under our definition of this group) extinct. Out of the extant animals for which the origin could be determined (341), two-thirds (67.4%) were exotic (e.g., bear, tiger) and one-third (32.6%) were native (e.g., house mouse, red fox). Furthermore, 30.6% of the extant animals were domestic species (e.g., house mouse, dog, cat, horse, duck, llama). Many represented cartoon characters, e.g., characters from PAW Patrol, Minnie and Mickey Mouse, and Hello Kitty. For a small number of animals (2.8%), it could not be determined whether they were domestic or not (e.g., it was unclear for some rabbits whether they represented a domestic rabbit or a different species).

4.3.3 Portrayals

Often animals were featured prominently as the focal point of the clothing item, although there also were subtle depictions (e.g., logos of brands such as Puma and Abercrombie & Fitch). Most animals were portrayed in unrealistic ways, as the depictions were simplified or abstracted to a varying extent. This influenced recognizability – see Figure 4.2; only 51.1% could be identified at the species level. Furthermore, 13.4% of the animals were identified at the genus level, 20.3% at the family level, and 13.4% at the order level. The remaining 1.7% could only

Figure 4.2 Portrayals ranged from (photo)realistic (a and b) to (highly) abstracted (c and d), influencing the level at which nonhuman animals could be identified; e.g., whereas (b) unmistakably portrays a tiger, (c) depicts penguins, yet which species they represent is unclear. Using contextual information, famous cartoon characters such as Mickey Mouse in (d) were identified at the species level, despite large dissimilarities with the species from which they have been derived. These examples from clothing items marketed by Zalando (a, b, and c) and H&M (d) were not part of the final dataset, yet feature portrayals similar to those coded during the project.

be assigned to a taxonomic class (e.g., "bird"). Mammals were specified at lower taxonomic ranks than animals from other taxonomic classes. Whereas 79.3% of mammals were identified as species, only 17.7% of non-mammalian classes could be assigned to the species rank ($\chi2(1, N = 827) = 311.28$, $p < .001$, Cramér's $V = 0.61$). About half of the mammals identified at the species level (48.9%) represented domestic animals.

About half of the clothing items (52.5%) depicted animals anthropomorphically. Clothes regularly featured anthropomorphized cartoon characters, and other animals with clothing or accessories, human behavior, and/or human facial features. In total, 44.8% of the animals were anthropomorphic, yet the proportion varied between different taxonomic classes ($\chi2(9, N = 821) = 186.10$, $p < .001$, Cramér's $V = 0.48$). Over half of the portrayed mammals (63.5%) and birds (58.1%) showed human characteristics, whereas only 21.9% of dinosaurs and no invertebrates (e.g., insects, arachnids) were depicted in an anthropomorphic way.

4.3.4 Difference in portrayal between genders

The portrayal of biodiversity differed between clothes marketed towards boys and girls, at the class, order, family, and species level – see Tables 4.1 - 4.4, Appendix 4.1. Clothing items marketed towards boys featured more animals (526) than those marketed towards girls (296). This difference seemed to be caused by a large number of dinosaurs, which were only featured on boys' clothes. Without dinosaurs, the number of animals in the dataset would be equal for boys and girls (297 versus 296, respectively). The other large difference between genders was that butterflies were restricted to girls' clothes.

Proportionally, both mammals and birds were more common on girls' clothing. Songbirds, rodents – in particular mice, represented mostly by the cartoon character Minnie Mouse – and rabbits and hares were depicted more often on girls' clothes. In addition, felids, notably house cats, were also found more frequently on girls' clothes. In contrast, canids, in particular dogs, and brown bears, were portrayed more frequently on boys' clothing.

Furthermore, animals portrayed on girls' clothes were anthropomorphized more often (52.2%) than those marketed as boys' clothing (40.9%) ($\chi2(1, N = 816) = 9.75$, $p = .002$, Cramér's $V = 0.11$). This may be explained by the frequent occurrence of cute-ified and feminized animals on girls' clothing (e.g., animals with feminine eyelashes, blushing cheeks, or a ribbon bow) – see Figure 4.3.

Figure 4.3 Nonhuman animals portrayed on girls' clothes were regularly 'cute-ified' and 'feminized', e.g. by adding blushing cheeks and feminine eyelashes (a). These characteristics were not found on boys' clothes (b). These examples from clothing items marketed by C&A were not part of the final dataset, yet feature portrayals similar to those coded during the project.

4.4 Discussion

Cultural products are thought not only to reflect but also impact people's perceptions, often through subtle and repeated exposure (Bornstein & D'Agostino, 1992; Gerbner, 1969; Potter, 2014; Zajonc, 1968), and in a rapidly urbanizing world cultural representations of animals will play an increasing part in shaping people's perceptions of biodiversity (Fernández-Bellon & Kane, 2019; Fukano et al., 2020; Kalof et al., 2015; Prévot-Julliard et al., 2015; Soga, Gaston, Yamaura, et al., 2016; Soga & Gaston, 2016). However, the potential to expand biodiversity awareness through such indirect exposure has been questioned. In this study, we explored children's clothing as a cultural source of information about animals. We sampled clothes from clothing retailers in the Netherlands, a highly urbanized country in Western Europe, and looked for possible biases and distortions in the portrayal of animals.

4.4.1 Biases in the portrayal

Although animals were a common theme in our sample of children's clothes, diversity was low and did not represent global biodiversity. Most animals that we encountered were vertebrates, in particular mammals, in line with previous findings in cultural products such as postal stamps (Nemésio et al., 2013), covers of nature magazines (Clucas et al., 2008), and picture books (Sousa et al., 2017). Besides mammals, dinosaurs were also featured often, and birds placed third. In particular, domestic and exotic animals were portrayed frequently, a pattern that has been found in other cultural sources as well (Burton & Collins, 2015; Celis-Diez et al., 2016; Sousa et al., 2017).

The skewed portrayal is likely to stem from deliberate choices by clothing designers based on what they expect to be popular animals in their target group. For instance, a general disregard of invertebrates by the lay public is well-known, and thought to be derived from the fact that invertebrates are phylogenetically, behaviorally, and physically very different from humans (Batt, 2009; Kellert, 1993; Plous, 1993). Furthermore, animals like spiders, mosquitos, and flies are known to provoke feelings of anxiety, antipathy, or disgust (Davey et al., 1998; Kellert, 1993; Prokop, Usak, Erdogan, et al., 2011), so designers may conclude that invertebrates will not appeal to consumers. In contrast, butterflies are generally loved by the public (Schlegel et al., 2016; Schlegel & Rupf, 2010; Shipley & Bixler, 2017), and not surprisingly they were featured quite regularly, on girls' clothes.

The strong bias towards mammals and dinosaurs also appears to be a strategy of connecting to customers' prior knowledge and interest. Mammals are generally well-known (Genovart et al., 2013; Hooykaas et al., 2019, Chapter 2; Huxham et al., 2006) and their fur and large, forward-facing eyes appeal to people (Smith et al., 2012), while large dinosaurs also are highly popular among children, who are often in awe of these extinct giants. In contrast, reptiles and amphibians often have a bad reputation (Alves et al., 2014; Nates Jimenez & Lindemann-Matthies, 2015b; Prokop et al., 2016), which may explain their scarcity in children's fashion.

Below the class level diversity was also low, even for mammals and dinosaurs. It seems that designers strategically focus on a very small selection of highly charismatic animals (Albert et al., 2018), although the limited portrayal probably also reflects a bias in their own perceptions towards generally well-known species. The prevalence of cartoon characters in the dataset further shows how the bias towards certain animals is partly driven by the entertainment industry,

which is tightly linked to the fashion industry and benefits from extending brand characters to various products (Hosany et al., 2013). For instance, the frequent occurrence of domestic species can partly be explained by the habit of portraying popular characters such as Mickey Mouse and PAW Patrol. However, domestic species, as well as exotic species, may also be a strategic choice when targeting an international market, as these animals are loved globally (Berland, 2019).

From a conservation perspective, the strong biases in the portrayal are unfortunate, as they may trigger misconceptions about species richness and abundance (Courchamp et al., 2018). Furthermore, many species from seldomly represented groups are threatened with extinction and would have much more to gain by being portrayed than dinosaurs and domestic species, whose survival does not depend on broad-based support for conservation. Although domestic animals can help foster connections between children and animals, it is further not clear to what extent these connections extend to wild animals (DeMello, 2012).

The lack of native species on children's clothes may unintentionally suggest that interesting animals can only be found abroad. This links to Lindemann-Matthies (2005), who reported that Swiss children when asked about their favorite species mainly mentioned exotic animals and rarely expressed their appreciation for native flora and fauna. By portraying predominantly exotic species that can be regarded as charismatic due to their aesthetic appeal, people may also incorrectly assume that animals in exotic places generally have these characteristics, even though many exotic species look very similar to native species.

4.4.2 Specificity and anthropomorphism

Animals were mainly depicted in simplified and unrealistic ways, which compromised recognizability. Only half of the animals, mostly mammals, could be identified at the species level. In particular, many animals were anthropomorphized. We assume that designers humanize animals for comic effects, e.g., by portraying a bear on a bike, but also to create an emotional bond between the viewer and the depicted animal (A. A. Y.-H. Chan, 2012; Marriott, 2002; Root-Bernstein et al., 2013). Given this, it is important to note that while mammals and birds were regularly anthropomorphized, no human characteristics were assigned to invertebrates. This may give the impression that they are less worthy

of affection and conservation (Root-Bernstein et al., 2013). In line with this thought, invertebrates might benefit from subtle anthropomorphism.

However, extreme forms of anthropomorphization may lead to misconceptions and reduced recognizability. It is unlikely that lay consumers associate cartoon characters like Mickey Mouse with the species that they have been derived from. Cartoon characters based on animals may thus become associated more with humans than with their real-life relatives, so that the emotional connection established through anthropomorphism no longer connects to the actual animal (Anderson & Henderson, 2005; Geerdts, Van de Walle, et al., 2016). Similarly, "cute-ified" depictions may trigger affection, yet not towards real animals (Cole & Stewart, 2016), compromising the potential to raise affinities towards animals.

4.4.3 Gender binary

The portrayal of animal biodiversity on children's clothing differed between genders. Not only did clothes marketed towards boys feature animals more frequently, certain animals were also associated with either boys' or girls' clothes. This links with Lash & Polyson (1988), who reported that people perceive many animals as either feminine or masculine, and to Cole & Stewart (2016), who noted that animal portrayals may act as gendering symbols. While dinosaurs were restricted to the boy section of the online shops, butterflies were only found on girls' clothes. Moreover, dogs and brown bears were found predominantly in the boys' corner, while mice, rabbits, domestic cats, and songbirds were featured more often on girls' clothes. It seems that clothing designers select animals deemed to be masculine (large, tough, and impressive) for boys' clothes, while they choose animals believed to be feminine (small, soft, and pretty) for clothes marketed towards girls. Furthermore, we noticed frequent occurrences of gendering, even in animals not typically associated with femininity. For instance, while deer appeared frequently on both boys' and girls' clothes, they were often and only feminized on the latter.

The gender binary in the portrayal may not directly limit opportunities for children to encounter biodiversity, as boys and girls may still see animals featured on clothes of the opposite gender. Moreover, clothes marketed at either boys or girls can be worn by both. However, through their products retailers do send the message to children that some parts of biodiversity belong to girls and

some to boys. The distinct separation could contribute to differential attitudes towards animals, which links to studies that have suggested that preferences for, emotional affection for, and fear of different types of animals differ per gender (Alves et al., 2014; Kellert & Berry, 1987; Lindemann-Matthies, 2005). This could ultimately impact conservation, as people might become more responsive to campaigns for animals associated with their gender.

The distinction is further questionable, because the differential portrayal reflects classical gender roles and may reinforce gender stereotypes (Cole & Stewart, 2016). Research has demonstrated that already at a young age children internalize traditional gender roles, in interaction with the physical and symbolic environments that surround them (Aubrey & Harrison, 2004; Auster & Mansbach, 2012; Blakemore, 2003; Murnen et al., 2016; Solbes-Canales et al., 2020). These constructs can limit children's opportunities when they grow up. From an equality as well as from a conservation strategic standpoint, it would be better when biodiversity is seen as something shared by everyone, regardless of gender and without implicit messages that certain animals are appropriate only for some. In line with this, we argue that when anthropomorphization is used as a strategy to make animals relatable, gendering is not the best way.

4.4.4 Limitations and future research

We note that portrayals do not automatically translate to what people learn from them and how people's attitudes will be affected. In our study, the animals were identified by experts, based on specific traits that laypeople may not be aware of. It is questionable whether laypeople would reach the same specificity and accuracy in their identification of the animals. People may even misidentify exotic species or generic depictions of animals (e.g., "a deer") as native species that they know. This implies that laypeople may grow positive affinities towards native species when they look similar to generic depictions on clothes, yet from the perspective of species literacy (Hooykaas et al., 2019, Chapter 2), the potential for people to get to know native species through prototypes is very limited. Future research could explore to what extent children are aware of the depicted animals on their clothes and how the way in which animals are portrayed (e.g., realistic, abstracted, or cute-ified) impacts affinities towards animals.

Furthermore, we gathered our data within a short timeframe, whereas today's fast fashion industry constantly produces new hypes and clothing collections

change continuously (Bhardwaj & Fairhurst, 2010). Although the main patterns and biases found in our study are expected to be fairly constant, some animals are associated with particular holidays or seasons, e.g., we found a considerable number of reindeer. Longitudinal studies could explore how the frequencies of different taxa vary through time, e.g., per season.

4.5 Conclusion

Clothes are usually not designed as educational tools, yet like other cultural products that portray animals they may still raise biodiversity awareness. However, in our study we found two patterns that currently limit this potential. First, the portrayal of animals was highly skewed, and differentiated between boys' and girls' clothing. Secondly, many portrayals were abstracted and anthropomorphized, obscuring the connection with the real animals from which they were derived.

Children's clothes currently seem to be dominated by a small subset of animals, many of which regularly appear elsewhere in society too, e.g., in other cultural products, in zoos, or around people's homes as companion animals. This will do little to help children with grasping the rich diversity of the animal kingdom. Although the choice for popular animals is understandable, there are many animals, also from groups currently portrayed rarely, that could inspire innovative designs that spark the interest of consumers. Considering portrayals, it would be inappropriate to criticize clothing designers for depicting animals in a non-realistic way, for instead of being purely referential, portrayals are designed as artistic symbols and metaphors too. In fact, subtle anthropomorphization may actually be a strategic choice for taxa that tend to provoke negative emotions in people. Still, it is questionable whether extreme alterations are needed to make animals appealing to customers.

Overall, we argue that the huge variety of animals that exists worldwide offers much more than the animals currently portrayed on children's clothes. To tap into this potential, a shift in ideas is required of what animals are suitable to portray. As clothes exist between the poles of supply and demand, clothing designers and retailers will need to be convinced that a more diverse portrayal of biodiversity will appeal to customers. Recognizing the increasing agency of the child consumer (Cook, 2004; Crewe & Collins, 2006), future research could explore children's

views on animal portrayals and thereby determine opportunities to diversify. Additionally, while it is important to avoid greenwashing (Bechlivanis, 2019; Delmas & Burbano, 2011; Niinimäki et al., 2020), partnerships between designers and conservationists could help achieve a more extensive representation of animal biodiversity in children's fashion, that would enrich children's perceptions and may ultimately contribute to biodiversity conservation.

The **badger** (Nederlands: **das**) lives in family groups. A family resides in an elaborate den, called a sett, that is passed on from one generation to the next.

Chapter 5

Animal Biodiversity and Specificity in Children's Picture Books

This chapter is based on:

Hooykaas, M. J. D., Holierhoek, M. G., Westerveld, J. S., Schilthuizen, M., & Smeets, I. (2022). Animal biodiversity and specificity in children's picture books. *Public Understanding of Science, 31*(5), 671–688. https://doi.org/10.1177/09636625221089811

Abstract

While animal biodiversity is declining globally, cultural representations of animals are highly prevalent in society and play an increasing part in shaping children's perceptions of animal diversity. We studied animal portrayals in children's picture books in the Netherlands, and coded over 2,200 animals from 217 award-winning books. We found a strong bias towards vertebrates, mammals in particular. Mammals were featured more often than other animals, played more prominent roles in the story, and were visually and textually specified more strongly. Furthermore, exotic and domestic species outnumbered native species. Picture books currently are likely to reinforce children's perceptions towards only a small part of animal biodiversity. While we realize that picture books have other primary aims, picture book makers could be inspired and encouraged to diversify and specify their portrayals of the natural world. This would broaden children's perceptions of the animal kingdom and could help foster lasting connections to biodiversity.

5.1 Introduction

Animal biodiversity is declining worldwide, with a large impact on humans and non-human animals alike (Ceballos et al., 2017; Dirzo et al., 2014). As conservation relies on public support (Home et al., 2009) and people tend to care about what they know (Schlegel & Rupf, 2010; Wilson & Tisdell, 2005), awareness in society about animals and their diversity is imperative. However, studies have demonstrated that people in Western societies have limited knowledge about animals; e.g. perceptions seem to be directed mostly towards exotic and domestic species, notably mammals (Ballouard et al., 2011; Lindemann-Matthies, 2005). It has been hypothesized that this lack of awareness is caused by a widening gap between humans and nature (Miller, 2005). Authors have noted that especially in highly urbanized countries, people have less opportunity and less motivation to experience biodiversity outdoors, resulting in an 'extinction of experience' (Cox et al., 2017; Pyle, 2011; Soga & Gaston, 2016). This may prevent people from learning about animals and developing meaningful connections with them.

However, people may also encounter animals indirectly, when they are exposed to cultural products that portray animals, such as books and films. These cultural representations can be regarded as agents of socialization that help build and reinforce perceptions (Gerbner, 1969; Kesebir & Kesebir, 2017; Potter, 2014). For instance, it has been reported that animal portrayals can foster knowledge about species (Pearson et al., 2011), raise interest (Fernández-Bellon & Kane, 2019; Fukano et al., 2020; Soga, Gaston, Yamaura, et al., 2016), and trigger feelings of empathy (Kalof et al., 2015; Pearson et al., 2011). Products aimed at children play a particularly important role, as young children are sensitive to cultural discourse about animals (DeMello, 2012; McCrindle & Odendaal, 1994), and their knowledge levels and affinities towards animals affect their future perceptions and pro-conservation behaviors (Hinds & Sparks, 2008; Kahn, 2002; Kellert, 1985, 2002; Pilgrim et al., 2007), making it important to understand the image that cultural products targeted at children convey of animals.

5.1.1 The potential of picture books

One product that features animals and that possibly impacts children's perceptions of animal diversity is a picture book. Most children in Western societies are exposed to picture books (Ghonem-Woets, 2009; Van den Eijnden, 2015), and while picture book makers rarely depict animals to transfer factual information

about them, they do portray animals in their stories and artwork. Animals may be portrayed as minor characters that illustrate environment settings, but they may also feature prominently as main and supporting characters, e.g. to serve as human replacements for comical purposes or to teach moral lessons and appropriate social behavior (Larsen et al., 2017; Sousa et al., 2017).

Picture books thus expose young readers subtly and repeatedly to animals, and in line with cultivation theory (Gerbner, 1969; Potter, 2014) and research on the impact of subtle, repeated exposure (Bornstein & D'Agostino, 1992; Kaikati & Kaikati, 2004; Roy & Chattopadhyay, 2010; Zajonc, 1968) they are likely to shape children's perceptions of animal diversity and their feelings about animals (Prokop, Usak, & Erdogan, 2011; Root-Bernstein et al., 2013). For instance, children may learn to distinguish and name different animals and may grow affinity towards animals that play leading roles in compelling stories. Previous studies have already demonstrated that young children are able to learn new biological facts from realistic picture books (Ganea et al., 2011; Kelemen et al., 2014). Picture books have further been used purposefully to expand children's vocabulary (Larragueta & Ceballos-Viro, 2018; Sénéchal et al., 1996) and visual literacy (Read & Smith, 1982), and to teach various subjects, ranging from environmental protection (Hsiao & Shih, 2016) and mathematics (Van den Heuvel-Panhuizen et al., 2009) to healthy foods (Heath et al., 2014) and ethnic and gender diversity (Wissman, 2019). In line with this, educators may wish to use picture books to introduce children to the animal kingdom, to help to counterbalance the loss of direct experiences with animals in nature.

However, several factors may limit children's opportunities to learn about animals through picture books. First, authors and illustrators may restrict their portrayals to a small number of well-known animals. It has been reported for different cultural products that mammals predominate (Fernández-Bellon & Kane, 2019; Huxham et al., 2006; Nemésio et al., 2013), and that exotic and domestic species outnumber native, wild species (Celis-Diez et al., 2016; Genovart et al., 2013; Moreno-Tarín et al., 2021). Skewed portrayals could explain why children's perceptions currently seem to be directed mostly towards these animals (Ballouard et al., 2011; Genovart et al., 2013; Lindemann-Matthies, 2005). For instance, it has been shown that children are unaware of many common animal species, i.e. there is a high 'species illiteracy' (Hooykaas et al., 2019, Chapter 2). Biases could also explain misconceptions about species richness and abundance

(Courchamp et al., 2018; Platt, 2013; Vázquez-Plass & Wunderle, 2010).

Secondly, children's opportunities to learn may be compromised by low specificity of portrayals. Artistic work can be highly distorted from reality (Marriott, 2002), and as a result depictions of animals may be identified only at a higher taxonomic level (e.g. as 'an insect'), offering little room to foster species literacy. Even when depictions are realistic or iconic, animals may still not be identified correctly if text references are unspecified (e.g. when a blackbird is referred to as 'bird'), or are lacking altogether.

Finally, picture book makers may portray animals anthropomorphically, e.g. with clothes or accessories, human behavior, or human facial expressions. This may make them relatable and likeable for children (A. A. Y.-H. Chan, 2012; Geerdts, 2016; Root-Bernstein et al., 2013), and some argue that subtle anthropomorphism in children's storybooks can aid in the learning of biological facts (Geerdts, Van de Walle, et al., 2016; McCabe & Nekaris, 2018). However, others have noted that anthropomorphization can negatively affect children's knowledge of animals (Ganea et al., 2014; Geerdts, Van De Walle, et al., 2016; Marriott, 2002; Waxman et al., 2014); for instance, it may limit recognizability and may induce misconceptions, as it can be challenging for children to differentiate what is real from what is true only in the story world (Strouse et al., 2018).

5.1.2 Aim of this study

As the human population grows and urbanization continues, cultural representations will increasingly mediate people's interactions with animals (Kellert, 2002), showing the importance of understanding what picture they convey. Picture books have been researched in the past for their representation of ethnic diversity and gender with the underlying idea that diverse portrayals can help develop an inclusive worldview (De Bruijn et al., 2021; Harlin & Morgan, 2009; Trepanier-Street & Romatowski, 1999). With a similar approach in mind, we aimed to elucidate the image of animals that picture books present to children, to clarify how the animal kingdom currently is appropriated in Western society and to explore learning opportunities for children.

We examined the portrayal of animals in picture books in the Netherlands, a highly urbanized country in Western Europe where species literacy of primary school children was found to be very low (Hooykaas et al., 2019, Chapter 2). In societies with high levels of urbanization, indirect experiences play a significant

part in shaping people's perceptions of biodiversity (Prévot-Julliard et al., 2015; Soga, Gaston, Yamaura, et al., 2016), which makes it apt to study Dutch children's books. Whereas previous studies have investigated animal portrayals in children's books recommended for usage in classrooms (Celis-Diez et al., 2016; Sousa et al., 2017), we examined award-winning picture books, as these are generally sold well (Squires, 2007) and are often read in non-school settings. Moreover, while other studies have mentioned children's books as a small part of a broader study (Genovart et al., 2013; Huxham et al., 2006), we studied in depth the diversity, specificity and anthropomorphization of animals in different roles.

To determine the diversity of animals represented in picture books and the way in which they are portrayed, we established which animal species, families, orders, and classes were most prevalent, analyzed the specificity of depictions and textual references, and calculated the proportion of anthropomorphic animals. As animals can be accorded different roles in the stories in which they figure, we finally examined possible differences in taxonomic prevalence, specificity, and anthropomorphism between main, supporting, and minor characters.

We studied the following research questions:

1) Which taxa and types of animals (i.e. exotic or native, and domestic or non-domestic) are portrayed, and how does this differ between main, supporting, and minor characters?
2) To which taxonomic level are the animals specified in the imaging and text, and how does this differ between classes and between main, supporting, and minor characters?
3) What proportion of the portrayed animals are anthropomorphized, and how does this differ between classes and between main, supporting, and minor characters?

5.2 Methods

To capture the current representation of animals in picture books available to Dutch children, we performed a quantitative content analysis, as follows.

5.2.1 Book selection

We included all books targeted at children aged 2-9 years that received an award in the Netherlands between 2010-2020 for best book, story, or artwork (Online Supplementary Materials: S_Ch5_Booklist). We excluded non-story books (e.g. seek and find books), omnibus editions, and books without illustrations to support the story. This yielded 217 book titles from 160 authors and 144 illustrators. The sample comprised 120 original Dutch books and 97 international books translated into Dutch.

5.2.2 Sampling animals

We included depictions of both extant and extinct animals, as well as cultural representations of these animals (e.g. depicted teddy bears). However, we excluded fantasy animals (mythical creatures such as unicorns and dragons) and biodiversity elements such as feathers, footprints, and bones.

Per book we included all main characters (playing the leading role and serving as protagonists), supplemented by up to 20 other animals. The latter group could be supporting characters (playing a supporting role essential to the storyline) or minor characters (part of the scenery). Each animal species was included once for each role in which it figured (e.g. if the protagonist was a cow, and a herd of cows was visible in the background, 'cow' was inserted twice, both as main and minor character). Animals mentioned in book titles were finally added to the sample if they had not already been coded; these could serve different roles in the storyline.

We started our selection on the first page of each story (e.g. skipping the cover), scanned each page from left to right and per page included the first five animals encountered. We avoided a scan from top to bottom, as this would have skewed results to flying animals, and we included a maximum per page to ensure covering different parts of the story. The animals included in the dataset were photographed, so that codings could be checked when a book borrowed from the library had been returned.

5.2.3 Coding animals

To code the sampled animals, we constructed a codebook (Online Supplementary Materials: S_Ch5_Codebook). Each animal was identified at the lowest possible taxonomic level, using context and cues (e.g. depicted scenery and text). Subsequently, the taxonomic affiliation was noted using the English Wikipedia (species, family, order, and class, and whether the animal was an invertebrate or vertebrate). For the purpose of this study, we treated dinosaurs as a taxonomic class, to separate them from other reptiles and birds. In addition, we coded the type of animal (native or exotic, domestic or non-domestic), using lists of animal species native to the Netherlands and a list of domestic animals.

To explore recognizability of the animals and the level of distortion in the portrayal, we finally noted for each animal the lowest taxonomic rank at which it was mentioned in the text, the lowest taxonomic rank at which it could be identified, and the depiction state (visually anthropomorphized or not). We distinguished different types of anthropomorphism: wearing clothes or accessories (e.g. jewelry), human behavior (including speech, use of human objects, bipedal walk, and human posture), and human facial features (including facial expressions, blushing cheeks, and feminine eyelashes) – see Figure 5.1.

For each animal, depictions throughout the book were used for coding; e.g. when an animal got dressed later in the story, it was coded as wearing clothes.

Figure 5.1 Different forms of anthropomorphism. Wearing clothing: a blackbird wearing a suit, hat, and briefcase (Houkema, 2010) (a); human facial expressions: a happy lion (Douglas & Riphagen, 2016) (b); human behavior: a hippopotamus reading on the toilet (Pfister, 2008) (c).

5.2.4 Intercoder reliability

Coding was executed by three researchers. The lead author, who is well-versed in the subject of biodiversity, verified the species identifications and if needed consulted experts (e.g. a paleontologist to help identify dinosaur species). The role in which an animal figured and the three types of anthropomorphism were coded independently by the first two authors and intercoder reliability was assessed by comparing codes of a randomly chosen 10% of the animals. The level of agreement was strong (McHugh, 2012), for role (percent agreement = 91.5%, Cohen's Kappa = .82), clothing/accessories (percent agreement = 98.7%, Cohen's Kappa = .94), human behavior (percent agreement = 93.0%, Cohen's Kappa = .82), and for human facial features (percent agreement = 91.2%, Cohen's Kappa = .80). The cases where there had been disagreement were resolved through discussion, after which the lead author double-checked similar cases elsewhere.

