

RESEARCH ARTICLE



Urban versus rural? The effects of residential status on species identification skills and connection to nature

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Abstract

1. Urbanization and urban lifestyles increasingly disconnect people from nature in a process that was termed the 'extinction of experience'. This loss of human–nature interactions can undermine both cognitive (ecological knowledge) and affective (emotional connection to nature) relations to nature, further impacting capabilities to experience, care for, benefit from and act to protect nature. Yet, the extent to which the urban life influences both cognitive and affective relations to nature, remains poorly understood and research is confined to a few countries and cultures.
2. We explored how cognitive and affective relations to nature can be related to people's childhood and current place of residency. We expected that urban dwellers, who have less opportunities to experience nature than their rural counterparts, will be less connected to nature and will demonstrate lower ecological knowledge than their rural counterparts.
3. We conducted four surveys in Israel, in urban and rural settings between 2015 and 2018 ($N = 1706$) to measure and compare (urban vs. rural) the following variables: (a) species identification skills (correctly identified); (b) familiarity (recognized), as two measures of cognitive relation with nature and (c) nature relatedness, as a measure of emotional connection to nature.
4. The ability to identify common plant, bird and butterfly species was poor in general (Av. = 3.83 out of 12), and lower for urban dwellers (Av. = 2.48) compared to their rural counterparts (Av. = 6.56). Differences in correct species identifications between urban and rural dwellers varied with taxa and peaked for butterflies (only 26 respondents managed to identify one species or more). We also identified an important gap between familiarity and species identification skills, especially for urban residents. Finally, people who currently live or used to live in rural areas during their childhood had higher scores of nature relatedness than their urban counterparts.
5. Our results highlight that decreased opportunity to interact with nature reduces cognitive and affective relations to nature. Such reductions can affect the overall preferences for human–nature relationships and exacerbate a pervasive negative cycle that modifies relational values such as, care for nature, sense of belonging,

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place and identity that influence both humans well-being and environmental stewardship.

KEYWORDS

environmental knowledge, experience of nature, nature relatedness, relational values, urban nature

1 | INTRODUCTION

Humanity has become predominantly urban, with over 54% of the world's population residing in cities today and 66% expected by 2050 (UN, 2015). While cities have become thriving centres of economic growth, innovation and knowledge production (Fischer et al., 2018), they also delete and degrade natural ecosystems (Lin & Fuller, 2013) and separate the majority of the world's population from experiencing nature (Soga & Gaston, 2016). Originally coined by Robert Pyle (1978, 1993), the 'extinction of experience' describes the loss of opportunities to experience nature that might result in an emotional disconnect from it. The extinction of experience (EoE) is a major concern, since nature provides a wide range of intangible and non-material 'services' or benefits to people (often referred to as cultural ecosystem services; MA, (Millennium Ecosystem Assessment), 2005) that were shown to influence people's well-being and health (Keniger et al., 2013). For instance, nature experiences offer psychological restoration or indirectly inspire recreational activities and exercise (Andersson et al., 2015; Hartig & Kahn, 2016). The loss of nature experiences may also undermine people's emotions, attitudes and behaviours toward nature, creating a vicious cycle that gradually intensifies the consequences of this phenomenon (Colléony et al., 2020). Yet, despite growing recognition and interest, understanding the processes that drive the EoE still needs comprehensive attention (Soga & Gaston, 2016).

Loss of opportunity to directly experience nature has been suggested as one of the main causes for the EoE (Soga & Gaston, 2016; Figure 1). Today, the majority of the world's population lives in biologically impoverished cities and individuals spend most of their time indoors, with limited opportunity to experience nature in their day-to-day life (Lacoeuilhe et al., 2017). Urban densification aggravates these problems by increasing geographic distances from natural environments and green spaces, resulting in shorter and less frequent visits to green spaces (Soga et al., 2015). This reduction is concerning, since nature experiences contribute to the construction of individual, cultural, environmental identities, the notion of a 'good life' and play an important role in shaping people's sense of belonging, connection and care for nature (Chan et al., 2016; Clayton, 2003). These relational values, i.e. preferences, principles and virtues about human-nature relationships, can influence individuals' moral values, perceptions of what constitutes well-being and environmental stewardship (Chan et al., 2016; Jax et al., 2018; West et al., 2018).

