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An Exploration into Direct Nature Experiences (DNE) and Biodiversity Knowledge amongst Island Children

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ABSTRACT

Children worldwide are increasingly deprived of direct nature experiences (DNE). Often rooted in restrictions of urbanization and modernization, this loss may hamper biodiversity conservation through erosion of biodiversity knowledge. Yet, the extent of this phenomenon in small cities, particularly in rapidly developing islands, remains understudied. This study aimed to compare the frequencies of DNEs based on islands and evaluate the influences of different islands and frequency of direct nature experiences on biodiversity knowledge among children. The sample consisted of 429, 11-12-year-old public-school children from seven islands. Findings of this online survey questionnaire show that the frequency of visiting nature places and contact with animals was not significantly different, but the frequency of contact with plants as well as the overall frequency of experiences was significantly different among the islands. Children have a low level of biodiversity knowledge but are better at identifying animals than plants. Biodiversity knowledge scores were not significantly different among islands. Hence, island environments have a significant effect on DNE frequency but not on biodiversity knowledge. Increased frequency of nature experiences has a significant positive effect on biodiversity knowledge. This effect is more evident when the frequency is more than once a month. The study suggests that the frequency of DNEs is more influential in determining children's biodiversity knowledge than their place of residence. Hence, meaningful nature experiences must be facilitated to promote biodiversity knowledge.

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Introduction

Children in contemporary societies might be victims of a loss of direct nature experiences or DNEs (Chawla, 2020; Skar et al., 2016; Soga et al., 2020; Soga & Gaston, 2016). Global studies often associate this phenomenon with negative changes in the everyday lives of children dwelling in populous, urban cities dominated by modern lifestyles (Almeida et al., 2018; Charles & Wheeler, 2012; Freeman et al., 2018; Hand et al., 2018; Imai et al., 2018; Muslim et al., 2019; Skar et al., 2016; Soga et al., 2018; Zhang et al., 2014). Although efforts to understand the consequences of this loss span many disciplines, much of it is driven by their underlying psychological and health benefits (e.g., Chawla, 2015; Soga et al., 2021). Nonetheless recent, evidence-based recommendations to the Conference of the Parties to the Convention on Biological Diversity affirm a rising concern among scholars over the implications of a decline in DNEs on biodiversity conservation. The scholars not only agree that engaging people with nature underpin biodiversity conservation but also underscore the need to address the widening gap between humans and nature as an indirect force driving biodiversity loss. Thus, they emphasize the importance of increasing DNEs and experiential learning to foster nature connections since childhood as a driver towards maintaining thriving ecosystems (Convention on Biological Diversity, 2018).

Nature experiences in childhood are a good start to becoming knowledgeable about the contrasting aspects of biodiversity, its relevance in human lives, and the role of humans in maintaining biodiversity (Mohamed, 2012; Morón-Monge et al., 2021; Navarro-Perez & Tidball, 2011; Yli-Panula et al., 2018). Although specific age-dependent responses remain contested (Braun & Dierkes, 2017), nature experiences before 11 - 12 years of age generally produce more sustained effects than similar experiences later in life (Lieflander et al., 2013). However, as outcomes may be linked to baseline levels of perceptions of nature established during childhood (Papworth et al., 2009; Soga & Gaston, 2018), scholars caution that the diverse contexts surrounding experiences must be discerned when drawing conclusions (Adams & Savahl, 2015; Chawla, 2009; Collado et al., 2016).

There is a noted lack of consensus in the literature regarding conceptualizations of *nature* and *nature experiences* (Chawla, 2020; Gaston & Soga, 2020; Longbottom & Slaughter, 2016; Rosa & Collado, 2019), which hampers analyzing studies on nature experiences among children. In its broadest sense, DNEs involve actual physical contact (Kellert, 2005) or informal, firsthand interactions with plants and animals in one's everyday life (Longbottom & Slaughter, 2016) and may occur in various natural environments (Rosa & Collado, 2019). Rather than quantifying *nature*, researchers sometimes represent this construct in terms of where children live, such as *place of residence* (Collado et al., 2015; Duron-Ramos et al., 2020) or *residential environment* (Imai et al., 2018). Where a child resides often determines the types and frequency of nature experiences they have and, subsequently, their nature conceptualizations (Collado et al., 2016). The outcomes often depend on the context of experience (Adams et al., 2017; Adams & Savahl, 2015; Chawla, 2020; Collado et al., 2015).

The *frequency* of DNEs examines how often children engage with nature. In one study, the frequency, measured as the number of times Spanish children participated in nature-based activities, was shown to vary significantly depending on their place of residence, with children living in mountain ranges having the highest and those living in urban areas having the lowest frequency (Collado et al., 2015). Similarly, the frequency of Japanese children visiting and observing wildlife in nearby natural environments decreased with urbanization (Soga et al., 2018). Similar trends are reported in other studies (e.g., Almeida et al., 2018; Muslim et al., 2019; Zhang et al., 2014). However, Adams and Savahl (2015) found that safety concerns can have a pivotal influence on children's engagements with surrounding nature.

Literature supports that congested, urban cities can reduce opportunities for children to engage with nature due to a loss of physical access through city design (Kellert et al., 2017; Louv, 2005) or diminished quantity and quality (Kai et al., 2014; Shanahan et al., 2017; Soga et al., 2018; Zhang et al., 2014). Whilst children may engage in ample nature experiences within limits afforded by cities (Almeida et al., 2018; Freeman et al., 2018), the quality of these experiences may be compromised given the depletion of native biodiversity therein. This situation is well illustrated in South Western China, where the younger generation report an inability to experience the sights and sounds of native birds as a consequence of urbanization (Kai et al., 2014). Comparably, invasive species have already affected wildlife composition in some islands of the Maldives (Emerten et al., 2009). These altered natural surroundings would restrict meaningful engagements with nature voluntarily or through formal means including school-based activities. Furthermore, children may be restricted to nature experiences in domesticated or vicarious settings (Keith et al., 2021). Importantly, children could become oblivious to the continuous negative shifts in their natural environs. Such negative shifts, currently known as the shifting baseline syndrome (Soga & Gaston, 2018) among children have been reported as early as 1995 (Kahn & Friedman, 1995) but is an understudied, yet worrisome phenomenon.

Literature indicates that restrictions in everyday life, like increased parental supervision (Larson et al., 2011; Skar & Krogh, 2009; Skar et al., 2016) and constraints on time spent outdoors (Chawla, 2020; Cheng & Monroe, 2012; Freeman et al., 2018; Skar et al., 2016; Zhang et al., 2014), may determine children's use of the available nature. Another contributing factor is a loss of orientations towards experiencing nature, which may manifest through more tempting alternatives, particularly sedentary, digitally-mediated pastimes (Ballouard et al., 2011; Larson et al., 2011), although exceptions can apply (Soga et al., 2016). In addition, subjective interpretations of experiences (Adams & Savahl, 2015; Collado et al., 2015), including associations with fear and danger (Adams & Savahl, 2015) may impede future nature-seeking behavior (Adams & Savahl, 2015; Collado et al., 2016). Critics worry that current research does not factor in contextual dimensions and underscore the need to understand them to promote nature experiences among children (Adams & Savahl, 2015; Chawla, 2009; Rosa & Collado, 2019). Given these variations, the true barriers or drivers of nature experiences remain unpredictable.