5.2.5 Data analysis

We compiled the data in Microsoft Excel 365, and performed descriptive and statistical analysis in IBM SPSS Statistics (version 25.0). Using frequency tables, we first explored prevalence of taxonomic groups per role and in total. Subsequently, we used two-tailed chi-square tests of independence with a significance level of $p \leq 0.05$ to analyze relationships between the categorical variables (taxonomic classes, role, anthropomorphism, and specificity of identification and text references). To account for multiple testing, we applied a strict Bonferroni adjustment when making multiple comparisons.

5.3 Results

Most books (97.3%) featured one or more animals, and in a majority (79.3%) animals were essential to the storyline, serving as main or supporting characters. The final dataset (Online Supplementary Materials: S_Ch5_Datasheet) comprised 2,237 animals in total: 155 main characters, 544 supporting characters, and 1,538 minor characters.

5.3.1 Taxonomic diversity

The majority (85.5%) of the animals portrayed in the picture books represented vertebrates. Mammals (43.9%) and birds (27.6%) were the most featured classes,

Table 5.1 Prevalence of animal classes portrayed in children's picture books (frequency counts for main, supporting, and minor characters, and total).

	Class (ordered according to frequency)	Role Main	Supp.	Minor	Total	
	Mammals	111	297	575	983	43.9%
	Birds	22	138	457	617	27.6%
	Insects	7	36	177	220	9.8%
	Bony fish	2	9	117	128	5.7%
	Reptiles	7	22	61	90	4.0%
	Dinosaurs	0	12	47	59	2.6%
	Amphibians	2	10	18	30	1.3%
	Snails and slugs	0	3	23	26	1.2%
	Arachnids	1	8	7	16	0.7%
	Crustaceans	1	2	10	13	0.6%
	Cephalopods	2	2	6	10	0.4%
	Jellyfish	0	1	8	9	0.4%
	Echinoderms	0	0	9	9	0.4%
	Bivalves	0	0	7	7	0.3%
	Cartilaginous fish	0	0	5	5	0.2%
	Sea anemones and corals	0	0	1	1	0.0%
	"Other invertebrates"	0	3	9	12	0.5%
	Total	155	544	1,538	2,237	100.0%

followed by insects (9.8%), bony fish (5.7%), reptiles (4.0%), dinosaurs (2.6%), and amphibians (1.3%). Other taxonomic classes, whether vertebrate or invertebrate, were present in the dataset only a few times or were lacking altogether – see Table 5.1.

From the animals, 79.7% could be assigned to a taxonomic order and 65.5% to a taxonomic family. The animals represented 79 orders and 143 families, yet only a few were portrayed frequently – see Tables 5.2 – 5.3.

Carnivores were the most featured order, with a high number of canids, felids, and bears. Also numerous were "even-toed ungulates and cetaceans", representing in particular bovids, pigs, and giraffids. Other mammalian orders that were portrayed often included rodents, due to the prevalence of mice and rats, odd-toed ungulates (mainly horses), rabbits and hares, and proboscideans (mostly elephants). Bird orders that were encountered frequently were songbirds and "waterfowl": ducks, swans, and geese. In addition, gallinaceous birds (e.g. chicken), charadriiforms (e.g. gulls), and owls were quite common as well.

Considering insects, a considerable number of butterflies, beetles – represented frequently by ladybirds – and hymenopterans (mainly bees), were found. Reptilian orders that were featured frequently were squamates (e.g. snakes) and crocodilians (mostly true crocodiles), while Saurischian dinosaurs (e.g. theropods and sauropods) represented the most encountered order of dinosaurs. Amphibians were represented predominantly by frogs.

Only 39.4% of the animals could be identified as distinct species. The top 20 comprised mostly mammals, especially domestic animals (e.g. dog, cat, horse), supplemented by a few native (e.g. red fox, wolf, red squirrel) and exotic species (e.g. brown bear, lion, hippopotamus) – see Table 5.4. In total, 155 different animal species were encountered.

The most abundant species, families, orders, and classes were similar in distribution among main, supporting, and minor roles – see Tables 5.1 – 5.4. However, even though mammals were consistently the top featured class, they were particularly dominant in the leading role, while birds, insects, and bony fish were more prevalent as minor characters – see Figure 5.2.

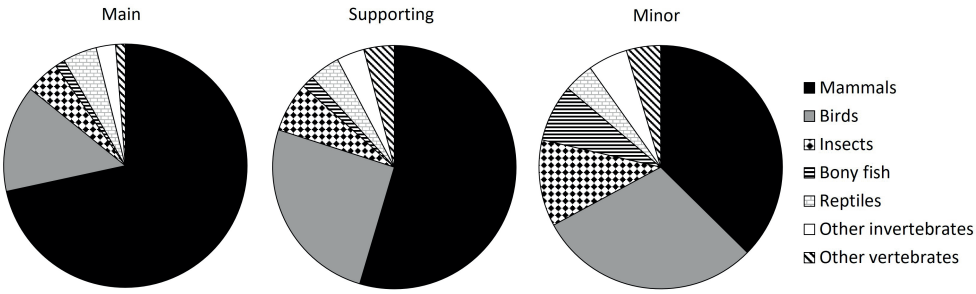


Figure 5.2 Proportion of animals featured in children's picture books belonging to a particular class, for main, supporting, and minor characters.

Table 5.2 Top 20 most featured animal orders portrayed in children's picture books (frequency counts for main, supporting, and minor characters, and total).

	Order (ordered according to frequency)	Main	Supp.	Minor	Total
	Carnivores	46	120	205	16.6%
	Even-toed ungulates and cetaceans	19	80	121	9.8%
	Rodents	11	22	59	4.1%
	Songbirds	1	12	77	4.0%
	Odd-toed ungulates	5	25	59	4.0%
	Rabbits, hares, and pikas	14	19	51	3.8%
	Butterflies and moths	0	8	75	3.7%
	Anseriforms ("waterfowl")	4	17	44	2.9%
	Gallinaceous birds	3	20	27	2.2%
	Proboscideans	9	17	22	2.1%
	Beetles	5	4	32	1.8%

	Charadriiforms	2	4	33	1.7%
	Squamates	0	6	32	1.7%
	Crocodilians	4	11	19	1.5%
	Saurischian dinosaurs	0	6	26	1.4%
	Owls	1	12	17	1.3%
	Anurans	2	9	17	1.3%
	Primates	2	4	19	1.1%
	Hymenopterans	0	10	13	1.0%
	Columbiforms	0	5	14	0.8%
	Other	27	133	576	32.9%
	Total	155	544	1538	100.0%

Note: The animal icons in black, dark gray, and light gray represent mammals, birds, and other animals, respectively.

Table 5.3 Top 20 most featured animal families portrayed in children's picture books (frequency counts for main, supporting, and minor characters, and total).

	Family (ordered according to frequency)	Main	Supp.	Minor	Total	
	Canids; e.g. dog, fox	20	44	80	144	6.4%
	Felids; e.g. cat, lion	9	40	66	115	5.1%
	Bovids; e.g. cow, sheep	8	40	47	95	4.3%
	Bears; e.g. brown bear, polar bear	15	27	49	91	4.1%
	Rabbits and hares; e.g. rabbit, hare	14	19	51	84	3.8%
	Horses; e.g. horse, donkey	4	19	52	75	3.4%
	Ducks, geese, and swans; e.g. mallard, domestic goose	4	17	44	65	2.9%
	Mice; e.g. house mouse, rat	9	13	37	59	2.6%
	Phasianids; e.g. chicken, Indian peafowl	3	20	26	49	2.2%
	Elephants and mammoths; e.g. African elephant	9	17	22	48	2.1%
	Pigs; e.g. pig, wild boar	4	18	24	46	2.1%
	Crocodiles; e.g. crocodile	4	10	13	27	1.2%
	True owls; e.g. eagle-owl, snowy owl	1	12	14	27	1.2%
	Squirrels; e.g. red squirrel	1	6	19	26	1.2%
	Giraffids; e.g. giraffe, okapi	4	6	15	25	1.1%
	Gulls, terns and skimmers; e.g. gull	1	3	20	24	1.1%
	Pigeons and doves; e.g. rock pigeon	0	5	14	19	0.8%

	Corvids; e.g. crow, jackdaw	0	2	17	19	0.8%
	Ladybird beetles; e.g. seven-spot ladybird	3	1	14	18	0.8%
	Deer; e.g. moose, reindeer	1	1	15	17	0.8%
	Other	41	224	899	1164	52.0%
	Total	155	544	1,538	2,237	100.0%

Note: The animal icons in black, dark gray, and light gray represent mammals, birds, and other animals, respectively.

Table 5.4 Top 20 most featured animal species in children's picture books (frequency counts for main, supporting, and minor characters, and total).

Species (ordered according to frequency)	Main	Supp.	Minor	Total	
Dog	9	32	64	105	4.7%
Cat	6	25	49	80	3.6%
Brown bear	12	13	30	55	2.5%
Horse	1	16	38	55	2.5%
Pig	4	18	22	44	2.0%
Chicken	2	15	22	39	1.8%
European rabbit	8	5	22	35	1.6%
Cow	2	12	14	28	1.3%
Sheep	1	15	9	25	1.1%
Mallard	3	9	10	22	1.0%
Red fox	7	3	10	20	0.9%
Goat	5	5	10	20	0.9%
Wolf	4	8	4	16	0.7%
Lion	1	5	9	15	0.7%
House mouse	2	5	6	13	0.6%
Red squirrel	1	3	9	13	0.6%
Common blackbird	1	3	8	12	0.5%
Rock pigeon	0	3	9	12	0.5%

	Hippopotamus	1	6	4	11	0.5%
	Tiger	1	6	4	11	0.5%
	Other	84	337	1185	1606	71.8%
	Total	155	544	1538	2237	100.0%

Note: The animal icons in black represent mammals, those in gray represent birds.

5.3.2 Type of animals

Virtually all animals (97.3%) represented extant animals. A quarter of these (24.3%) were domestic and represented companion (e.g. cat, dog) or farm animals (e.g. horse, pig). In fact, of the top ten most featured animal species, nine were domestic. Main and supporting characters were more likely to represent domestic species than minor characters ($\chi2(2) = 36.16$, $p < .001$, Cramér's V = 0.13).

Of the extant animals for which the origin could be determined, two-thirds (65.6%) were exotic (e.g. bear, crocodile, penguin) and one-third (34.4%) were native (e.g. common blackbird, mallard, red fox). Prevalence of exotic animals did not differ between roles, and books from Dutch publishers did not portray native animals more frequently than international publishers. Finally, we note that one in five animals (20.3%) was a cultural representation (e.g. cuddly toy, statue, or painting).

5.3.3 Specificity of portrayals

Depending on their role in the story, animals were depicted prominently or inconspicuously. Often the depictions were abstracted, prototypical (e.g. generic birds), or unrealistic; e.g. we noticed inaccuracies, such as a female blackbird character portrayed with male plumage. Whether an animal name was mentioned in the text depended on the role of the character in the story. While most of the main (78.7%) and supporting characters (82.7%) were mentioned in the text, minor characters were referred to only occasionally (16.7%).

The majority of text references were above species level (59.8%), yet there were differences between classes ($\chi2(8) = 190.40$, $p < .001$, Cramér's V = 0.48). Whereas the majority of references to mammals (61.3%) were at the species level, only

15.6% of references to other animals were species specific. Birds were frequently mentioned at the class ('bird'), or family level (e.g. 'penguin', 'duck', 'woodpecker'), while references to reptiles and insects were generally at the order (e.g. 'snake', 'turtle', 'butterfly') or family level (e.g. 'crocodile', 'bee'). Moreover, dinosaurs were mentioned mainly at the class level ('dinosaur') and invertebrates other than insects were generally referred to at the class (e.g. 'snail') or order (e.g. 'spider') level. Bony fish were usually mentioned as 'fish', an informal name that may refer to animals from different classes (Appendix 5.1).

The greater specificity in references to mammals was found for both main ($\chi2(1) = 12.48$, $p < .001$, Cramér's V = 0.32), supporting ($\chi2(1) = 99.08$, $p < .001$, Cramér's V = 0.47), and minor characters ($\chi2(1) = 72.66$, $p < .001$, Cramér's V = 0.53). We checked whether the higher specificity in references to mammals stemmed from the abundance of domestic animals in the dataset, which were often mammalian and mentioned at the species level more frequently than non-domestic species ($\chi2(1) = 291.68$, $p < .001$, Cramér's V = 0.62), but this was not the case.

The limited specificity of visual and textual portrayals affected recognizability, and overall only 39.4% of the animals could be identified as distinct species, many representing domestic animals. In addition, 4.9% of the animals were identified at the genus level (e.g. giraffe), 21.2% at the family level (e.g. ladybird), 14.2% at the order level (e.g. beetle), and 20.2% at the class level (e.g. insect). Mammals were recognizable as distinct species much more frequently (65.8%) than other animals (18.7%); ($\chi2(1) = 511.40$, $p < .001$, Cramér's V = 0.48). Furthermore, main and supporting characters were identified at the species level more frequently (56.1% and 53.1%) than minor animal characters (33.2%); ($\chi2(2) = 88.28$, $p < .001$, Cramér's V = 0.20).

5.3.4 Anthropomorphism

Anthropomorphism was encountered in most books (77.4%); in total 42.1% of the animals were portrayed anthropomorphically. While the majority of the main (96.1%) and supporting characters (63.2%) were anthropomorphic, only 29.2% of the minor characters were accorded with human characteristics; the differences were significant ($\chi2(2) = 390.38$, $p < 0.001$, Cramér's V = 0.42). Human facial features were the most common way in which the animals were anthropomorphized (33.5%), followed by human behavior (25.9%), and clothing/accessories (14.3%); this pattern was found for main, supporting, and minor characters (Appendix 5.2).

Animals were often anthropomorphized in multiple ways simultaneously.

Anthropomorphism differed between taxonomic classes. Mammals were anthropomorphized more frequently (57.3%) than other animals combined (30.2%) – see Table 5.5. They were depicted regularly with clothes or accessories, human behavior, and human facial features, while anthropomorphism was rare especially in portrayals of birds and fish. However, mammals were anthropomorphized more frequently only in the supporting ($\chi2(1) = 31.03$, $p < .001$, Cramér's V = 0.24) and minor role ($\chi2(1) = 66.70$, $p < .001$, Cramér's V = 0.21); no significant difference was found between mammals and other animals for main characters. Moreover, we note that amphibians and reptiles were accorded with human facial features and behavior relatively often too (Appendix 5.3).

Table 5.5 Comparison between the prevalence of different types of anthropomorphism in mammals and other animals.

Type of Anthropomorphism	Mammals	Other animals	$\chi2$	φ_c
Clothing	22.4% (220/983)	8.1% (101/1254)	92.02***	0.20
Behavior	37.3% (367/983)	16.9% (212/1254)	119.88***	0.23
Facial features	46.0% (452/983)	23.7% (297/1254)	123.01***	0.23
Any	57.3% (563/983)	30.2% (379/1254)	165.40***	0.27

Note: χ^2=Chi square value; φ_c = effect size (phi coefficient or Cramér's *V*); *** = $p < .001$. Degrees of freedom was 1 for each comparison.

5.4 Discussion

Although most picture books are not specifically designed to educate children about the natural world, they may play an important role in offering children opportunities to learn about animals. We examined the image that picture books convey of animals and their diversity, by sampling animal portrayals from a large collection of award winning picture books in the Netherlands.

5.4.1 A skewed portrayal

Animals were abundant in our sample of award-winning children's books, and they regularly played an essential role in the story. However, the portrayal was highly skewed towards vertebrates, particularly mammals, a pattern in line with

previous research on picture books (Huxham et al., 2006; Sousa et al., 2017) and other cultural products aimed at children, such as magazines (Vrla et al., 2020). While mammals predominated, especially as main and supporting characters, other animals such as birds, insects, and bony fish were portrayed less frequently and often figured as minor characters, even though actual species richness and abundance is higher for these groups than for mammals. In fact, invertebrates account for over 95 percent of worldwide biodiversity (Brusca et al., 2016). Apart from taxonomic biases, exotic and domestic animals were highly abundant, in line with previous research on cultural representations (Ballouard et al., 2011; Celis-Diez et al., 2016; Huxham et al., 2006).

The biases that we found may be explained by a strategy of featuring animals that are generally loved and known by readers. By portraying mammals, particularly domestic species and charismatic, exotic animals such as bears and lions, picture book makers tap into people's affinities for 'loveable' animals with fur and forward-facing eyes (Albert et al., 2018; Genovart et al., 2013; Lindemann-Matthies, 2005; Macdonald et al., 2015), while the limited presence of invertebrates, especially in essential roles, may flow from assumptions that these animals do not appeal to people (Batt, 2009; Kellert, 1993). However, the portrayal also partly reflects abundance and the actual likelihood of encountering animals. For instance, depicting insects and birds as background characters mirrors real experiences in nature, while the prevalence of domestic species and cultural representations (e.g. teddy bears) may be explained by the anthropogenic environments in which many stories were set. Such domestic settings may be easy to relate to for children growing up in Western societies. Finally, the biases are likely to stem partly from skewed perceptions of authors and illustrators (Kesebir & Kesebir, 2017), as they can only portray what they are aware of themselves.

The biases that we found may hinder children in developing an accurate understanding of animal diversity. For instance, children may assume that frequently depicted species are abundant even though they may occur in low numbers in the wild (Courchamp et al., 2018; Platt, 2013). A bias towards mammals in cultural products may further explain why children generally identify native mammals more readily than birds and insects (Hooykaas et al., 2019, Chapter 2), even though outdoors they are more likely to encounter the latter. Moreover, as mostly exotic and domestic animals are featured, children may conclude that animals worthy of their attention can only be found abroad or in domestic settings (Ballouard et

al., 2011; Lindemann-Matthies, 2005; Verboom et al., 2004). This is unfortunate, because native species can provide children with opportunities to develop a 'sense of place', a feeling of attachment to the local environment (Horwitz et al., 2001).

5.4.2 Specificity and anthropomorphism

Many animals were portrayed in simplified and abstracted ways, and text references were often missing or above the species level. The visual distortions and the limited text references reduced recognizability, and overall only a minority of the animals could be identified as distinct species, the majority representing animals that are generally well known (e.g. domestic species). Specificity of the portrayals further differed between roles and taxa. Main and supporting characters were specified more than minor characters, and mammals were specified more than other taxa, who were regularly depicted as generic prototypes and mentioned at high taxonomic levels.

Whereas experts may accurately identify animals even when representations are distorted or when text references are missing, laypeople may not. Portrayals with low specificity will not help expand laypeople's limited ability to distinguish and name species, which is unfortunate, as people tend to care about what they know (Balmford et al., 2002) and an inability to name parts of the natural world may lead to a loss of attention for it (Macfarlane, 2015, 2017). Since mammals were portrayed with higher specificity, picture book makers may further inadvertently create the impression that other animals are less diverse.

Many animals were further portrayed with human facial features, human behavior, or clothes. In many stories animals acted as human substitutes; e.g. they lived in a house and celebrated birthdays. Notably, main characters were anthropomorphized, probably because it is deemed to be most important for them to be relatable and likeable for readers. Moreover, leading characters were usually featured prominently and frequently, making them relatively easy to anthropomorphize. Likewise, some animals, notably mammals, were anthropomorphized more frequently than others probably because they can be accorded human characteristics more easily; e.g. bipedal walk is hard to include in portrayals of fish and snakes. However, certain types of anthropomorphism (e.g. human facial expressions) were common in animals other than mammals too, especially in amphibians and reptiles.

Anthropomorphization probably reduces recognizability by distorting the link

with the real animal that a character represents, and may induce misconceptions (Ganea et al., 2014; Geerdts, Van De Walle, et al., 2016; Marriott, 2002; Waxman et al., 2014). For example, anthropomorphic non-conspecific animal characters in stories often help each other, whereas in reality cooperative behavior between different species is rare. Although friendly portrayals may trigger positive feelings and facilitate connections with animals (A. A. Y.-H. Chan, 2012; Geerdts, 2016; Root-Bernstein et al., 2013), they can also lead people to think that wild animals can be readily approached without risk (Barney et al., 2005; Root-Bernstein et al., 2013; Tate & Pelton, 1980). Compared to the comical and stereotypical characters in picture books, real animals may further appear dull (Oswald, 1995), and differences in anthropomorphization between taxa may lead children to view some animals as loveable subjects and other animals as mere objects (Cole & Stewart, 2016; Root-Bernstein et al., 2013).

5.4.3 Directions for future research

It is important to emphasize that portrayals do not automatically translate to learning outcomes and changed attitudes. Children experience difficulty in differentiating reality and fantasy, and it is unlikely that children always link highly transformed figures to the real animals that they represent (Strouse et al., 2018). Even animals that are portrayed realistically may be difficult to identify, e.g. when there are large shifts in perspective and an animal is depicted relatively small on one page, and large on another (Dove, 2011; Poulsen et al., 1979). However, even when children are not able to identify an animal accurately, they may still develop interest in animals and learn about them. For example, a story about an exotic caterpillar that transforms into a butterfly will teach a child about the lifecycle of native butterflies too. Further research is needed to determine the exact impact of animal portrayals in picture books on children.

Furthermore, the vital role of parents and teachers should not be overlooked, as by reading stories to children they play a vital part in mediating the exposure to animal biodiversity (Greenhoot et al., 2014; Justice et al., 2005). Depending on their own prior knowledge, parents and teachers will elaborate more or less about the animals that are depicted. Moreover, they may not be aware of suitable books and ways to use them; e.g. opportunities to discuss with children (Duursma et al., 2008; Strouse et al., 2018). It is thus important to explore how teachers and parents can be encouraged and supported.

Finally, we note that knowledge about animals encompasses more than the ability to identify them. Apart from identification skills, species literacy also involves knowledge about species' habitat, diet, and living community (e.g. what kind of animals naturally occur together). We noticed that animals were often displaced from their natural environment, as most stories took place in human-altered settings, and the few books that did portray natural landscapes usually displayed highly simplified habitats. This links to studies reporting misconceptions in children about the places where animals occur (Strommen, 1995; Torkar, 2016). Moreover, animals regularly ate human food and were portrayed alongside species that they would never encounter in the wild. Future studies on picture book representations could incorporate such dimensions of biodiversity awareness.

5.5 Conclusion

Picture books hold potential to raise awareness about animals, which is important considering the widening gap between people and nature. However, the image of animals that is currently conveyed to readers is not very diverse and rather unspecified. Our sample of Dutch award-winning picture books was highly skewed and animals were often visually and textually simplified. Mammals predominated, mainly in roles essential to the storyline, and were specified and anthropomorphized frequently, while animals such as birds, insects, and fish often served to illustrate the environment and were portrayed rather generically. Well known exotic and domestic species further outnumbered native species. The current representation of animals is likely to both reflect and further skew current perceptions of animals in Western society, and offers children few opportunities to connect with local fauna.

Although artistic freedom of picture book makers is important, we believe that the educational potential of picture books could be tapped into by inspiring illustrators and authors to include a larger diversity of animals in their stories and artwork. Biodiversity professionals could show picture book makers opportunities to diversify. For instance, native species can be easily incorporated in stories set in urbanized environments, which would help dismantle human-nature binaries by making urban children aware that they share the places where they live with wildlife. Even among invertebrates there are many suitable candidates to portray,

as a few books in our sample with striking invertebrate characters (e.g. octopus, stag beetle, peacock butterfly) showed. Moreover, parents and teachers should be encouraged and aided in selecting books that are likely to expand children's perceptions and that may spark discussion about animal diversity. Ultimately, a diverse and specified portrayal of animals could help foster lasting connections between younger generations and the large variety of animals found on our planet.

Part III:

Perspective from Communicators

The **house sparrow** (Nederlands: **huismus**) exhibits sexual dimorphism: the plumage of the male (left) clearly differs from that of the female (right).

Chapter 6

Children's Species Literacy as Estimated and Desired by Biodiversity Communicators: A Mismatch with the Actual Level

This chapter is based on:

Hooykaas, M. J. D., Aten, C., Hemelaar, E. M., Albers, C. J., Schilthuizen, M., & Smeets, I. (2021). Children's species literacy as estimated and desired by biodiversity communicators: A mismatch with the actual level. *BioRxiv*, 1–15. https://doi.org/10.1101/2021.11.10.466733

Abstract

In order to engage people effectively on the topic of biodiversity, communication is needed that strikes a chord with the public. For this, communicators should be aware of current knowledge levels in their target groups. We compared biodiversity communicators' estimates of the average level of species literacy in primary school children with the actual level. Moreover, we explored the importance that communicators placed on species literacy and the level that they desired. Estimations of children's average knowledge level varied widely and differed from the actual level. In particular, communicators overestimated the species literacy level. Although most biodiversity communicators agreed that knowledge about species is important, their view differed as to why species literacy would be important. Moreover, communicators differed with respect to the relative importance attached to different knowledge components. Professionals may thus benefit from a detailed framework of species literacy that illustrates different aspects and values. Most importantly, our findings suggest that to bridge the gap between actual and desired knowledge levels in children effectively, biodiversity communicators first need to become more aware of current perceptions in young audiences.

6.1 Introduction

At a time of great biodiversity loss and a widening gap between people and nature, conservationists are faced with a challenging task to build broad-based support for conservation (Ceballos et al., 2015, 2017; Miller, 2005; Pyle, 2011). Communicators can make a valuable contribution by promoting awareness about biodiversity in the public (Bickford et al., 2012). However, while certain segments of society have successfully been reached, it has been acknowledged that, overall, laypeople are not well-informed about biodiversity (Navarro-Perez & Tidball, 2012), showing that communication about biodiversity has not yet been as effective as it could be.

Studies in different countries have demonstrated that laypeople, particularly primary school children, lack broad as well as in-depth knowledge about species (Balmford et al., 2002; Huxham et al., 2006; Torkar, 2016); i.e., they have low levels of species literacy (Hooykaas et al., 2019, Chapter 2). For instance, in the Netherlands primary school children regularly failed at identifying common, native animals that can be easily encountered (Hooykaas et al., 2019, Chapter 2), implying that they are disconnected from their local environment. This indicates that barriers need to be overcome by biodiversity communicators, as unknown species will not easily strike a chord with the public and their names may be perceived as jargon.

For biodiversity communicators it is important to take into account the knowledge levels present in their audiences, as these influence people's expectations and determine the ways they will respond (Buijs et al., 2008; R. A. Thompson & Zamboanga, 2003). Prior knowledge affects subsequent learning and plays an important role in the construction of new understanding (Hailikari et al., 2007, 2008; National Research Council, 2000, 2007, 2009). To achieve high-quality communication, communicators should therefore connect to people's knowledge base in a strategic manner. Messages will then be better comprehended and more readily received, and learning outcomes will be more likely to be in line with those intended (Wratten & Hodge, 1999).

However, before communicators can craft messages or devise strategies according to people's existing knowledge, they should first be aware of it. It is therefore imperative that they can accurately estimate knowledge levels in their audiences. Yet, studies conducted outside of the field of biodiversity communication have demonstrated that estimating prior knowledge can be quite

hard. For example, nursing professionals and physicians regularly experience difficulties in estimating health literacy in their patients (Bass et al., 2002; Kelly & Haidet, 2007; MacAbasco-O'Connell & Fry-Bowers, 2011), frequently resulting in overestimations (Dickens et al., 2013). In addition, teachers have been reported to fail at accurately estimating knowledge levels in their students (Perrenet, 2010; Schutte, 2010; Storm, 2012).

A mismatch between estimated and actual knowledge levels poses a problem as it may hamper communication. Overestimations can lead communicators to calibrate their language to a level above that of their public, resulting in messages that are not understood correctly by the audience, while underestimations may lead to needless repetition of information (Kelly & Haidet, 2007; Schutte, 2010). For instance, nature guides or text editors unaware of low species literacy levels may mention species names that act as jargon, while those who underestimate knowledge levels may elaborate on already well-known species, which may bore people and will not expand their perceptions of biodiversity. Ultimately, a bad fit may prevent educational and communicational goals from being achieved (Bass et al., 2002; Hailikari et al., 2008); e.g., it could make it harder to foster species literacy effectively and could hamper citizen science projects where participants are asked to count and record species (S. Falk et al., 2019).

Although research on knowledge estimations has been conducted in other fields of expertise, such as healthcare and education, no previous study has investigated biodiversity communicators' perceptions of knowledge levels in laypeople. Research in this direction is important, as it may help explain current communication outcomes and can aid biodiversity communicators in reaching out successfully to broader audiences than before, so that eventually broad-based support for biodiversity conservation can be realized. It is especially relevant to study communicators' awareness of knowledge levels in primary school children, as they are at a suitable age to learn about species and represent a generation that holds the key in addressing the biodiversity crisis in the future (Kahn, 2002; Kellert, 1985, 2002; Magntorn & Helldén, 2006; R. L. White et al., 2018).