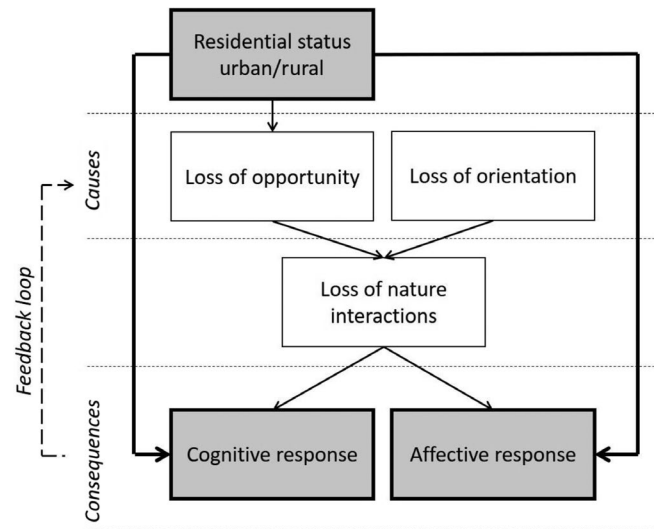


FIGURE 1 Loss of nature interactions is mainly caused by loss of orientation (willingness to engage with nature; not explored in this study) and loss of opportunity. Loss of nature interactions affects cognitive and affective responses to nature, which in turn, influence the causes of loss of nature interactions in a feedback loop. Residential status (urban/rural) can be used as a proxy to explore loss of opportunity. In this study, we explored how residential status relates to cognitive and affective response (grey boxes and thick arrows), in the context of the extinction of experience framework

Clayton and Myers (2009) suggested that interactions with the natural environment cause cognitive and affective responses that in turn may influence environmental attitudes and behaviours. Indeed, mounting empirical evidence has demonstrated the positive relationships between nature experiences, connection to nature, knowledge about nature, pro-environmental values, attitudes and behaviours (Chawla, 2020; Ives et al., 2017; Nisbet et al., 2009; West et al., 2018). For instance, among adults, inhabitants of greener neighbourhoods reported higher levels of nature relatedness (i.e. affinity for nature) than those living in less green environments (Shanahan et al., 2017). Higher levels of nature relatedness can lead to stronger engagement in pro-environmental behaviours, as a recent comprehensive meta-analysis has demonstrated (Whitburn et al., 2020). Nature experiences are also considered one of the major foundations for the development of ecological knowledge (Bögeholz, 2006; Obery & Bangert, 2017). Ecological knowledge was defined as general knowledge and understanding of ecological concepts and processes (Cosquer et al., 2012; Pitman et al., 2016).

The process of ecological knowledge acquisition is recognized as one of the cultural ecosystem services (cognitive services) and ecological knowledge constitutes part of the human-natural capital that is important for the realization of tangible and non-tangible benefits from nature (Chan & Satterfield, 2015; Fish et al., 2016). Beyond these instrumental benefits, ecological knowledge, connection to nature and caring for nature sometimes interact and lead to greater commitment to protect the natural world and foster environmental stewardship (Chawla, 2020; West et al., 2018).

Changes in the cognitive and affective responses to nature can thus alter individuals' relational values and also threaten the delivery of cultural ecosystem services (Chan et al., 2016). These changes can reduce people's capabilities for nature-related activities, influence the identities of individuals and make it more difficult to interact with, connect to and care for the natural environment (Maller, 2009), and this in turn may further hinder future nature experiences. Decline in ecological knowledge is particularly alarming, as it is considered as a prerequisite to performing ecological behaviours (Frick et al., 2004; Otto & Pensini, 2017; Prévot et al., 2018). Today, in many parts of the world, ecological knowledge is decreasing rapidly across generations (Aswani et al., 2018; Daniels et al., 2012). This decline is happening mostly in wealthy and more developed countries, which rely very little on local natural goods and services supply, further detaching people from the local environment (Pilgrim et al., 2007). One type of ecological knowledge is the ability to identify species, as names are among the basic and essential components of people's relationship with nature (Kai et al., 2014). Studies have shown that although knowledge of species names and functions on the whole is poor, appreciation and attitudes toward species increase when individuals manage to identify them correctly (Cox & Gaston, 2018; Lindemann-Matthies, 2002; Pilgrim et al., 2007). Therefore, the EoE can seriously jeopardize efforts to redress the environmental crisis on its consequences for humans and nature, as it modifies the way people interact with nature, feel connected to nature, know about nature and think of themselves as part of the natural world (Gaston & Soga, 2020).

Yet, the extent to which the EoE can influence the cognitive and affective responses towards nature is not well understood (Soga & Gaston, 2016). The challenge in exploring consequences of the EoE is the need to monitor affective and cognitive responses toward nature over time (Colléony et al., 2020). However, to our knowledge data allowing this rarely exist (e.g. Oh et al., 2020). Because loss of opportunity is considered one of the main causes of the extinction of experience, comparing affective and cognitive responses to nature of urban versus rural residents can provide useful insights into the consequences of the extinction of experience (Figure 1). Furthermore, studies that focused on the causes or consequences of the EoE are largely based on Western, English-speaking countries (Pett et al., 2016), and this limits our understanding of the EoE, as responses are known to vary across countries and cultures (e.g. Colléony et al., 2019). In particular, large differences were found between European and Middle Eastern countries in terms of landscape preferences or affective and cognitive response to nature (Buijs et al., 2009; Colléony et al., 2019).

