Species literacy: the perception and cultural portrayal of animals

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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

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.

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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,

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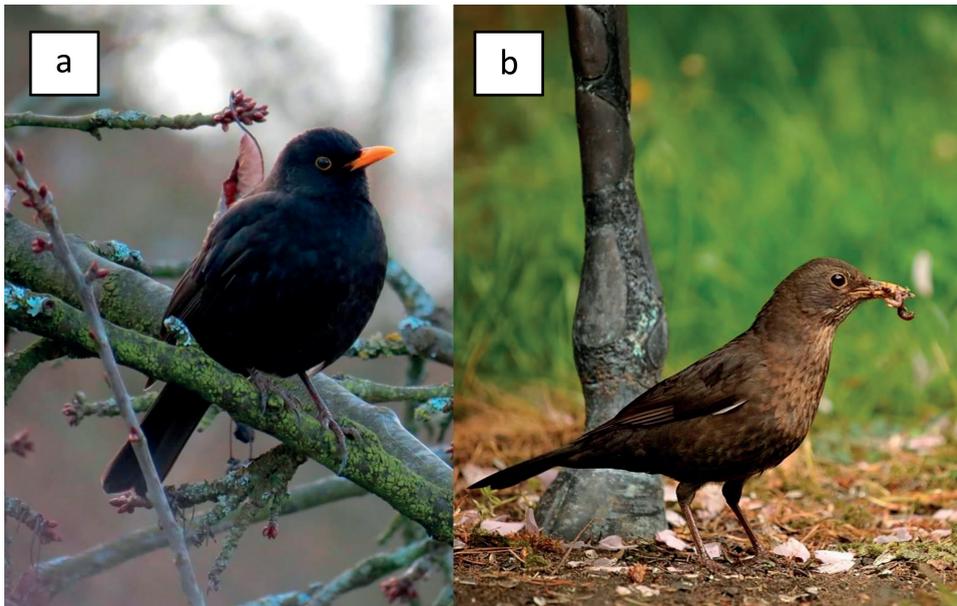
Figure 2.1 Male (a) and female (b) blackbird (*Turdus merula*; Dutch: merel); photo credits a. Manfred Richter b. Susan Mielke

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.
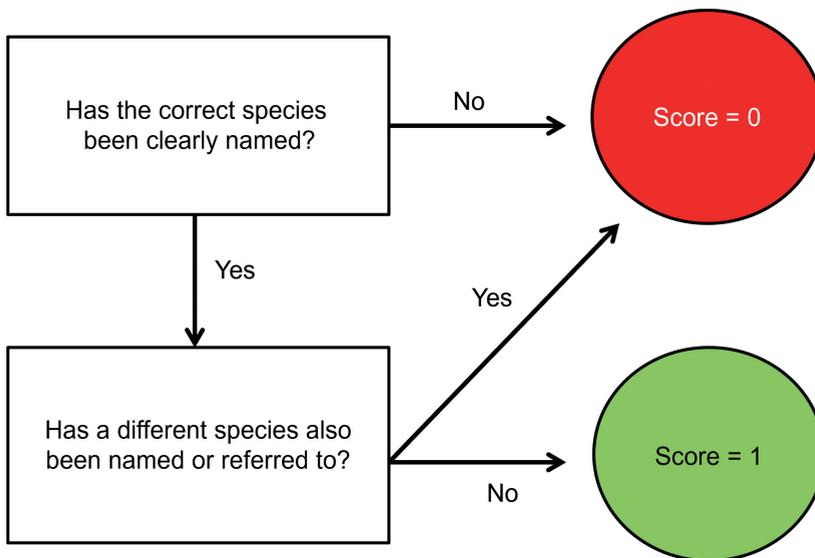

Figure 2.2 Basic coding scheme used for scoring the answers provided during the identification test.

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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.
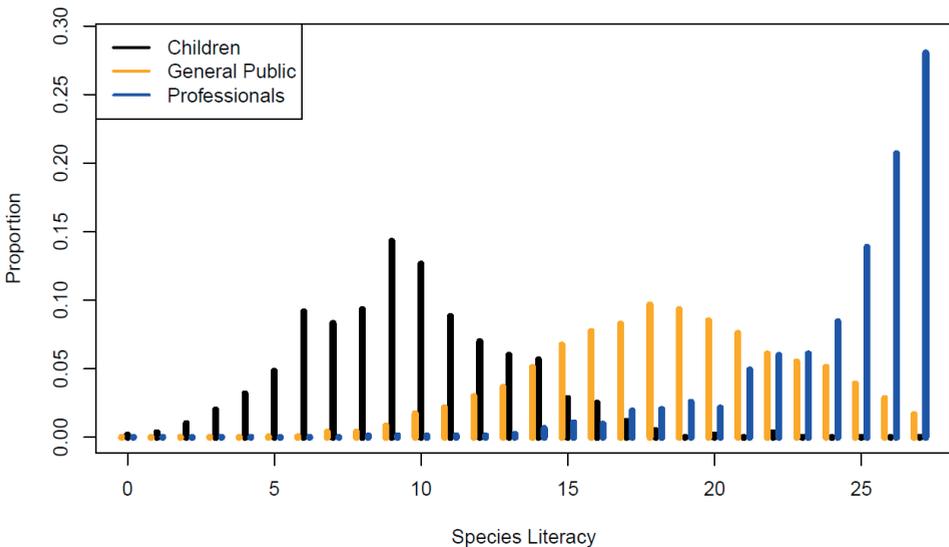

Figure 2.3 Distribution of species literacy in the three target groups (i.e. the proportion of each target group achieving a certain identification score)

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

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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.