A good knowledge of biodiversity is essential for its conservation (Genovart et al., 2013; Jiwa & Esa, 2015; Yli-Panula et al., 2018). However, being complex and multifaceted, it is challenging to define and operationalize this concept (van Weelie & Boersma, 2018). Thus, the literature cites several disparate indicators of biodiversity, including species identification knowledge (Albo et al., 2019; Almeida et al., 2018; Ballouard et al., 2011; Freeman et al., 2018; Genovart et al., 2013), morphology (Otto & Pensini, 2017; Villarroel et al., 2018) and the organism's environment (Paraskeva-Hadjichambi et al., 2012). Although knowledge alone may be insufficient to motivate pro-conservation action (Akintunde, 2017; Roczen et al., 2014), a thorough understanding can stimulate positive affective attitudes towards biodiversity. Furthermore, sound knowledge may correct misconceptions or negative perceptions (Albo et al., 2019; Duron-Ramos et al., 2020; Pam et al., 2021; Soga et al., 2020), which then can indirectly trigger positive conservation behavior.

Findings on the influences of DNEs on biodiversity knowledge are inconsistent. Whilst DNEs often improve biodiversity knowledge (Albo et al., 2019; Almeida et al., 2018; Cornelisse & Sagasta, 2018; White et al., 2018), sometimes they do not (Schlegel et al., 2015). Such discrepancies could be due to differences in the dimensions examined. Furthermore, indirect nature experiences, such as visits to zoos (Almeida et al., 2018) and vicarious experiences through media and books (Genovart et al., 2013), sometimes report a greater impact on knowledge than direct ones. Such effects, however, are marred by better knowledge of exotic species than locally abundant wildlife (Almeida et al., 2018; Genovart et al., 2013).

Scholars underscore the need to identify ways to enhance nature contact within everyday use urban areas (Chawla, 2015, 2020; Keith et al., 2021; Oke et al., 2021). Yet, facilitating them meaningfully would pose challenges amidst congested, human-imprinted environments. Meanwhile, with approximately two-thirds of the world's population predicted to become urbanites by 2050 (United Nations Department of Economic and Social Affairs Population Division, 2019) this situation can worsen for children in small towns and cities across the globe and particularly more so in tiny vulnerable islands like the Maldives. Given that a decline in DNEs among children often stems from urbanization and modernization (Almeida et al., 2018; Muslim et al., 2019; Soga et al., 2018; White et al., 2018; Zhang et al., 2014), the status and implications to conservation in the Maldives must be understood to mitigate emerging issues and prevent irreversible damage.

This study is underpinned by the modified Experiential Learning Theory (Morris, 2019) and the Model of Modes of Experiencing Nature and Modes of Learning in Childhood Development (Kellert, 2005). Both approaches support the contextual basis of experiences in learning and the philosophy of place-based education, which advocates hands-on, real-world learning experiences in the local community and the environment (Duffin & Perry, 2019; Flanagan et al., 2019). Furthermore, active experiential learning can shift children's learning roles from participatory to constructive ones (Feyzioğlu & Demirci, 2021). Thus, DNEs may create such shifts that help children understand the systemic and interrelated concepts of biology which can then positively work towards biodiversity conservation.

Limited available literature strongly indicates that present-day Maldivian children are deprived of DNEs (Mohamed, 2012; Mohamed et al., 2019) with subsequent erosion of local biodiversity knowledge. Nature knowledge is learned only through schoolbooks within the formal context of the national curriculum. In this structured setting, global knowledge takes precedence over local knowledge (Mohamed, 2012). Yet, experiential learning is emphasized in the national curriculum of the Maldives to inculcate pro-conservation knowledge from childhood (National Institute of Education, 2014). Without sufficient DNEs, children would not acquire the deep understanding of and attachment to nature that have hitherto guided sustainable use of its valuable biodiversity (Mohamed, 2012).

This study contributes to the general ongoing academic discourse on nature experiences among children, and in particular, to the scant literature on the influences of these experiences on biodiversity knowledge in various global contexts, especially on small, vulnerable islands. Specifically, this study helps towards filling a gap in the context of the Maldives, where baseline levels of DNEs and biodiversity knowledge among children are practically non-existent in published literature. Gaining insights into these baselines provides crucial information that can guide future actions toward sustainable conservation efforts in the country. This study aims to compare the frequencies of direct nature experiences based on island environments and evaluate the influences of island environments and the frequency of DNEs on biodiversity knowledge among 11–12-year-old Maldivian children.

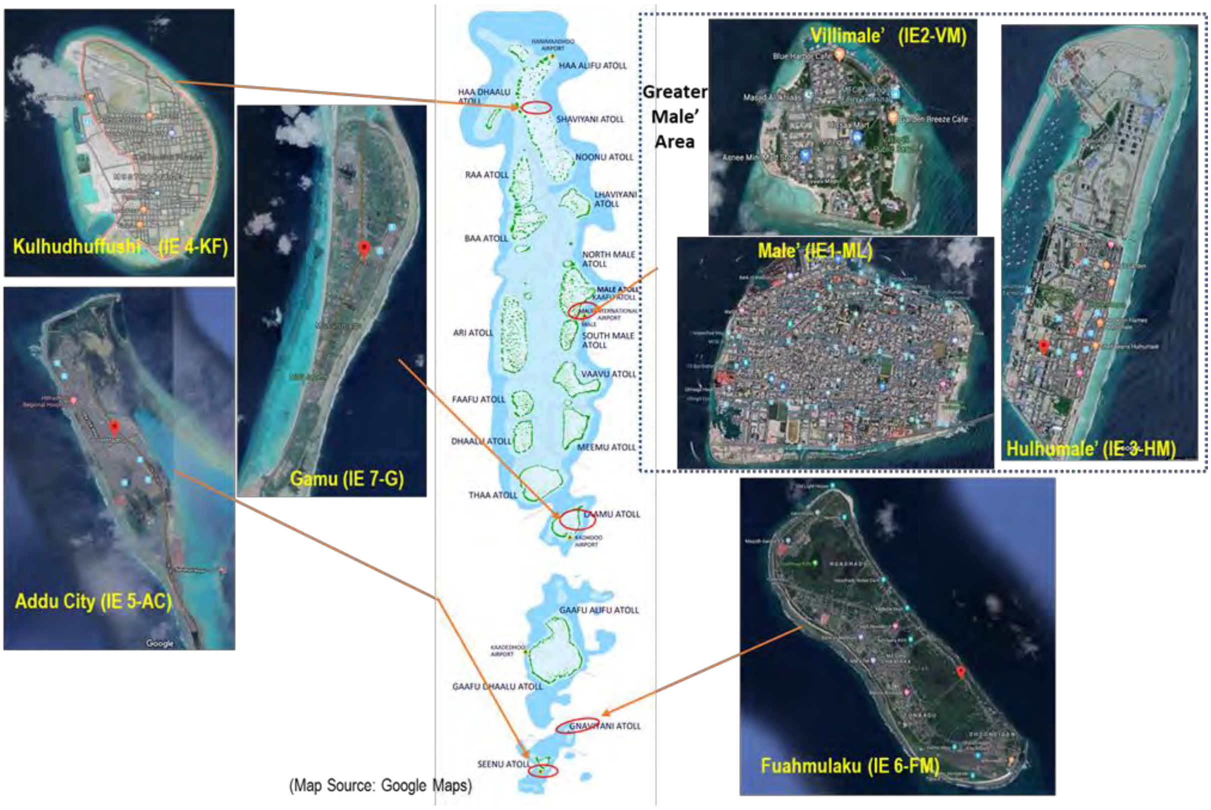
Methods

Participants and Study Locations

A total of 429 children comprised of 195 males (45.5%) and 234 females (54.5%), with an average age of 11.8 years belonging to seven distinct islandscapes (from now on referred to as Island Environments (IEs) or islands and shown in Figure 1) participated in the survey. The islands were categorized based on island area, population density (No/ha), level of infrastructure, and other developmental criteria and types of natural spaces that are unique to the islands and potentially available for nature experiences. The categories are Male' (IE1-ML), Villimale' (IE2-VM), Hulhumale' (IE3-HM), Kulhudhuffushi (IE4-KF), Addu City (IE5-AC), Fuvahmulah (IE6-FC) and Gamu (IE7-G) in order of decreasing population density and unique features. Of the IEs, three belong to the Greater Male' Area, which includes Male', the capital city (see Figure 1).