In this study, we used the type of residential environment as a proxy for the loss of opportunities to experience nature, a cause of the EoE (Figure 1), and compared potential consequences on cognitive and affective responses between urban and rural dwellers in Israel. The rate of population growth in Israel is among the highest in the western world, alongside its rapid land development (Shoshany & Goldshleger, 2002). Israel is also considered as a local biodiversity hotspot (Gavish, 2011) providing vast opportunities to experience nature. Yet, recent evidence demonstrates that Israelis are less knowledgeable about and connected with nature and interact less with nature than French and English residents (Colléony et al., 2019). This makes Israel an ideal location for exploring our research question in a Middle Eastern context. We gathered data from four surveys ($N = 1706$) and compared familiarity with common species and the ability to identify those species correctly as proxies for ecological knowledge (cognitive responses) between urban and rural inhabitants in Israel. We also compared their levels of nature relatedness (affective responses). We hypothesized that since people living in urban areas have lower opportunities to interact with nature, they would be less familiar with, knowledgeable about and connected with nature, than their rural counterparts.

2 | METHODS

2.1 | Surveys

We analysed data from four separate surveys, assessing different aspects of people's responses to nature that were conducted between 2015 and 2018 in Israel (Table 1). All surveys were in Hebrew, two surveys were conducted in-situ and two were online. For each survey, we provided description of the study, participants gave informed consent and responses were anonymous; ethics approval for all surveys was provided by the Technion Social and Behavioral Sciences Institutional Review Board (approval numbers 2015-123 for first two surveys; 2017-45 and 2018-24, for the third and fourth surveys, respectively).

Ecological knowledge and connection to nature were measured using the same scales across all surveys. Ecological knowledge is multidimensional, and one way to measure it is through species identification skills (e.g. Dallimer et al., 2012). Species identification skills are considered a fundamental component for further learning and understanding biodiversity and ecological processes (Dallimer et al., 2012; Randler, 2008; White et al., 2018). We therefore measured species identification skills following Colléony et al. (2019) and Dallimer et al. (2012). Species identification skills were measured in surveys 1-3 but not in the fourth one (Table 1). Participants were asked to label images of twelve bird, butterfly and flowering plant species (four for each taxon). For each taxonomic group, the illustrations represented four species that are common in both urban and rural contexts even if under different proportions (Table 2). We interviewed ornithologists, botanists and lepidopterologists with experience in outreach activities to select ten native and two

TABLE 1 Description of the four surveys used in this study

Group	Place of survey	Method	Number of participants	Period of data collection	Aim of survey	Publication
Locals and farmers in north of Israel	Rural areas in the eastern part of the Jezreel Valley, Israel	Online via websites and Facebook	296 + 42 farmers in focus groups	2015–2016	Understand the attitudes of farmers and the rural community towards sustainable agriculture	Unpublished data
General public	Public gardens in Netanya a coastal city, situated 26 km north of Tel Aviv	Face to face in public gardens	600	2015	Explore the relationships between biodiversity and well-being	MSc thesis, Tzunz (2017)
General public	Across Israel	Online by a market-based company (Qualtrics)	174	2017	Explore how spending more time outside can influence peoples' experience of nature, and affective and cognitive responses to nature	Colléony et al. (2019)
Visitors to a nature reserve	Ramat HaNadiv, a nature reserve adjacent to urban areas in northern Israel	Face to face	594	2018	Explore visitor's experiences of nature in the reserve	Unpublished data

Group	Latin name	Common name	Species identification skills (%)	Familiarity (%)
Birds	<i>Passer domesticus</i>	House sparrow	46.7	88.6
	<i>Pycnonotus xanthopygos</i>	White-spectacled bulbul	31.4	61.5
	<i>Acridotheres tristis</i>	Common myna	14.9	65.3
	<i>Columba livia domestica</i>	Domestic pigeon	72.1	95.3
Butterflies	<i>Pieris rapae</i>	Small cabbage white	20.4	57.7
	<i>Lampides boeticus</i>	Pea blue	2.9	24.8
	<i>Papilio machaon</i>	Old World swallowtail	11.7	48.5
	<i>Vanessa cardui</i>	Painted lady	4.04	52.9
Flowers	<i>Senecio vernalis</i>	Eastern groundsel	25.2	65.0
	<i>Lupinus pilosus</i>	Blue lupine	17.8	67.1
	<i>Oxalis pes-caprae</i>	Bermuda Buttercup	28.8	81.1
	<i>Papaver subpiriforme</i>	Semitic poppy	69.8	92.8

TABLE 2 List of bird, butterfly and flower species that were chosen to assess ecological knowledge and familiarity in Israel. These species were selected as they are native and non-native species that are among the most common and widespread species in both urban and rural areas in Israel. Numbers represent percentages of respondents who correctly identified and recognized (familiarity) each species

non-native species (one bird and one flowering plant species) that are widespread and well recognized by the public in Israel. Research conducted in the same areas of our surveys have also demonstrated that the selected species were common and widespread in the study areas (Colléony & Shwartz, 2019b; Segre et al., 2019; Shwartz et al., 2008; Tzunz, 2017).

Participants were first asked to select the species they know and then to name them. Species identification skills were therefore measured in two ways: (a) the number of common species (0–12) people think they recognize (*familiarity*); and (b) the number of correct identifications of common species (0–12) at the genus or family level (depending on the taxa; Colléony et al., 2019; *species identification skills*).

