

1 Children's Species Literacy as Estimated and Desired by 2 Biodiversity Communicators: a Mismatch with the Actual Level

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17 **Abstract**

18 While biodiversity decline continues and laypeople's knowledge about species is limited, especially in
19 children, high-quality communication is needed to raise awareness. For this, communicators should
20 be aware of current knowledge levels in their target groups. We compared biodiversity
21 communicators' estimates of the average species literacy level in primary school children with the
22 actual level. Moreover, we explored the importance that communicators placed on species literacy
23 and the level that they desired. Estimations of children's average knowledge level varied widely and
24 differed from the actual level. In particular, communicators overestimated the species literacy level.
25 Although most biodiversity communicators agreed that knowledge about species is important, their
26 view differed as to why species literacy would be important. Moreover, communicators differed with
27 respect to the relative importance attached to different knowledge components. Professionals may
28 thus benefit from a detailed framework of species literacy that illustrates different aspects and
29 values. Most importantly, our findings suggest that to bridge the gap between actual and desired
30 knowledge levels in children effectively, biodiversity communicators first need to become more
31 aware of current perceptions in young audiences.
32

33 **Keywords:**

34 1: biodiversity; 2: science communication; 3: prior knowledge; 4: species knowledge; 5: knowledge
35 estimations
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43 1. Introduction

44 At a time of great biodiversity loss and a widening gap between people and nature, conservationists
45 are faced with a challenging task to build broad-based support for conservation (Ceballos et al., 2015,
46 2017; Miller, 2005; Pyle, 2011). Communicators can make a valuable contribution by raising
47 awareness about biodiversity in the public (Bickford et al., 2012). However, while certain segments of
48 society have successfully been reached, it has been acknowledged that, overall, laypeople are not
49 well-informed about biodiversity (Navarro-Perez and Tidball, 2012), showing that communication
50 about biodiversity has not yet been as effective as it could be.

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

59 For biodiversity communicators it is important to take into account the knowledge levels
60 present in their audiences, as these influence people's expectations and determine the ways they will
61 respond (Buijs et al., 2008; Thompson and Zamboanga, 2003). Prior knowledge affects subsequent
62 learning and plays an important role in the construction of new understanding (Hailikari et al., 2007,
63 2008; National Research Council, 2000, 2007, 2009). To achieve high-quality communication,
64 communicators should therefore connect to people's knowledge base in a strategic manner.
65 Messages will then be better comprehended and more readily received, and learning outcomes will
66 be more likely to be in line with those intended (Wratten and Hodge, 1999).

67 However, before communicators can craft messages or devise strategies according to
68 people's existing knowledge, they should first be aware of it. It is therefore imperative that they can
69 accurately estimate knowledge levels in their audiences. Yet, studies conducted outside of the field
70 of biodiversity communication have demonstrated that estimating prior knowledge can be quite
71 hard. For example, nursing professionals and physicians regularly experience difficulties in estimating
72 health literacy in their patients (Bass et al., 2002; Kelly and Haidet, 2007; MacAbasco-O'Connell and
73 Fry-Bowers, 2011), frequently resulting in overestimations (Dickens et al., 2013). In addition, teachers
74 have been reported to fail at accurately estimating knowledge levels in their students (Perrenet,
75 2010; Schutte, 2010; Storm, 2012).

76 A mismatch between estimated and actual knowledge levels poses a problem as it may
77 hamper communication. Overestimations can lead communicators to calibrate their language to a
78 level above that of their public, resulting in messages that are not understood correctly by the
79 audience, while underestimations may lead to needless repetition of information (Kelly and Haidet,
80 2007; Schutte, 2010). For instance, nature guides or text editors unaware of low species literacy
81 levels may mention species names that act as jargon, while those who underestimate knowledge
82 levels may elaborate on already well-known species, which may bore people and will not expand
83 their perceptions of biodiversity. Ultimately, a bad fit may prevent educational and communicational
84 goals from being achieved (Bass et al., 2002; Hailikari et al., 2008); e.g., it could make it harder to

85 foster species literacy effectively and could hamper citizen science projects where participants are
86 asked to count and record species (Falk et al., 2019).