Figure 1

The Study Locations in the Maldives



Sampling

The sampling pool consisted of 2919 children from diverse social backgrounds attending grade six classes in the 26 public schools on the seven islands. Since the islands have vastly different numbers of children per site, a proportionate stratified random sampling method was applied to draw the samples with each island considered as one stratum. This method allows for a better representation of each stratum in the sample than simple random sampling (Cohen et al., 2018; Creswell & Plano Clark, 2018). The final sample analyzed consisted of 429 local Maldivian children, with approximately proportionate numbers in each stratum.

Data Collection Tool

A questionnaire was designed to address the topics: children's frequency of direct nature experiences and biodiversity knowledge. Each construct was assessed on different scales described below. These are parts of a larger questionnaire designed for a more in-depth study.

Frequency of Nature Experiences

The *frequency* of direct nature experiences (DNEs) measures how often children have contact with nature on their islands. To measure this variable, each child was asked three questions about their participation in nature-based activities: (1) *"How often do you* ***visit natural places*** *(e.g., beach, mangrove, wooded area, park)?"* (2) *"How often do you touch (or closely observe, pick flowers)* ***plants*** *in nearby natural places?"* (3) *"How often do you observe closely (or touch)* ***animals*** *(e.g., birds or insects) in nearby natural places?"*. These three activities are from now on referred to as (1) *frequency of visiting natural* *places*; (2) *frequency of contact with plants*, and (3) *frequency of contact with animals*, respectively. Their responses were scored on a four-point scale (0= *Never*, 1= *Less than once a month*, 2 = *At least one or more times every month*, 3 = *Almost every day*). The mean of the three activities indicates the overall frequency of DNEs and is represented by an *overall Experience Frequencies Score (EF Score)*. In addition, the mean EF score for each activity was also calculated. The influence of DNEs on variables was examined at these four levels. The scores for each level range from 0 to 3. The questions and scale are adapted from Soga et al. (2016, 2018) who established an internal consistency, Cronbach alpha = 0.67 for their scale. A similar scale by Collado et al. (2015) report an alpha value of 0.68. The internal consistency of the scale for the present study, with a Cronbach alpha coefficient of 0.52 is considered poor, but acceptable considering that it is a short scale of just three items. Being sensitive to the number of items, low scores of Cronbach alpha = 0.5 are common for short scales (of less than five items) (Pallant, 2016). The mean inter-item correlation for the items was .28 which lies within an optimal range of 0.2 to 0.4 (Briggs & Cheek, 1986 as cited in Pallant, 2016).

Biodiversity Knowledge

In this study, biodiversity knowledge refers to the species identification knowledge of local terrestrial plants and animals that children may encounter in their everyday surroundings (i.e., IEs). Of the plants, two are specialized for mangroves but are important for the biodiversity of the Maldives. To measure children's biodiversity knowledge, they were presented with 30 large color photographs of 20 animals and 10 plants chosen (Figure 2) as part of a questionnaire.

Figure 2

The 30 Species Used to Test Children's Biodiversity Knowledge

Note: (1) Caterpillar, (2) Frog, (3) Snail, (4) Butterfly, (5) Hermit Crab, (6) Crab, (7) Waterhen, (8) Lizard, (9) Spider, (10) Bat, (11) Gecko, (12) Wasp, (13) Centipede, (14) Dragonfly, (15) Earthworm, (16) Rhinoceros Beetle, (17) Bee, (18) Cotton Stainer Bug, (19) Grasshopper, (20) Tadpole, (21) Screw pine, (22) Mangrove, (23) Indian Almond, (24) Mangrove Apple, (25) Sea Hibiscus, (26) Jamaican Cherry, (27) Banyan Tree, (28) Ball nut Tree, (29) Sea Lettuce, (30) Breadfruit

A question was posted below each photograph asking children to name the species. Incorrect, mis- or non-identification was scored (0) and correct identifications (+1). The sum was expressed as a *Biodiversity Knowledge Score* which ranged from 0 to +30 per child for the 30 items. Color photographs have been used in earlier studies to examine nature contact and biodiversity knowledge studies (Almeida et al., 2018), affective attitudes, and willingness to conserve biodiversity (Soga et al., 2016). Since the scale is dichotomous, a Kuder Richardson 20 test, a general version of Cronbach alpha for the items was performed to determine reliability. The score for this test was 0.87. Therefore, the scale has a good internal consistency.

Validity and Reliability

Prior to administering the instrument, its' validity and reliability were established. Face validity examines whether an instrument appears to measure what it claims to measure (Cohen et al., 2018; Teddlie & Tashakkori, 2009). Two experts were provided with a rating tool and the instrument to assess the face value of the content, language, clarity, timing, appropriateness, and quality of images. Content validity assesses the degree to which an instrument truly measures the content it purports to measure in sufficient depth and breadth (Cohen et al., 2018; Teddlie & Tashakkori, 2009). Four independent experts in the field were provided with a rating tool and the instrument to assess the adequacy and appropriateness of the content, language, clarity, and timing. Overall, the instrument was considered a good tool to elicit the required information by the experts. The rating tools are provided in Appendix A. In addition, construct validity which determines whether an instrument truly measures the proposed hypothetical constructs (Cohen et al., 2018; Teddlie & Tashakkori, 2009) was established using the Kaiser-Myer-Olkin (KMO) test. The KMO test is an important way to determine construct validity (Massey, 2019). The tests confirmed that the scales used are adequate for Factor Analysis. Therefore, they are reliable sources of data that are valid and measure the intended concepts. Reliability is discussed in the preceding section.

Recruitment and Consent

Prior to data collection, mandatory permission by the Ministry of Education, participating schools, parents, and participants were secured using a formal protocol of the Maldives and Universiti Sains Malaysia.

Research Procedure

With the restriction of the prevailing COVID-19 pandemic situation, data were collected online using a Google survey questionnaire form with the help of teachers appointed by the participating school in each study site. Children were provided with a link to the questionnaire at a time and an online classroom platform, which invariably was Google Meet, chosen by the focal point. The teachers in charge and researchers were online (author one on video) to ensure as best as possible that the questionnaires were answered in a safe setting under reliable supervision, to explain the details of the survey, and attend to issues that may arise. The questionnaire was given in the English language only, but children were free to write in a local language, for example, when naming species. Before beginning the process, the researcher ensured that children understood the purpose and research context and assured their rights to confidentiality. No time limit was applied as many children faced network issues.

Data Analysis

Data were analyzed using IBM SPSS v26. Descriptive statistics were applied for each variable. Skewness and kurtosis, a Kolmogorov-Smirnov test as well as visual assessments of data distributions in a histogram and a Q-Q plot were done to determine the normality of the data. According to guidelines provided by authors (Cohen et al., 2018; Hair et al., 2014; Pallant, 2016; Tabachnick & Fidell, 2013), the EF scores and BK Scores were reasonably normally distributed.