Connection to nature was assessed using the short version of the Nature Relatedness Scale (Nisbet & Zelenski, 2013; Nisbet et al., 2009). Respondents were asked to rate their level of agreement to each statement on a 5-point scale, from 1-Strongly disagree to 5- Strongly agree. A nature relatedness score was derived for each respondent by averaging the scores of the six items after verifying the internal consistency (Cronbach's alpha = 0.83).

In each survey, we also collected demographic information: gender, level of education (elementary, high school, professional diploma, first degree and second degree+) and age group (18–24, 25–34, 35–44, 45–54, 55–64, 65+). To compare urban and rural dwellers, we collected information regarding their current

place of residency using an urbanization scale following Shwartz et al. (2012). The scale was similar across all surveys and presented five levels: (a) Large city, (b) Medium/small city, (c) Settlement, (d) Village, (e) Moshav or Kibbutz. Large city and Medium\small city were later recoded as urban areas and Settlement, Village, Moshav or Kibbutz were coded as rural. We proceeded similarly to assess the childhood place of residence, with a 5-point scale recoded as urban/rural.

2.2 | Data analysis

Statistical analyses were conducted in R (version 3.5.0; R Core Team, 2014). First, we built a GLMM with negative binomial error structure for count data to test the differences between familiarity and species identification skills for urban and rural dwellers. We constructed a new variable containing the two ecological knowledge scores together (i.e. two values per each participant). This variable was used as dependent variable, while the type of ecological knowledge (familiarity/species identification skills), place of current residency and their interaction were entered as fixed effect and respondent ID as random terms. We then used Tukey HSD post-hoc analysis to compare the differences between the types of knowledge and place of residency. Second, we built two separate GLMMs with negative binomial error structure to explore which variables (current residency, childhood residency, age, gender and education) explain the variance in species identification skills and familiarity (two dependent variables). The variable 'survey' was entered as a random factor to account for data dependency. For all three models we explored both Poisson and negative binomial error structures, given the skewed nature of our count data (species identification skills and familiarity). Negative binomial models error structures were used as they performed better for all three models. Multicollinearity was tested with variance inflation factors (Akinwande et al., 2015) and we found no evidence for multicollinearity (all VIFs < 4; Gareth et al., 2013). We checked normality assumption by plotting residuals. Best predictive models were obtained using stepwise regression analysis based on akaike information criteria (AIC).

Then, we conducted a chi-square test to test whether the difference in ability to recognize and identify species between urban and rural dwellers was homogenous across the three taxonomic groups, thus testing whether the number of recognized and identified species

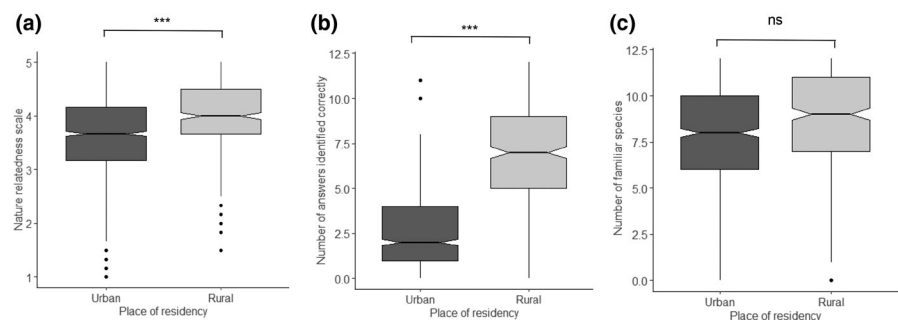
distribute uniformly among taxa. We also explored the difference in distribution of the number of correct identifications between urban and rural inhabitants using a Kolmogorov–Smirnov test. Finally, we built one GLMM with Gaussian error structure to explore the relationship between nature relatedness and the exploratory variables (current residency, childhood residency, age, gender and education). We used a linear mixed model for this analysis since the dependent variable was the averaged nature relatedness score (and not count data like species identification skills). The variable 'survey' was also entered as a random factor. We checked normality assumption by plotting residuals and checked for multicollinearity using variance inflation factors for the model. Best predictive models were obtained using stepwise regression analysis based on AIC. *p*-value of best predictive model was obtained using LMERTEST package (Kuznetsova et al., 2017).

3 | RESULTS

The majority of survey respondents were urban dwellers (70.5%, of total 1706 participants) comprising mostly females (58.2%), mainly with a bachelor's degree (35%) between the ages of 35 and 44 (32.6%). Rural residents were also mostly female (47.3%), with bachelor's degree (42.7%), between ages 35 and 44 (33.3%). The domestic pigeon, semitic poppy and house sparrow were the species most participants managed to correctly identify (72.1%, 69.8% and 46.7% of respondents respectively) and the species people were most familiar with (95.3%, 92.8.% and 88.6% respectively).