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

96 In addition to accurate estimations of knowledge levels in their audiences, communicators
97 benefit from having a clear picture of what level of knowledge they strive for in their audiences. This
98 can help set educational goals and provide clarity about the steps needed to achieve desired
99 outcomes. While biodiversity communicators are expected to regard knowledge about biodiversity
100 valuable and important, it is not yet clear what their views are about specific forms of it, such as
101 species literacy. For instance, it is not known what the desired levels of species literacy would be and
102 if and why communicators think that knowledge about species is important or not. Research in this
103 direction can provide insight into the values attached to knowledge about biodiversity, and
104 biodiversity communicators, educators, and conservationists may use this information to underline
105 the importance of their own activities.

106 In this study we compared the average species literacy level of primary school children as
107 estimated by biodiversity communicators in the Netherlands with the actual level, which had been
108 determined during a previous project carried out just before the current study (Hooykaas et al.,
109 2019). We further compared the estimated and actual average species literacy levels with the
110 desired level, and we explored the importance placed by biodiversity communicators on species
111 literacy.

112

113 We investigated the following research questions:

114

115 1) Are biodiversity communicators aware of the species literacy level in primary school children aged
116 9-10 years old?

117 2) What is the desired level of species literacy in primary school children aged 9-10 years old
118 according to biodiversity communicators and how does this compare to the actual level?

119 3) What importance do biodiversity communicators place on species literacy in laypeople?

120

121 **2. Methods**

122 We constructed a survey (Appendix A) in Qualtrics (<https://www.qualtrics.com>) targeted at Dutch
123 biodiversity communicators: people who communicate nature, biodiversity or animals in their
124 voluntary or paid work. The survey was administered between May and July 2018, by sending an
125 invitation via e-mail to a large number of Dutch organizations and institutions involved with nature
126 and biodiversity, such as nature conservancy organizations, environmental education institutions,
127 ecological consultants, and zoos. Participation was anonymous, avoiding social desirability or

128 'prestige bias' in the answers and taking into account privacy regulations (Streiner, David et al.,
129 2015).

130 First, the communicators were asked to take a species identification test that had just been
131 used during a different part of an overarching research project on communicating biodiversity, to
132 assess species literacy levels in Dutch primary school children aged 9-10 years old. Full methods are
133 described in Hooykaas et al. (2019). The identification test comprised 27 animal species native to the
134 Netherlands, and participants were asked to provide the name of each depicted species, thereby
135 identifying it as precisely as possible. Included species were mainly those occurring regularly in Dutch
136 (sub)urban areas (e.g., house sparrow (*Passer domesticus*)), supplemented by a few species
137 encountered predominantly outside urban areas (e.g., wild boar (*Sus scrofa*)). In the test, each animal
138 was represented by one or two color pictures from the website <https://pixabay.com/> – see Figure 1.

139 After communicators had finished the species identification test, they were asked to
140 estimate the species literacy level of primary school children aged 9 or 10 years old (i.e. their average
141 achieved identification score: the number of correct identifications), and they were asked what the
142 desired species literacy level in this group would be (i.e. the desired average achieved identification
143 score). Communicators were also asked whether or not they had targeted primary school children
144 aged 9-10 in their communication in the past 5 years, to investigate the influence of experience with
145 the target group on estimation accuracy. Finally, we explored the importance placed by biodiversity
146 communicators on species literacy, by asking them whether they agreed with the statement "it is
147 important for people to recognize many animal species" on a 10-point scale and offering them the
148 possibility to elaborate their answer with arguments.



149
150 **Fig. 1.** Female (a) and male (b) chaffinch (*Fringilla coelebs*); photo credits a. [Kathy Büscher](#) b. [Klimkin Sergey](#).

151
152 **2.1. Analyses and statistical procedures**

153 Data were compiled in Microsoft Excel and subsequently processed with IBM SPSS Statistics 25.0.
154 First, we used Welch' independent samples *t*-tests to compare the average species literacy level in
155 primary school children aged 9-10 as estimated and considered desirable by the communicators on
156 the one hand with the actual level on the other. For the actual species literacy level, we used the
157 average achieved identification score of 602 children ($M = 9.5$, $SD = 3.4$), established during the
158 research project mentioned before that took place just prior to the current project; most children
159 (86.9%) had recognized less than half of the species. Moreover, we compared the communicator-
160 estimated average species literacy level in primary school children aged 9-10 by the communicators

161 with the level considered desirable using a paired *t*-test. To account for multiple testing, a strict
162 Bonferroni correction was applied.