In addition to accurate estimations of knowledge levels in their audiences, communicators benefit from having a clear picture of what level of knowledge they strive for in their audiences. This can help set educational goals and provide clarity about the steps needed to achieve desired outcomes. While biodiversity communicators are expected to regard knowledge about biodiversity valuable

and important, it is not yet clear what their views are about specific forms of it, such as species literacy. For instance, it is not known what the desired levels of species literacy would be and if and why communicators think that knowledge about species is important or not. Research in this direction can provide insight into the values attached to knowledge about biodiversity, and biodiversity communicators, educators, and conservationists may use this information to underline the importance of their own activities.

In this study we compared the average species literacy level of primary school children as estimated by biodiversity communicators in the Netherlands with the actual level, which had been determined during a previous project carried out just before the current study (Hooykaas et al., 2019, Chapter 2). We further compared the estimated and actual average levels of species literacy with the desired level, and we explored the importance placed by biodiversity communicators on species literacy.

We investigated the following research questions:

1) Are biodiversity communicators aware of the species literacy level in primary school children aged 9-10 years old?
2) What is the desired level of species literacy in primary school children aged 9-10 years old according to biodiversity communicators and how does this compare to the actual level?
3) What importance do biodiversity communicators place on species literacy in laypeople?

6.2 Methods

We constructed a survey (Online Supplementary Materials: S_Ch6_Questionnaire) in Qualtrics (https://www.qualtrics.com) targeted at Dutch biodiversity communicators: people who communicate nature, biodiversity or animals in their voluntary or paid work. The survey was administered between May and July 2018, by sending an invitation via e-mail to a large number of Dutch organizations and institutions involved with nature and biodiversity, such as nature conservancy organizations, environmental education institutions, ecological consultants, and zoos. Participation was anonymous, avoiding social desirability or 'prestige bias' in the answers and taking into account privacy regulations (Streiner, David et al., 2015).

First, the communicators were asked to take a species identification test that had just been used during a different part of an overarching research project on communicating biodiversity, to assess species literacy in Dutch primary school children aged 9-10 years old. Full methods are described in Hooykaas et al. (2019, Chapter 2). The identification test comprised 27 animal species native to the Netherlands, and participants were asked to provide the name of each depicted species, thereby identifying it as precisely as possible. Included species were mainly those occurring regularly in Dutch (sub)urban areas (e.g., house sparrow (*Passer domesticus*)), supplemented by a few species encountered predominantly outside urban areas (e.g., wild boar (*Sus scrofa*)). In the test, each animal was represented by one or two color pictures from the website https://pixabay.com/ – see Figure 6.1.

After communicators had finished the species identification test, they were asked to estimate the species literacy level of primary school children aged 9 or 10 years old (i.e. their average achieved identification score: the number of correct identifications), and they were asked what the desired level of species literacy in this group would be (i.e. the desired average achieved identification score). Communicators were also asked whether or not they had targeted primary school children aged 9-10 in their communication in the past 5 years, to investigate the influence of experience with the target group on estimation accuracy. Finally, we explored the importance placed by biodiversity communicators on species literacy, by asking them whether they agreed with the statement "it is important

Figure 6.1. Female (a) and male (b) chaffinch (*Fringilla coelebs*; Dutch: vink); photo credits a. Kathy Büscher b. Klimkin Sergey.

for people to recognize many animal species" on a 10-point scale and offering them the possibility to elaborate their answer with arguments.

6.2.1 Analyses and statistical procedures

Data were compiled in Microsoft Excel and subsequently processed with IBM SPSS Statistics (version 25.0). First, we used Welch' independent samples *t*-tests to compare the average level of species literacy in primary school children aged 9-10 as estimated and considered desirable by the communicators on the one hand with the actual level on the other. For the actual species literacy level, we used the average achieved identification score of 602 children (M = 9.5, SD = 3.4), established during the research project mentioned before that took place just prior to the current project; most children (86.9%) had recognized less than half of the species. Moreover, we compared the communicator-estimated average level of species literacy in primary school children aged 9-10 by the communicators with the level considered desirable using a paired *t*-test. To account for multiple testing, a strict Bonferroni correction was applied.

To provide insight into the importance placed by biodiversity communicators on species literacy, we analyzed the answers to the 10-point scale question, and we used pattern analysis (Braun & Clarke, 2006) to carry out inductive coding of the additional remarks provided by the participants. The codes were eventually grouped into categories. To avoid subjectivity, codes and categories were designed by three researchers and discussed among colleagues. Depending on the variation in arguments provided by the participants, each answer received one or more codes (identical codes were not repeated). After one researcher had coded the dataset, half of the coded answer fragments were selected randomly and coded independently and blind to the previous coding by a second researcher. Intercoder reliability was high (percent agreement = 81%, Cohen's Kappa = .80), indicating a strong level of agreement between the two coders (McHugh, 2012). Subsequently, the discrepancies were discussed by the coders and resolved.

6.3 Results

6.3.1 Descriptive statistics

The final dataset (Online Supplementary Materials: S_Ch6_Datasheet) included 677 biodiversity communicators (e.g., nature guides, communicators in zoos, spokespersons and text editors at nature conservancy organizations, and ecological consultants).

6.3.2 Species literacy estimations by communicators

Communicators' estimations of the average species literacy level in primary school children aged 9-10 varied widely and regularly differed from the actual level – see Figure 6.2. The average identification score in primary school children

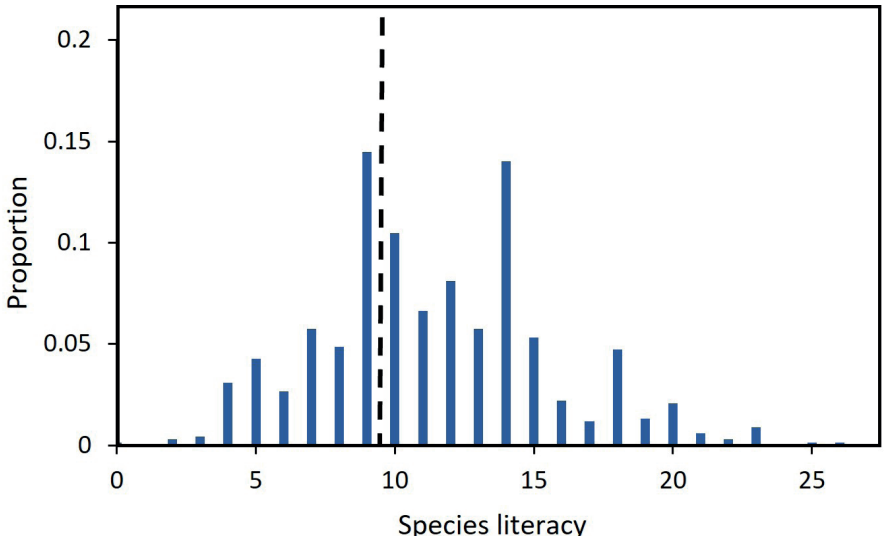


Figure 6.2 Distribution of biodiversity communicators' estimations of the average level of species literacy (i.e. identification score) in primary school children aged 9-10. The actual level, established during a previous research project just prior to the current study, is depicted with a dashed line. We note that communicators were asked to estimate the level of species literacy on a scale from 0 to 27, where a few levels (e.g., 5, 9, 14) were indicated. Although this may explain the peak at 9 species, and might thus have increased the number of communicators with accurate estimations, the wide range in estimations demonstrates clearly that most communicators were unaware of the actual knowledge level.

as estimated by communicators (M = 11.4, SD = 4.2) was higher than the actual achieved score in this group (M = 9.5, SD = 3.4); $t(1269.5) = 9.20$, $p < .001$. In fact, 53.5% of the communicators overestimated the knowledge level (e.g., one in three incorrectly assumed that the average child would correctly identify over half of the species). Only one in four communicators (25.0%) estimated species literacy in children accurately, at an average achieved identification score of 9 or 10 out of 27 species, and 21.6% of the communicators underestimated species literacy in primary school children.

Next, we investigated the influence of experience with primary school children as a target group on communicators' estimations, by comparing the estimates of children's species literacy made by communicators with (59.8%) and without (40.2%) children aged 9-10 as a target group. Estimations by communicators with children as a target group (M = 11.4, SD = 4.2) and by communicators without children as a target group (M = 11.5, SD = 4.1) did not differ significantly, $t(589.67) = 0.34$, $p = .736$).

6.3.3 Desired levels of species literacy

To further put children's level of species literacy in perspective, we compared the actual and estimated level with the level as desired by the communicators. Significant differences were found. The desired average level of species literacy (M = 14.8, SD = 5.1) was considerably higher than both the actual average level (M = 9.5, SD = 3.4); $t(1197.1) = 22.11$, $p < .001$ and the estimated average level (M = 11.4, SD = 4.2); $t(676) = 19.39$, $p < .001$. While 23.3% of the communicators would be satisfied with the actual level of species literacy (desiring no more than 10 out of 27 species to be correctly identified), the majority (76.7%) wished for a higher knowledge level – see Figure 6.3. For instance, two in three communicators (65.9%) expressed that children should be able to identify over half of the species.

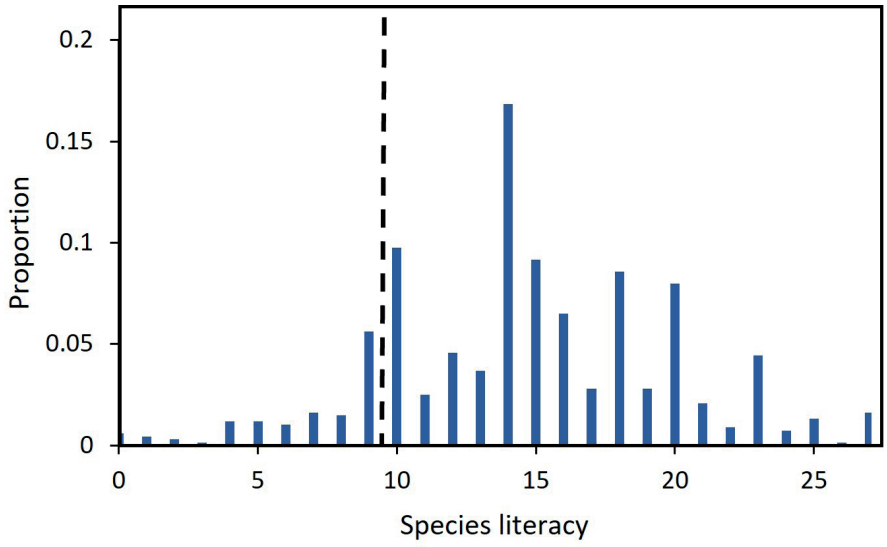


Figure 6.3 Distribution of the desired average level of species literacy (i.e. identification score) in primary school children aged 9-10 according to biodiversity communicators. The actual level, established during a previous research project just prior to the current study, is depicted with a dashed line.

6.3.4 Importance placed on species literacy

The majority of the communicators attached importance to species literacy; on a 10-point scale 78.7% provided scores of 6 to 10 to the statement that people should be able to recognize many different animal species. Only a minority of the participants (4.9%) placed little to no importance on knowledge about species in laypeople (score 0 to 4).

To provide further insight into communicators' perceptions of the importance of species literacy, we carried out inductive coding of the remarks provided by the participants. Each answer received 1 or more codes, and the total number of coded answer fragments (634) exceeded the number of communicators that provided remarks (439 out of 677). There were seventeen different codes grouped into three categories: *1 = Species literacy is important,* 2 = *Species literacy is not important*, and 3 = *Species literacy is not as or as important as…* – see Table 6.1. Each category contained the same four themes (insight, interest/experience, affinities/care, well-being) supplemented by a few separate codes. In addition, an eighteenth code contained 69 fragments that could not be assigned any of the

Table 6.1 Overview of the codes and categories used during the inductive coding process of the remarks made by the communicators. The percentages show how many of the 439 communicators providing remarks used an argument with that particular code.

Code Title	Description	Example	%
Category 1: Species literacy is important, because…			
Important for insight	...it can lead to further knowledge, awareness, understanding, insight, or skills related to species/nature, or is needed to achieve this	"Then you see the diversity that is present and you will notice the disappearance of certain animals"	8.7
Important for interest/experience	...it can provoke interest in, and add to the experience of species/nature, or is needed to achieve this	"Species knowledge makes the experience of nature more interesting. Seeing two birds differs from seeing a house sparrow and a kingfisher"	9.3
Important for affinity/care	…it can raise affinities towards, appreciation of, or respect and concern for species/nature, or is needed to achieve this	"People care about what they know"	20.7
Important for well-being	...it can increase a person's well-being (e.g., feelings of joy/pleasure), or is needed to achieve this	"Recognizing species is fun"	9.1
Important familiarity	…it is important to get to know and be familiar with the local environment	"It helps if you are familiar with your environment, just like knowing street names or colleagues"	3.4
Important knowledge base	…because it should be part of a person's knowledge base and/or upbringing	"You do not need to know every bird, but a number of basic animals comes in handy"	10.0

Category 2: Species literacy is not important, because…			
Not important for insight	…it does not lead to further knowledge, awareness, understanding, insight, or skills related to species/nature, or is not needed to achieve this	"Species knowledge does not lead to knowledge about nature"	0.2
Not important for interest/experience	…it does not provoke interest in, or add to the experience of species/nature, or is not needed to achieve this	"Without knowing the names of animal species, interest in nature is possible too"	1.6
Not important for affinity/care	…it does not raise affinities towards, appreciation of, or respect and concern for species/nature, or is not needed to achieve this	"Love for nature does not depend on species knowledge"	2.7
Not important for well-being	…it does not increase a person's wellbeing (e.g., feelings of joy/pleasure), or is not needed to achieve this	"You do not need to recognize everything in order to enjoy it"	3.6
Not important for everyone	…it is only useful or important for some (e.g., experts/hobbyists), and not for others	"Not everyone has to be a species expert"	4.6
Not important to name	…specifically the naming of species is not important	"A small bird often looks like a different species. I do not see a problem in calling it a little brown bird"	12.5
Not important now	...people do not need it in the modern world	"If you grow up in an urban environment, you have other priorities. In this world created by man, knowing animal species is not necessary"	0.7

Category 3: Species literacy is as or not as important as...			
As or not as important as insight	…other types of knowledge, awareness, understanding, insight, or skills related to species/nature	"For me understanding the system is more important than knowledge about each individual link"	11.8
As or not as important as interest/ experience	…interest in, or experience of species/nature	"For me, it is more about experiencing nature"	9.8
As or not as important as affinity/care	…affinities towards, appreciation of, or respect and concern for species/nature	"Love for nature is more important than knowing as many species as possible"	13.4
As or not as important as well-being	…a person's well-being (e.g. feelings of joy/ pleasure)	"It is more important that people enjoy nature"	6.4
Other			
Other	Unclear, incomplete or uninformative answers	"Species knowledge is not the only thing that matters"	15.7

previous 17 codes, e.g., because they were not an answer to the actual question ('*the more knowledge, the better*') or neutral ('*no opinion*').

Different reasons were expressed by the biodiversity communicators as to why knowledge about species would be important or not. Of the coded answer fragments, 42.4% underlined the importance of species literacy. In particular, a considerable number of communicators expressed that species knowledge may help to create affinities towards nature and species, ultimately contributing to conservation. Participants also argued that knowledge about species, common everyday species especially, should be part of any person's knowledge base, in line with comments from communicators that it is important specifically to be familiar with your surroundings. Furthermore, communicators noted that knowledge about species can provoke curiosity and can strengthen nature experiences, can contribute to well-being, e.g., by triggering joy and building a person's confidence to talk about nature, and that knowledge and skills related to species (e.g., observing) can lead to further insights and broader understanding. For example, people knowledgeable about species may notice and pay attention to ongoing changes in population densities.

Of the coded answer fragments, 18% were objections against the idea that species literacy would be important. For instance, some communicators considered knowledge about species to be useful only for experts and hobbyists and a few expressed that people nowadays do not need knowledge about species, because information can be retrieved quickly and citizens are less directly dependent on natural resources. In particular, we found evidence for a lack of agreement among professionals of the importance of knowing species names; it was argued that this would have little value in itself. Furthermore, some communicators questioned the need to be knowledgeable about species for being able to enjoy, value, or grow interest and insight in nature.

Finally, in 28.7% of the coded answer fragments, communicators compared knowledge about species to things that they attached equal or more importance to, such as interest in and experience of nature, and enjoyment of nature. In particular, communicators stressed the importance of respect and care for nature and species, which they argued should be prioritized. They expressed that as long as people appreciate and cherish nature, knowing much is not

really vital. Finally, some communicators emphasized that in-depth knowledge about species and skills such as observing were most important. For instance, they stressed the importance of grasping the 'big picture' and becoming aware of interdependencies between species and between species and the environment.

6.4 Discussion

6.4.1 Communicators' understanding of children's species literacy level

While biodiversity decline continues and laypeople's knowledge about species is limited, especially in children, high-quality communication is needed to help build stewardship for biodiversity. To strike a chord with the public, communicators need to be sensitive to perceptions present in their target audiences (Bass et al., 2002; Schutte, 2010; Wratten & Hodge, 1999). We explored whether biodiversity communicators were aware of the species literacy level in primary school children, by asking them to estimate the average score that children aged 9-10 would achieve in an identification test comprising native animal species.

The results demonstrated that most communicators were unaware of the species literacy level in primary school children; their estimations varied widely. In particular, many communicators overestimated the level of species literacy. Surprisingly, experience with children as a target group did not correlate with better estimations. The results are in line with previous studies that have reported professionals in other fields to experience difficulty in estimating prior knowledge levels (Dickens et al., 2013; MacAbasco-O'Connell & Fry-Bowers, 2011; Perrenet, 2010; Schutte, 2010).

The mismatch uncovered between the estimated and actual knowledge level indicates a barrier to successful communication. Nature educators might currently not be aware that certain species names of common animals are likely to be perceived by children as jargon. As we expect the mismatch to apply to more than just the identification of species (e.g. communicators will probably also overestimate what children know about species' habitat, diet, and behavior), messages may currently be crafted by communicators that will not be understood as intended.

6.4.2 Species literacy as desired and perceived by communicators

To further put the level of species literacy in primary school children into perspective, we compared it with the level as desired by biodiversity communicators and we explored the perceived importance attached to species literacy.

Three quarters of the communicators desired the level of species literacy in children to be higher than it actually was. Corroborating these results, communicators generally placed importance on species literacy. Remarkably though, views differed as to why knowledge about species would be important. Some communicators expressed that knowledge about species simply should be part of a person's knowledge base; e.g., it was stated that people should be familiar with the local environment, which links with the idea that knowledge about flora and fauna can provide people with a 'sense of place and belonging' (Horwitz et al., 2001; Standish et al., 2013). Most viewed species literacy not as a goal in itself, but rather as a basic step that helps achieve broader understanding, enriches a person's life by raising interest and well-being, and/or that instills love and respect for nature. These views are in line with reports that knowledge about species can help shift people's perceptions and raise affinities towards them (Barnett, 2019; Lindemann-Matthies, 2005; Schlegel & Rupf, 2010; Wilson & Tisdell, 2005) and the notion that species names are part of a language that a person needs to communicate successfully and confidently about nature (Magntorn & Helldén, 2005). The role that communicators ascribed to species knowledge as providing people with insights, e.g. making them aware of changes in the environment, and as contributing to nature experiences, may prove vital at a time when nature degradation continues and people are at an increasing risk of losing connections with nature (Miller, 2005; Pauly, 1995; Pyle, 2011; Soga & Gaston, 2018).

We further note that biodiversity communicators did not attach the same level of importance to different components of species literacy. Most importantly, there was disagreement about the value of naming species. Some communicators stated that naming species has little value in itself, despite the fact that previous authors have argued that a name can be a starting point for more meaningful learning and discussion (Magntorn & Helldén, 2005; Ohl et al., 2014). Similarly, although most communicators wished laypeople to care about nature and to understand 'the big picture', some questioned the contribution that species literacy can make in this respect and thus seemed unaware of the role attributed by past authors to factual knowledge in allowing people to build understanding,

interest, and appreciation; a pathway that has actually been covered extensively in educational literature (Amer, 2006; Weilbacher, 1993) and has been supported by empirical research (Cosquer et al., 2012; Lindemann-Matthies, 2005; Schlegel & Rupf, 2010; Shwartz et al., 2014). In fact, accessible as they are and easy to relate to, species can be tools in helping people grasp complex, abstract concepts like biodiversity, food webs, and ecosystems (Barker & Slingsby, 1998; Orr, 2005).

6.4.3 Future directions

It is important to mention that we focused our study on estimations of average levels of knowledge, i.e. the identification score that an average child would achieve. However, children differ from one another with respect to what they know, and it is questionable whether communication materials calibrated at an average knowledge level will strike a responsive chord with those who are not average (Wals, 1994). When designing a message aimed at primary school children, it may thus be better to calibrate the level below the actual average level, although the needs of children with greater bodies of knowledge should also not be neglected. Future research could explore how best to address heterogeneous audiences when communicating biodiversity.

Moreover, while we studied communicators' estimations of the knowledge level in primary school children, future projects could explore the extent to which communicators are aware of perceptions in high school students and adults. For instance, studies could investigate whether communicators working at nature conservancy organizations are aware of knowledge levels in their lay members.

6.5 Conclusion

To increase awareness about biodiversity effectively, biodiversity communicators should have a clear picture of prior knowledge in their audiences and the desired outcomes that they strive for. Only then will they be able to meaningfully connect to people's perceptions and take the necessary steps to achieve the desired level. To our knowledge, this study was the first to investigate species knowledge levels as estimated and desired by biodiversity communicators. We demonstrated that estimating prior knowledge levels in primary school children is difficult for people who communicate about biodiversity, extending the findings in other disciplines (Bass et al., 2002; Kelly & Haidet, 2007; Perrenet, 2010;

Storm, 2012). Communicators overestimated and wished for higher knowledge levels in children, suggesting that current educational materials and messages may not connect to existing knowledge. Such misfit between estimated and actual knowledge levels may prevent learning goals from being achieved and may partly explain why conservationists have yet been unsuccessful at reaching certain segments of society.

Moreover, although most biodiversity communicators agreed that species literacy is valuable, we uncovered disagreement among biodiversity communicators as to why species literacy or components of species literacy would be important. This suggests that professionals may benefit from a detailed framework of species literacy that integrates different aspects and values. Such a framework may also encourage biodiversity communicators, educators, and conservationists in their work and could assist them in the design of educational materials and in accounting for the relevance of their activities to society and employers.

Our study further highlights the potential of assessments to bridge the gap between expected and actual knowledge levels (Hailikari et al., 2007). Assessments may help communicators in attuning messages to the appropriate level, in identifying misconceptions to be addressed, and in determining the specific target group that will benefit most from communication or education (Penn et al., 2018; Peterson et al., 2008; Vincenot et al., 2015). Communicators could, for instance, use a series of online quizzes, which would simultaneously provide valuable insights into people's perceptions, while entertaining participants and encouraging them to learn and find out more about biodiversity, adding to their impact and scope. While we focused on prior knowledge, we recommend that factors such as interest, expectations, and personal experiences are also explored further via such assessments, as they too influence the way people respond to messages, and providing information at the right level will in itself not be enough to change attitudes and behavior (Buijs et al., 2008; J. H. Falk & Adelman, 2003; Fischer & Young, 2007; Novacek, 2008; Vázquez-Plass & Wunderle, 2010). As perceptions depend on context and change over time, we recommend assessments to be repeated regularly.

All in all, we demonstrated gaps between the perceived, desired and actual level of species literacy in Dutch primary school children. This suggests that to engage young generations with biodiversity and to reach desired knowledge

levels, communicators will benefit from first becoming more aware of current perceptions in children. Efforts to identify, differentiate and get to know the audiences they try to reach would provide biodiversity communicators with opportunities to improve their outreach, which could help achieve broad-based support for conservation.

The **common hedgehog** (Nederlands: **egel**) has a varied diet that includes snails and slugs, earthworms, and insects. When a hedgehog is born, a protective membrane covers the quills.

Chapter 7

Expanding the Role of Biodiversity in Laypeople's Lives: The View of Communicators

This chapter is based on:

Hooykaas, M. J. D., Schilthuizen, M., & Smeets, I. (2020). Expanding the role of biodiversity in laypeople's lives: The view of communicators. *Sustainability*, *12*(7), 2768. https://doi.org/10.3390/su12072768

Abstract

Biodiversity is a fundamental part of sustainable development, yet it is threatened by numerous factors associated with human population growth. The current lack of broad-based support for biodiversity conservation may be explained by the widening gap between people and nature. In order to conserve biodiversity, people should be engaged in biodiversity, yet it is not yet clear what potential is present in highly urbanized environments. We conducted semi-structured interviews with twelve biodiversity communicators in the Netherlands, a highly urbanized country, and used their perceptions and experiences to explore motivations, opportunities and challenges for expanding the role of biodiversity in people's lives in an increasingly urban world. Overall, the interviewees perceived the current role of biodiversity in laypeople's lives to be too limited, but they were positive about the potential to expand the role. Based on communicators' perceptions potential lies in a combination of direct exposure to biodiversity outdoors, the media, and education. Furthermore, strategically designed communication is also expected to play an essential part in opening people's eyes for biodiversity. The results are valuable both at national and international levels, as they can motivate and aid professionals operating in urbanized contexts at reaching out to their audiences about biodiversity.

7.1 Introduction

There is a growing recognition that biodiversity is essential for sustainable development, reflected in the Sustainable Development Goals adopted by all United Nations member states in 2015 (United Nations, 2019). Increasing evidence demonstrates that biodiversity directly and indirectly contributes to sustainability, as it is interwoven with the three pillars that support a sustainable world: economy, society and environment (Brundtland, 1987; Niesenbaum, 2019; Schultz et al., 2016). Given this, biodiversity will be vital for meeting the needs of both current and future generations (Brundtland, 1987; United Nations, 2012).

Biodiversity has been linked to critical processes and functions in ecosystems (Cardinale et al., 2012; Mace et al., 2012), and to people's well-being and health (Carrus et al., 2015; Sandifer et al., 2015). For instance, biodiversity supports food production, which may reduce poverty, and urban vegetation may enhance citizens' mental state (Blicharska et al., 2019; National Research Council, 1999). Biodiversity further provides people with educational opportunities and other enriching ways of interacting with nature (Curtin, 2009, 2010; Fuller et al., 2007; Muratet et al., 2015). In line with this, it has been argued that biodiversity should be included in education for sustainable development (UNESCO, 2012) and sustainable urban development (Barrico & Castro, 2016; Nilon et al., 2017; Shwartz et al., 2014).

However, while the importance of biodiversity for sustainable development is receiving increased attention, biodiversity itself is rapidly declining (Ceballos et al., 2015, 2017). Ecosystems, species and populations are exposed to numerous threats, including loss and deterioration of natural habitats, overexploitation of organisms, and climate change (Díaz et al., 2019; Dirzo et al., 2014). As a result, species are becoming extinct at a speed of up to 1000 times the natural background rate of extinction (De Vos et al., 2014; Pimm et al., 2014), and worldwide around 1 million species of animals and plants are now threatened with extinction, many within decades (Díaz et al., 2019). If biodiversity loss continues, this will have far-reaching consequences, as it may compromise valuable contributions of biodiversity to ecosystem services, ultimately limiting its potential for sustainability.

Although biodiversity conservation has received attention in national and international agendas (CBD, 2013; Dijksma & Mansveld, 2013; Ministry of Economic Affairs, 2014a, 2014b; United Nations, 1992), focus seems to have been largely on legislating access to (genetic) resources (Bockmann et al., 2018;

Divakaran Prathapan et al., 2018; Ribeiro, Carolina et al., 2018; Watanabe, 2015). Furthermore, current mobilization of the public seems to fall short given the severity of the biodiversity crisis (Courchamp et al., 2018). This is worrisome, as protection of biodiversity depends on broad-based support from the public for continuous budgets and acceptance (Christie et al., 2006; Home et al., 2009). Moreover, public concern about biodiversity may encourage decision makers and drive public policy (Burstein, 2010; Page & Shapiro, 1983), and the current limited involvement from society will probably be insufficient for governments to change course (Novacek, 2008).

7.1.1 Connecting people and biodiversity

The lack of public support may be due to the widening gap between people and nature that is occurring simultaneously with the decline in biodiversity (Miller, 2005). As the human population grows, natural habitats are converted to anthropogenic environments, which may cause an *extinction of experience*: a cycle of reduced opportunities for people to experience nature, apathy towards the natural world, and further degradation and loss of nature (Pyle, 2011; Soga, Gaston, Koyanagi, et al., 2016; Soga & Gaston, 2016). Exacerbating this loss of opportunity and orientation are people's fading memories of past levels of biodiversity, so that younger generations get used to lower baselines (Kahn, 2002; Kai et al., 2014; Papworth et al., 2009; Pauly, 1995). This masks the total decline and results in lower expectations regarding the quantity and quality of nearby nature (Miller, 2005).