In general, species identification was low (Mean + SE = 3.83 ± 0.09 out of 12 species; Figure 2) and lower than the average number of species participants were familiar with (7.86 ± 0.10 SE). The interaction between the type of knowledge and place of residency was significant (-0.84 ± 0.03 SE, $p < 0.001$). Thus, familiarity was significantly higher than species identification skills for both urban and rural residents and the difference was particularly important among urban inhabitants (Figure 3). Our models showed that respondents who currently live and those who spent their childhood in urban areas had significantly lower scores of species identification skills across taxa than respondents in rural areas (Table 3). Older respondents and those with higher education level showed higher scores of species identification than younger and less educated respondents (Table 3). Familiarity did not differ between urban and rural

FIGURE 2 Boxplots (box-and-whiskers plot) presenting comparisons of (a) nature relatedness, (b) species identification skills and (c) familiarity, between urban (dark grey) and rural (light grey) inhabitants. Horizontal black lines indicate the median values, while the notched section shows 95% confidence interval of the median. Significance levels are shown: *** $p < 0.001$



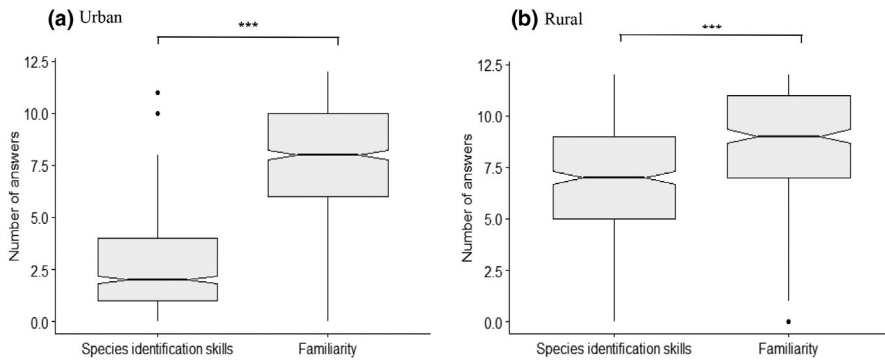


FIGURE 3 Boxplots (box-and-whiskers plot) presenting comparisons between familiarity and species identification skills for urban (a) and rural (b) inhabitants. Horizontal black lines indicate the median values, while the notched section shows 95% confidence interval of the median. Significance levels are shown based on Tukey HSD analysis: *** $p < 0.001$

TABLE 3 Effect sizes and standard errors of three mixed-effects linear models explaining nature relatedness, familiarity and species identification skills. Empty cells are for variables that were omitted during the model selection process. Significance levels are shown: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

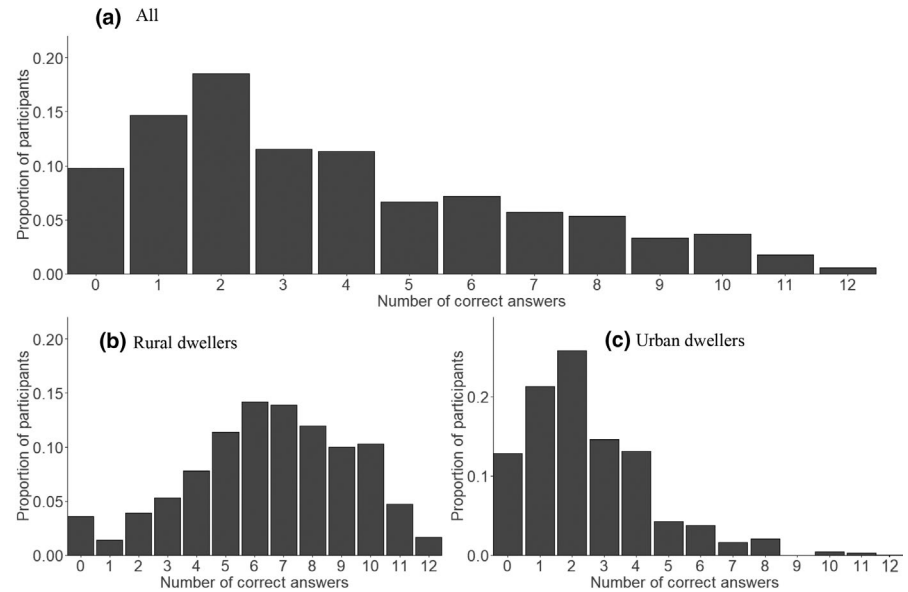
Variables	Nature relatedness		Familiarity	Species identification skills
	Linear mixed model		Negative binomial mixed model	Negative binomial mixed model
Intercept	3.73 ± 0.21***		1.71 ± 0.16	1.34 ± 0.23***
Current residency	Rural (<i>reference</i>)	—	—	—
	Urban	-0.18 ± 0.05***	0.006 ± 0.03	-0.82 ± 0.05***
Childhood residency	Rural (<i>reference</i>)	—	—	—
	Urban	-0.1 ± 0.05**	-0.05 ± 0.02	-0.19 ± 0.04***
Age	18–24 (<i>reference</i>)	—	—	—
	25–34	-0.12 ± 0.081	0.02 ± 0.05	-0.02 ± 0.1
	35–44	-0.06 ± 0.08	0.12 ± 0.05*	0.25 ± 0.1*
	45–54	0.04 ± 0.085	0.14 ± 0.05*	0.15 ± 0.1
	55–64	0.09 ± 0.091	0.18 ± 0.06**	0.22 ± 0.1*
	65+	0.07 ± 0.089	0.13 ± 0.05*	0.19 ± 0.1*
Education	Elementary (<i>reference</i>)	—	—	—
	High school	0.17 ± 0.145	0.04 ± 0.64	10.44 ± 0.16**
	Professional diploma	0.235 ± 0.142	0.1 ± 0.06	0.6 ± 0.16***
	First degree	0.236 ± 0.14	0.08 ± 0.06	0.58 ± 0.16***
	Second degree+	0.22 ± 0.142	0.1 ± 0.066	0.68 ± 0.165***
Gender	Female (<i>reference</i>)	—	—	—
	Male	-0.04 ± 0.04	—	—
Random effects		Variance (SD)		
Survey		0.51 ± 0.71	0.08 ± 0.29	0.03 ± 0.194