One-way analysis of variance or one-way ANOVA tests were done to compare the frequencies of DNE measured as EF scores among the seven island environments (IE) with IE as the independent variable and the EF scores as the dependent variables. One-way ANOVA tests were also conducted to examine differences in the biodiversity knowledge measured by a Biodiversity Knowledge (BK) Scores (dependent variable), based on different IEs and frequency of DNEs (independent variables).

For frequencies of nature experiences, one-way ANOVA tests first evaluated the influence of frequency of *visiting natural places*, *contact with plants,* and *contact with animals* on BK Scores. In each test, participants in the sample (N = 429) were classified into four categories according to the frequency of experiences (i) Group 1: *never* (ii) Group 2: *less than once a month*; (iii) Group 3: *at least one or more times every month*; (iv) Group 4: *almost every day*. In this situation, the frequency of experiences was treated as a categorical variable. Multiple comparisons using Tukey post hoc HSD test were then done to determine where the actual differences lie. Following the post hoc tests, regrouping and recoding were done based on the number of cases and significance to obtain more meaningful results by doing a t-test. The four groups were collapsed into two groups: (i) Group 1, by combining the categories *never* and *less than once a month,* and (ii) Group 2 by combing the categories, *at least one or more times every month* and *almost every day*. After collapsing, Group 1 was categorized as *less than once a month* and Group 2 as *more than once every month*. Prior to the tests, conformity to the assumptions of the tests was determined using a Levene's test for homogeneity of variances and Levene's test for equality of variances for ANOVA and t-test respectively, using the cut-off point of $p > .05$. The effect size was estimated using eta squared.

A Pearson correlation was done to examine the relationship between frequencies of DNEs, measured by the EF Score and Biodiversity Knowledge (BK) Scores for the sample (N=429).

Findings

Differences in Frequencies of Direct Nature Experiences by Island Environments

A comparison of relative frequencies (RF) of visiting natural places, contact with plants, and contact with animals among seven islands is shown in Table 1.

Table 1

Relative Frequency (RF%) for Frequencies of Visiting Natural Places, Contact with Plants and Contact with Animals Among Seven Island Environments

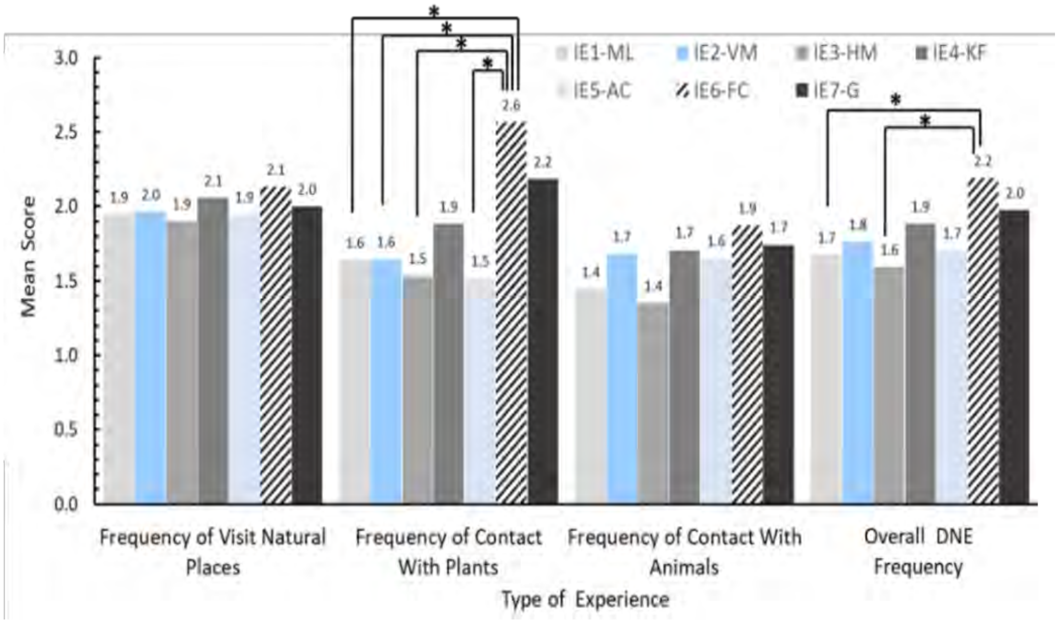
		Frequency of Visits to Natural Places				Frequency of Contact with Plants				Frequency of Contact with Animals			
Island	N	Never	Less than once a month	At least one or more times every month	Almost every day	Never	Less than once a month	At least one or more times every month	Almost every day	Never	Less than once a month	At least one or more times every month	Almost every day
IE1-Male'	203	1.0	23.6	55.2	20.2	16.3	28.6	30.0	25.1	27.6	25.6	21.7	25.1
IE2-Villimale'	28	0.0	28.6	46.4	25.0	21.4	21.4	28.6	28.6	17.9	32.1	14.3	35.7
IE3-Hulhumale'	60	1.7	23.3	58.3	16.7	23.3	25.0	26.7	25.0	28.3	28.3	23.3	20.0
IE4-Kulhudhuffushi	34	0.0	20.6	52.9	26.5	8.8	35.3	14.7	41.2	23.5	23.5	11.8	41.2
IE5-Addu City	54	1.9	22.2	55.6	20.4	27.8	18.5	27.8	25.9	22.2	18.5	31.5	27.8
IE6-Fuvahmlah	23	0.0	13.0	60.9	26.1	4.3	0.0	30.4	65.2	17.4	21.7	17.4	43.5
IE7-Gamu	27	3.7	22.2	44.4	29.6	11.1	14.8	18.5	55.6	18.5	22.2	25.9	33.3
Overall	429	1.2	22.8	54.5	21.4	17.5	24.5	27.3	30.8	24.9	24.9	21.9	28.2

As seen in Table 1, overall, 21.4% reported visiting natural places *every day.* Most (54.5%) children visit *at least one or more times every month*, with a range of 44.4%–60.9% among the seven islands. Overall, 1.2% of children reported *never* visiting natural places. This group includes children in Male', Hulhumale', Addu, and Gamu. The combined scores of visiting natural places *almost every day and more than once a month* exceed 70% for each island and 75% for the sample. Overall, most (30.8%) children reported contact with plants *every day*, with a range between 25.0% to 65.2% among the seven islands. Overall, 17.5% of children reported *never* contacting plants inclusive of children from all seven islands, with the highest (27.8%) reported by Addu. The combined score for contact with plants *almost every day and more than once a month* range from 51.7%-95.6% among islands and is 58.4% for the sample. Overall, most (28.2%) children reported contact with animals *every day* with a range between 20.0%-43.5% while 24.9%, reported *never* doing so. Children from all islands reported *never* contacting animals with a range of 17.4%-28.3%. The combined scores for contacting animals *almost every day* and *more than once a month* ranges from 43.3%-60.9% among islands and it is 50.1% for the sample. The highest frequencies for all three activities are found for Fuvahmulah: visit natural places *at least one or more times every month* (RF = 60.9%) and contact with plants (RF = 65.2%) and animals (RF = 43.5%) *almost every day*.

Results of the one-way ANOVA to determine significant differences in the frequencies of direct natures experiences based on island environments are presented in Table 2 and summarized in Figure 3.