The decline in biodiversity and the disconnection between people and nature are also reflected in society. It has been reported that nature is portrayed less than before in cultural products such as songs and film scripts (Kesebir & Kesebir, 2017; Mccallum & Bury, 2013) and that nature vocabulary is lost from societal and daily conversation (Barnett, 2019; Macfarlane, 2016, 2017; Morris & Macfarlane, 2017; Stibbe, 2012, 2014). Moreover, studies in different countries have suggested that laypeople's ecological knowledge is decreasing (Pilgrim et al., 2008). There is a growing literature suggesting a general lack of biodiversity awareness in the lay public (Balmford et al., 2002; Hooykaas et al., 2019, Chapter 2; Huxham et al., 2006; Lindemann-Matthies & Bose, 2008). For instance, people may not be aware of species richness in their immediate environment (Dallimer et al., 2012; Olive, 2014; Pett et al., 2016; Shwartz et al., 2014).

These trends are worrisome, as they could make it hard to engender broad-based support for biodiversity conservation. A public illiterate about biodiversity will further not be equipped to make informed decisions. To change this, people need to be engaged in biodiversity, and improved strategies and various forms of communication are required to disseminate biodiversity effectively to society. In particular highly urbanized countries are faced with the challenge of making biodiversity an issue that all people can relate to (Dunn et al., 2006).

However, it is not yet clear what potential is present in areas that have become or are becoming increasingly urbanized. While it will be harder to provide urbanites with direct experiences of wilderness, cities do harbor synanthropes: species that adapt well to environments made by humans (McKinney, 2006; Schilthuizen, 2018). Moreover, while city dwellers may have fewer nature experiences outdoors (Soga et al., 2018), they can still learn about biodiversity via vicarious experiences with various cultural sources that portray the natural world, which are abundant in urban environments (Soga, Gaston, Yamaura, et al., 2016). More research is required to establish whether the urban environment is sufficient for human-nature interactions to unfold, and what role communication could play.

Exploring best practices in biodiversity communication is a good first step towards expanding the role of biodiversity in laypeople's lives. People who professionally communicate biodiversity to a lay audience have gained personal experience with disseminating information about biodiversity in many forms. Moreover, they are faced with challenges associated with the rapidly urbanizing world, including loss of nature experiences and knowledge in their audiences. Finally, while contact between people and nature may be declining, biodiversity communicators are expected to play an increasingly important role in promoting awareness and support for biodiversity conservation. Exploring their perceptions and personal experiences therefore sheds light on the potential to raise biodiversity awareness and support even in the most urbanized countries. Such insights are valuable at international levels and may empower those involved in nature communication and education, which could ultimately help avert biodiversity loss.

7.1.2 Aim of the study and research questions

We conducted an interview study with 12 biodiversity communicators in the Netherlands, one of the most urbanized and densely populated countries in the

world, with 92% of the population residing in cities (Worldometers.info, 2019). Although levels of education in the Netherlands are relatively high, biodiversity awareness is limited (Hooykaas et al., 2019, Chapter 2; UEBT, 2018; Verboom et al., 2004). In addition, Dutch citizens were found to be a little less positive about the importance of biodiversity than people from other members of the European Union, and relatively few felt personally affected by biodiversity loss (European Commission, 2013).

We adopted a qualitative approach, as we aimed to explore in depth the range in individual perceptions. We aimed to answer the following questions:

1) How do biodiversity communicators perceive the current role of biodiversity in Dutch laypeople's lives?
2) How do biodiversity communicators perceive the desired role of biodiversity in Dutch laypeople's lives?
3) According to biodiversity communicators, which potential is present for expanding the role of biodiversity in laypeople's lives in the Netherlands?
4) What are best practices in communicating biodiversity amongst Dutch biodiversity communicators?

7.2 Methods

To explore in depth the perceptions of Dutch biodiversity communicators we adopted a qualitative research approach, conducting semi-structured interviews and using qualitative content analysis. We chose a qualitative methodology as it provides opportunities and flexibility suitable for grasping the variety of views in different people (Evers, 2015a; E. Jensen & Laurie, 2016). In this way, the approach can also complement quantitative studies.

7.2.1 Selection of participants

We targeted biodiversity communicators in the Netherlands, regarded as people who communicate nature or biodiversity in their paid or voluntary work to the general public, or to specific groups such as children, farmers or building contractors. As we aimed to map the range in perceptions instead of quantifying the frequency of certain views or generalizing an 'average view' (Flyvbjerg, 2006), we purposively searched for people within and outside of our network with different professions or voluntary work and different mediums of communication.

When a potential interviewee was found, an invitation was sent via e-mail or social media (e.g., LinkedIn).

Within twelve interviews we achieved saturation, evidenced by repetition of certain answers and arguments provided by the interviewees. As the number of participants was sufficient for the aims of our study (e.g., we did not seek to quantify differences between gender) we decided to stop the sampling process at that point. This was in line with Guest, Bunce, and Johnson (Guest et al., 2006), who concluded that a sample of twelve interviews would be sufficient for discovering a full range of themes and for crafting a stable codebook. The interviewees, aged 28 to 65, included 6 men and 6 women – see Table 7.1.

Table 7.1 Overview of the twelve participants, with their profession (main paid or voluntary work related to biodiversity) and age; pseudonyms have been used to guarantee anonymity.

Participant	Age	Profession
1 Tara	42	Urban ecologist and ecological advisor
2 Helen	44	Coordinator of funding related to biodiversity; initiator neighborhood nature garden
3 Oliver	39	Urban ecologist and media communications officer; chairman bird shelter
4 Matt	64	Editor-in-chief at a zoo; chairman natural city park
5 Amy	36	High school teacher (biology-related subjects) and PhD-student
6 Shane	36	Ecological consultant
7 Norman	58	Self-employed writer/text-editor, writing mainly about biodiversity
8 Rick	28	Project manager nature conservation organization
9 Ulrika	42	Self-employed park ranger and nature communicator; initiator people-nature connection project
10 Barbara	65	Nature guide/nature educator
11 Edward	62	Project leader Natural History Institute; member of municipality committees about greenspace
12 Nancy	56	Primary school teacher

7.2.2 Instrument

The interviews were semi-structured and covered in the following order:

- the role of biodiversity in the profession and personal life of the interviewee
- the role of biodiversity in the lives of Dutch laypeople, as perceived by the interviewee
- potential to expand the role of biodiversity in Dutch laypeople's lives, as perceived by the interviewee.

These themes were chosen in light of existing literature and the overarching research project on communicating biodiversity of which the study was part. The sequence of the three themes was chosen, because an initial focus on participants themselves would be a good starting point for them to start thinking about the lay public and the Netherlands in general.

We used an interview guide with mainly open-ended questions. Per theme questions were phrased in a neutral and non-leading way (e.g., 'How do you perceive…' and avoiding 'Don't you think that…?'). In addition to the main questions, keywords and possible follow-up and probing questions were added to the interview guide to anticipate and facilitate in-depth exploration. In practice participants regularly raised issues referred to in the questions even before these questions were asked, which confirmed the natural flow in the themes and questions.

In this paper we use the term biodiversity in line with the definition of the Convention of Biological Diversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (United Nations, 1992). To account for differences in interpretation of the multi-dimensional and value-laden concept (Dreyfus et al., 1999; Fiebelkorn & Menzel, 2013; Gayford, 2000; Van Weelie & Wals, 2002), we asked each interviewee as a first question to express their view on the term.

To test the interview guide a pilot interview was conducted, after which formulation and order of some questions was altered. The interview guide can be found in the Online Supplementary Materials (S_Ch7_Interview_Guide).

7.2.3 Conducting the interviews

All interviews were conducted in 2018 and 2019 by the first author, who made individual appointments with the participants beforehand. Each interview was in Dutch, face to face and conducted at a quiet place (e.g., a private office). On the way to each interview the interviewer prepared mentally by 'bracketing' (Sorsa et al., 2015), and before the interview started he aimed to establish rapport with the interviewee, e.g., by reassuring the participant that there were no wrong answers (Evers, 2015a).

Before the first interview question was asked, the study and interview were briefly introduced without directing the respondent towards certain themes. All respondents were guaranteed anonymity and informed consent was obtained from the participants via a written consent form (Online Supplementary Materials: S_Ch7_Consent_Form). No time restrictions were placed on the interviews, and the respondents were informed that they were free to leave at any time. After permission was granted by the participants, interviews were audio-recorded.

To allow for a natural flow of the conversation, participants were encouraged to elaborate on their answers, and the interviewer followed where the participants would lead him. As a result, the order of the questions occasionally differed from the sequence in the interview guide. Moreover, certain questions were rephrased so that they fitted the respondent (e.g., primary school teacher Nancy was asked about her classroom experience). Lastly, to allow for emerging insights, some interview questions were added or rephrased as the research progressed, which is important for uncovering new concepts and exploring themes thoroughly (Gioia et al., 2012). For instance, in the first interview the influence of the media on people's perceptions of biodiversity emerged, so we added questions related to this subject in following interviews. For the above reasons each interview was unique concerning the exact order of the questions, the time spent on each specific question, and the depth with which each theme was explored. On average the interviews lasted 1h30 min (1h15 min – 2h30 min).

7.2.4 Analysis

Audio-recordings of the interviews were transcribed verbatim using Express Scribe (version 8.14). The transcribed interviews were coded and analyzed with ATLAS.ti (version 8.2.34), following the basics of thematic analysis as described by Braun and Clarke (Braun & Clarke, 2006).

The transcripts were analyzed in three phases. In the first phase, the first author took stock of the data by skimming through the transcripts, and he designed an initial set of codes. Some codes were based on the literature and the research questions, while others emerged from the data. The first and last author checked the reliability of the codebook as suggested by Evers (Evers, 2015b) by independently coding one transcript and comparing their results; discrepancies were resolved after discussion, e.g., a few codes were refined and clarified. For instance, it was decided that the code 'Prof_role_personal', concerning the role that biodiversity plays in the personal life of the interviewee, should exclude past experiences, as the code 'Prof_expanded' already covered that. The two researchers then independently coded a second transcript, and after discussion the researchers concluded that the codebook was now stable and reliable. The final codebook can be found in Table 7.2.

In the next phase, the first author coded the remaining transcripts, meanwhile writing memos. For each code, variation was mapped and patterns were sought in segments from all transcripts taken together. Moreover, overarching outcomes and relationships between different codes were traced (e.g., by comparing and connecting coded segments from different codes). For instance, it became clear that in describing ways to expand the role of biodiversity in people's lives, interviewees referred to both past and current experiences with nature, which were part of different codes. Progress was regularly discussed by all three researchers.

In the third and final phase, the outcomes of the analysis were put into a broader perspective, by making connections to the literature and by determining possible future directions for research.

Table 7.2 Codebook used to code the interview transcripts. With 'role of biodiversity' we refer to people's knowledge/skills/awareness, interest/experience, affinities/care, behavior, and values related to biodiversity. For clarity, two codes not relevant to answering the research questions are not displayed.

Code Nr.	Code Title	Description (references made by the interviewee to…)
Theme 1: Current role of biodiversity in laypeople's lives		
1	Laypeople_role	…the role that biodiversity plays in the lives of laypeople and his/her thoughts and/or feelings about this.
Theme 2: Desired role of biodiversity in laypeople's lives		
2	Laypeople_role_should	…the role that biodiversity should or would not need to play in the lives of laypeople.
3	Laypeople_role_important_why	…why the role that biodiversity plays in the lives of laypeople is important or not important (e.g., the link between knowledge-interest-affinities).
4	Prof_role_personal	…the role that biodiversity currently plays in his/her personal life.
5	Prof_motivation_aims	…his/her goals, aims and motivations in the profession, including actual outcomes.
Theme 3: Potential to expand the role of biodiversity in Dutch laypeople's lives		
6	Expanded_prof	…when, where and/or how the role that biodiversity plays in his/her life expanded/developed.
7	Expand_lay_opportunities	…potential opportunities in the Netherlands for laypeople to develop/expand the role that biodiversity plays in their lives; excluding those in the profession of the participant (= Code 10) and media (= Code 9).
8	Expand_lay_barriers	…potential challenges/barriers for laypeople to develop/expand the role that biodiversity plays in their lives; excluding those specifically experienced in the profession of the participant (= Code 10) and media (= Code 9).

9	Expand_media	…the influences of the media on the role that biodiversity plays in laypeople's lives, including their potential in expanding/developing it.
Theme 4: Best practices in communicating biodiversity amongst Dutch biodiversity communicators		
10	Prof_com_how	…effective or non-effective ways of communication related to biodiversity in the profession, i.e., what does or does not work or should be kept into account.
11	Prof_com_how_challenge	…potential challenges/barriers experienced in communication related to biodiversity in the profession.

7.3 Results

We describe results within four overarching themes: (1) current role of biodiversity in Dutch laypeople's lives, (2) desired role of biodiversity in Dutch laypeople's lives, (3): potential to expand the role of biodiversity in Dutch laypeople's lives, and (4): best practices in communicating biodiversity amongst Dutch biodiversity communicators. In line with O'Brien et al. (2014), we selected quotations that clearly articulated general patterns in the data to illustrate findings, and translated them from Dutch to English. Ellipses show where parts of the sentence non-essential to the meaning were omitted. To ensure anonymity pseudonyms have been used to indicate participants.

7.3.1 Theme 1: Current role of biodiversity in laypeople's lives

We asked the biodiversity communicators how they perceive the current role of biodiversity in laypeople's lives. Overall the interviewees consider the role to be rather limited. Several express that most citizens do enjoy and appreciate biodiversity consciously or unconsciously, apparent from recreation in greenspace, anecdotes at social gatherings, and conversations about local wildlife, yet the interviewees also argue that laypeople's perceptions of biodiversity are incomplete, and their connection with it superficial. According to the communicators, biodiversity only plays a big role in the lives of a small group of hobbyists and nature lovers who regularly visit nature (e.g., to watch wildlife).

Lack of awareness

The majority of the communicators note that many laypeople have poor knowledge of biodiversity. For instance, it is mentioned that people do not seem to understand that different species depend on each other. Edward exemplifies this by referring to people who put up nest boxes, as they would like to see more birds, yet they do not want insects.

In particular, it is mentioned that many citizens, adults as well as children, know little about species occurring in the local environment. It seems that perceptions are directed more to charismatic, exotic species. When self-employed writer Norman presented one of his books to a group of rural children and showed them a common coot (*Fulica atra*), he recalls his surprise when none of them succeeded in identifying the bird, even though it can be found almost everywhere in the Netherlands:

I thought that they would start shouting 'COOT!' (laughs) That did not happen. And then (…) hesitantly, you know: "grebe?" (Norman)

Several communicators further describe that laypeople are not aware of changes in biodiversity. For instance, Shane refers to his vacation on Hawaii, where he noticed tourists in awe of the jungle, not aware of the deteriorating ecosystem, where invasive species have replaced native species:

Actually, not one tree or plant is native there, they are all exotic. But their experience is totally awesome: "The nature on Hawaii is marvellous!" That is what people tell you, while my heart aches as I'm walking there. (Shane)

In line with this, Ulrika expresses that many Dutch citizens have forgotten how varied and biodiverse meadows looked in the past:

They rush past those bright green deserts thinking: "oh yes, those are meadows". But that is not true. Those bright green fields, that is all just desert. An ecological disaster zone. (Ulrika)

Ambivalent attitudes

Apart from a lack of knowledge, the communicators express that laypeople's attitudes towards biodiversity are mixed. They mention that many laypeople do not see themselves as part of nature and in line with this, several note that many citizens do appreciate biodiversity, yet from a distance. For these people, nature is miles away, and should not be in their backyard:

There are many people who say: "You know, we shouldn't aim to turn cities into nature reserves. There are nature reserves and there are cities, and there is countryside. Countryside that's where potatoes should be harvested, cities are where people drive around or get stuck in traffic, and nature reserves, that's where deer roam and birds sing." (Oliver)

In addition, several interviewees mention that people seem unaware of what biodiversity offers them. For instance, Oliver mentions that some people may say they do not really like nature, whereas in fact they will enjoy bird sounds

in a park. Furthermore, exciting elements of nature regularly go unnoticed by people, and people may not realize that species viewed as a nuisance may in fact provide balance in the ecosystem, thereby preventing pests later on. Several communicators argue that laypeople often focus on a small number of obvious utilitarian services that biodiversity provides:

> *A tree is for providing shade, a tree is not for insects or for birds. And parks exist because you want to be able to walk somewhere (…) It is more like a décor. (…) That it's a tree that constitutes a living community of insects and herbivores and fungi, most people are not aware of that and therefore do not appreciate that. (….) I think that's a great shame, because people no longer see the dynamics and the interesting phenomena. (Edward)*

Others too describe that the lay public may use biodiversity as a décor. Shane notes that predominantly exotic biodiversity, such as tigers and elephants, is used as background scenery to pose with for pictures, while Oliver describes the ambivalent attitudes that people may display towards city animals:

> *One day they feed pigeons and the other day they say "they shit on everything". (…) Once (pigeons) are called "flying rats" and then again they are "so beautiful", and then they take a picture of the bridge together with those pigeons, and say "the city is such a beautiful place". (Oliver)*

Taken together, the interviewees think that many Dutch laypeople perceive biodiversity in a limited and superficial way, as many citizens lack knowledge and awareness of biodiversity, show mixed attitudes, and seem unaware of what biodiversity could offer them.

7.3.2 Theme 2: Desired role of biodiversity in laypeople's lives

When asked to describe the desired role of biodiversity in laypeople's lives, many biodiversity communicators express that it is a shame when people are unaware of biodiversity and the role that it could play in their lives. They describe the relevance and value of biodiversity in their own lives, and advocate expanding the role in laypeople's lives:

I think the world around us is so fascinatingly beautiful. I really can't understand that so many people are so indifferent about it. I think that it's a shame, because I think it can enrich your life. (Rick)

Basic knowledge and awareness

According to the interviewees, laypeople should have a general understanding of biodiversity. Amy mentions the importance of understanding 'the big picture' or 'system' from an ecological and evolutionary point of view, and she prioritizes concepts and knowledge about processes. Similarly, Matt emphasizes that people should be aware that biodiversity provides stability in an ecosystem, and that species are connected to each other and to the environment. In line with this, Oliver states:

Being aware that your life and the life of all those plants and animals are connected in a certain way, and that you have an impact on those other species, and vice versa they also have an impact on you, I think that that realization is important, that you understand that you cannot completely shut yourself off from that. (Oliver)

Furthermore, several communicators argue that laypeople should have basic knowledge about species:

Children must know the difference between a frog and a toad. I seriously think that that's important. And that you know that it's a cold-blooded animal. And of course that you have mammals...How many adults would call a roe "deer". Honestly, that makes my hair stand up on the back of my neck. (Ulrika)

However, the opinions of the interviewees differ as to which level of specificity is required. Several communicators prioritize that people can distinguish species or know in-depth information about them, instead of naming them:

Whether you know that a grebe is called a grebe, I find that less interesting than its behavior. (Amy)

In line with this, Oliver mentions that in order to enjoy bird sounds, you do not really need to know which species is singing. In his view species names are labels that have little value in themselves, although you do need them when you communicate about species. In contrast, a few communicators strongly advocate the value of species identification skills and the relevance of names. For instance, Norman compares species, including their names, to words that a person needs to talk the language of nature, and he sees naming as a necessary step towards knowing more about species and loving them.

Independent of the level of specificity, the majority of the communicators stress that people should become familiar with local flora and fauna. For instance, Helen would like children to know which birds live in their neighborhood, and Oliver mentions that children should become aware that hedgehogs not only live in the forest, but also visit gardens. Primary school teacher Nancy argues firmly that not only her pupils but people in general should get to know native species, and compares this to knowing the city or country where you live. She sees it as part of connecting to the environment and believes that native flora and fauna should be the starting point in learning about biodiversity:

> *I think it is strange when you sit in your garden and you do not recognize a red admiral that flies past you, while you do know the name of a butterfly in Brazil. Well, it shouldn't be like that. First you should know what you have in your own country, and only then what is on offer abroad. (Nancy)*

Value of biodiversity knowledge

The communicators provide different arguments why laypeople should learn about biodiversity. Some mention that knowledge about biodiversity can enhance a person's well-being in nature; e.g., because species that pose risks such as nettles can then be avoided, while fear for harmless species such as dead nettles (*Lamium*) is reduced. Moreover, several interviewees argue that knowledge can add joy to the experience of nature. In particular, Norman voices this thought strongly, and he draws from his personal experiences as a diver in the Grevelingen, a Dutch salt lake:

> *Incomprehensible how people went diving in the Grevelingen without knowing species. At least, that is <u>really</u> not fun! The water is cold, cloudy...In order to have fun diving there you need to recognize that small sea squirt, and that anemone, and thus also all that little stuff. (Norman)*

Even in the absence of a real encounter, Norman argues that knowledge may trigger feelings of joy:

> *Just <u>knowing</u> that a tiger is living somewhere, (...) even if you don't see it, is sufficient for me. So the <u>knowing</u> is very important. (Norman)*

Several interviewees further point to a link between knowledge and awareness, i.e., that knowledge can 'open people's eyes to what is out there', again providing people with positive experiences:

> *If you don't know at all that it exists, then you don't see it. You will just cycle past two grebes in courting display, but you won't realize it. But if you know it exists, then you notice it, and then you probably also like to see and recognize things. (Amy)*

Similarly, it is noted by several communicators that knowledge about biodiversity can provoke curiosity and spark a sense of wonder. Thereby, basic knowledge may encourage people to learn more:

> *Suppose you know five species of trees (...) only then will you see "Damn it, that is <u>not</u> an elm, that must be something else. So what is it then?" You are only going to wonder about that if you already know those five. (Norman)*

Nature educator Barbara also believes that knowledge can induce interest, yet she also witnessed the opposite. She recalls that during one of her excursions a boy with well-developed identification skills quickly labeled a honeysuckle plant and walked on, while other children were mesmerized by the plant's tropical vine-like appearance. Therefore, Barbara argues that knowledge, '*head*', should always go hand in hand with '*heart*' and '*hands*'.

Finally, the communicators argue that knowledge about biodiversity may

ultimately contribute to pro-environmental attitudes and pro-environmental behavior. For instance, it is expressed by several interviewees that growing awareness about species can trigger feelings of admiration, appreciation, and care for them. Ulrika is convinced that humans have an innate love for nature that needs to be stimulated via education. High school teacher Amy hopes to empower her pupils via her teaching, so that they can make informed decisions, e.g., about making a bee-friendly garden or giving money to environmental charities. In line with this, Tara mentions biodiversity awareness as an important precursor for sustainability and '*a better world*'.

Overall, the communicators attach great importance to biodiversity, and to the role of it in laypeople's lives, and this motivates them in their profession. Via their work many of the communicators hope to broaden people's perceptions of biodiversity and trigger their interest and sense of wonder, which they think could ultimately instill feelings of love and care for nature and the environment. Most importantly, the interviewees want to offer people the chance to open their eyes for biodiversity. In the following section we will distill opportunities and challenges in expanding the role of biodiversity in laypeople's lives from the experiences and thoughts of the communicators.

7.3.3 Theme 3: Potential to expand the role of biodiversity in Dutch laypeople's lives

The biodiversity communicators were asked how they perceive the potential in the Netherlands for laypeople to learn about, and develop interest and appreciation for biodiversity. We discuss opportunities and challenges in three main areas: (1): direct experience with available biodiversity, (2): media, and (3): education.

Potential of direct experience with available biodiversity

Most importantly, the communicators firmly argue that even though the Netherlands is highly urbanized, there exist many opportunities for people to come into contact with biodiversity. Ulrika and Oliver note that Dutch biodiversity is actually surprisingly rich, as the country constitutes a river delta:

> *I think that the opportunities are huge in the Netherlands. (...) There is no country in the world with such rich biodiversity…for we are and will always be the river delta of Europe. So it is just one large, wet mess here. And we know that, but we*

don't realize how cool that is. Because we like to see impressive mountains, but how rich is biodiversity there? Here biodiversity is rich, due to that soggy mess. That's why we have so many species. (Ulrika)

Moreover, the communicators stress that biodiversity is not limited to nature reserves and that plants and animals can be found in abundance in cities too:

Nature doesn't start at a nature reserve. (...) Nature starts right outside your front door. (...) There are always lichens on the pavement. (Ulrika)

Nancy refers to the tiny pond in her own city garden, in which she counted over 80 smooth newts and 40 toads, while Oliver mentions the port area in Rotterdam, where a large and healthy population of rabbits can be found, in addition to orchids, vast numbers of butterflies, and seals. Several interviewees even state that in the Netherlands nowadays biodiversity is probably higher in cities than in rural areas, where biodiversity has declined. Therefore, species may actually be more readily encountered in cities. In line with this, Rick mentions that fascinating natural phenomena take place even in gardens:

I sometimes tell an audience, when I give a lecture: "You don't need to watch television. If you have a nice, good garden, a soap opera will be performed right in front of you. That just happens, at least when you see it, when you pay attention to it". (Rick)

However, although the interviewees note that biodiversity is present, limitations to direct experiences with it both in and outside of cities are voiced as well. Several communicators describe that in a densely populated country, people face many distractions. For instance, although there are nature reserves in the Netherlands, Shane argues that high visitation numbers detract from the experience of nature there. Similarly, Amy describes that urban children often face distractions on their way to school, such as traffic, shops, and playgrounds, so they are more likely to overlook biodiversity, even though species may be as numerous inside as outside of cities.

In addition, it is mentioned that availability of and accessibility to greenspace differs between locations. For instance, Nancy argues that in light of safety,

children living in cities with lots of traffic have less freedom of movement to explore their neighborhood. Furthermore, several communicators note that biodiversity is rarely integrated in urban design:

> *What you notice is that at the drawing table, when the plan is actually designed, there is never an ecologist, but always a landscape architect. And landscape architects love cultivated trees, (…) they love sleek design, neat little rows... (Shane)*

In line with this, city parks are often overregulated, as they are generally expected to look tidy and not be of any nuisance. Helen recalls that her idea of planting thorny bushes in the natural community garden that she initiated, was challenged as it might cause children's trousers to be torn. Similarly, Shane experienced that a housing association incorrectly assumed that residents wished for house sparrows to be removed from their street, whereas in fact they considered the birds part of their home.

Rick argues that future cities should incorporate more greenspace, and he states that the potential in raising people's awareness of biodiversity will depend on it:

> *If we continue with the current vision on shaping and building cities, then indeed there is a substantially lower proportion of the Dutch population for which potential will exist to open their eyes. (Rick)*

Potential of the media

In addition to direct experiences of biodiversity, communicators also mention indirect ways that hold potential for expanding the role of biodiversity in laypeople. In particular, it is expressed that the media can help raise awareness about and trigger interest in biodiversity. Primary school teacher Nancy notices the impact of the media in her classroom:

> *Of course you have got the BBC. And now the Netherlands of course is also starting to make fantastic nature films...And the children here who are allowed to frequently watch nature films, well, you just notice that, they know a lot. (Nancy)*

In particular, Norman attaches great importance to media such as books, photographs, and movies, as he believes that they add value to outdoor observations. He argues that outdoor animal sightings are often brief and disappointing, and that indoor materials such as books with beautiful photographs can counterbalance this. Moreover, he points out that media can portray a tiny beetle just as beautifully as an elephant.

Still, a few limitations related to the media are expressed as well. For instance, several interviewees note that the media involve the use of only a few senses, and that they may distort people's perceptions of biodiversity. Ulrika refers to the grassy plains featured in the pre-school television series 'Teletubbies', which look nothing like biodiverse meadows:

> *One big bright green plain. With a small hill. Then there is one flower there, and there is one flower there. (...) As such it is actually already indoctrinated: a meadow looks uniformly green. (Ulrika)*

Moreover, it is noted that the media feature spectacular images, after investment of much time and effort in shooting them, and that they use bombastic music and sounds. As a result, people may be disappointed by their actual nature experience outdoors. In addition, the communicators note that local flora and fauna currently receive little attention in the media, as exotic species predominate. Self-employed writer Norman correspondingly expresses that book publishers are usually mostly interested in books about charismatic and exotic animals, such as elephants or birds of prey. Finally, Edward mentions a popular Dutch TV-host of nature series for children, who unintentionally seems to encourage undesirable behavior of handling all animals that are encountered instead of simply observing them.

Taken together, currently the interviewees do not regard the media as a suitable replacement for outdoor nature experiences, yet potential could be increased if the media would broaden their scope to local and everyday biodiversity.