inhabitants, nor with childhood place of residence but was positively associated with age (Table 3).

Only six participants (0.55%), all rural dwellers, correctly identified the 12 species, whereas 106 respondents (9.76%) could not identify a single species (Figure 4a). The distribution of the number of correct identifications differed between urban and rural inhabitants, with a Gaussian-like distribution for rural inhabitants and a Poisson-like distribution for urban dwellers (Kolmogorov–Smirnov test; $D = 0.65$, $p < 0.001$; Figure 4b,c). All respondents managed to identify bird and flowering plant species better than butterfly species and rural inhabitants identified all species better than

urban dwellers, but the difference was stronger for butterflies ($\chi^2 = 15.234$, $df = 2$, $p < 0.001$). Only 26 urban respondents (4%) managed to correctly identify one butterfly species or more, while 226 rural participants (50%) managed to correctly identify at least one butterfly species. The share of correct identification of at least one flower or bird species was slightly higher for rural than urban dwellers (94% vs. 80% for birds and 80% vs. 71% for flowers). The vast majority of both urban and rural inhabitants were familiar with at least one flowering species (97% and 88%, respectively), bird species (96% and 95%, respectively) and to a lesser extent butterfly species (74% and 65%, respectively).

FIGURE 4 Proportion of respondents per number of correct species identification, for (a) all participants, (b) rural dwellers and (c) urban dwellers



For nature relatedness, mean score was 3.78 ± 0.02 SE and was significantly lower for urban dwellers compared to rural inhabitants (Table 3; Figure 2). Respondents who spent their childhood in urban areas also reported significantly lower scores of nature relatedness than those who spent their childhood in rural areas (Table 3). We did not find any significant relationship with age, gender and education.

4 | DISCUSSION

The extinction of experience (EoE) is a global issue that can affect the affective and cognitive responses to nature and undermine the efforts to conserve biodiversity (Soga & Gaston, 2016, Figure 1). Affective and cognitive responses to nature are key factors that shape the way people relate to nature, including their preferences, values and virtues that can influence capabilities to experience nature, caring for and about nature and other behaviours conducive to a good life and environmental stewardship (Chan et al., 2016; Jax et al., 2018; West et al., 2018). Degradation of emotional connection to nature and knowledge about nature also threatens the provision of cultural ecosystem services that enable people to benefit from multiple ecosystem services (Chan & Satterfield, 2015). In this paper, we explored the effect of residential areas, as a proxy for loss of opportunity to experience nature, on both cognitive (species identification skills) and affective (connection to nature) responses to nature (Figure 1). Consistent with previous research (Lin et al., 2014; Soga et al., 2016), we found that urban dwellers, who have fewer opportunities to interact with nature than rural inhabitants, have lower connection to nature and species identification skills, a form of ecological knowledge (Kai et al., 2014), compared to their rural counterparts. Because these components are principal contributors for the constructions of relational values (Chan et al., 2016), attitudes and behaviours towards nature (Clayton & Myers, 2009), and the provision of cultural ecosystem services (Chan & Satterfield, 2015), we highlight the importance of

promoting policies that enhance ecological knowledge and connection to nature in urban areas.

Cognitive and affective responses are developed through experiences of nature, particularly during childhood, but also on an everyday basis for adults (Chawla, 2020; Clayton et al., 2019; Coldwell & Evans, 2017; Hinds & Sparks, 2008). Thus, reduction in nature interactions is likely to affect individuals' affinity towards nature, creating a vicious cycle of impoverishment of nature experiences (Soga & Gaston, 2016). Here, we found that individuals who are less exposed to nature on an everyday basis (urban residents) reported much lower levels of connection to nature than individuals who are more exposed to nature (rural inhabitants). Consistently, in Australia, Shanahan et al. (2017) found that people were more connected to nature in sprawling city design than individuals in compact ones (where individuals are less exposed to nature). The average nature relatedness score in our study was higher than those previously reported in France and the UK (Colléony et al., 2019). In contrast, in their cross-cultural study, Colléony et al. (2019) found that Israeli respondents showed lower levels of nature relatedness than French and UK respondents. One possible explanation for this difference is that 30% of the participants in our study were rural dwellers. Most people in Israel and organisation for economic co-operation and development countries reside in urban areas (e.g. in Israel, about 90% of the population live in cities; CBS (Central bureau of Statistics Israel), 2015) and therefore studies today mostly survey urban dwellers. This shows the importance of conducting surveys in different contexts to get a holistic understanding of individual differences in human–nature relationships.