Figure 3

Mean EF Scores for Visit to Natural Places, Frequency of Contact with Plants, Frequency of Contact with Animals, and Overall DNE Frequency by Island Environment



Note: Type. * < *p* .05. Error bars show 95% CI (SEM). IE1-ML (Male', N= 203), IE2-VM (Villimale', N= 28), IE3-HM (Hulhumale', N=60), IE4-KF (Kulhudhuffushi, N= 34), IE5-AC, (Addu City, N= 54), IE6-FC (Fuvahmulah, N= 23), IE7-G (Gamu, N=27).

Table 2

ANOVA Results for Differences in the EF Scores by Island Environments

Island	N	M	SD	SE	95% CI for Mean		F	df	Sig.	η²
					Lower	Upper				
Visits to Nature Places										
IE1-Male'	203	1.95	0.69	0.05	1.85	2.04	0.44	6, 422	.850	0.01
IE2-Villimale'	28	1.96	0.74	0.14	1.68	2.25				
IE3-Hulhumale'	60	1.90	0.68	0.09	1.72	2.08				
IE4-Kulhudhuffushi	34	2.06	0.69	0.12	1.82	2.30				
IE5-Addu City	54	1.94	0.71	0.10	1.75	2.14				
IE6-Fuvahmlah	23	2.13	0.63	0.13	1.86	2.40				
IE7-Gamu	27	2.00	0.83	0.16	1.67	2.33				
Total	429	1.96	0.70	0.03	1.90	2.03				
Contact with Plants										
IE1-Male'	203	1.64	1.03	0.07	1.50	1.78	4.30	6, 422	.000	0.06
IE2-Villimale'	28	1.64	1.13	0.21	1.21	2.08				
IE3-Hulhumale'	60	1.53	1.11	0.14	1.25	1.82				
IE4-Kulhudhuffushi	34	1.88	1.07	0.18	1.51	2.25				
IE5-Addu City	54	1.52	1.16	0.16	1.20	1.84				
IE6-Fuvahmlah	23	2.57	0.73	0.15	2.25	2.88				
IE7-Gamu	27	2.19	1.08	0.21	1.76	2.61				
Total	429	1.71	1.08	0.05	1.61	1.82				
Contact with Animals										
IE1-Male'	203	1.44	1.14	0.08	1.29	1.60	1.24	6, 422	.285	0.03
IE2-Villimale'	28	1.68	1.16	0.22	1.23	2.13				
IE3-Hulhumale'	60	1.35	1.10	0.14	1.07	1.64				
IE4-Kulhudhuffushi	34	1.71	1.24	0.21	1.27	2.14				
IE5-Addu City	54	1.65	1.12	0.15	1.34	1.95				
IE6-Fuvahmlah	23	1.87	1.18	0.25	1.36	2.38				
IE7-Gamu	27	1.74	1.13	0.22	1.29	2.19				
Total	429	1.53	1.15	0.06	1.43	1.64				
Overall Experience Frequency Score										
IE1-Male'	203	1.68	0.67	0.05	1.58	1.77	3.05	6, 422	.006	0.04
IE2-Villimale'	28	1.76	0.77	0.15	1.46	2.06				
IE3-Hulhumale'	60	1.59	0.65	0.08	1.43	1.76				
IE4-Kulhudhuffushi	34	1.88	0.78	0.13	1.61	2.15				
IE5-Addu City	54	1.70	0.77	0.11	1.49	1.91				
IE6-Fuvahmlah	23	2.19	0.67	0.14	1.90	2.48				
IE7-Gamu	27	1.98	0.75	0.14	1.68	2.27				
Total	429	1.74	0.71	0.03	1.67	1.80				

As seen from Table 2, EF score of DNEs for all three measures, visits to natural places (M = 2.13, SD = 0.63), contact with plants (M = 2.57, SD = 0.73) and contact with animals (M = 1.87, SD = 1.18) was highest for Fuvahmulah. The EF score of visits (M = 1.90, SD = 0.68) and contact with animals (M = 1.35, SD = 1.10) is the lowest for Hulhumale'. For contact with plants, the EF score is lowest for Addu City (M = 1.52, SD = 1.16). The *overall* EF Score is highest (M = 2.19, SD =0.67) for Fuvahmulah, followed by Gamu, Kulhudhuffushi, Villimale', Addu City, Male', and lowest (M = 1.59, SD = 0.65) for Hulhumale' (see Table 2, Figure 3).

ANOVA tests revealed no significant differences at the $p < .05$ level in EF scores for visit: F (6, 422) = 0.44, p = .850 or contact with animals: F (6, 422) = 1.24, p = .285 among the islands. A statistically significant difference was found at the $p < .05$ level in EF scores for contact with plants: F (6, 422) = 4.30, p = .000. The actual difference in EF scores between the groups was medium as indicated by the effect size (η^2 = .06). Post-hoc comparisons indicated that the EF score for Fuvahmulah (M = 2.57, SD = 0.73) was significantly different from Male' (M = 1.64, SD = 1.03), Villimale' (M = 1.64, SD = 1.13), Hulhumale' (*M* = 1.53, *SD* = 1.11) and Addu (*M* = 1.52, *SD* = 1.16). Gamu (*M* = 2.19, *SD* = 1.08), and Kulhudhuffushi (*M* = 1.88, *SD* = 1.07) did not differ significantly from any other group (see Table 2, Figure 3).