Potential of education

Finally, education is highlighted by several interviewees as having potential for growing biodiversity awareness. Several communicators argue firmly that younger generations in particular are a suitable target group for learning about biodiversity, e.g., because they tend to be interested in nature and may stimulate

their parents to learn about biodiversity as well. In particular, outdoor school activities are thought to add value to education about biodiversity. For instance, primary school teacher Nancy expresses enthusiastically that she taught her pupils to use binoculars, and that they went to a city park to watch birds and butterflies. Similarly, nature educator Barbara states that children learn much from the outdoor project that she is involved in, as they are allowed to directly experience and explore nature during unscheduled hours, while being assisted by nature educators. High school teacher Amy makes sure outdoor activities are included during the yearly school camp, and she prioritizes biology experiments to be conducted outdoors.

It is further mentioned that nature education should start in primary school and continue into high school, and that it would be helpful to improve the structuring of nature education; e.g., provide weekly lessons about nature or make it compulsory for schools to occasionally visit Dutch nature reserves. Ulrika argues that the Netherlands is a rich country that should have the means to allocate sufficient time and money to nature education. Finally, in addition to the role that schools could play, educational programs and projects organized by non-governmental organizations are mentioned as a pathway to learn about biodiversity, such as the OERRR-club for children from Natuurmonumenten and the webcam project 'Enjoy Spring' from Vogelbescherming Nederland.

However, a few challenges to expanding the role of biodiversity via education are also noted. For instance, it is mentioned that currently Dutch school budgets for nature education are very limited. Moreover, primary school teacher Nancy expresses that young children are often very enthusiastic about nature, yet they seem to lose their interest later on, as high schools spend little attention on nature education. However, high school teacher Amy argues that young adolescents are mostly interested in their own bodies during puberty, so biodiversity is more suitable for lower and higher ages. Moreover, she states that high school curricula are already packed with other important topics that demand attention (e.g., global diseases and food production):

> *If I were to set priorities, then knowledge about nature would rank relatively low I'm afraid, because I think those other things are also very important to them. (Amy)*

Finally, barriers are mentioned that prevent teachers from doing outdoor projects; e.g., that they can be a hassle to organize, or that suitable locations to do the projects can be far away. Edward further mentions that to avoid risks, schools do not always allow children to freely explore and experience nature, as he noticed when he suggested to do a bumblebee project with high school children:

> *So I thought "they are going to catch bumblebees". Well that was out of the question according to the school, (…) because "there could be someone allergic to bee stings and bees are dangerous, they sting". I wonder: how will those children grow up? Please allow them to discover things! (Edward)*

Taken together, despite several challenges, the biodiversity communicators see potential in the Netherlands for laypeople to experience biodiversity directly and indirectly and thus to learn about and connect with biodiversity via both direct and indirect experiences. However, they do note that people will need help, and they describe how communication can help realize the existing potential. In line with this, the next section describes how the interviewees communicate biodiversity in their profession, providing further insights into how the role of biodiversity may be successfully expanded in laypeople's lives.

7.3.4 Theme 4: Best practices in communicating biodiversity amongst Dutch biodiversity communicators

The biodiversity communicators were asked how they communicate biodiversity in their paid or voluntary work. From the interviews we distilled three main considerations that the interviewees keep into account when communicating biodiversity to a lay audience: (1): choosing the right examples, (2): connecting with the target group, and (3): translation via imagination.

Choosing the right examples

The interviewees carefully choose examples to communicate. Several communicators mention that they thoughtfully select examples that will spark interest; e.g., topics that are new to the public. Self-employed writer Norman states that after hearing in a natural history museum from a taxidermist that crows have white feathers underneath their black plumage, he added this surprising detail

to the book he was writing. Similarly, editor-in-chief Matt, who works at a zoo, expresses that he includes intriguing details about animal behavior in his texts, and for this he draws from facts that are new to him as well.

Several communicators prefer to communicate everyday examples of local biodiversity, such as common city animals. These may serve as eye openers, showing the public what can be seen in the immediate, often urban surroundings:

> *Something which is commonplace can very well be a discovery for someone who has never been made aware of it. So when you point out to people such small everyday findings in their own environment, then this will enrich their daily experience. (Oliver)*

One of the benefits of communicating about local flora and fauna is that these can be seen in real life, adding to people's experience. Norman highlights native plants in particular as reliable starting points for experiencing biodiversity outdoors, instead of animals like birds, which you may not always encounter:

> *First have a look at plants, because those you can see anytime and anywhere, and you can name them. (…) When you only look at birds, then you could return home with "it failed", and with plants you never have that. (Norman)*

Similarly, lichens are pointed out by a few interviewees as being fascinating subjects for people, especially when they hear interesting facts about them and observe them closely (e.g., with a hand lens).

In addition to local biodiversity, several communicators draw from exotic biodiversity in their communication; e.g., Matt, who works in a zoo. Norman argues that in communication native biodiversity can be nicely supplemented by exotic biodiversity. He has regularly combined exotic and native animals in his writing, thereby illustrating similarities and simultaneously sparking interest in both local and global biodiversity:

> *The tiger: fantastic predator. Catches prey three times as heavy as itself. But we have the weasel, and it catches prey twenty times as heavy as itself. (Norman)*

Norman further mentions that he frequently combines a range of species in his stories, to illustrate that biodiversity encompasses a multitude of lifeforms, yet he does choose clear representatives for each animal group (e.g., one mammal, one bird, one insect…). In this way he provides focus in his communication. Others also intentionally choose a clear focal point in their communication:

> *You may point at twenty bird species, but then most of it passes you by. But if you nicely elaborate on just one, so that they really get to know the species, and you talk to those people again weeks later, they say: "Yes, I now see song thrushes everywhere", or "I see dunnocks everywhere". (…) Suddenly they see it. It had always been there. Yet now it has obtained meaning. (Oliver)*

Connecting with the target group

To communicate successfully, the biodiversity communicators use different ways of connecting to their target group. For instance, several communicators suggest to use interaction, and to think of what appeals to the views and interests of the audience, so that more people coming from different groups can be effectively addressed. Rick, who as a project manager communicates with farmers and site managers, notes that his target group may hold prejudiced views against those who communicate biodiversity. He therefore is careful in choosing the wording in his communication, and he strategically chooses an opening:

> *Farmers who are interested in nature often are because they like birds, such as meadow birds. And that is then your opening. (...) I always try to connect to the question of the specific person (…). So if I know that you like birds, then I will sketch the importance of insects from the perspective of birds, whereas if I talk to a manager who really loves a specific butterfly - they too exist - then I use <u>that</u> perspective. (Rick)*

Similarly, ecological consultant Shane experiences that clients from building companies, his usual target group, are rarely interested in flora and fauna; they just want to hear the implications that biodiversity present on their building site will have for their project. He therefore tries to find an opening to discuss biodiversity by connecting to clients' personal experiences with wildlife, and he notices that this makes clients more receptive to discuss and find solutions.

In order to strike a chord with the public, multiple communicators further point out that they prefer to craft positive messages, as these will be more readily received by the audience. For example, Rick states that a campaign about roadside flowers in which he was involved was named 'My roadside is flowering' instead of 'My roadside is mown', and Matt and Norman recommend to communicate possible solutions together with problems. In line with this, primary school teacher Nancy emphasizes that in education an enthusiastic role model is vital.

Translation of biodiversity

When crafting messages, the majority of the interviewees keep into account prior knowledge of their target group by avoiding jargon. For instance, a few interviewees prefer to skip the term 'biodiversity' and use 'nature' instead, and ecological consultant Shane intentionally avoids scientific species names in his rapports, as he argues that everyday names are more likely to spark interest and create an opening for dialogue. On the other hand, it is also mentioned that in communication some difficult words are fine (e.g., when they are explained) and it is argued that references to species should not be too vague, especially when names are informative:

> *Every animal should have its name. So if you want to communicate, then "bird" or "insect" is unsatisfactory, "dragonfly" or "butterfly" is also unsatisfactory, yet a "swallowtail" is okay - you know. And I do that intuitively. (Norman)*

Moreover, the communicators use metaphors to make complex subjects related to biodiversity accessible; e.g., nature educator Barbara compares pastures low in biodiversity to deserts, and thinks such translation aids retention. Working at a nature conservation organization, project manager Rick refers to the 'nectar scale' which his company designed. Roadside managers and owners can use this scale to determine the value of roadsides for pollinating insects on a scale of 1 to 5. Rick argues that the scale acts like a common language for ecologists, roadside managers and roadside owners, and he notices that the nectar scale motivates participants to improve the score. He links the success of the scale to its accessibility, as it is easy to understand and use:

> *If you have a scale from one to five, everybody understands that if you score a one, you simply score below par. Yet if you would say "I have a roadside here and there are ten types of plants and five types of insects" nobody or only a few people will grasp that that is actually very few. (Rick)*

In addition to metaphors, the biodiversity communicators also describe other creative ways of translating biodiversity in their communication or education, e.g., to increase interest and retention. For example, several communicators mention that they use mnemonics to help people identify flora and fauna, and some use games to educate their public about biodiversity; e.g., Ulrika uses the game *statues* to communicate the lives of animals when she educates children.

7.4 Discussion

7.4.1 Current role of biodiversity in Dutch laypeople's lives

Biodiversity is seen as a fundamental part of sustainable development (Niesenbaum, 2019; Schultz et al., 2016), yet it is under threat by a range of anthropogenic factors (Ceballos et al., 2017; Díaz et al., 2019; Dirzo et al., 2014; Pimm et al., 2014). This makes it increasingly important that laypeople are aware of and support biodiversity. However, when we asked twelve biodiversity communicators about the current role of biodiversity in laypeople's lives in the Netherlands, they considered the role to be limited and fairly superficial. They argued that although Dutch citizens derive benefits from biodiversity, many are not aware of what biodiversity offers them or do not consciously value it. This is in line with Irvine et al. (2010), who reported that biodiversity was not perceived by park visitors as important, yet it was actually one of the reasons why they visited green space. Moreover, the interviewees stated that Dutch laypeople have poor knowledge of native species, and several mentioned how the limited perceptions of biodiversity may lead people to normalize lower biodiversity levels than in the past. These findings corroborate previous studies that have reported low levels of awareness about native flora and fauna (Balmford et al., 2002; Hooykaas et al., 2019, Chapter 2; Huxham et al., 2006; Lindemann-Matthies & Bose, 2008), and link to the shifting baseline syndrome (Kahn, 2002; Kai et al., 2014; Miller, 2005; Papworth et al., 2009; Pauly, 1995).

In addition, the interviewees described ambivalent attitudes towards biodiversity, e.g., that many laypeople feel detached from biodiversity, using it predominantly as a décor to pose with for pictures or walk through. This links with Vining et al. (2008), who reported that nature was generally viewed by participants as pristine areas untouched by humans. Several communicators noted that laypeople appreciate biodiversity mainly from a distance, which links with the "not in my backyard syndrome" (Verboom et al., 2004). However, it could also be that people are currently not aware of what they can do for biodiversity themselves (J. H. Falk, 2005; Olive, 2014).

7.4.2 Desired role of biodiversity in Dutch laypeople's lives

Drawing from their personal experiences, the communicators attached great importance to biodiversity. They thought it was a shame that currently many laypeople are unaware of it, and this motivated them in their profession. It was mentioned that every person has an innate love for nature that just needs to be reinforced, echoing the 'biophilia hypothesis' which states that humans have an attachment to nature rooted in their biology (Kellert & Wilson, 1993). In line with this, the interviewees advocated expanding the role of biodiversity in laypeople's lives. Most importantly, they would like to grant people opportunities to open their eyes for biodiversity.

Most interviewees argued that the lay public should have some basic knowledge of biodiversity. Opinions differed with regard to the specific knowledge people should have (e.g., some prioritized broader concepts, while others emphasized the importance of facts such as species names). In particular it was emphasized that people should be familiar with local flora and fauna, which links with the thought that getting to know the local environment (e.g., the species living there) can provide people with a 'sense of place and belonging' (M. Clarke, 2013; Cox & Gaston, 2015; Horwitz et al., 2001; Standish et al., 2013).

The communicators provided different reasons why laypeople should learn about biodiversity. Some pointed out that knowledge can reduce risks from or fear of species, thereby enhancing a person's well-being in nature. Moreover, several interviewees argued that knowledge about biodiversity adds joy and depth to the experience of nature, in line with Fuller et al. (2007), who demonstrated that psychological benefits of exposure to urban greenspace increased with higher levels of biodiversity. Knowing species was further compared to knowing the

words of a language, which links with the idea that a person needs to know species names in order to talk confidently about nature (Magntorn & Helldén, 2005).

In addition, it was mentioned that knowledge about biodiversity may provoke interest, and may stimulate people to become aware of what can be found in the immediate environment, thereby opening their eyes to the beauty and wonder of nature. The communicators argued that knowledge may ultimately trigger feelings of admiration and appreciation, consistent with studies that have concluded that knowledge about species can help shift people's perceptions and raise affinities towards them (Barnett, 2019; Lindemann-Matthies, 2005; Schlegel & Rupf, 2010; Wilson & Tisdell, 2005). Furthermore, it was expressed that raising awareness about biodiversity could help people at making informed decisions, ultimately contributing to pro-environmental attitudes and pro-environmental behavior, which links with the finding that people's willingness to pay for conservation of species tends to increase with knowledge about them (Martín-López et al., 2007; P. C. L. White et al., 1997, 2001; Wilson & Tisdell, 2005).

Finally, a few interviewees noted that knowledge about biodiversity may occasionally detract from a person's experience of nature; e.g., noticing that a nature reserve is deteriorating may decrease the joy walking there. In light of this, several communicators noted that strategies aimed at building awareness about biodiversity should not overlook people's attitudes and behavior.

7.4.3 Potential to expand the role of biodiversity in Dutch laypeople's lives

The interviewees saw great potential in the Netherlands for people to learn about biodiversity. They described opportunities for expanding the role of biodiversity in laypeople's lives in three main areas: direct experiences outdoors, media and education. Interestingly, even though the Netherlands is a highly urbanized country, the communicators were confident that many opportunities exist for Dutch citizens to come into contact with biodiversity. Not only did some interviewees note that the Netherlands is a river delta rich in biodiversity, most of the communicators emphasized that flora and fauna can be readily found in cities, and some stated that biodiversity may even be higher there than in rural areas, where biodiversity has declined. In line with this, McKinney (2008) has noted that moderately urbanized environments may have higher species richness than the native ecosystems they replaced.

Despite the opportunities however, obstacles to outdoor experiences with biodiversity were pointed out as well. Urban distractions such as traffic may lead people to overlook biodiversity, and high visitation numbers in nature reserves can detract from the experience of nature, in line with Staats & Hartig (2004), who found that students preferred to spend time alone in nature to find mental restoration. Furthermore, it was mentioned that availability of and accessibility to greenspace differs between locations, and that children often have limited opportunities to freely explore their environment. This connects to Cox et al. (2017), who surveyed urban residents in the UK, and reported that the majority of human-nature interactions were experienced by only one third of the population, and to Lerman & Warren (2011), who suggested that city residents who live near the urban core will have fewer opportunities to experience biodiversity. This pattern is worrisome, as people who spend little time in nature are less likely to develop a strong connection to it (Cheng & Monroe, 2012) or to support conservation (Soga, Gaston, Yamaura, et al., 2016).

Moreover, several communicators expressed that greenspace is expected to look tidy and not be of any nuisance, so as a result it is overregulated. It was argued that biodiversity should be integrated more into urban design, suggesting in line with previous research that urban planners, architects and housing corporations would benefit from education about biodiversity (Barrico & Castro, 2016; Parris et al., 2018). This could inspire them to combine 'messy' parts that have ecological functions with 'orderly frames' (Nassauer, 1995), so that both care for biodiversity and aesthetics are served, and people are more likely to accept the design (Gobster et al., 2007). Furthermore, misconceptions may be resolved; e.g., wrong assumptions that citizens would dislike cohabitation with flora and fauna (Muratet et al., 2015; Vaske et al., 2011). Similarly, communication about the value of urban wastelands and ecological design choices (e.g., by explaining how the design benefits biodiversity such as birds or butterflies) may increase city residents' acceptance and help biodiversity conservation in the long run (Bonthoux et al., 2014; Qiu et al., 2013).

In addition to direct experiences of biodiversity, communicators highlighted the media as a pathway through which awareness about biodiversity can be raised. For instance, the media were pointed out as an effective and reliable starting point for experiencing biodiversity. Indeed, previous research has suggested that vicarious experience with cultural sources that portray biodiversity can partially

substitute or supplement direct experiences (Randler, 2010; Soga, Gaston, Yamaura, et al., 2016), and as urbanization continues, the media may need to play an increasingly important part, as they have an extensive reach and can thereby shape many people's perceptions (Elder et al., 1998; Novacek, 2008).

Still, despite the potential that was voiced, the media were not regarded as suitable replacement for outdoor nature experiences. It was noted that they involve the use of only a few senses, and may cause people to develop distorted views of nature, so that direct experiences with actual biodiversity outdoors may appear dull and unrewarding. This might even lead people to think that 'real nature' is only found elsewhere (Hanski, 2005; Verboom et al., 2004). Furthermore, some media that are popular among children in the Netherlands may unintentionally encourage people to interact with biodiversity in undesirable ways (e.g., by touching or catching). This links to Barney et al. (2005), who mentioned that seemingly benign attitudes towards animals fostered through the media can harm animals if people feel encouraged to pursue them. Lastly, the communicators noted that charismatic and exotic species predominate in the media, a pattern that has been reported for various types of media (Ballouard et al., 2011; Celis-Diez et al., 2016; Clucas et al., 2008; Courchamp et al., 2018). Therefore, in order to realize the potential of the media, the communicators argued that the scope should be broadened to feature local, everyday flora and fauna more. This might be done by purposefully weaving less charismatic species into storylines (Yong et al., 2011). The highly popular nature documentary series 'Life in the Undergrowth', which portrays invertebrates, demonstrates that with the right approach the scope in biodiversity can be broadened without negative effects on approval ratings or viewing figures (Cheesman & Key, Roger, 2007).

Finally, education was mentioned by several interviewees as a key in growing biodiversity awareness. In particular, younger generations were seen as a suitable and strategic target group, a view shared by previous researchers (Chawla & Salvadori, 2003; Kahn, 2002; Kellert, 1985; Rivas & Owens, 1999). For instance, it was pointed out that via children, parents may be stimulated to learn about biodiversity, in line with Diris & Lambrix (2010). It was argued that nature education should start early, in primary school, and continue into high school. However, while it was expressed that the Netherlands is a rich country, it was also noted that school budgets for nature education are limited. Furthermore, while outdoor school activities were highlighted as being very valuable, it was

mentioned that barriers can prevent school children from going outdoors (e.g., limited greenspace in the vicinity schools, or safety concerns). Although curriculum demands might be an obstacle, some communicators argued that it could be helpful if nature education were more structured (e.g., by making visits to nature reserves compulsory).

Taken together, it was revealed that opportunities to expand the role of biodiversity in laypeople's lives are perceived to be numerous, yet several challenges will need to be overcome. To help fulfill the existing potential, effective communication about biodiversity will be vital.

7.4.4 Best practices in communicating biodiversity amongst Dutch biodiversity communicators

The interviews revealed that the biodiversity communicators carefully determine the subjects that they communicate. Importantly, the interviewees described a strategy of focusing on a limited number of examples, connecting to cognitive load theory (Paas et al., 2003; Sweller et al., 1998), and to previous studies that have recommended to restrict the number of species in an identification task for children (Randler, 2008b; Randler & Bogner, 2006). Moreover, they take care in choosing examples that will spark interest; e.g., topics that are new for the public and possibly even new to the communicator. Many communicators preferred to use native species in their communication, in particular common, everyday species such as city animals, plants and lichens, which can open people's eyes for what can be found in their immediate surroundings, adding value to people's daily nature experiences. On the other hand, some communicators stressed that there is no need to exclude exotic biodiversity; e.g., they described how exotic species can be strategically combined with local species.

Furthermore, the biodiversity communicators described how they aim to strike a chord with the public; e.g., by using enthusiasm and positive messages. They purposefully connect to the interests and the knowledge level of their target group; e.g., they carefully choose wording and a strategic opening, so that messages are better understood and more readily received. This links with past studies that have clearly demonstrated that existing perceptions influence subsequent learning (Hailikari et al., 2008; R. A. Thompson & Zamboanga, 2003). Tailoring messages to the perspectives of audiences is a well-known communication strategy, yet research has suggested that in practice messages

regularly mismatch perceptions in the public (Dickens et al., 2013; J. H. Falk, 2005; Kelly & Haidet, 2007; Storm, 2012). The examples described by the interviewees support the idea that getting to know intended audiences (e.g., via assessments or dialogue) is vital for strengthening communication and reaching broader audiences (Buijs & Elands, 2013; Hailikari et al., 2007, 2008; Jansen et al., 2010).

Finally, the interviewees mentioned creative forms to translate biodiversity to a broad audience, such as metaphors, mnemonics and games, which according to past studies add to people's learning process. For instance, it has been demonstrated that good mnemonics linking the name of a species to its morphology produce higher retention rates than pictorial determination keys, making them an effective teaching method in education alongside field work (Stagg & Donkin, 2015).

7.4.5 Limitations

We will note a few limitations related to this study. First of all, in this paper we have used the term biodiversity in line with the definition of the Convention of Biological Diversity (United Nations, 1992), yet we did not provide the interviewees with this definition. Instead, we asked the participants to express their view on the concept. Although only a few noted genetic diversity and some seemed to use the term biodiversity as a synonym for 'nature', all interviewees did mention variety of life forms, in line with the official definition.

Secondly, as in most qualitative research, the study represents the social reality of a selective number of interviewees, so caution should be exercised in generalizing the results and extrapolating them to other settings. Still, we believe that our study provides valuable insights applicable to wider contexts, as the perceptions of the communicators described in this paper seemed to be mostly directed towards urbanized environments in general instead of the specific Dutch context. Moreover, most core perceptions and themes will have been covered due to the purposive sampling method we used, and the current setup proved to be successful in identifying 'black swans': observations that do not fit the expected patterns (Flyvbjerg, 2006). For instance, while we did expect the interviewees to describe why knowledge about biodiversity would be valuable, the communicators also described how under some circumstances knowledge can detract from nature experience.

Finally, some views expressed by the interviewees do not seem to match

learning theory. Some quotations suggest linear relationships between knowledge, attitudes, and behavior, even though studies have pointed out that in reality such relationships are complex, showing the limitations of knowledge-deficit models (C. Mooney, 2010; Owens, 2000). For communicators it is important to be aware of this when disseminating information about biodiversity to the public. In addition, some questions remain. For instance, future research could elucidate the relative potential of different types of media, outdoor experiences, and educational programs, and could explore ways to confront the challenges raised by the interviewees. Furthermore, it would be valuable to include extra target groups in future research to supplement the current study. For instance, it would be interesting to involve both urban planners and the general public, as they may perceive the existing potential differently than biodiversity communicators.

7.5 Conclusion

Before biodiversity can contribute to sustainability, it will have to be conserved, and awareness and support for its protection therefore needs to be raised. This is becoming increasingly important, due to the widening gap between people and nature (Miller, 2005; Pauly, 1995; Pyle, 2011; Soga & Gaston, 2018). As an increasing number of people are living their lives at a growing distance from nature, biodiversity conservation will depend more and more on urbanites and the role that biodiversity plays in their lives (Dunn et al., 2006).

We explored how biodiversity communicators perceive the need and potential for expanding the role of biodiversity in laypeople's lives in the Netherlands. Overall, Dutch laypeople were perceived to have a limited perception of biodiversity, and the communicators felt motivated to expand it. Most importantly, the interviewees argued that people should get the chance to 'open their eyes' for biodiversity, which would ultimately benefit both themselves and biodiversity. Despite being highly urbanized, The Netherlands was deemed to hold much potential for engaging people with biodiversity, offering a positive message in the increasingly urban world.

Based on our study, success will depend on pathways that offer people ways to interact with biodiversity in both direct and indirect ways. First, citizens should have sufficient opportunities to experience biodiversity directly. This highlights the need of future urban design where people and biodiversity share the landscape,

and shows the importance of education and communication about the values of greenspace and biodiversity in cities, targeted at urban planners, architects, housing corporations, as well as the general public. In addition, teachers should be offered materials and tools to do outdoor projects in the vicinity of their schools (e.g., about lichens or street weeds). Secondly, indirect experiences with biodiversity should be facilitated via the media and in education. The current bias towards exotic species could be counterbalanced by replacing, or supplementing exotic species with local, everyday species that people can encounter in their daily lives. Finally, our study underlines the importance of carefully designed communication that matches the public. This highlights the need to get to know intended audiences (e.g., via assessments and dialogue), helping communicators to reach out successfully to laypeople about biodiversity.

All in all, this study highlights opportunities to connect people with biodiversity, also in highly urbanized countries. The perceptions of the communicators may empower and motivate other professionals, which can help open people's eyes for biodiversity and build broad-based support for conservation.

Part IV:

Reflection and Future Directions

The **kingfisher** (Nederlands: **ijsvogel**) is a territorial bird species specialized in catching fish. Its nest is often found in a burrow excavated in a river bank.

Chapter 8

Discussion

This thesis provides insight into people's perception of animal biodiversity. This is valuable from a scientific perspective, and it is also important in the context of conservation, as biodiversity is currently declining rapidly and the relationship between humans and nature is under increasing pressure. The six studies presented in this dissertation were all set in the Netherlands. As a densely populated country, the Netherlands constitutes a good model to assess (dis) connections between people and nature in a world that is increasingly urbanized.

In this final part of my thesis I will highlight the main findings of my research, and I will point out how the findings connect to each other. Moreover, I will give an overview of important implications of the findings and corresponding recommendations for conservationists and communicators. Finally, I will note directions for further research, emphasizing the value of continued efforts to study people's perceptions of biodiversity.

8.1 Species literacy in the Netherlands

8.1.1 Levels of species literacy in laypeople and professionals

In the first part of this thesis I have explored levels of species literacy in the Netherlands, as a *pars pro toto* to study biodiversity awareness.

Chapter 2 explained the new concept species literacy, which consists of two main components: broad knowledge about species, which involves knowledge of basic characteristics and names of species that enable a person to distinguish and identify species, and in-depth knowledge about species, which involves background information about species, e.g. where and how they live. Moreover, Chapter 2 discussed a quantitative research project that used a species identification test comprising native animal species to assess the levels of species literacy in primary school children and the general public. The species literacy level of biodiversity professionals was also determined, which put into perspective laypeople's perceptions. **Chapter 3** presented results of an animal knowledge test among a large sample of adult participants, which tested their species identification skills and in-depth knowledge about species, and included both native and exotic animals.

Whereas species literacy was high among professionals, laypeople's perception of animals turned out to be meager. Professionals performed better both at identifying animal species and answering in-depth knowledge questions about their origin, habitat, diet, or behavior. As shown in Chapter 2, species literacy was especially low in primary school children, who on average identified only one in three native animal species.

Laypeople knew only a specific fraction of animal biodiversity. In particular, people were well informed about mammals, which was in line with previous findings in other countries (Huxham et al., 2006; Lindemann-Matthies, 2005; Patrick et al., 2013). As mammals that received high identification rates such as foxes and hedgehogs are rarely encountered outdoors due to their reclusive way of life, direct exposure to animals in the wild clearly is no prerequisite for becoming familiar with animals, although it cannot be ruled out that rare encounters leave particularly large and lasting impressions. A more likely explanation for people's familiarity with mammals is their frequent portrayal in human culture, as discussed in Chapters 4 and 5. This is in line with the test results presented in Chapter 3, where exotic animals that are regularly displayed in cultural products

and the media (e.g. giant panda), were well-known not only by professionals but by lay participants as well.

The poor ability to identify native birds and butterflies was striking, especially in primary school children. Over 80% of the children failed to identify common bird species such as the house sparrow, blackbird, and jackdaw. As these species prevail in densely populated areas in the Netherlands, their low identification rates are unlikely to stem from a lack of opportunity to experience them directly. More likely reduced engagement with the outdoors, little time spent in and on the local environment (e.g. during (non-)formal education), and possibly a lack of interest in native animals, prevents people from familiarizing themselves with these animals.

In addition to a restricted range of animals, laypeople's understanding of animal species was shallow, evidenced by limited specificity of respondents' answers and misconceptions about animals' way of life. Answers to the identification test discussed in Chapter 2 were frequently provided at superordinate levels (e.g. the red admiral butterfly was often named 'butterfly', the 'chaffinch' often referred to as 'bird'). Furthermore, as reported in Chapter 3, people were more likely to correctly identify species than to exhibit in-depth knowledge about them. Misconceptions were uncovered about species' origin, habitat, diet, and behavior, some of which seemed to be caused by extrapolation of traits from species' relatives that people may know from zoos or from portrayals in the media (e.g. wrong assumptions that all penguins live in polar regions). It appears that names and physical characteristics often serve as a starting point when people get to know species, and that understanding may remain fragmentary if this is not accompanied or followed up by in-depth information about the animals' way of life.