The importance of childhood experiences of nature for the development of an affinity towards nature during adulthood has been repeatedly shown (Chawla, 2020; Collado et al., 2013; Müller et al., 2009). Our study shows that individuals who grew up in rural environments and potentially had more opportunities to experience nature in their daily lives than urban dwellers, had stronger connection with nature at adulthood. This provides additional support to

previous evidence on the relationship between childhood experiences of nature and adult nature connection (Chawla, 2020). Today however, direct experiences of nature are being rapidly transformed to more vicarious ones, largely based on screen-mediated experiences that prioritize vision as the basis of a modified and sometimes simplified nature experience (Truong & Clayton, 2020). Children with rich and multisensory experiences of nature can feel the differences. Still, it remains unclear that those who spend most of their days in front of a screen with limited direct nature experiences perceive these differences as well (Truong & Clayton, 2020). For these children, the perception of nature, their relationships with nature, sense of belonging and care for nature can change considerably and this may challenge our ability to address the global societal and environmental issues (Chan et al., 2016; Jax et al., 2018; West et al., 2018). This is because mounting empirical evidence demonstrates the positive relationships between meaningful and early experiences of nature, connection to nature, knowledge about nature and pro-environmental attitudes and behaviours (Chawla, 2020; Hunter, 2011; Truong & Clayton, 2020). Thus, our results indicate that if urbanization and vicarious experience of nature will continue to alienate children and adults from nature, we could expect an increased erosion in the emotional connection to nature. Designing biophilic cities that provide cultural ecosystem services by promoting opportunities for nature experiences and capabilities is important to strengthen emotional connection to nature and potentially disrupt the negative cycle caused by the EOE (Beatley, 2011; Chan & Satterfield, 2015; Shwartz, 2017).

Nature experiences are also important drivers of ecological knowledge (Clayton et al., 2019; Prévot et al., 2018). Consistently, we found that individuals who are less exposed to nature (urban residents) displayed particularly low species identification skills compared to their rural counterparts. This is in line with results of previous studies in other parts of the world (e.g. in Australia; Pitman et al., 2016). Despite the low scores on species identification skills, individuals in our study felt they were relatively familiar with the species. This raises an interesting question regarding the importance of biological classification knowledge compared to a simple feeling of familiarity. Knowledge on the relationships between people's identifications skills, familiarity and ecological knowledge, which is more complex and nuanced than the previous two, is scarce and should be further developed (Kai et al., 2014). However, naming species is the most basic way of representation, which enables us to communicate and think about species in specific terms (Borkfelt, 2011). Naming species was also shown to be critical for including them in conservation policies (Delić et al., 2017). Therefore, we believe that the ability to name species has stronger consequences on the relationship between people and biodiversity, even more than people's sense of familiarity with a given species, although research is still needed to establish this assumption.

In accordance, few studies have found that the ability to correctly name species had significant influence on children's and adults' appreciation and feelings towards those species (e.g. Cox & Gaston, 2018; Lindemann-Matthies, 2002), relating to an extent

cognitive and affective responses to nature. In their framework for cultural ecosystem services, Fish et al. (2016) classify knowledge and connection to nature among the cultural ecosystem benefits, under the identity and capability dimensions (respectively) that shape together with experiences the environmental spaces and cultural practices. Thus, the loss of species identification skills we have demonstrated represents a sort of reduction in ecological knowledge that may alter the relational processes that people create through interactions with nature (Fish et al., 2016). This may shape people's capabilities and willingness to interact with nature, individual and environmental identities (e.g. sense of place and belonging) that influence nature experiences. Interactions are a necessary prerequisite for experiences, but experiences are more than just interactions. Experiences have emotional, and physical dimensions, including knowledge, skills, attitudes and behaviour, and are dependent on social context (Clayton et al., 2017; Gaston & Soga, 2020). These experiences further allow for creating the capabilities for nature-related activities that are also important for retrieving benefits from nature (Chan & Satterfield, 2015; Chan et al., 2012). Erosion in experiences and capabilities for nature-related activities can further exacerbate the deleterious cycle caused by the EoE and widen the gaps between people and nature.