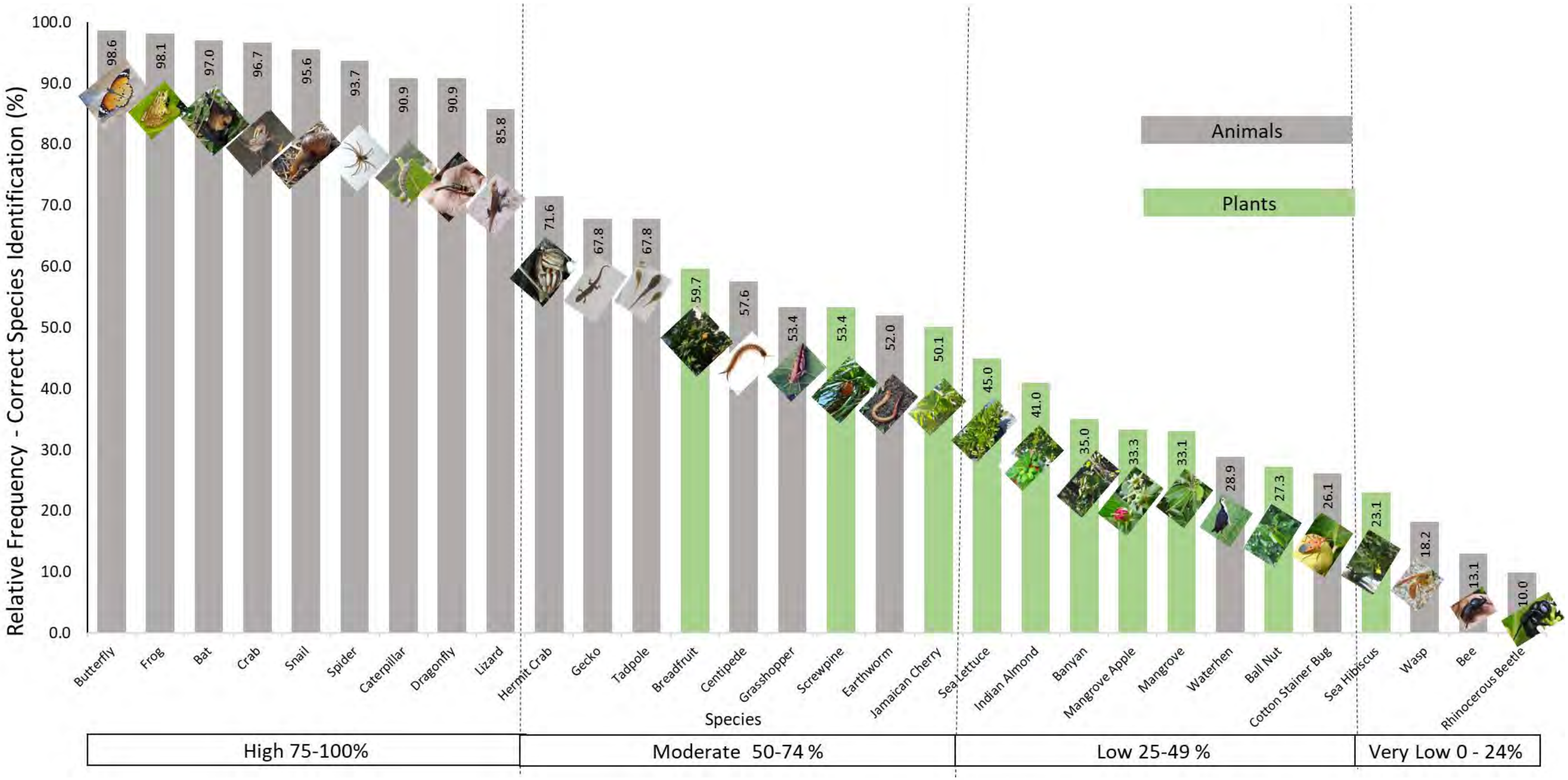
The one-way ANOVA showed a statistically significant difference at the $p < .05$ level in the *overall* EF Score among the seven islands: F (6, 422) = 3.045, $p = .006$ although, the actual difference in mean scores was only close to medium as indicated by the effect size ($\eta^2 = .04$). Post-hoc comparisons using the Tukey HSD test showed that the EF score for Fuvahmulah (*M* = 2.19, *SD* = 0.67) was significantly different from Male' (*M* = 1.68, *SD* = 0.67) and Hulhumale' (*M* = 1.59, *SD* = 0.65). No significant differences were found among other islands (Table 2, Figure 3).

Levels of Biodiversity Knowledge

The sum of correct identifications for 30 species was counted for the sample (N=429). Based on the proportion of children able to correctly identify species, the relative frequencies (RF) of correct identifications for each species were then categorized and ranked into four levels, namely, high (between 75-100%), moderate (between 50-74%), low (between 25-49) and very low (between 0-24%) to compare levels of biodiversity knowledge (BK) for species identification. The levels of identification are shown in Figure 4.

Figure 4

Ranking of Relative Frequencies of Correct Identification of Species



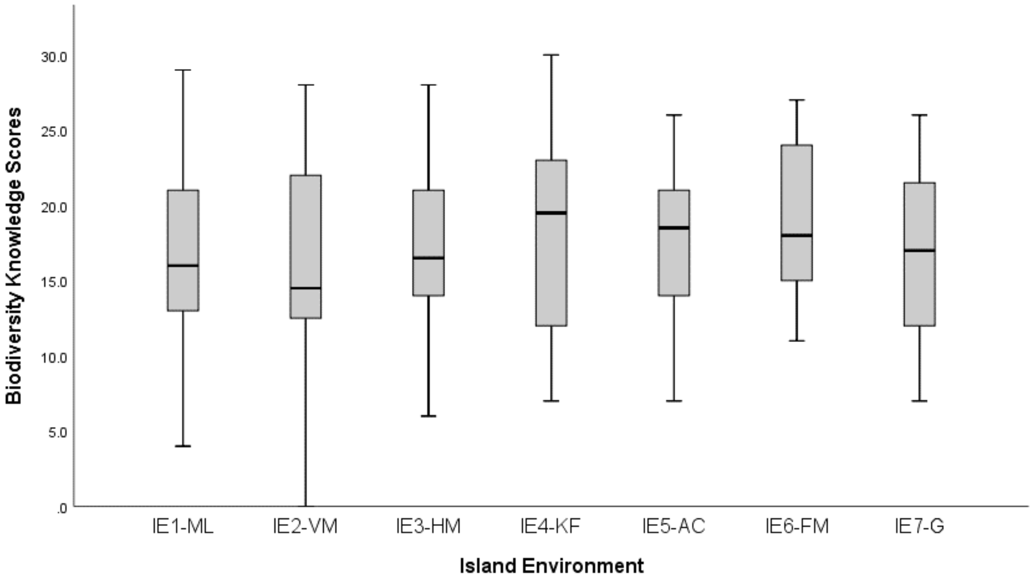
Across the seven islands, children showed high levels of BK (> 85%) for only 9 out of 20 animal species (in decreasing order of RF: butterfly, frog, bat, crab, snail, spider, caterpillar, dragonfly, and lizard) with the highest level shown for butterfly (RF = 98.6%) and the lowest for lizard (85.8%) in this category. This category did not contain any plants. Children showed moderate levels of BK for 5 animals (RF in decreasing order: hermit crab, house gecko, tadpole, centipede, grasshopper, earthworm) and three species of plants (breadfruit > screw pine > Jamaican cherry). Low levels were reported for two animals (waterhen > cotton stainer bug). Out of ten plant species, children showed low levels of BK for six plants (RF: sea lettuce > Indian almond > banyan, mangrove apple > mangrove > ball nut). Very low levels were shown for three species of animals (Wasp > Bee > Rhinoceros beetle) and for one plant species (Sea hibiscus). Overall, of the 20 animals evaluated, the highest RF was obtained for the butterfly (98.6%) and the lowest for the rhinoceros beetle (10.0). For the ten plants evaluated, the highest Rf was for the breadfruit tree (59.7%) and the lowest for the sea hibiscus (23.1%) (see Figure 4).

Variations in Biodiversity Knowledge by Island Environments

The variations in Biodiversity Knowledge Scores are presented in Figure 5.

Figure 5

Comparison of the Biodiversity Knowledge Scores Among Seven Island Environments



Note: The black horizontal bars represent the median, and the ends of the boxes represent the first and the third interquartile range. The ends of whiskers represent the lowest and highest values. IE1-ML (Male', *N* = 203), IE2-VM (Villimale', *N* = 28), IE3-HM (Hulhumale', *N* =60), IE4-KF (Kulhudhuffushi, *N* = 34), IE5-AC, (Addu City, *N* = 54), IE6-FC (Fuvahmulah, *N* = 23), IE7-G (Gamu, *N* = 27).

As seen in Figure 5, the BK Score is most varied for Villimale' (range = 28) and least for Fuvahmulah (range = 16). Median values were different for all islands with the highest for Kulhudhuffushi (*Md* = 19.5) and the lowest for Villimale' (*Md* = 14.5). The interquartile ranges are also varied with the lowest range (*IQ* = 7.0) for Hulhumale' and Addu and the highest for Kulhudhuffushi (*IQ* = 11.25).

The results of the one-way ANOVA as presented in Table 3 show no statistically significant differences at the $p < .05$ in Biodiversity Knowledge Scores (BK Scores) among the seven islands: F (6, 422) = 1.12, p = .248. The effect size was small (η^2 = .02). The highest BK Score was reported for

Fuvahmulah (*M* = 19.04, *SD* = 5.09) and lowest for Male' City Villimale' (*M* =16.14, *SD* = 6.91), Male' (*M* = 16.8, *SD* = 5.5) and Gamu (*M* = 16.78, *SD* = 5.51).