8.1.2 Drivers of species literacy

Apart from current levels of species literacy, Chapter 2 has discussed possible determinants of species literacy. Correlation and regression analyses on data from the species identification test revealed factors associated with species identification skills and suggested pathways that foster knowledge about species.

I found indications that both direct and indirect experiences with biodiversity drive species literacy in laypeople. Participants with a garden identified a greater number of animals than those without a garden, which suggests that people become aware of native species when observing wildlife close to their homes, in

line with the idea that bird feeding can connect people to nature (Cox & Gaston, 2015, 2016). Species literacy was also associated with media exposure, yet it only was a significant contributor in the model for the general public, not in the model for children 9/10 years old. The question arises whether there may be fewer opportunities for Dutch children than for adults to learn about local biodiversity through the media, e.g. due to a stronger focus on foreign nature in media aimed at children.

I further found support for the idea that when people become familiar with species, they develop a raised interest and affinity towards them (Palmberg et al., 2015; Schlegel & Rupf, 2010). People's identification skills correlated positively with laypeople's attitudes towards nature and animals. However, it is important to note that the direction of the interaction could not be determined. Positive attitudes towards animals can trigger people to search for information about species, so that they become more knowledgeable. Most likely an interplay exists between knowledge, interest, and affinity.

Finally, associations were established between species literacy and demographic variables. Species literacy increased with age, which seems to suggest that Dutch citizens develop knowledge about species over the course of their lives, yet it should be noted that this pattern is also in line with the process of generational amnesia, whereby knowledge about the environment is lost over generations, e.g. because of reduced experience of biodiversity (Kahn, 2002; Papworth et al., 2009). Furthermore, species literacy increased with educational level, suggesting that people derive part of their knowledge about species during formal education. Lastly, although in the general public population, male participants achieved slightly higher scores than females, in children gender did not seem to modulate the relationship with local fauna.

8.1.3 The association between species identification and in-depth knowledge

The research project discussed in Chapter 2 used participants' ability to identify species presented to them as photographs to determine species literacy levels, similar in approach to a large number of previous studies that have used species identification tests not only to determine which species people can identify, but also to measure what people know about species or nature overall. However, it was actually not yet known to what extent species identification is a reliable

indicator for in-depth knowledge about species. To fill this important gap in the literature, I investigated the presumed association between these two important components of species literacy.

As described in Chapter 3, species identification turned out to be a reasonably good indicator for in-depth knowledge about species, and a far better predictor than alternative variables such as age and gender. The odds for having in-depth knowledge about the origin of species, their habitat, diet, or behavior were considerably higher for those who correctly identified species as compared with those who did not correctly identify species. The findings suggest that as people develop species identification skills, this triggers them to learn more about the way of life of species too (Barker & Slingsby, 1998; Leather & Quicke, 2009). Moreover, people may use their in-depth knowledge to identify species, strengthening the association between the two knowledge components. All in all, we can conclude that species identification tests are suitable tools for professionals to determine levels of species literacy.

8.2 Cultural representations of animals

In the second part of this thesis I have examined the portrayal of animals in cultural products aimed at children. These cultural representations are likely to both reflect and impact people's perceptions of animal biodiversity. **Chapter 4** presented the findings of a project where a sample of over 800 animals portrayed in children's fashion was coded, while **Chapter 5** discussed the analysis of a sample of over 2,000 animals depicted in children's picture books. Studying the taxa and types of animals portrayed in these two product categories and the way in which they were represented, I explored how the animal kingdom is currently appropriated by fashion designers and picture book makers.

Despite the different nature of fashion and literature, I uncovered transcending patterns through my analysis. Children's clothes and picture books both featured animals frequently, yet of limited diversity. Strong biases were found. Vertebrates outnumbered invertebrates, in line with cultural sources such as postage stamps (Nemésio et al., 2013), nature magazines (Clucas et al., 2008), and Instagram (Heathcote, 2021). Insects were restricted largely to butterflies in girls' fashion, and to elements of scenery in picture books. Still, within vertebrates there was variation too. Notably, mammals were numerous and depicted prominently. In

picture book stories they regularly served as protagonists, while animals such as birds and fish were portrayed more subtly and less frequently, despite being more abundant and species rich in the outside world. Additionally, exotic and domestic animals were prevalent, a pattern that has been found previously for other cultural sources as well (Ballouard et al., 2011; Burton & Collins, 2015; Celis-Diez et al., 2016; Sousa et al., 2017). Finally, in children's fashion some animals were restricted to either boys' or girls' clothing; e.g. dinosaurs were only encountered on clothes marketed at boys.

Only a minority of the animals could be identified at the species level. Animals were depicted in various artistic styles and often their portrayals were abstracted and transformed, which reduced their recognizability. Many animals were anthropomorphized, as they were depicted as wearing clothes, having human facial expressions, and/or behaving as humans. On clothes marketed at girls, animals were often cute-ified and feminized. In picture books, text references to animals were often missing, and when animals were mentioned, they were often named above the species level, even in cases when distinct species had been depicted. Interestingly, specificity of the portrayals differed between taxonomic groups, as mammals were depicted and named at the species level more frequently than other animals.

The limited range of animals featured in childrenswear and picture books may flow from a poor understanding of animal diversity in designers, illustrators, and authors. After all, these creatives can only portray animals that they are aware of. However, representations of animals in cultural products may also be understood from a strategic and commercial point of view. It seems that cultural product makers depict animals that are likely to resonate well with the public. For instance, people tend to appreciate the appearance of mammals (Macdonald et al., 2015; Smith et al., 2012) while they dislike invertebrates for their dissimilarity to humans (Batt, 2009). Such predispositions may explain why mammals are generally overrepresented in cultural products and why invertebrates are underrepresented as compared to their actual diversity and abundance. Creatives also seem to strategically tap into people's affinity for domestic animals and their attraction to exotic megafauna (Lindemann-Matthies, 2005). It was striking that books from Dutch publishers portrayed as few species native to the Netherlands as books from foreign publishers.

A commercial standpoint also helps to explain the way in which animals

are portrayed in cultural products. Picture book makers and fashion designers probably anthropomorphize, cute-ify, and artistically transform animals to make them appealing and easy to relate to (A. A. Y.-H. Chan, 2012; Marriott, 2002; Root-Bernstein et al., 2013). In contrast, specifying animal portrayals – representing animals at a low taxonomic level and making them recognizable – may not be deemed relevant for attracting customers to buy clothes or for conveying picture book stories.

8.3 The perspective of biodiversity communicators

In the third and final part of this thesis I have investigated the perspective of biodiversity communicators. Involving communicators in the research was highly valuable, as high-quality communication is seen as an important key in engaging lay audiences on biodiversity (CBD, 2013). Communicators have potential to sensitize people to the natural environment and they can aid people in expanding and specifying their perception of biodiversity and according vocabulary.

First, from the idea that being aware of existing perceptions in target audiences is vital for communicating effectively, I used an innovative approach to explore whether biodiversity communicators are aware of existing knowledge levels. While establishing the average level of species literacy in primary school children and professionals (Chapter 2), participating communicators were asked to make an estimation of children's knowledge level. Subsequently I could compare communicators' estimates to the actual level (**Chapter 6**). Furthermore, Chapter 6 discussed communicators' views on why knowledge about species would be important or not, and the desired level of species literacy. **Chapter 7** described a qualitative research project for which I carried out interviews with biodiversity communicators. I studied their views on the current and desired role of biodiversity in laypeople's lives, their experience with and thoughts about communication, and opportunities and challenges that they perceived in connecting people to biodiversity in the densely populated Netherlands.

Biodiversity communicators were aware that laypeople's current perception of biodiversity is limited. During the interviews discussed in Chapter 7, communicators described how they felt motivated in their work by laypeople's poor understanding, and they noted the ambivalent attitudes that Dutch citizens express towards biodiversity. They argued that opening people's eyes

for biodiversity would benefit both people and biodiversity, and they aimed for a bigger role of biodiversity in laypeople's lives. Still, as reported in Chapter 6, at a more detailed level I found that most communicators were unaware of the average knowledge level in primary school children aged 9/10 years old, whether they had experience with children as a target group or not. In particular, many respondents overestimated the average level of species literacy.

It was apparent from both projects that biodiversity communicators generally valued knowledge about species. As shown in Chapter 6, most desired the level of species literacy in children to be higher than the actual level. However, communicators disagreed on the components of species literacy that would be important, e.g. while some attached importance to naming species, others downplayed the value of knowing names. Moreover, some communicators seemed unaware of the role that factual knowledge can play in fostering understanding (Amer, 2006; Weilbacher, 1993), interest (Cosquer et al., 2012), and appreciation (Lindemann-Matthies, 2005; Schlegel & Rupf, 2010); e.g. some did not seem to grasp the value of species as tools to comprehend biodiversity and other complex concepts such as ecosystems and food webs (Barker & Slingsby, 1998; Orr, 2005). Others did note relations between knowledge, attitudes, and behavior, yet they seemed to overlook limitations of knowledge-deficit models (C. Mooney, 2010; Owens, 2000). Communicators' views further differed as to why species literacy would be important. For instance, some linked knowledge about species to broader understanding of nature, while others stated that species knowledge may stimulate interest and positive attitudes towards species.

Finally, as discussed in Chapter 7, communicators saw much potential in the Netherlands to engage people with biodiversity, an encouraging view at a time when the relationship between humans and nature is under increasing pressure and nature conservation is increasingly dependent on people living in urbanized environments. Based on communicators' views potential lies in a combination of direct experiences with biodiversity outdoors, the media, and education. Moreover, strategically designed communication holds keys in opening people's eyes for biodiversity. Still, despite this optimistic view on opportunities to expand the role of biodiversity in laypeople's lives, barriers were mentioned as well that will need to be overcome to fulfill the potential. For instance, people may be easily distracted from nature in crowded settings, biodiversity is integrated and regulated poorly in urban design, and accessibility to greenspace differs between

locations. Moreover, the interviewees noted that the media may distort views on biodiversity, and that schools face challenges such as low budgets. Some of these impediments to the experience of biodiversity will be discussed in the following section, where I describe practical implications of the findings.

8.4 Implications of the findings

The low level of species literacy that was uncovered in laypeople, especially in children, implies that a large part of the Dutch population currently does not derive the benefits associated with knowledge about species. Instead, they miss out on opportunities for enriching, joyful, and rewarding experiences with biodiversity, and the potential is unexploited to develop a sense of place through familiarity with local biodiversity (Horwitz et al., 2001; Standish et al., 2013). It will be difficult for people unaware of species to know how a species is faring, and to make judgements and informed decisions about policies and actions that may affect these species. Additionally, it is questionable whether current knowledge levels are sufficient for achieving ecological and environmental literacy (Barker & Slingsby, 1998; Cutter-Mackenzie & Smith, 2003; Roth, 1992), both of which are crucial in a world with a rapidly growing population that puts increasing pressure on the environment and poses a significant challenge to sustainable development (Bergaglio, 2017). Overall, a restricted perception of animal biodiversity affects laypeople's lives in multiple ways, but there are important implications for professionals too.

8.4.1 Implications for conservation

Possible effects on people's attitudes and behavior

For conservationists it is important to realize that people tend to care about what they know (Balmford et al., 2002; Schlegel & Rupf, 2010), and an inability to name species may lead to a loss of attention for them (Macfarlane, 2015, 2017). This raises concern for vulnerable species that received low identification rates, such as the black-tilled godwit. Biases in the types of animals that people do and do not know can influence which conservation initiatives and policies receive support (Davies et al., 2018; Wilson & Tisdell, 2005), and may impact directions for biodiversity research (Jarić et al., 2019; Troudet et al., 2017). Misconceptions

about species may also affect people's attitudes towards them. Species wrongly believed to be health risks, such as the non-venomous grass snake that was regularly thought to be venomous (Chapter 3), may experience persecution (Corbett et al., 2005). Limited understanding of species may further prevent people from making informed decisions and from personal actions that benefit species, e.g. people can aid animals that visit their garden effectively only if they are aware of their requirements (e.g. what would be suitable nesting sites or the kind of food they depend on).

From a conservation perspective, the current patterns in species literacy are further worrisome, because they suggest a disconnection of Dutch citizens from the local environment. Unfamiliarity with local biodiversity may lead people to think that conservation efforts abroad should be prioritized (Ballouard et al., 2011; Verboom et al., 2004). As people are likely to overlook animals that they cannot identify, people with a low level of species literacy may also undervalue biodiverse habitats (Shwartz et al., 2014; Weilbacher, 1993), may not notice declines in biodiversity, and may experience difficulty in making informed decisions with regard to such alterations. Indications of this have been pointed out in Chapter 7; the interviewees outlined examples of people unaware that invasive species had replaced native species, and of people having got used to shifted baselines. Such lack of awareness could hamper support for nature protection legislation and conservation measures. As low levels of species literacy can ultimately interfere with biodiversity conservation, conservationists should be aware of factors that drive people's perception of biodiversity.

The impact and potential of cultural representations

In this thesis I have demonstrated that cultural sources targeted at children paint a limited and distorted picture of the animal kingdom, and there is much evidence that this influences which animals people know. It even seems that the impact of such indirect exposure to biodiversity currently outweighs the impact of direct experience with biodiversity. As reported in Chapters 4 and 5, children's clothes and picture books overrepresented mammals and depicted them in greater specificity as compared to other animals, which suggests that they foster familiarity mostly with mammals. Moreover, cultural products seem to direct people's perceptions towards foreign species, as animals exotic to the Netherlands were featured frequently in picture books and childrenswear, and

native species were mistaken for exotic animals in the identification test.

Cultural portrayals of animals may impact conservation in different ways. First, people may develop affinity towards regularly featured animals at the expense of other animals. The focus on vertebrates and exotic species may lead people to think that invertebrates and native species are not worthy of their attention and support. This links back to children's higher interest in foreign animals as compared to animals that occur in the Netherlands. People may further overestimate the natural abundance of animals that are featured frequently, even when they are in fact threatened (Courchamp et al., 2018). People's view on animals can also be distorted by the artistic transformation that animals go through when they are portrayed in cultural sources. Compared to anthropomorphic animal characters real animals may appear dull, and the unequal attribution of human characteristics to different animal groups may trigger affectionate feelings for some (notably mammals) while others (e.g. invertebrates) may be perceived as mere objects (Cole & Stewart, 2016; Root-Bernstein et al., 2013). Unrealistic and anthropomorphic portrayals can further induce misconceptions, e.g. about behavior (Ganea et al., 2014; Geerdts, Van De Walle, et al., 2016; Marriott, 2002; Waxman et al., 2014). In some cases this can undermine positive attitudes towards animals, e.g. people may approach wild animals that they recognize as 'friendly characters' (McCrindle & Odendaal, 1994), and may wish to keep popular animal characters as pets (T. A. Clarke et al., 2019; Root-Bernstein et al., 2013).

Overall, the distorted and unspecified portrayal restricts current opportunities for Dutch children to familiarize themselves with animals through cultural products. However, as the current portrayal is likely to stem partly from a limited perception of animal diversity in cultural product makers, there is potential for a more diverse representation of animals. Of course, tendencies to depict mammals will not change easily, and as products such as clothes are destined for an international market, exotic animals will inevitably dominate. Still, opportunities remain, as the representation of such popular groups can be diversified and specified too. Partnerships with conservationists could encourage creatives to weave underrepresented species and animal groups into artwork and storylines or to highlight them in special or limited editions. Conservationists could further help educators in selecting products most suitable for expanding perceptions (e.g. picture books that portray the local environment).

Expanding opportunities for direct experiences with biodiversity

While urbanization continues and the gap between humans and nature widens, cultural representations of animals play an increasing part in people's daily exposure to biodiversity. However, animal portrayals still can best be regarded as a supplement rather than a substitute for outdoor nature experience, as the opportunities that they provide are restricted, e.g. due to the biases described above and the limited senses stimulated through vicarious experiences with nature. It is therefore vital that conservationists do not overlook the importance of facilitating direct experience with nature.

To offer people opportunities to engage with flora and fauna outdoors, biodiversity should be an integral part of urban design. It is vital that conservationists and urban ecologists are involved in the design process, not only because they can then directly influence plans, but also because they can educate important actors such as urban planners, architects and housing corporations about the importance of biodiversity and about strategic ways to incorporate biodiversity in the landscape or in architecture (Apfelbeck et al., 2020; Barrico & Castro, 2016; Parris et al., 2018). As such, false assumptions in these actors – e.g. that citizens would dislike natural types of greenspace and would dislike flora and fauna – can also be countered (Muratet et al., 2015; Vaske et al., 2011).

While offering room to biodiversity in cities could help people in having enriching interactions with species, it is important to reiterate that many laypeople were unfamiliar with animals that are common in the Netherlands and abundant in (sub)urban areas. As noted by interviewees in Chapter 8, biodiversity in the Netherlands may even be higher in cities than in rural areas, where biodiversity has declined. This links to McKinney (2008), who argued that moderately urbanized environments may have higher species richness than the native ecosystems they replaced. Instead of a lack of opportunity to experience species directly due to limited abundance, it is more likely that people's unfamiliarity with local biodiversity is caused by some of the barriers to outdoor experience mentioned in Chapter 7, such as urban distractions (e.g. traffic) and limited accessibility to greenspace.

Possibly people need certain types of greenspace where they can unwind and calmly take in the surroundings, in order to notice and enjoy species that actually occur outside of these locations too. During the interviews it was mentioned that locations differ with respect to the availability and accessibility of greenspace,

which links to Cox et al. (2017), who found that for urban residents in the UK the majority of human-nature interaction was experienced by only one third of the population. This may imply that a considerable part of Dutch citizens may not develop a strong, personal connection to nature (Cheng & Monroe, 2012), which could hamper conservation in the future (Soga, Gaston, Yamaura, et al., 2016). To counteract this, biodiversity sensitive urban design (Garrard et al., 2018) could help create areas of urban nature that allow valuable interactions between citizens and the natural world to unfold.

Additionally, communication will need to play an important role in opening people's eyes for what is around them.

8.4.2 Implications for communication

Restricted knowledge as a barrier to engagement

Although communication is acknowledged as an important pathway to connect people to biodiversity, significant challenges emerged from the research. First, the considerable knowledge gap between professionals and laypeople may hinder communication. Laypeople's low level of knowledge about native animals could make it harder to discuss biodiversity in a way that is locally relevant (Magntorn & Helldén, 2005), and as the majority of the Dutch public is aware of just a small range of animals, only specific species will resonate with the public when they are used as flagships in campaigns.

Furthermore, current levels of species literacy seem to be lower than communicators expect, as many communicators overestimated children's average level of species literacy. Current messages and materials may thus not align with existing knowledge. Species names wrongly presumed to be part of the vocabulary of the target group may act as jargon, so messages are misunderstood. Mismatches between communicators' assumptions of what audiences know and what they really know may partly explain why certain segments of the public have not yet been reached successfully (Elder et al., 1998).

An encouraging thought is that when communicators would become more aware of current knowledge levels in laypeople, this may generate momentum to combat the current lack of understanding. After all, most communicators desired an average level of species literacy in children that was higher than it actually was, they just were not aware that the knowledge level was as low as it was.

The value of species identification tests

To get to know and differentiate target groups, communicators could use knowledge assessments. In particular, my research has demonstrated the versatility and usefulness of species identification tests. As demonstrated in Chapter 3, species identification proves to be a decent impression of a person's in-depth knowledge about species, and may serve as an indicator of people's affinity with nature too. Moreover, in Chapter 2 we have seen that identification tests can be used to obtain information about the (dis)connection between people and the local environment, and about the likely impact of direct and indirect experiences with biodiversity on people's perceptions. The great enthusiasm exhibited by both young and adult respondents to participate in the tests suggests that such assessments can actually become quite popular, at least when they are presented as 'quizzes'.

Communicators could use a series of quizzes to explore knowledge levels and possible misunderstandings in their audiences. Such tests could be localized; e.g. school teachers could include species that their pupils encounter in the schoolyard. The results can help attune messages to an appropriate level and help address specific misconceptions, so that target groups are engaged more effectively on the topic of biodiversity. Of course, providing information at an appropriate level will in itself not be sufficient for changing people's attitudes and behavior (Buijs et al., 2008; J. H. Falk & Adelman, 2003), yet it is a start. In addition, factors such as interest, expectations, and personal experience with biodiversity can be examined with short tests, as they too influence people's response to messages.

Strategies in communication and education

Communicators may be inspired by the best practices in biodiversity communication as described in Chapter 7. First, and as noted above, professionals should aim to strike a chord with the public, e.g. by connecting to existing knowledge levels. Additionally, creative translation of biodiversity by using metaphors, mnemonics, and games can help people understand and remember messages. Careful selection of species to communicate can prevent cognitive overload while making sure that examples are accessible and relatable for people. In this regard it is advisable to embed species in context, as this is more likely to spark interest and can help achieve a more rounded understanding of

species, in line with Randler (2008), who posited that simple labeling of species as educational tasks may prove detrimental. Taking into account laypeople's shallow perception of biodiversity, I further point out that communicators can foster species literacy most effectively by being specific in their wording and the images they use for illustration.

In particular, young children are an important target group for communicators, as the average level of species literacy was found to be very low in these future decision makers. Moreover, childhood is a strategic starting point for raising biodiversity awareness, as children are generally open to information about nature and animals (DeMello, 2012; McCrindle & Odendaal, 1994), and through younger generations older generations (e.g. parents) can be reached too (Diris & Lambrix, 2010; Dixon et al., 2005; Remmele & Lindemann-Matthies, 2018). The most obvious place to educate children about biodiversity and to develop species identification skills will be at school, as many children can be reached via this route, including those with the least prior exposure to nature that will benefit most from such education (R. L. White et al., 2018).

Some of the communicators participating in the studies presented in Chapters 6 and 7 proposed to define a canon of animals that should become part of every person's knowledge base. This links to Pyle (2003), who argued that apart from literacy and numeracy, familiarization with the local environment should also be an important educational goal. Regardless of whether a biodiversity canon would be used or not, I do recommend to integrate species literacy in primary school curricula and to subtly weave animal diversity into different school subjects (e.g. biology, art, and language).

Communicators could inspire and support teachers by designing and proposing educational materials and accessible and affordable programs to observe and monitor species in the close vicinity to school. Such projects aimed at the local environment have been shown to expand children's perceptions of biodiversity and to foster positive attitudes towards native species (Lindemann-Matthies, 2005, 2006).

A framework for species literacy

Finally, it is important to consider the disagreement revealed among biodiversity communicators as to why species literacy would be relevant for laypeople. Some of the professionals seemed unaware of the range of values that knowledge about

species can offer to people, so they may not invest in raising species literacy in their lay audiences. As a consequence, the public may remain 'species illiterate' and the potential of species literacy will not be fully realized, which could ultimately make it harder to achieve broad-based biodiversity awareness. It is thus important that professionals grow understanding of the versatility of knowledge about species and the value it holds for laypeople.

To clarify and disseminate the concept of species literacy, I have constructed a framework. The framework shows the components of species literacy (Figure 8.1), the potential effects of species literacy on five personal domains (Figure 8.2), and a schematic overview of the hypothesized relationships between the personal domains and their connection to species literacy (Figure 8.3). By providing

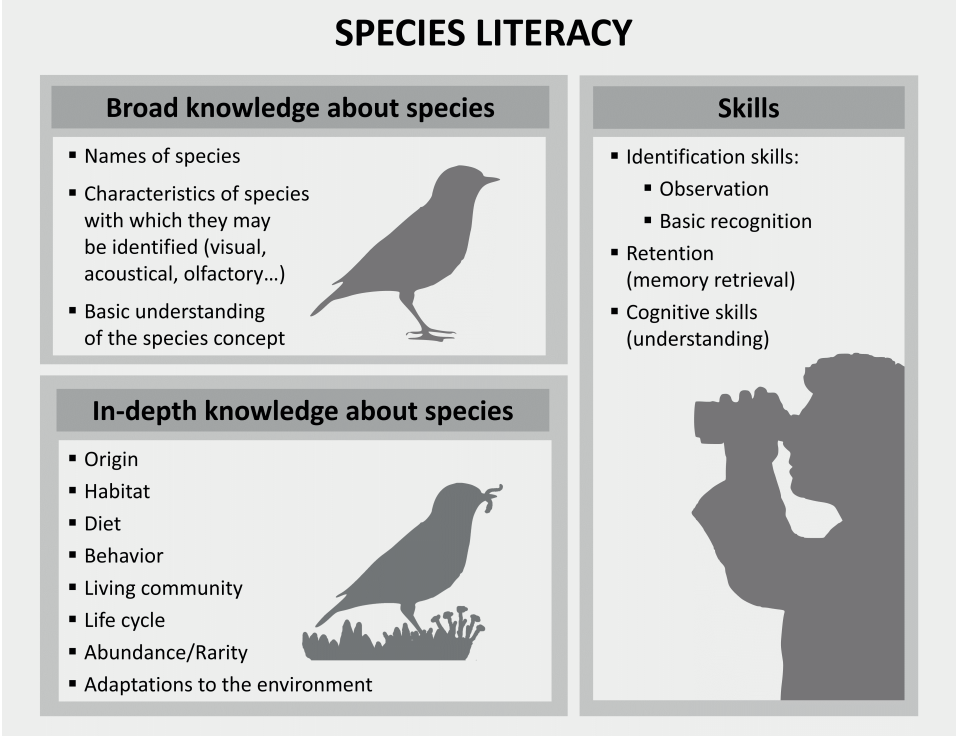


Figure 8.1 Schematic overview of the components of species literacy. Species literacy comprises broad as well as in-depth knowledge about species. It involves knowledge of facts, basic awareness and understanding, but also competences and skills, in particular species identification skills.

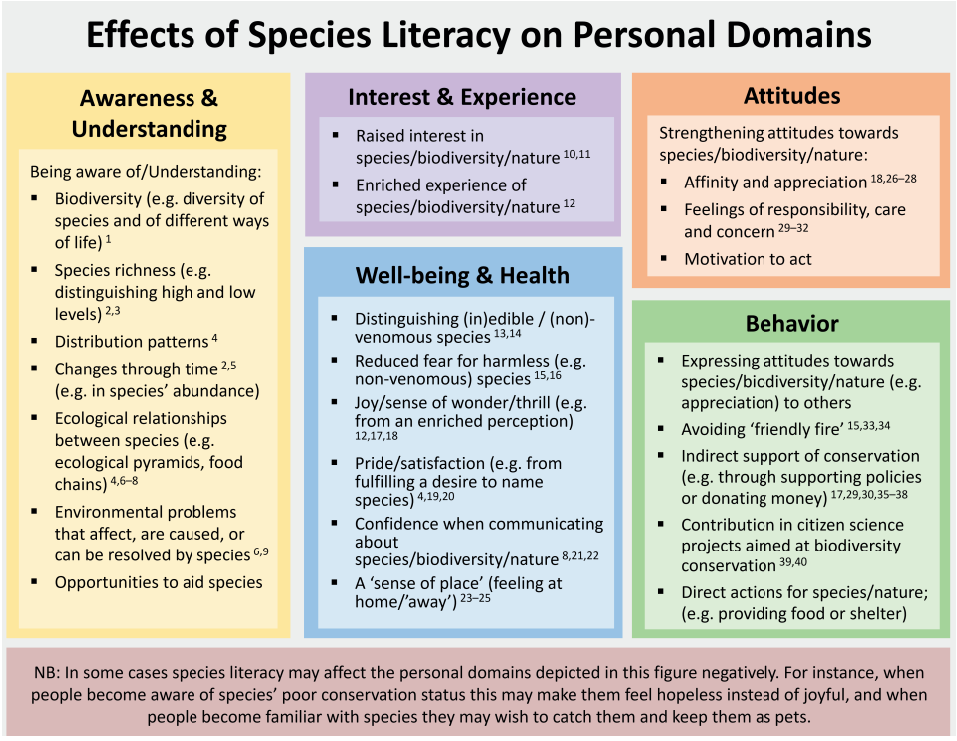


Figure 8.2 Potential effects of species literacy on five personal domains. 1: Elder et al. (1998); 2: Dallimer et al. (2012); 3: Shwartz et al. (2014); 4: Barker & Slingsby (1998); 5: Herzon & Mikk (2007); 6: Dayton & Sala (2001); 7: Magntorn & Helldén (2006); 8: Weilbacher (1993); 9: Patrick et al. (2013); 10: Cosquer et al. (2012); 11: Palmberg et al. (2015); 12: Ganzevoort & Born (2019); 13: (Corbett et al. (2005); 14: Fančovičová & Prokop (2011); 15: Alves et al. (2014); 16: Breuer et al. (2015); 17: Cox & Gaston (2015); 18: Wilson & Tisdell (2005); 19: Milstein (2011); 20: Tull (1994); 21: Magntorn & Helldén (2005); 22: Scott & Boyd (2014); 23: Buijs et al. (2008); 24: Horwitz et al. (2001); 25: Standish et al. (2013); 26: Lindemann-Matthies (2005); 27: Nates Jimenez & Lindemann-Matthies (2015); 28: Schlegel & Rupf (2010); 29: Balmford et al. (2002); 30: Bowen-Jones & Entwistle (2002); 31: Home et al. (2009); 32: Penn et al. (2018); 33: Olive (2014); 34: Somaweera et al. (2010); 35: Peterson et al. (2008); 36: Senzaki et al. (2017); 37: White et al. (1997); 38: White et al. (2001); 39: Genet & Sargent (2003); 40: Lepczyk et al. (2004).