163 To provide insight into the importance placed by biodiversity communicators on species
164 literacy, we analyzed the answers to the 10-point scale question, and we used pattern analysis
165 (Braun and Clarke, 2006) to carry out inductive coding of the additional remarks provided by the
166 participants. The codes were eventually grouped into categories. To avoid subjectivity, codes and
167 categories were designed by three researchers and discussed among colleagues. Depending on the
168 variation in arguments provided by the participants, each answer received one or more codes
169 (identical codes were not repeated). After one researcher had coded the dataset, half of the coded
170 answer fragments were selected randomly and coded independently and blind to the previous
171 coding by a second researcher. Intercoder reliability was high (percent agreement = 81%, Cohen's
172 Kappa = 0.798), indicating a strong level of agreement between the two coders (McHugh, 2012).
173 Subsequently, the discrepancies were discussed by the coders and resolved.

174

175 **3. Results**

176

177 *3.1. Descriptive statistics*

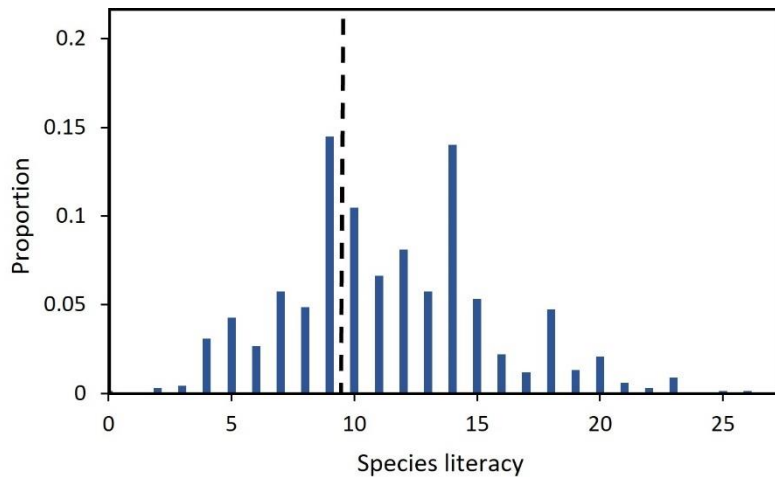
178 The final dataset (Appendix B) included 677 biodiversity communicators (e.g., nature guides,
179 communicators in zoos, spokespersons and text editors at nature conservancy organizations, and
180 ecological consultants).

181

182 *3.2. Species literacy estimations by communicators*

183 Communicators' estimations of the average species literacy level in primary school children aged 9-
184 10 varied widely and regularly differed from the actual level - see Figure 2. The average identification
185 score in primary school children as estimated by communicators ($M = 11.4$, $SD = 4.2$) was higher than
186 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
187 the communicators overestimated the knowledge level (e.g., one in three incorrectly assumed that
188 the average child would correctly identify over half of the species). Only one in four communicators
189 (25.0%) estimated species literacy in children accurately, at an average achieved identification score
190 of 9 or 10 out of 27 species, and 21.6% of the communicators underestimated species literacy in
191 primary school children.

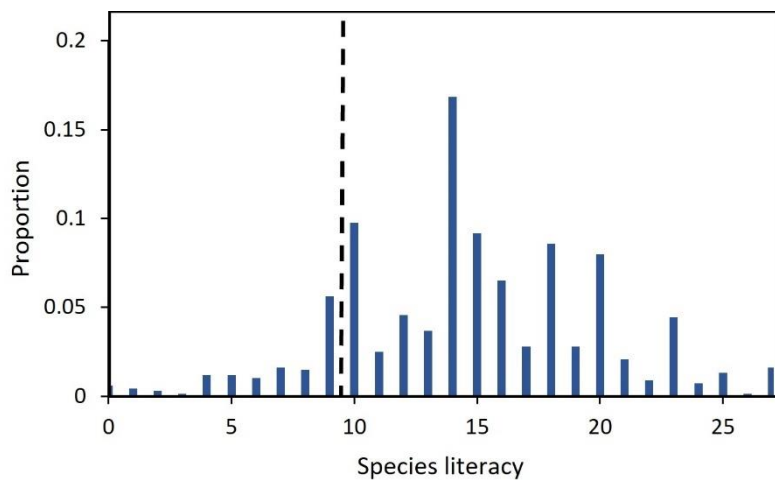
192 Next, we investigated the influence of experience with primary school children as a target
193 group on communicators' estimations, by comparing the estimates of children's species literacy
194 made by communicators with (59.8%) and without (40.2%) children aged 9-10 as a target group.
195 Estimations by communicators with children as a target group ($M = 11.4$, $SD = 4.2$) and by
196 communicators without children as a target group ($M = 11.5$, $SD = 4.1$) did not differ significantly,
197 $t(589.67) = 0.34$, $p = .736$.