Studies that adopted a linear, unidirectional approach seeking to relate biodiversity and well-being to align the agendas of public health and conservation have found inconsistent results (reviewed by Pett et al., 2016). One possible explanation for these inconsistencies is that most of these studies were conducted in urban areas in developed countries, where affective and cognitive responses to nature are already eroded and therefore capabilities to experience nature influence the people–biodiversity relationships. In accordance, these studies showed that the perception of species richness and ability to identify species was relatively low across all taxa, although scores are higher for bird species than for plant and butterfly (Dallimer et al., 2012; Lindemann-Matthies, 2002; Shwartz et al., 2014; but see Fuller et al., 2007; Lindemann-Matthies et al., 2010 for plants). While we found similar results, our study suggests that urban dwellers lose even more ability to identify butterfly species than rural inhabitants. This is profoundly concerning, as it suggests that loss of opportunity may alter individuals' relationship with some taxa more than with others. If we do not act to avert this phenomenon, individuals' baseline for biodiversity will even decrease further, in a phenomenon called 'shifting baseline syndrome' (Soga & Gaston, 2018). In other words, members of each new generation will accept lower levels of biodiversity as normal and declines or extinctions of some species will happen unnoticed and not be fought against, ultimately aggravating the biodiversity crisis.

Increasing experiences with nature to mitigate this phenomenon can be done through several possible ways. One way is through education and knowledge transmission, which are often regarded as a necessary route to sustainability that can be a precursor to well-functioning societies (Chan et al., 2020; Sachs et al., 2019). Further, environmental knowledge and education can enhance connectedness,

care and kinship—relational values that support multiple benefits for people and nature (Chan et al., 2020; West et al., 2018). Another way to increase experiences with nature is through fostering environmental stewardship, as a reference to attitudes, and practice of care for nature (Jax et al., 2018). Opportunities to embed concepts and actions associated with care for nature can also be sought in practices and institutions (Cheng & Monroe, 2012; Lindemann-Matthies, 2006).

A few caveats are warranted here. First, we did not directly measure the extent of nature experiences. Our study relied on the assumption that urban residents interact less often with nature than their rural counterparts (Figure 1). This assumption is based on previous evidence that the extent of green spaces is lower in urban areas than more natural ones (Antrop, 2004; Foley et al., 2005; McKinney, 2008), and that distance to green spaces is negatively correlated with the frequency of nature experiences (Soga & Gaston, 2016; Soga et al., 2015). Thus, we used the type of residential environment as a proxy for opportunity to experience nature, a cause of the extinction of experience (Soga & Gaston, 2016) and explored consequences on cognitive and affective responses to nature (Figure 1). Future studies should consider measuring nature experiences as well to address this limitation. Second, our study relied on correlational data only, and we cannot ascertain that it is the environment respondents were exposed to (urban vs. rural) that affected their affinity towards nature and not their affinity towards nature that drove their choice of residential environment. We recommend establishing experimental studies and/or long-term monitoring programs to measure the consequences of a loss of opportunities and orientation to experience nature. Finally, as we discussed earlier our study measured a narrow aspect of ecological knowledge by using species identification skills as a proxy (Randler, 2008; White et al., 2018). We acknowledge that this proxy does not cover the broad definition of ecological knowledge needed to account for future nature-related behaviours (Kaiser & Fuhrer, 2003; Orr, 1992). Future studies could explore consequences on other forms of knowledge (Frick et al., 2004).

Since the proportion of people living in cities is expected to continue growing (United Nations, Department of Economic and Social Affairs, Population Division, 2019), it is urgent to enhance both connection to nature and varying forms of ecological knowledge, especially in cities, to safeguard the delivery of the multitude of cultural ecosystem services associated with nature. Simply creating more opportunities for nature interactions (e.g. by increasing accessibility to green spaces in cities) may not be enough to achieve this, and it is important to engage people with nature and facilitate interactions (Colléony & Schwartz, 2019a; Colléony et al., 2019). Citizen science programs can play a great role for promoting nature interactions and enhancing ecological knowledge (Domroese & Johnson, 2017; Schuttler et al., 2018). Urban design can also enhance the ability to learn about nature in cities (e.g. tiny road signs that illustrate areas where wildlife is present), but this avenue remains overlooked (Schwartz, 2017). Local initiatives of turning a neglected area to a flowering garden for all residents to enjoy and care may be a great

opportunity for encouraging engagement with nature, safeguarding biodiversity and attracting useful pollinators (Clayton et al., 2017; Kingsley et al., 2009). Given the importance of childhood experiences of nature, evoking affective and cognitive responses will prove particularly beneficial if implemented at early age (Cheng & Monroe, 2012; Clayton et al., 2019; Collado et al., 2013). Urban children today spend much of their time in school or within the borders of their neighbourhood (Soga & Gaston, 2018). Therefore, much of the efforts that focus on promoting experiences of nature (e.g. educational programs; Lindemann-Matthies, 2006), should take place in the areas where children spend most of their time.

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CONFLICTS OF INTEREST

The authors of this manuscript do not have any direct or indirect conflict of interest, financial or personal relationships or affiliations to disclose. A.S. is an associate editor for People and Nature but was not involved in the peer review and decision-making process.

AUTHORS' CONTRIBUTIONS

D.B., A.C. and A.S. conceived the ideas and designed the methodology; D.B. and A.C. collected and analysed the data. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Dryad Digital Repository <https://doi.org/10.5061/dryad.ncjxkst2> (Bashan et al., 2021).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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