Table 3

ANOVA Results for Biodiversity Knowledge by Island Environments

Island	N	M	SD	SE	95% CL for Mean		F	df	Sig.	η²
					Lower	Upper				
IE1-Male'	203	16.75	5.52	0.39	15.99	17.51	1.12	6, 422	.248	0.02
IE2-Villimale'	28	16.14	6.91	1.30	13.47	18.82				
IE3-Hulhumale'	60	17.28	5.57	0.72	15.85	18.72				
IE4-Kulhudhuffushi	34	18.29	6.46	1.11	16.04	20.55				
IE5-Addu City	54	17.67	4.29	0.58	16.50	18.84				
IE6-Fuvahmlah	23	19.04	5.09	1.06	16.84	21.25				
IE7-Gamu	27	16.78	5.51	1.06	14.60	18.96				
Total	429	17.15	5.55	0.27	16.62	17.67				

Differences in Biodiversity Knowledge by Frequency Nature Experiences

The following sections describe the results of ANOVA and t-tests to examine differences in biodiversity knowledge based on the frequency of direct nature experiences.

Differences in Biodiversity Knowledge by Frequency of Visiting Natural Places

Results of the ANOVA test to explore the influence of *frequency of visiting natural places* on BK Scores given in Table 4 show a statistically significant difference at the $p < .05$ level in BK Score for the four groups: F (3, 425) = 4.24, $p = .006$. The actual difference was small as indicated by the effect size ($\eta^2 = .03$). Post-hoc comparisons using the Tukey HSD test revealed that the mean BK Score for Group 2 (*less than once a month*) (*M* = 15.52, *SD* = 5.75) was significantly different from Group 3, (*At least one or more times every month*) (*M* = 17.81, *SD* = 5.25). Group 1 (*Never*) (*M* = 19.2, *SD* = 5.75) and Group 4 (Almost every day) (*M* = 17.09, *SD* = 5.78) did not differ significantly from any other group.

Table 4

Results of ANOVA for BK Scores by Frequency of Visiting Natural Places

Group	Frequency of Visits to Natural Places	N	M	SD	SE	95% CI for Mean		F	df	Sig.	η²
						Lower	Upper				
1	Never	5	19.20	5.76	2.58	12.05	26.35	4.24	3, 425	.006	0.03
2	Less than once a month	98	15.52	5.75	0.58	14.37	16.67				
3	At least one or more times every month	234	17.81	5.25	0.34	17.13	18.48				
4	Almost every day	92	17.09	5.77	0.60	15.89	18.28				
	Total	429	17.15	5.55	0.27	16.62	17.67				

After regrouping following ANOVA, a Levene's Test for Equal variances (at $p > .05$) demonstrated that the assumption of equal variance of scores for the two new groups, Group 1: *less than once a month* (*N* = 103) and Group 2: *more than once every month* (*N* = 326) is not violated (p =.56). An independent-samples t-test to compare the BK Scores for the two new groups shows a significant difference in scores for Group 1 (*M* = 15.70, *SD* = 5.77) and Group 2 (*M* = 17.60, *SD* = 5.41; t (427) = -3.067, $p = .002$, two-tailed). The magnitude of the differences in the means was small ($\eta^2 = .02$) (Table 5).

Table 5

T-Test Results for BK Scores Frequency of Visit to Natural Places

Group	Frequency of Visits to Natural Places	N	M	SD	SE	95% CI for Mean		t	df	Sig.	η²
						Lower	Upper				
Group 1	Less than once a month	103	15.70	5.77	0.57	14.57	16.83	-3.067	427	.002	0.02
Group 2	More than once every month	326	17.02	5.41	0.30	17.02	18.19				

Differences in Biodiversity Knowledge by Frequency of Contact with Plants

Results of the one-way ANOVA to explore the impact of *Frequency of contact with plants*, on the BK Score, as presented in Table 6, show a statistically significant difference at the $p < .05$ level in BK scores for the four groups: F (3, 425) = 2.955 p = .032. The actual difference in mean scores was small as indicated by the effect size (η^2 =.02). Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Group 1: *never* (M = 15.59, SD = 5.68) was significantly different from Group 4: *almost every day* (M = 17.83, SD = 5.51). Group 2 (M = 16.93, SD = 5.56) and Group 3 (M = 17.57, SD = 5.36) did not differ significantly from any other group.

Table 6

Results for ANOVA for BK Scores by Frequency of Contact with Plants

Group	Frequency of Contact with Plants	N	M	SD	SE	95% CI for Mean		F	df	Sig.	η²
						Lower	Upper				
1	Never	75	15.59	5.68	0.66	14.28	16.89	2.96	3, 425	.032	0.02
2	Less than once a month	105	16.93	5.56	0.54	15.86	18.01				
3	At least one or more times every month	117	17.57	5.36	0.50	16.59	18.55				
4	Almost every day	132	17.83	5.51	0.48	16.88	18.77				
	Total	429	15.59	5.68	0.66	14.28	16.89	2.96			

After regrouping was done as before, a Levene's Test for Equal variances (at $p > .05$) demonstrated that the assumption of equal variance of scores for the two new groups, Group 1: *less than once a month* (N=180) and Group 2: *more than once every month* (N = 249) is not violated (p =.67). An independent-samples t-test conducted to compare the mean BK knowledge scores for the two new groups shows a significant difference in scores for Group 1 (M = 16.37, SD = 5.63) and Group 2 (M = 17.07, SD = 5.43; t (427) = -2.473, p = .014, two-tailed). The magnitude of the differences in the means was small (η2= .01) (Table 7).

Table 7

T-Test Results for BK Scores by Frequency of Contact with Plants

Group	Frequency of Contact with Plants	N	M	SD	SE	95% CI for Mean		t	df	Sig.	η²
						Lower	Upper				
1	Less than once a month	180	16.37	5.63	0.42	15.54	17.20	-2.473	427	0.014	0.01
2	More than once every month	249	17.71	5.43	0.34	17.02	18.38				

Differences in Biodiversity Knowledge by Frequency of Contact with Animals

The one-way ANOVA to explore the impact of frequency of contact with animals, on BK Scores, as shown in Table 8, demonstrated a statistically significant difference at the $p < .05$ level in BK scores for the four groups: F (3, 425) = 3.639 p = .013. The actual difference in mean scores was small as indicated by the effect size (η^2 =.03). Post-hoc comparisons indicated that the mean score for Group 1 (*never*) (M = 16.36, SD = 5.32) was significantly different from Group 4 (*almost every day*) (M = 18.52, SD = 5.6). Group 2 (M = 16.90, SD = 5.61) and Group 3 (M = 16.57, SD = 5.4) did not differ significantly from any other group.

Table 8

ANOVA Test Results for BK Score by Frequency of Contact with Animals

Group	Frequency of Contact with Animals	N	M	SD	SE	95% CI for Mean		F	df	Sig.	η²
						Lower	Upper				
1	Never	107	16.36	5.32	0.51	15.34	17.37	3.64	3, 425	.013	0.03
2	Less than once a month	107	16.90	5.61	0.54	15.82	17.97				
3	At least one or more times every month	94	16.57	5.44	0.56	15.46	17.69				
4	Almost every day	121	18.51	5.61	0.51	17.50	19.52				
	Total	429	17.15	5.55	0.27	16.62	17.67				

As before, a Levene's Test for Equal variances (at $p > .05$) done after regrouping, demonstrated that the assumption of equal variance of scores for the two new groups, Group 1: *less than once a month* (N = 214) and Group 2: *more than once every month* (N = 215) is not violated (p =.16). An independent-samples t-test conducted to compare the mean biodiversity knowledge scores for the two new groups demonstrate a significant difference in scores for Group 1 (*less than once a month*) (M = 16.63, SD = 5.46) and Group 2 (*more than once every month*) (M = 17.67, SD = 5.61; t (427) = -1.945, p = .050, two-tailed). The magnitude of the differences in the means was very small (η^2 = .01) (see Table 9).