198
199 **Fig. 2.** Distribution of biodiversity communicators' estimations of the average species literacy level (i.e.
200 identification score) in primary school children aged 9-10. The actual level, established during a previous
201 research project just prior to the current study, is depicted with a dashed line. We note that communicators
202 were asked to estimate the species literacy level on a scale from 0 to 27, where a few levels (e.g., 5, 9, 14) were
203 indicated. Although this may explain the peak at 9 species, and might thus have increased the number of
204 communicators with accurate estimations, the wide range in estimations demonstrates clearly that most
205 communicators were unaware of the actual knowledge level.

206 207 3.3. Desired levels of species literacy

208 To further put children's species literacy level in perspective, we compared the actual and estimated
209 level with the level as desired by the communicators. Significant differences were found. The desired
210 average species literacy level ($M = 14.8$, $SD = 5.1$) was considerably higher than both the actual
211 average level ($M = 9.5$, $SD = 3.4$); $t(1197.1) = 22.11$, $p < .001$ and the estimated average level ($M =$
212 11.4 , $SD = 4.2$); $t(676) = 19.39$, $p < .001$. While 23.3% of the communicators would be satisfied with
213 the actual species literacy level (desiring no more than 10 out of 27 species to be correctly
214 identified), the majority (76.7%) wished for a higher knowledge level – see Figure 3. For instance, two
215 in three communicators (65.9%) expressed that children should be able to identify over half of the
216 species.



217
218 **Fig. 3.** Distribution of the desired average species literacy level (i.e. identification score) in primary school
219 children aged 9-10 according to biodiversity communicators. The actual level, established during a previous
220 research project just prior to the current study, is depicted with a dashed line.

221

222 3.4. Importance placed on species literacy

223 The majority of the communicators attached importance to species literacy; on a 10-point scale
224 78.7% provided scores of 6 to 10 to the statement that people should be able to recognize many
225 different animal species. Only a minority of the participants (4.9%) placed little to no importance on
226 knowledge about species in laypeople (score 0 to 4).

227 To provide further insight into communicators' perceptions of the importance of species
228 literacy, we carried out inductive coding of the remarks provided by the participants. Each answer
229 received 1 or more codes, and the total number of coded answer fragments (634) exceeded the
230 number of communicators that provided remarks (439 out of 677). There were seventeen different
231 codes grouped into three categories: 1 = *Species literacy is important*, 2 = *Species literacy is not*
232 *important*, and 3 = *Species literacy is not as or as important as...* – see Table 1. Each category
233 contained the same four themes (insight, interest/experience, affinities/care, well-being)
234 supplemented by a few separate codes. In addition, an eighteenth code contained 69 fragments that
235 could not be assigned any of the previous 17 codes, e.g., because they were not an answer to the
236 actual question (*'the more knowledge, the better'*) or neutral (*'no opinion'*).

237
238 Different reasons were expressed by the biodiversity communicators as to why knowledge about
239 species would be important or not. Of the coded answer fragments, 42.4% underlined the
240 importance of species literacy. In particular, a considerable number of communicators expressed that
241 species knowledge may help to create affinities towards nature and species, ultimately contributing
242 to conservation. Participants also argued that knowledge about species, common everyday species
243 especially, should be part of any person's knowledge base, in line with comments from
244 communicators that it is important specifically to be familiar with your surroundings. Furthermore,
245 communicators noted that knowledge about species can provoke curiosity and can strengthen
246 nature experiences, can contribute to well-being, e.g., by triggering joy and building a person's
247 confidence to talk about nature, and that knowledge and skills related to species (e.g., observing) can
248 lead to further insights and broader understanding. For example, people knowledgeable about
249 species may notice and pay attention to ongoing changes in population densities.