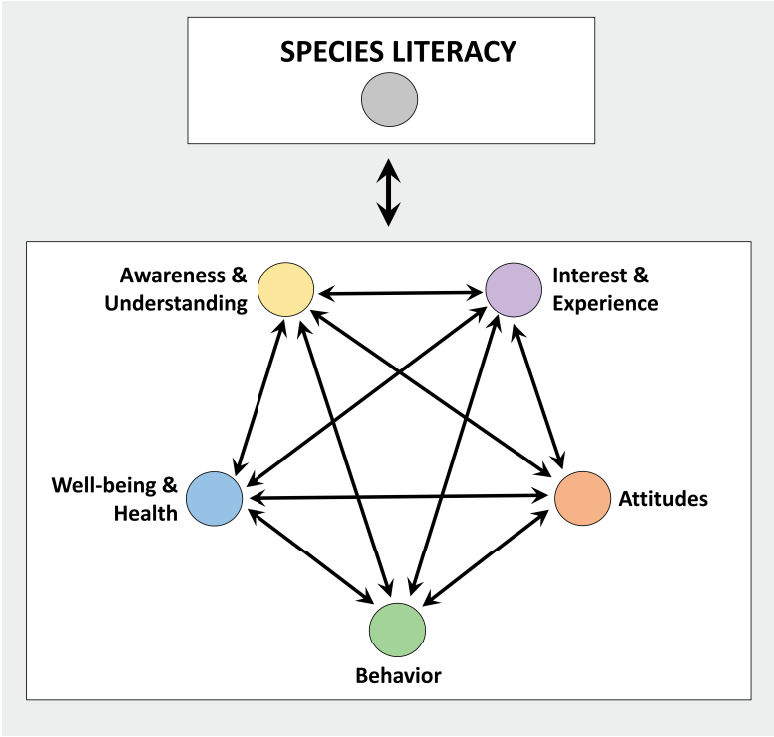


Figure 8.3 Model of the hypothesized relationships between the personal domains and their connection to species literacy. The model illustrates that species literacy and the personal domains influence each other reciprocally. Example cases can be thought of for each relationship. For instance, becoming aware that greenfinches exist and that they eat seeds (species literacy) can lead people to provide sunflower seeds for them in the garden during winter (behavior), which may attract other birds too, that people will subsequently become familiar with. Becoming aware of the diversity of life (broader awareness/deeper understanding) can instill a sense of responsibility (attitudes), and a feeling of responsibility may vice versa stimulate people to learn about environmental problems that affect species.

an overview of the contributions that knowledge about species can make to broader awareness and deeper understanding, interest, well-being, affection, and behavior, the framework can aid communicators in setting educational goals, and in underscoring the importance of their educational activities related to biodiversity awareness. Furthermore, distribution of this framework among researchers and communicators (e.g. at schools and conservation agencies) may generate impetus to study and foster species literacy in society.

8.4.3 Implications for future research

Whereas the restriction in laypeople's perception of animals holds significant implications in itself, the cross-sectional setup of the species literacy assessment did not reveal if and to what extent knowledge has actually been lost. Recent research in Germany has suggested that over a period of 12 years grammar students' knowledge about species declined by 15 percent (Gerl et al., 2021). Future longitudinal research could use species literacy assessments at regular intervals to track changes over time. This could elucidate whether the low level of species literacy in primary school children signals a growing distance between humans and nature. New studies on biodiversity awareness in the Netherlands could include a greater variety of invertebrates, amphibians and fish, and could incorporate taxa such as plants and fungi. Moreover, factors such as interest, expectations, and personal experience with biodiversity could be examined alongside knowledge levels. Projects that assess laypeople's perceptions could be strategically combined with research on professionals' awareness of these perceptions.

Future studies could further delve deeper into the different determinants of species literacy. The regression models presented in Chapter 2 for primary school children and the general public only accounted for part of the variance in laypeople's knowledge levels, and this suggests that there may be important drivers for species literacy that have yet to be uncovered. One of these factors may be 'green role-models' during childhood such as teachers, family members, and media personalities that mediate exposure to biodiversity. Remmele and Lindemann-Matthies (2018) demonstrated that children's and their parents' familiarity with species was positively related, although the relationship proved to be stronger for plants than for animals. More extensive scales to measure direct and indirect experience with biodiversity combined with qualitative research to

help grow understanding of the factors that impact people's perceptions would be valuable. In addition, projects could study the relationships depicted in Figure 8.3 between species literacy, broader awareness and deeper understanding of biodiversity, interest and experience, well-being and health, attitudes, and behavior. In this light it would be interesting to differentiate different components of species literacy (e.g. species' names, conservation status, and way of life), as these probably have different effects on people.

With regard to cultural representations of biodiversity some important questions also remain. First, future studies could investigate how cultural representations of animals vary and change through time, and how products and media targeted at adults differ from those aimed at children. Beyond the taxa and types of animals that are depicted, and the specificity of their portrayals, such studies could also examine the portrayal of habitats, behaviors, diets, and living communities. Moreover, researchers could determine to what extent people, notably children, are aware of animals that they encounter as cultural representations. While images of animals unquestionably affect people's views on animals, laypeople are less likely than professionals to link highly transformed animal figures to the animals that they represent, and the exact impact on species literacy is currently still unknown. A valuable line of inquiry would further be to investigate how portrayals of the natural world influence people's predisposition towards engaging with the outdoors. On the one hand portrayals may trigger interest and an inclination to explore, yet on the other hand local biodiversity may appear dull and unrewarding after exposure to spectacular or comical images of animals. Finally, a promising avenue for further investigation of cultural products is to study how the portrayal of animal biodiversity can be diversified, through preference-tests with consumers, and also through in-depth interviews with creatives, to uncover the processes that determine their subject and design choices.

Finally, we need continued efforts to map opportunities and barriers to connect laypeople, children especially, with the local environment. Future research could explore how teachers and parents can best be supported in educating children about native biodiversity. In this respect it is important to note that opportunities and challenges to the experience of nature differ between contexts. Educators at schools in city centers or in low socio-economic neighborhoods face different challenges as opposed to educators in rural settings and high-socio-economic

environments, which shows the importance of localized case studies. From the idea that biodiversity sensitive urban design can ultimately help open people's eyes for biodiversity and help them connect with nature, mixed-method setups are further needed that study biodiversity awareness in actors such as landscape architects and housing corporations, and its impact on urban planning.

8.5 Synthesis

In this thesis I have outlined the results of six empirical research projects focused at biodiversity awareness in the Netherlands. Through my studies I have demonstrated that the perception of animal biodiversity is limited in the Dutch lay public. Primary school children in particular seem to be species illiterate. They regularly failed at identifying common and conspicuous animals, which points to a lack of familiarity and connection with the local environment.

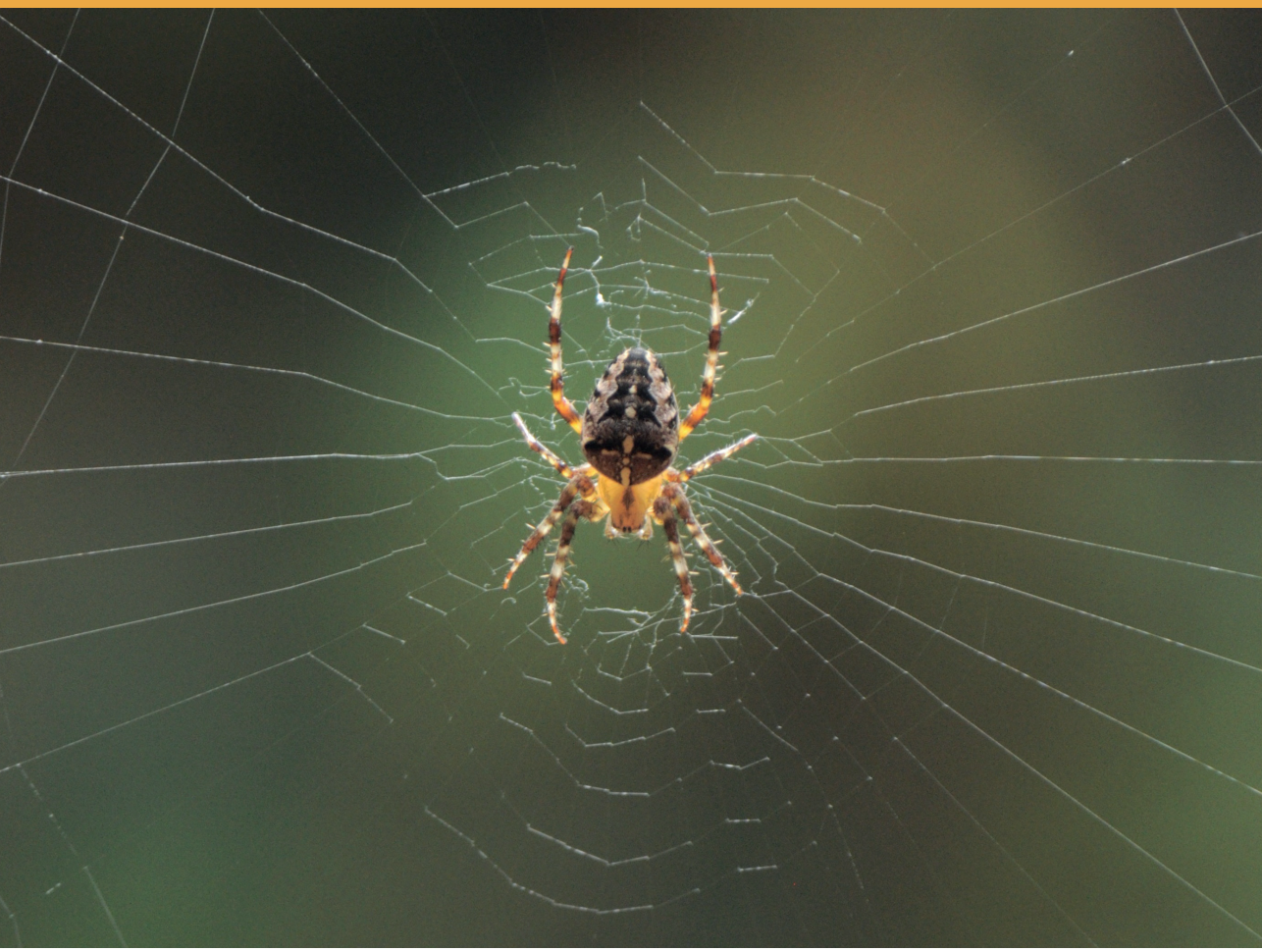
Knowledge patterns mirrored the patterns uncovered in cultural portrayals of animals. Animals well known by people, such as mammals and species exotic to the Netherlands, predominated children's fashion and picture books, while animals such as birds and butterflies that were portrayed less frequently and in less specific manners, were hardly in laypeople's minds. As such, the findings of my research on cultural representations of animals align with the findings of my research on perceptions of animal biodiversity: both reflect a gap between people and nature. The animals that people do know are quite difficult to experience directly, either because of their reclusive lifestyles (native mammals) or their foreign origins (exotic megafauna from overseas), while species that people can easily encounter outdoors seem to go by unnoticed.

The revealed patterns imply that Dutch laypeople currently miss out on enriching experiences with biodiversity. Laypeople's restricted and biased perception further poses a challenge for conservationists, who ultimately depend on the public for broad-based support, and for communicators, who play an important role in connecting people to the natural world. Based on my research, promising avenues to foster species literacy and engage people with biodiversity are 1) realizing opportunities to experience biodiversity outdoors and in education, 2) diversifying cultural representations of animals, and 3) deploying strategically designed communication.

To realize the potential of these pathways, conservationists, communicators, and researchers should:

- …study, become aware of, and disseminate to both professional and lay audiences the values of species literacy, to fulfill the potential of knowledge about species
- …use tools such as species identification tests to get to know target groups and apply best practices in communication, to boost public engagement with biodiversity
- …encourage schools to integrate species literacy in the curriculum and provide them with appropriate educational materials, to improve nature education and raise biodiversity awareness
- …make sure to be involved in urban planning, to achieve biodiversity sensitive urban design
- …inspire creatives to diversify and specify their portrayals of the natural world, to increase the educational contribution of cultural representations

Following these recommendations can help nurture lasting connections with biodiversity that will enrich people's lives and will help support conservation of the great diversity of life on our planet.



The **cross spider** (Nederlands: **kruisspin**) is usually encountered in late summer and autumn, when the large females are prominent in their orb webs. To show a female his willingness to mate, a male cross spider taps her web rhythmically.

Addendum

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Appendix 2.1

Guidelines used to score the answers provided during the species identification test. A more elaborate overview of the guidelines can be found in the Online Supplementary Materials (S_Ch2_Scoring_Guide).

Type of answer	Example	Score
Correct answer: correct (everyday/partial) name	e.g. 'fox' (instead of 'red fox')	1
Correct answer in a different language	e.g. 'rotfuchs' (instead of 'red fox')	1
Multiple correct answers	e.g. 'fox, Vulpes vulpes'	1
Correct specification	e.g. 'mammal - fox' or 'fox, mammal'	1
Spelling mistakes	e.g. 'red fffox'; e.g. 'foks'	1
Correct answer with a sign of doubt	e.g. 'fox?'	1
Correct name of female or male of the species	e.g. 'vixen'	1
'Neutral additions' to a correct answer	e.g. 'nice fox'; e.g. 'Eurasian fox'; e.g. 'hungry fox'; e.g. 'forest fox'; e.g. 'small fox'	1
Incorrect answer	e.g. 'don't know'; e.g. 'dog' (when 'fox' is asked for)	0
Both correct and incorrect answer	e.g. 'fox, wolf'	0
'Group/broad thinking'	e.g. 'a fox like animal'	0
Negative answer	e.g. 'not a fox'	0
Unclear/incorrect specification	e.g. 'fox or mammal'; e.g. 'fox - rodent'	0
Name of an animal character from cartoons or fables without the correct species name	e.g. 'Reynard'	0
Additions that turn a correct answer into an incorrect answer	e.g. 'snow fox'	0

Appendix 3.1

Identification and in-depth knowledge rates among laypeople and professionals.

Species	% Identification			% In-depth knowledge			% In-depth knowledge when correctly identified		
	Lay	Profs	All	Lay	Profs	All	Lay	Profs	All
Origin									
American bison	87.9	93.5	89.4	77.0	85.3	79.3	84.0	88.6	85.3
Cardinal tetra	47.3	65.8	52.2	42.0	50.9	44.4	50.0	60.8	53.7
Jaguar	40.1	59.5	45.3	29.0	49.9	34.6	54.4	74.6	61.4
White-handed gibbon	69.8	87.8	74.7	49.0	58.4	51.5	52.4	61.1	55.1
Fire salamander	49.1	69.0	54.4	33.6	61.1	40.9	53.2	82.0	63.0
American alligator	32.7	45.8	36.3	40.4	49.5	43.0	87.0	87.6	87.4
European badger	78.7	92.2	82.3	81.7	91.8	84.5	94.2	96.9	95.0
Eurasian bullfinch	40.5	62.5	46.4	71.7	81.7	74.4	92.6	95.5	93.6
Emu	69.2	72.6	70.1	54.9	64.9	57.5	60.1	72.3	63.5
Capybara	91.3	97.3	92.9	63.9	80.1	68.2	66.8	81.6	70.9
Black-footed penguin	76.6	78.8	77.1	27.1	57.5	35.2	27.6	61.9	37.1
Common wombat	90.1	95.3	91.5	76.6	88.0	79.6	81.4	90.6	83.9
Secretarybird	67.6	84.1	72.0	58.3	72.2	62.0	65.9	79.6	70.2
Cougar	73.6	87.9	77.4	57.1	76.0	62.1	68.7	82.4	72.8
Red-bellied piranha	82.1	91.2	84.5	76.4	83.0	78.2	82.6	87.8	84.1
Habitat									
Meerkat	98.5	99.3	98.8	96.4	99.3	97.2	96.9	99.5	97.6
Chamois	46.3	62.1	50.4	82.5	85.5	83.3	90.5	94.0	91.6
Goldcrest	53.2	75.3	59.2	32.5	53.9	38.3	41.9	63.7	49.4
Okapi	93.0	97.0	94.1	25.4	50.2	32.1	26.2	51.1	33.1
Fallow deer	78.4	83.4	79.7	68.1	80.0	71.3	74.9	87.0	78.2
Common crossbill	47.1	67.5	52.6	37.1	55.5	42.1	51.0	70.4	57.9
Black-tailed prairie dog	28.5	49.4	34.2	20.7	38.1	25.4	61.4	73.1	66.0
Eurasian red squirrel	87.8	93.6	89.4	97.5	98.7	97.9	98.9	99.2	99.0
Bearded reedling	35.4	62.6	42.9	38.5	60.3	44.3	64.0	81.0	70.6
Naked mole-rat	92.1	96.8	93.4	44.0	66.5	50.0	45.4	67.8	51.6
Southern ground hornbill	47.2	66.7	52.7	26.2	41.5	30.4	34.6	52.8	40.9
Malayan tapir	84.0	91.9	86.1	73.0	84.3	76.1	77.6	86.4	80.1
Black-tailed godwit	62.9	78.1	67.0	93.5	97.0	94.5	96.6	99.0	97.3
Fennec fox	37.8	66.9	45.7	43.0	72.4	51.1	80.3	93.6	85.7
Polar bear	99.7	100.0	99.8	99.9	100.0	99.9	99.9	100.0	99.9

Species	% Identification			% In-depth knowledge			% In-depth knowledge when correctly identified		
	Lay	Profs	All	Lay	Profs	All	Lay	Profs	All
Diet									
Common kingfisher	89.6	96.9	91.4	72.2	91.3	77.2	80.3	94.2	84.2
European goldfinch	49.1	73.0	55.3	44.5	66.2	50.2	67.1	82.4	72.5
Eurasian otter	67.9	86.8	72.8	64.3	85.0	69.6	90.0	96.6	92.0
Peregrine falcon	47.1	66.9	52.3	21.3	45.6	27.7	33.4	60.8	42.7
European green woodpecker	58.5	79.2	63.9	14.8	30.0	18.8	17.4	34.9	23.1
European mole	99.1	99.6	99.2	86.0	91.5	87.3	86.3	91.6	87.6
Bearded vulture	40.7	63.1	46.6	6.9	24.5	11.5	13.0	36.5	21.3
Barn swallow	62.4	81.8	67.4	69.3	84.2	73.1	85.1	93.5	87.7
Common eider	47.4	69.0	53.0	21.6	40.7	26.6	25.3	48.2	33.1
Koala	98.8	99.6	99.0	75.5	83.5	77.5	76.0	83.5	77.9
Coconut lorikeet	55.2	71.2	59.4	14.4	34.0	19.5	21.6	45.7	29.2
Marine iguana	48.2	65.2	52.7	29.1	51.5	35.0	54.9	73.7	60.9
Wolf	88.7	96.1	90.6	53.8	70.3	58.1	56.7	71.6	60.8
Gelada	8.4	27.2	13.3	5.6	19.7	9.2	49.6	65.0	57.9
Giant panda	99.8	100.0	99.8	97.6	98.7	97.9	97.7	98.7	98.0
Behavior									
White stork	93.7	97.0	94.5	87.2	94.3	89.0	90.2	95.4	91.6
Roe deer	70.4	77.5	72.1	34.6	58.7	40.9	39.0	65.1	46.4
Red deer	86.5	93.2	88.2	81.3	89.7	83.4	84.5	91.8	86.4
European robin	96.2	98.5	96.8	78.9	88.7	81.4	79.9	89.3	82.3
Leopard seal	30.1	51.8	35.9	18.5	37.9	23.6	42.2	61.7	49.5
Long-tailed tit	72.9	82.4	75.3	27.4	44.6	32.5	32.1	51.6	37.8
Common cuckoo	44.3	68.3	50.6	50.5	72.5	56.3	97.1	98.9	97.6
Common shelduck	33.7	64.3	41.7	22.8	44.0	28.3	38.6	58.9	46.9
African wild dog	49.6	73.5	55.9	23.0	40.9	27.7	36.1	52.1	41.6
Northern pike	83.4	91.8	85.5	69.1	80.6	72.1	73.3	82.5	76.0
Grass snake	30.1	53.9	36.3	29.7	35.8	31.4	50.9	53.9	52.2
Tufted duck	71.5	81.1	74.0	73.7	81.0	75.6	74.3	82.6	76.8
Red-backed shrike	28.0	53.2	34.6	26.7	52.0	33.4	59.9	80.4	68.1
European hare	91.5	95.3	92.5	39.4	48.2	41.7	41.4	49.0	43.5
Common warthog	62.5	73.7	65.2	12.4	21.5	14.9	15.1	25.7	18.3

Appendix 3.2

Odds ratios (ORs) for in-depth species knowledge among professionals and laypeople who did or did not correctly identify species, and Pearson correlations between species identification and in-depth species knowledge (subdivided into four themes).

	N	OR	95%	CI	*r*	*p*
Professionals						
Origin	920	9.38	8.56	10.28	0.73	<0.01
Habitat	985	8.36	7.66	9.13	0.75	<0.01
Diet	956	20.67	18.43	23.18	0.77	<0.01
Behavior	957	8.51	7.76	9.33	0.77	<0.01
Total	1,909	10.09	9.63	10.57	0.83	<0.01
Laypeople						
Origin	2,543	4.81	4.59	5.03	0.67	<0.01
Habitat	2,650	4.94	4.72	5.16	0.63	<0.01
Diet	2,681	13.19	12.46	13.96	0.70	<0.01
Behavior	2,644	6.05	5.77	6.35	0.66	<0.01
Total	5,259	6.25	6.10	6.40	0.76	<0.01
All respondents						
Origin	3,494	5.75	5.52	5.99	0.72	<0.01
Habitat	3,680	5.72	5.50	5.95	0.71	<0.01
Diet	3,675	15.05	14.31	15.82	0.76	<0.01
Behavior	3,649	6.75	6.48	7.04	0.73	<0.01
Total	7,249	7.18	7.04	7.33	0.81	<0.01

Appendix 4.1

Comparison between the prevalence of the most featured animal classes, orders, families, and species on clothes marketed at boys and girls.

	Boys (n=526)	Girls (n=296)	χ^2	φ_C
Class				
Mammals	47.5%	65.5%	24.74***	0.173
Dinosaurs	43.5%	0.0%	178.63***	0.466
Birds	4.4%	13.2%	21.05***	0.160
Insects	0.0%	20.6%	117.09***	0.377
Order				
Carnivores	29.5%	22.0%	5.45	0.081
Saurischian dinosaurs	25.7%	0.0%	90.90***	0.333
Even-toed ungulates and cetaceans	9.7%	14.5%	4.37	0.073
Rodents	5.3%	16.9%	29.52***	0.189
Ornithischian dinosaurs	13.9%	0.0%	45.08***	0.234
Butterflies and moths	0.0%	19.9%	112.95***	0.371
Rabbits, hares, and pikas	0.2%	6.4%	30.96***	0.194
Songbirds	0.6%	5.4%	19.61***	0.154
Pterosaurs	2.9%	0.0%	8.60*	0.102
Odd-toed ungulates	1.1%	2.7%	2.76	0.058
Family				
Canids	12.7%	4.1%	16.44***	0.141
Felids	6.8%	13.5%	10.04*	0.111
Deer	7.8%	11.1%	2.60	0.056
Mice	4.4%	15.5%	30.72***	0.193
Tyrannosaurids	10.6%	0.0%	33.82***	0.203
Bears	7.2%	3.0%	6.15	0.086
Ceratopsids	5.5%	0.0%	16.92***	0.143
Stegosaurids	5.3%	0.0%	16.31***	0.141
Rabbits and hares	0.2%	6.4%	30.96***	0.194
Brush-footed butterflies	0.0%	6.1%	32.70***	0.199
Pteranodontids	2.9%	0.0%	8.60*	0.102
Species				
House mouse	4.4%	15.5%	30.72***	0.193
Dog	10.3%	2.0%	19.00***	0.152
Brown bear	4.4%	0.3%	10.88*	0.115

Cougar	2.5%	3.4%	0.57	0.026
Moose	2.9%	2.7%	0.02	0.004
Domestic cat	0.6%	6.1%	23.11***	0.168
Reindeer	2.5%	2.0%	0.17	0.014
Tiger	3.0%	0.3%	6.84	0.091
T-rex	2.7%	0.0%	8.02	0.099

Note: Only classes, orders, families, and species with expected cell counts above 5 were included in the table. $\chi 2$ = Chi square value; φc = effect size (phi coefficient or Cramer's *V*); * = $p < .05$, ** = $p < .01$., *** = $p < .001$.

Appendix 5.1

Specificity of text references per class.

		Total number of text references	Species	Genus	Family	Order	Class	Other
	Mammals	445	61.3%	5.6%	27.9%	5.2%	0.0%	0.0%
	Birds	211	21.8%	4.7%	24.6%	7.1%	41.7%	0.0%
	Insects	44	11.4%	2.3%	34.1%	47.7%	4.5%	0.0%
	Reptiles	34	0.0%	0.0%	52.9%	44.1%	2.9%	0.0%
	Bony fish	30	20.0%	3.3%	10.0%	0.0%	0.0%	66.7%
	Dinosaurs	27	0.0%	14.8%	0.0%	0.0%	85.2%	0.0%
	"Other invertebrates"	26	7.7%	0.0%	15.4%	42.3%	30.8%	3.8%
	Amphibians	11	9.1%	0.0%	0.0%	90.9%	0.0%	0.0%
	Cartilaginous fish	1	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%

Note: Percentages indicate the proportion of references at the species, genus, family, order, class, or 'other' level.

Appendix 5.2

Prevalence of different types of anthropomorphism in main, supporting, and minor characters.

		Type of Anthropomorphism			
		Clothing	**Behavior**	**Facial features**	**Any form**
Role	Main	34.2%	81.9%	91.0%	96.1%
	Supp.	17.8%	40.3%	55.5%	63.2%
	Minor	11.1%	15.1%	19.9%	29.2%
	Total	14.3%	25.9%	33.5%	42.1%

Appendix 5.3

Prevalence of different types of anthropomorphism per class.

			Type of Anthropomorphism			
	Class	Total	Clothing	Behavior	Facial features	Any form
	Amphibians	30	20.0%	53.3%	46.7%	70.0%
	Mammals	983	22.4%	37.3%	46.0%	57.3%
	Reptiles	90	10.0%	24.4%	52.2%	56.7%
	"Other invertebrates"	105	4.8%	14.3%	41.9%	43.8%
	Insects	220	9.1%	20.5%	34.1%	37.7%
	Birds	617	9.4%	16.7%	13.6%	23.2%
	Cartilaginous fish	5	0.0%	20.0%	20.0%	20.0%
	Bony fish	128	1.6%	3.9%	17.2%	18.8%
	Dinosaurs	59	1.7%	8.5%	16.9%	16.9%
	Total	2237	321	579	749	942

Note: The proportion of animals portrayed anthropomorphically was higher for amphibians than for mammals, but statistical testing revealed that this difference was not significant ($\chi^2(1) = 1.93$, $p = .165$, Cramér's $V = 0.04$).

Overview supplementary materials (Online)

The following supplementary materials can be found in the online repository 4TU.ResearchData (doi: 10.4121/19673580):

Chapter 2
S_Ch2_Questionnaire
S_Ch2_Scoring_Guide
S_Ch2_Datasheet

Chapter 3
S_Ch3_Questionnaire
S_Ch3_Datasheet

Chapter 4
S_Ch4_Codebook
S_Ch4_Datasheet

Chapter 5
S_Ch5_Booklist
S_Ch5_Codebook
S_Ch5_Datasheet

Chapter 6
S_Ch6_Questionnaire
S_Ch6_Datasheet

Chapter 7
S_Ch7_Interview_Guide
S_Ch7_Consent_Form

The **small tortoiseshell** (Nederlands: **kleine vos**) feeds on nectar from various flowers. Its caterpillars are more picky in their choice of food and depend on common nettles.

Dutch Summary

Nederlandse Samenvatting

Samenvatting

Dit proefschrift biedt inzicht in het beeld dat mensen hebben van dierlijke biodiversiteit, factoren die hierop van invloed zijn, en mogelijkheden om de rol die biodiversiteit speelt in het leven van mensen te vergroten. Dit is waardevol vanuit wetenschappelijk perspectief, en ook belangrijk in de context van natuurbescherming, nu het verlies aan biodiversiteit voortduurt en de relatie tussen mens en natuur steeds verder onder druk staat. **Hoofdstuk 1** beschrijft de achtergrond van mijn onderzoek in meer detail. Aan de hand van literatuur belicht ik de waarden van en de bedreigingen voor biodiversiteit. Het is belangrijk dat mensen op de hoogte zijn van biodiversiteit en dat er draagvlak is voor natuurbescherming, maar dit is niet vanzelfsprekend aangezien onze moderne samenleving geïsoleerd is geraakt van de natuur. Er is sprake van een 'uitsterven' of 'uitdoven' van directe natuurervaringen, en de afstand tussen mens en natuur lijkt zich ook te manifesteren in culturele uitingen. Communicatie wordt gezien als een goed startpunt om een besef van biodiversiteit en steun voor natuurbescherming te genereren, maar er zijn uitdagingen, zoals het beperkte begrip dat mensen vermoedelijk hebben van biodiversiteit.

De zes studies die in dit proefschrift worden beschreven zijn uitgevoerd in Nederland: een dichtbevolkt land dat in een wereld die verstedelijkt een goed en interessant model vormt om de verbinding tussen mens en biodiversiteit in kaart te brengen. Naast huidige kennisniveaus (deel 1) beschrijft mijn proefschrift onderzoek naar dierlijke biodiversiteit in culturele producten (deel 2) en kansen en barrières om de rol van biodiversiteit in het leven van mensen uit te breiden (deel 3).

Deel I: Soorten-geletterdheid in Nederland

In het eerste deel van dit proefschrift heb ik kennis over soorten gebruikt als een lens om biodiversiteitsbewustzijn te bestuderen. **Hoofdstuk 2** legt het nieuwe concept *species literacy* (in het vervolg: soorten-geletterdheid) uit, dat bestaat uit twee hoofdcomponenten: brede kennis over soorten (breedtekennis) en diepe kennis over soorten (dieptekennis). Breedtekennis betreft kennis van basale kenmerken en namen die iemand in staat stellen om soorten te onderscheiden en te identificeren, terwijl 'dieptekennis' achtergrondinformatie betreft, bijvoorbeeld over waar en hoe een soort leeft. Hoofdstuk 2 presenteert bovendien een

onderzoeksproject dat een soortenidentificatietest met inheemse diersoorten gebruikte om het niveau van soorten-geletterdheid onder basisschoolkinderen, het algemeen publiek, en biodiversiteitsprofessionals te bepalen. **Hoofdstuk 3** beschrijft eveneens resultaten van een kennistest over dieren, in dit geval een test met inheemse en uitheemse dieren waarbij volwassen deelnemers werden getoetst op zowel hun breedtekennis als dieptekennis.

Soorten-geletterdheid bleek vooral gebrekkig onder basisschoolkinderen, die gemiddeld slechts één op de drie inheemse diersoorten herkenden. Deelnemers hadden bovendien een scheef en oppervlakkig beeld van dieren. Zoogdieren waren bekend, waaronder inheemse soorten die je buiten zelden tegenkomt, zoals vos en egel. Rechtstreekse blootstelling aan dieren in het wild lijkt dus geen voorwaarde om met hen vertrouwd te raken, vermoedelijk omdat culturele representaties van dieren alternatieven bieden om ze te leren kennen, zoals wordt besproken in hoofdstukken 4 en 5. Deelnemers hadden moeite vogels en vlinders te herkennen; meer dan 80% van de kinderen slaagde er niet in vogels zoals de huismus, merel en kauw te benoemen. Deze soorten zijn talrijk in dichtbevolkte gebieden in Nederland en er is dan ook geen gebrek aan gelegenheid om ze in het echt te zien. Mogelijk komen mensen niet in contact met deze dieren door verminderde affiniteit met activiteiten buitenshuis, weinig tijd die in en aan de lokale omgeving wordt besteed (bijv. in onderwijs), en een gebrek aan belangstelling voor inheemse dieren. Oppervlakkige kennis bleek uit de lage specificiteit van antwoorden; zo werd de atalanta vaak 'vlinder' genoemd, de 'vink' vaak 'vogel'. Bovendien presteerden respondenten beter in het identificeren van dieren dan op het gebied van dieptekennis. Er bleken misverstanden te bestaan over de herkomst, habitat, dieet en gedrag van soorten, waarvan sommige vermoedelijk ontstaan als mensen kenmerken van verwante soorten extrapoleren. Zo kunnen mensen bijvoorbeeld ten onrechte veronderstellen dat alle soorten pinguïns leven in poolgebied.

Factoren die samenhangen met soorten-geletterdheid

Naast kennisniveaus behandelt het eerste deel van dit proefschrift ook factoren die samenhangen met soorten-geletterdheid en onderzoek naar samenhang tussen verschillende componenten van soorten-geletterdheid. Zoals beschreven in hoofdstuk 2 heb ik aanwijzingen gevonden dat zowel directe als indirecte ervaringen met biodiversiteit kennis over soorten beïnvloeden.

Identificatievaardigheden bleken positief gecorreleerd te zijn met de houding ten opzichte van natuur en dieren, en deze resultaten komen overeen met het idee dat wanneer mensen vertrouwd raken met soorten, dit hun interesse en affiniteit kan versterken. Vermoedelijk is er sprake van een wisselwerking tussen kennis, belangstelling en affiniteit. Tot slot werden verbanden vastgesteld tussen soorten-geletterdheid en demografische variabelen; zo nam soortenkennis toe met leeftijd. Nederlanders lijken dus in de loop van hun leven kennis over soorten te vergaren, al kan dit patroon ook een weerspiegeling zijn van zogenaamde 'generationele amnesie', een proces waarbij kennis verloren gaat in de loop van generaties.

In het onderzoeksproject besproken in hoofdstuk 2 werd het vermogen van deelnemers om soorten te identificeren aan de hand van foto's gebruikt om het soorten-geletterdheid niveau te bepalen. Deze aanpak is vergelijkbaar met een groot aantal eerdere studies die identificatievaardigheden hebben gebruikt om te meten wat mensen weten over soorten of natuur. Het was echter niet bekend of soortidentificatie daadwerkelijk een betrouwbare indicator is voor dieptekennis over soorten, en ik heb deze belangrijke kennislacune opgevuld door de veronderstelde associatie tussen deze twee belangrijke componenten van soorten-geletterdheid te verkennen. Zoals beschreven staat in hoofdstuk 3 is gebleken dat soortidentificatie een redelijk goede indicator is voor dieptekennis, en een veel betere voorspeller dan alternatieve variabelen zoals leeftijd en gender. De kans dat iemand de herkomst van soorten, hun habitat, dieet of gedrag kende was aanzienlijk groter als een soort correct was geïdentificeerd. Identificatietesten blijken betrekkelijk goede instrumenten te zijn om het niveau van soorten-geletterdheid van een doelgroep te bepalen.

Deel II: Culturele representaties van dieren

In het tweede deel van dit proefschrift heb ik representaties van dieren op culturele producten onderzocht. Deze culturele voorstellingen weerspiegelen niet alleen het beeld dat mensen hebben van dierlijke biodiversiteit, het is aannemelijk dat ze dit beeld op hun beurt ook weer beïnvloeden. **Hoofdstuk 4** presenteert de bevindingen van een project waarbij een steekproef werd genomen van meer dan 800 dieren afgebeeld op kinderkleding, terwijl **Hoofdstuk 5** de analyse bespreekt van een steekproef van meer dan 2000 dieren uit prentenboeken.

Zowel kinderkleding als prentenboeken portretteerden veelvuldig dieren, maar de diversiteit bleek betrekkelijk laag te zijn. Gewervelde dieren waren talrijker dan ongewervelden, en met name zoogdieren waren vaak en prominent afgebeeld. In prentenboeken speelden ze regelmatig de hoofdrol, terwijl dieren die in werkelijkheid talrijker en soortenrijker zijn, zoals vogels en vissen, vaker op de achtergrond en in lagere aantallen voorkwamen. Exotische en gedomesticeerde dieren waren ook relatief talrijk. In kindermode viel op dat sommige dieren beperkt waren tot ofwel jongens- of meisjeskleding; zo waren dinosaurussen alleen te vinden op kledingstukken gericht op jongens, en vlinders alleen op die gemarket naar meisjes.

Slechts een minderheid van de geportretteerde dieren kon worden geïdentificeerd op soortniveau. Dieren werden dikwijls artistiek, geabstraheerd en vervormd weergegeven, wat hun herkenbaarheid verminderde. Dieren waren ook vaak geantropomorfiseerd, met name zoogdieren en dieren die de hoofdrol speelden in prentenboeken, en op meisjeskleding viel op dat dieren dikwijls schattige en vrouwelijke kenmerken waren toebedeeld. In prentenboeken ontbraken vaak verwijzingen naar de afgebeelde dieren in de tekst, en als ze werden genoemd, werden de dieren doorgaans benoemd boven soortniveau. Opvallend was hierbij dat zoogdieren vaker op soortniveau werden afgebeeld en benoemd dan andere dieren.

De beperkte diversiteit aan dieren die werd gevonden kan het gevolg zijn van een oppervlakkig en scheef beeld van het dierenrijk onder ontwerpers, illustratoren en auteurs, maar kan ook vanuit een commercieel oogpunt worden verklaard. Het lijkt er namelijk op dat makers van culturele producten dieren portretteren waarvan ze verwachten dat deze aanslaan bij het publiek. De affiniteit en afkeer die mensen hebben voor bepaalde diergroepen kan verklaren waarom zoogdieren, exotische dieren en gedomesticeerde dieren oververtegenwoordigd, en ongewervelden ondervertegenwoordigd waren. Vanuit een commercieel standpunt kan bovendien de manier waarop dieren worden afgebeeld in culturele producten worden begrepen. Vermoedelijk transformeren illustratoren van prentenboeken en modeontwerpers dieren om ze aantrekkelijk en toegankelijk te maken, terwijl het specificeren van dierportretten niet relevant wordt geacht om een snaar te raken bij potentiële klanten.

Deel III: Het perspectief van communicatoren

In het derde en laatste deel van dit proefschrift heb ik het perspectief van biodiversiteits-communicatoren verkend. Communicatie wordt beschouwd als een belangrijke sleutel om leken te betrekken bij biodiversiteit. Vanuit de gedachte dat het voor effectieve communicatie belangrijk is om de voorkennis van een doelgroep te kennen, bespreekt **Hoofdstuk 6** een studie waarin communicatoren werd gevraagd om het gemiddelde niveau van soorten-geletterdheid in te schatten van basisschoolleerlingen van 9/10 jaar oud. Deze schattingen werden vergeleken met het werkelijke kennisniveau, gelijktijdig bepaald tijdens het project besproken in hoofdstuk 2. Hiernaast werden ook de opvattingen van communicatoren verkend over waarom soortenkennis wel of niet belangrijk zou zijn, en welk niveau zij wensten. **Hoofdstuk 7** beschrijft een kwalitatief onderzoeksproject waarvoor ik interviews met twaalf communicatoren heb uitgevoerd. Ik bracht hun ideeën in kaart over de huidige en gewenste rol van biodiversiteit in het leven van mensen, hun ervaringen met en gedachten over de communicatiepraktijk, en de kansen en uitdagingen die zij zagen in een dichtbevolkt land als Nederland om mensen in aanraking te brengen met biodiversiteit.

Communicatoren waren zich ervan bewust dat leken een beperkt beeld hebben van biodiversiteit, maar desondanks overschatten de meesten het gemiddelde niveau van soorten-geletterdheid onder basisschoolkinderen. Over het algemeen waardeerden communicatoren soortenkennis, en wensten een hoger kennisniveau dan het huidige. Ze waren het echter niet eens over de kenniscomponenten die belangrijk zouden zijn; sommigen hechtten bijvoorbeeld belang aan het benoemen van soorten, terwijl anderen het kennen van soortnamen onbelangrijk achtten. Bovendien leken sommige communicatoren zich niet bewust van de rol die feitenkennis kan spelen bij het bevorderen van begrip, interesse en waardering, en leken sommigen voorbij te gaan aan de beperkingen van kennis-deficiëntie modellen. Er werden daarnaast verschillende argumenten gegeven waarom kennis over soorten belangrijk zou zijn. Zo koppelden sommigen soortenkennis aan een breder begrip van de natuur, en anderen aan interesse of een positieve houding ten opzichte van soorten.

De geïnterviewde communicatoren zagen veel potentie in Nederland voor mensen om biodiversiteit te leren kennen, en er kwamen drie routes naar voren om dit te bewerkstelligen: het stimuleren van directe ervaringen met biodiversiteit

buitenshuis, via de media en in onderwijs. Belangrijk is daarnaast strategisch opgezette communicatie om de ogen van mensen te openen voor biodiversiteit. Ondanks de optimistische kijk van de geïnterviewden, werden ook barrières genoemd die moeten worden overwonnen om het potentieel te verwezenlijken. Zo wordt biodiversiteit momenteel nog slecht geïntegreerd in het ontwerp van steden, varieert de toegankelijkheid van groene gebieden, kunnen de media een vertekend beeld geven van biodiversiteit, en hebben scholen te maken met belemmeringen zoals lage budgetten.

Implicaties van de bevindingen

In **Hoofdstuk 8**, het laatste hoofdstuk van dit proefschrift, beschrijf ik de implicaties van de verschillende bevindingen. Zo impliceert de gebrekkige kennis van soorten die is vastgesteld dat een groot deel van de Nederlandse bevolking momenteel kansen misloopt op verrijkende ervaringen met biodiversiteit. Voor mensen onbekend met soorten zal het moeilijk zijn om te weten hoe het deze soorten vergaat, en om mee te denken over beleidszaken die deze soorten beïnvloeden. Bovendien is het de vraag of het huidige kennisniveau voldoende is om een goed begrip van ecologie en milieu te ontwikkelen.

De resultaten hebben verder belangrijke implicaties voor natuurbescherming. Voor natuurbeschermers is het belangrijk om te beseffen dat bekend bemind en onbekend onbemind kan maken. In dit licht is de gebrekkige herkenning van kwetsbare soorten zoals de grutto zorgelijk, net als verwarring tussen giftige en niet-giftige soorten, bijvoorbeeld als mensen een ringslang onterecht aanzien voor een giftige adder. Het scheve beeld dat mensen hebben van dierlijke biodiversiteit zou ertoe kunnen leiden dat bepaalde soorten wel en andere soorten geen steun krijgen. Onbekendheid met de nabije leefomgeving en de soorten die daar leven kan mensen het idee geven dat natuurbescherming zich moet richten op het buitenland. Aangezien mensen dieren die ze niet kunnen identificeren waarschijnlijk over het hoofd zien, schatten mensen bovendien gebieden met een hoge biodiversiteit mogelijk niet op waarde en merken ze verlies van biodiversiteit misschien niet op. Al met al kan een beperkt beeld van biodiversiteit een obstakel zijn om draagvlak voor natuurbescherming te bereiken.

Culturele producten kunnen eveneens van invloed zijn op natuurbescherming.

Het vertekende beeld dat zij presenteren van het dierenrijk kan vertrouwdheid en affiniteit bevorderen met dieren die geregeld worden afgebeeld, ten koste van andere. De indruk kan ontstaan dat dieren die zelden of niet worden afgebeeld, of aan welke zelden toegankelijke, menselijke kenmerken wordt toebedeeld, zoals ongewervelden, geen aandacht en steun verdienen. Onrealistische dierportretten kunnen bovendien misverstanden veroorzaken, bijvoorbeeld over het natuurlijk gedrag van dieren. Hoewel de neiging om zoogdieren en exotische dieren af te beelden niet snel zal veranderen, zijn er mogelijkheden om de representatie te diversifiëren en specificeren, bijvoorbeeld door samenwerkingsverbanden tussen natuurbeschermers en creatieve makers van culturele producten.

Vanuit het perspectief van natuurbescherming is het verder belangrijk dat mensen meer mogelijkheden wordt geboden voor directe ervaringen in de natuur, om hen in contact te brengen met flora en fauna. Biodiversiteit zou een integraal onderdeel moeten zijn van het stadsontwerp, waarbij natuurbeschermers en stadsecologen moeten worden betrokken. Tegelijkertijd is het belangrijk om op te merken dat hoewel stedelijke biodiversiteit mensen verrijkende ervaringen kan bieden, veel mensen onbekend bleken te zijn met dieren die talrijk zijn in stedelijk gebied. Mogelijk is er momenteel gebrek aan bepaalde typen groene gebieden waar mensen de omgeving rustig in zich op kunnen nemen, om vervolgens ook daarbuiten soorten op te merken. Zo werd tijdens de interviews genoemd dat de beschikbaarheid en toegankelijkheid van natuur verschilt per plek. Dit zou kunnen betekenen dat een aanzienlijk deel van de Nederlandse bevolking geen sterke, persoonlijke band met de natuur ontwikkelt, wat toekomstig natuurbehoud in de weg kan staan.

Naast implicaties voor natuurbeschermers volgen uit de beschreven studies ook een aantal belangrijke implicaties voor communicatoren. Naast een biodiversiteitsgevoelig stadsontwerp om directe interactie tussen burgers en de natuurlijke leefomgeving te faciliteren, zal communicatie namelijk een belangrijke rol moeten spelen om de ogen van mensen te openen voor wat er om hen heen leeft. Uit het onderzoek zijn echter uitdagingen naar voren gekomen voor mensen die biodiversiteit communiceren naar een breed publiek, zoals de aanzienlijke kenniskloof tussen professionals en leken. Deze kloof impliceert dat slechts bepaalde dieren weerklank vinden bij het Nederlands publiek. Bovendien is aangetoond dat het huidige kennisniveau onder basisschoolkinderen lager ligt dan veel communicatoren verwachten. Huidige boodschappen en materialen

sluiten dus mogelijk niet goed bij hen aan; zo kunnen soortnamen fungeren als jargon. Een bemoedigende gedachte is echter wel dat als communicatoren zich meer bewust zouden worden van het huidige kennisniveau, dit een impuls zou kunnen geven om het gebrek aan inzicht te bestrijden. Veel van hen wensten namelijk in kinderen een hoger kennisniveau en waren zich er niet van bewust dat de kennis momenteel zo gebrekkig was.

Om doelgroepen te leren kennen, kunnen communicatoren kennistoetsen gebruiken. In het bijzonder heeft mijn onderzoek de veelzijdigheid en bruikbaarheid aangetoond van soortidentificatietesten. Het is gebleken dat identificatievaardigheden een behoorlijk goede indruk geven van dieptekennis over soorten. Bovendien kunnen identificatietesten informatie verschaffen over de verbinding tussen mensen en de lokale omgeving, over de affiniteit van mensen met natuur, en over de vermoedelijke invloed van directe en indirecte ervaringen met biodiversiteit op de kennis van mensen. Het grote enthousiasme onder respondenten, jong en oud, laat zien dat zulke toetsen heel populair kunnen worden, zeker als ze gepresenteerd worden als 'quizzen'. Communicatoren zouden met een reeks quizzen het kennisniveau en mogelijke misverstanden bij het publiek in kaart kunnen brengen, om vervolgens hun communicatie op het juiste niveau af te stemmen en doelgericht misvattingen aan te aanpakken. Bovendien kunnen ook interesse, verwachtingen en persoonlijke ervaring met biodiversiteit via korte testen in kaart worden gebracht. Tenslotte beïnvloeden ook deze factoren de reactie van een publiek.

Communicatoren kunnen zich verder laten inspireren door de bevindingen in hoofdstuk 7. Zo wordt op basis van de ervaringen en gedachten van de geïnterviewden aangeraden ernaar te streven een snaar te raken bij het publiek door aan te sluiten bij het kennisniveau, creatief gebruik te maken van metaforen en ezelsbruggetjes, en de soorten waarover wordt gecommuniceerd zorgvuldig te kiezen. Gezien de oppervlakkige kennis onder leken wijs ik er bovendien op dat kennis over soorten het meest effectief kan worden bevorderd door specifiek te zijn in tekst en beeld. Met name jonge kinderen zijn een belangrijke doelgroep, aangezien soorten-geletterdheid in deze groep bijzonder gebrekkig bleek te zijn en kinderen ontvankelijk zijn voor informatie over natuur en dieren. Bovendien kunnen via jonge generaties ook oudere worden bereikt. De meest voor de hand liggende plaats om kinderen voor te lichten over biodiversiteit en om ze identificatievaardigheden bij te brengen is op school. Het wordt aangeraden om

soorten-geletterdheid te integreren in leerprogramma's van de lagere school en om diversiteit van dieren te verweven in schoolvakken (bv. biologie, kunst en taal). Communicatoren kunnen leerkrachten inspireren en ondersteunen door educatief materiaal en toegankelijke en betaalbare programma's beschikbaar te stellen voor het bestuderen van soorten rond de school.

Om communicatoren meer inzicht te geven in de veelzijdigheid van soorten-geletterdheid en de verschillende waarden van deze kennis, is tot slot een raamwerk geconstrueerd dat de verschillende componenten, de mogelijke effecten op vijf persoonlijke domeinen, en de veronderstelde relaties tussen de persoonlijke domeinen en hun samenhang met soorten-geletterdheid weergeeft. Communicatoren kunnen aan de hand van het raamwerk educatieve doelen stellen en het belang van hun educatieve activiteiten op het vlak van biodiversiteitsbewustzijn onderstrepen. Bovendien kan het kader een impuls geven aan vervolgonderzoek naar kennis over soorten en inspanningen om deze kennis te vergroten.

Aanbevelingen voor vervolgonderzoek

Uit dit proefschrift volgen interessante mogelijkheden voor vervolgonderzoek. Zo zou longitudinaal onderzoek kunnen uitwijzen of de gebrekkige soortenkennis onder basisschoolkinderen wijst op een groeiende afstand tussen mens en natuur. Naast kennisniveaus kunnen projecten ook factoren zoals interesse, verwachtingen en persoonlijke ervaring met biodiversiteit verkennen, waarbij dan ook de mate waarin professionals hiervan op de hoogte zijn wordt meegenomen. Bovendien zouden toekomstige studies dieper kunnen ingaan op factoren die samenhangen met soortenkennis, en de relaties kunnen bestuderen tussen soortenkennis, breder bewustzijn en dieper begrip van biodiversiteit, interesse en ervaring, welzijn en gezondheid, houding en gedrag. Men zou hierbij onderscheid kunnen maken tussen de verschillende componenten van soorten-geletterdheid, aangezien deze vermoedelijk verschillende uitwerkingen hebben op mensen.

Ook zijn er nog diverse mogelijkheden voor toekomstig onderzoek omtrent culturele representaties van dieren. Studies kunnen nagaan hoe producten en media gericht op volwassenen verschillen van die gericht op kinderen, en kunnen vaststellen in hoeverre mensen, met name kinderen, zich bewust zijn van dieren die zij als culturele voorstellingen tegenkomen. Bovendien kan men

verkennen hoe de huidige representatie van biodiversiteit in culturele producten kan worden gediversifieerd, bijvoorbeeld met keuzetesten onder consumenten en via interviews met ontwerpers.

Tot slot moeten we ons blijven inspannen om de mogelijkheden en belemmeringen in kaart te brengen om leken, en dan met name kinderen, in contact te brengen met de nabije leefomgeving. Zo is er behoefte aan projecten die denkbeelden onderzoeken van actoren die betrokken zijn bij het ontwerp van steden, zoals landschapsarchitecten en woningbouwcorporaties, en de impact hiervan op stadsplanning.

Synthese

Dit proefschrift beschrijft de resultaten van zes empirische onderzoeksprojecten gericht op biodiversiteitsbewustzijn in Nederland. Het Nederlandse publiek bleek een gebrekkig beeld te hebben van dierlijke biodiversiteit. Basisschoolkinderen in het bijzonder slaagden er vaak niet in om veelvoorkomende dieren te identificeren, wat wijst op een gebrek aan vertrouwdheid en verbondenheid met de lokale omgeving. De gevonden patronen in kennis weerspiegelen de patronen die aan het licht kwamen in het onderzoek naar culturele representaties van dieren. Dieren die bekend waren bij mensen, zoals zoogdieren en exoten, overheersten in kindermode en prentenboeken, terwijl dieren zoals vogels en vlinders, die minder vaak en op minder specifieke manieren werden afgebeeld, nauwelijks bekend waren onder respondenten. Culturele producten en de kennis die mensen hebben van dieren weerspiegelen dus beide een kloof tussen mensen en de natuur: de dieren die mensen kennen kom je buitenshuis zelden tegen, terwijl soorten die je buiten gemakkelijk treft mensen onopgemerkt voorbij lijken te gaan.

Nederlanders lopen op het moment verrijkende ervaringen met biodiversiteit mis. Het gebrekkige en scheve beeld dat leken hebben van dierlijke biodiversiteit is bovendien een uitdaging voor natuurbeschermers, die afhankelijk zijn van draagvlak vanuit de maatschappij, en voor communicatoren, die een belangrijke rol spelen in het verbinden van mensen met de natuur. Om soortenkennis te bevorderen en mensen bij biodiversiteit te betrekken zijn de volgende routes veelbelovend: 1) het creëren van mogelijkheden om biodiversiteit buitenshuis en via onderwijs te ervaren, 2) het diversifiëren van culturele representaties van

dieren, en 3) het inzetten van strategisch ontworpen communicatie. Om het aanwezige potentieel te realiseren, moeten natuurbeschermers, communicatoren en onderzoekers:

- …zich bewust worden van de waarden van soorten-geletterdheid en inzichten hierover verspreiden onder zowel professionals als leken, om de potentie van kennis over soorten te benutten
- …gebruik maken van tools zoals soortidentificatietesten om doelgroepen te leren kennen en best practices op communicatiegebied toepassen, om betrokkenheid van het publiek bij biodiversiteit te vergroten
- …scholen aanmoedigen om soorten-geletterdheid in hun educatieve programma op te nemen en hen van passend lesmateriaal voorzien, om natuuronderwijs te versterken en biodiversiteitsbewustzijn te vergroten
- …ervoor zorgen dat zij bij stadsinrichting worden betrokken, om tot een biodiversiteitgevoelig stadsontwerp te komen
- …ontwerpers van culturele producten inspireren hun portrettering van de natuurlijke leefwereld te diversifiëren en te specificeren, om de educatieve bijdrage van culturele representaties te vergroten

Het opvolgen van deze aanbevelingen kan helpen een duurzame band met biodiversiteit te laten ontluiken die het leven van mensen verrijkt en bijdraagt aan het behoud van de grote verscheidenheid aan leven op onze planeet.

Curriculum vitae

Michiel Jan Dirk Hooykaas was born on the 20th of March, 1987. From an early age he was captivated by the natural world and felt strongly about its preservation. In 2005, he obtained his high school diploma (gymnasium) at the Visser 't Hoofd Lyceum in Leiden and started studying biology at Leiden University. After finishing his bachelor's degree in 2008, he followed the Master track Biology and Science Communication and Society, which he completed with an internship at the Communication Department of Natura Artis Magistra in Amsterdam, the oldest zoo in the Netherlands.

Following his graduation in 2011, Michiel became an employee of the Entomology Digitization Project at Naturalis Biodiversity Center, and he developed content for KIJK Magazine. He then became a biology lecturer at the Institute of Biology in Leiden. From 2012 onwards he designed and taught courses for biology students, in particular about diversity and evolution of the animal kingdom and about popular scientific writing. In addition to lectures and workshops, he organized labs and supervised teams of student assistants. Michiel obtained his University Teaching Qualification (BKO), and he was nominated biology lecturer of the year twice.

In 2017, Michiel started his PhD-research at the Department of Science Communication and Society (SCS), where he studied people's perception of animal biodiversity. Notably, he explored species literacy, a concept which he had coined when writing his PhD-proposal, and the way that cultural sources portray animals. During his PhD-trajectory Michiel supervised science communication students, and he coordinated the BSc biology course Biodiversiteit Dier, for which he was nominated for the 'Leidse Onderwijs-op-afstandprijs' in 2020. Moreover, he presented the findings of his research at conferences and in the media and wrote and performed a song about species identification. In May, 2022, Michiel started working as a researcher and education coordinator at Naturalis Biodiversity Center, with the ultimate aim of strengthening biodiversity education and connecting people and nature.

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