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

258 Finally, in 28.7% of the coded answer fragments, communicators compared knowledge about
259 species to things that they attached equal or more importance to, such as interest in and experience
260 of nature, and enjoyment of nature. In particular, communicators stressed the importance of respect
261 and care for nature and species, which they argued should be prioritized. They expressed that as long
262 as people appreciate and cherish nature, knowing much is not really vital. Finally, some
263 communicators emphasized that in-depth knowledge about species and skills such as observing were
264 most important. For instance, they stressed the importance of grasping the 'big picture' and
265 becoming aware of interdependencies between species and between species and the environment.

266 **Table 1.** Overview of the codes and categories used during the inductive coding process of the remarks made
 267 by the communicators. The percentages show how many of the 439 communicators providing remarks used an
 268 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

269 4. Discussion

270

271 4.1. Communicators' understanding of species literacy levels

272 In order to build stewardship for biodiversity, communication is needed that strikes a chord with the
273 lay public. For this, communicators need to be aware of perceptions present in their target audiences
274 (Bass et al., 2002; Schutte, 2010; Wratten and Hodge, 1999). We explored biodiversity
275 communicators' awareness of the species literacy level in primary school children, by asking them to
276 estimate the average score that children aged 9-10 would achieve in an identification test comprising
277 native animal species.

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

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

290

291 4.2. Species literacy as desired and perceived by communicators

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

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

311 increasing risk of losing connections with nature (Miller, 2005; Pauly, 1995; Pyle, 2011; Soga and
312 Gaston, 2018).

313 We further note that biodiversity communicators did not attach the same level of
314 importance to different components of species literacy. Most importantly, there was disagreement
315 about the value of naming species. Some communicators stated that naming species has little value
316 in itself, despite the fact that previous authors have argued that a name can be a starting point for
317 more meaningful learning and discussion (Magntorn and Helldén, 2005; Ohl et al., 2014). Similarly,
318 although most communicators wished laypeople to care about nature and to understand ‘the big
319 picture’, some questioned the contribution that species literacy can make in this respect and thus
320 seemed unaware of the role attributed by past authors to factual knowledge in allowing people to
321 build understanding, interest, and appreciation; a pathway that has actually been covered
322 extensively in educational literature (Amer, 2006; Weilbacher, 1993) and has been supported by
323 empirical research (Cosquer et al., 2012; Lindemann-Matthies, 2005; Schlegel and Rupf, 2010;
324 Shwartz et al., 2014). In fact, accessible as they are and easy to relate to, species can be tools in
325 helping people grasp complex, abstract concepts like biodiversity, food webs, and ecosystems
326 (Barker and Slingsby, 1998; Orr, 2005).

327

328 *4.3. Future directions*

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

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

342

343 *4.4. Conclusion*

344 To increase awareness about biodiversity effectively, biodiversity communicators should have a clear
345 picture of prior knowledge in their audiences and the desired outcomes that they strive for. Only
346 then will they be able to meaningfully connect to people’s perceptions and take the necessary steps
347 to achieve the desired level. To our knowledge, this study was the first to investigate species
348 knowledge levels as estimated and desired by biodiversity communicators. We demonstrated that
349 estimating prior knowledge levels in primary school children is difficult for people who communicate
350 about biodiversity, extending the findings in other disciplines (Bass et al., 2002; Kelly and Haidet,
351 2007; Perrenet, 2010; Storm, 2012). Communicators overestimated and wished for higher knowledge
352 levels in children, suggesting that current educational materials and messages may not connect to
353 existing knowledge. Such misfit between estimated and actual knowledge levels may prevent

354 learning goals from being achieved and may partly explain why conservationists have yet been
355 unsuccessful at reaching certain segments of society.

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

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

377 All in all, we demonstrated gaps between the perceived, desired and actual average species
378 literacy level in Dutch primary school children. This suggests that to reach desired knowledge levels
379 in young generations, communicators will benefit from first becoming more aware of current
380 perceptions in children. Efforts to identify, differentiate and get to know the audiences they try to
381 reach would provide biodiversity communicators with opportunities to improve their outreach,
382 which could help achieve broad-based support for conservation.

383

384

385 **Supporting information**

386 Appendix_A_Questionnaire

387 Appendix_B_Datasheet

388

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396

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398 We have no conflicts of interest to disclose.

399

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