Table 9

T-test Results for BK Score by Frequency of Contact with Animals

Group	Frequency of Contact with animals	N	M	SD	SE	95% CI for Mean		t	df	Sig.	η²
						Lower	Upper				
1	less than once a month	214	16.63	5.46	0.37	15.89	17.36	-1.945	427	.050	0.01
2	more than once every month	215	17.67	5.60	0.38	16.91	18.42				

Relationship Between Experience Frequency Score and Biodiversity Knowledge

The relationship between the mean frequency of Direct Nature Experiences (EF Score) and Biodiversity Knowledge (Biodiversity Knowledge Scores) was analyzed using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. Results show a significant positive correlation between the two variables, r = –.166, N = 429, at $p < .01$, (p = 0.001) with high levels of frequency of EF scores associated with higher Biodiversity Knowledge Scores.

Discussion

This study aimed to compare the frequencies of direct nature experiences (DNEs) based on island environments and evaluate the influences of island environments and frequency of DNEs on biodiversity knowledge among children. The study showed that except in Fuvahmulah, children's visit to nature places generally occurs at higher frequencies than either contact with plants or animals. ANOVA tests confirm differences only for contact with plants and the overall DNE frequency. Post hoc tests showed that children from Fuvahmulah had contact with plants at a significantly higher frequency than Villimale', Male', Hulhumale' and Addu and their overall experience score was also significantly higher than children in Male' and Hulhumale'. These findings are in line with the studies that demonstrate that children's frequency of DNEs depends on where the child lived (Almeida et al., 2018; Collado et al., 2015; Muslim et al., 2019; Mustapa et al., 2018; Soga et al., 2018) represented by the islands in this study.

Previous studies show that children's opportunities to engage with nature (Almeida et al., 2018; Kai et al., 2014; Soga et al., 2018; Zhang et al., 2014) and independence of movement (Muslim et al., 2019) generally decline with urbanization. Such evidence suggests that the higher frequency of DNEs in Fuvahmulah may be attributed to better opportunities afforded by its unique landscape, being the only island that is also an entire atoll with lush indigenous biodiversity. Additionally, its lower urbanization may offer greater opportunities and less constraints for independent nature explorations. In contrast, Male', Hulhumale' and Villimale' (districts of the capital, Male' City) are densely populated with far less indigenous natural places and vegetation. Hulhumale' is an entirely artificial island with substantial alien biodiversity. Hence, opportunities can be expected to be lower and constraints higher in these more urbanized islands.

In contrast to the findings that establish a decrease in frequency with the degree of urbanization (Soga et al., 2018; Zhang et al., 2014), in this study, the observed differences did not follow the expected trend from the highest for Gamu and to the lowest for Male' based on the criteria discussed in the methods section. One reason may be the difference in criteria for categorizing locations among studies. It must be noted that while it is preferable to create gradients of nature continuum (Gundersen et al., 2016), biodiversity (Freeman et al., 2018), or tree cover (Shanahan et al., 2017), such information is lacking in published literature in the context of the Maldives. To estimate such parameters would be beyond the scope of this study.

Findings demonstrated that overall, children had low levels of species identification knowledge although they were better at identifying animals than plants. High identification levels were found for only nine out of twenty animals, namely butterfly, frog, bat, crab, snail, spider, caterpillar, dragonfly, and lizard. The findings suggest that in general children have poor knowledge of plants. Quite notably, the lowest identification is for the sea hibiscus, which is ubiquitous in all neighborhoods. Also, lower than expected levels were found for sea lettuce, Indian almonds, banyan, and ball nut commonly found on roads, around schools, and in neighborhoods except for Hulhumale' where they are confined mostly to beach areas. Although children in Fuvahmulah demonstrated the highest biodiversity knowledge and the least variation in scores compared to other islands, no significant differences in biodiversity knowledge based on islands were found. These findings suggest that merely being surrounded by nature may not be enough to contribute to knowledge. The results are consistent with those of Schlegel et al. (2015), who could not establish significant differences in species identification knowledge among children based on where they lived. In contrast to this study, differences in identification knowledge based on location have been demonstrated, although, unlike the current work, these studies focused on the identification of invertebrates (Cornelisse & Sagasta, 2018) or plants (Villarroel et al., 2018). Like the present findings, children in other countries have also been found to have little knowledge about local animal species (e.g., Pam et al., 2021).

In general, this study demonstrates a positive influence of increased frequency of DNEs and biodiversity knowledge. More specifically, increased frequency of visiting nature places, contact with plants, and contact with animals has a significant positive effect on biodiversity knowledge. Hence, this study broadly reflects the works of others that demonstrate the positive effects of increased DNEs of various forms on biodiversity knowledge (Albo et al., 2019; Almeida et al., 2018; Barthel et al., 2018; Cornelisse & Sagasta, 2018; Otto & Pensini, 2017; White et al., 2018). In particular, the results are consistent with those which show positive influences of regular DNEs on species identification knowledge (Albo et al., 2019; Almeida et al., 2018; Cornelisse & Sagasta, 2018; Villarroel et al., 2018). Furthermore, post hoc and *t*-tests confirm that experiencing contact with nature more than once a month results in significantly greater biodiversity knowledge scores. These results, combined with the lack of significant differences in biodiversity knowledge based on islands suggest that the frequency of DNEs is more influential in determining biodiversity knowledge than where a child lives. Unlike many studies that depend on assumptions that rural children have greater contact than urban counterparts (Cornelisse & Sagasta, 2018; Duron-Ramos et al., 2020), the present study adds a quantitative element to the expression of frequency of contact with nature in terms of how often children engage with it to achieve positive effects. The latter, while understudied, can have implications when strategizing ways to facilitate meaningful nature experiences for children within the limits of where they live.

There are several limitations to this study. Most importantly, data were collected in the midst of the COVID-19 pandemic which had movement restrictions among the islands. Being limited to self-reports and the prevailing circumstances, recall bias is plausible. Also, the low reliability of the DNE scale may have limited measuring subtle differences in experiences. One reason for the higher frequency of visits may be partly due to the lack of distinction between nature places. It is customary for children in the Maldives to visit beaches frequently hence they may have reported higher levels for this category. The study focused only on species identification although biodiversity knowledge embodies multiple dimensions. Children may also gain knowledge in more ways than through DNEs that may not be accounted for in this study. Despite limitations, the study undoubtedly gives valid insight into DNEs and biodiversity knowledge among Maldivian children where scant information of this kind exists in published literature. More in-depth studies are needed to quantify the categorization of IEs and determine the true accessibility of natural places, drivers, and barriers to DNEs among Maldivian children.

Conclusion and Implications

This study highlights that the place where a child lives, specifically, island environments, significantly influences the frequency of DNEs but not biodiversity knowledge. However, the frequency of DNEs exerts a significant influence on biodiversity knowledge. Species identification knowledge is generally low among children, especially for locally abundant plants and some common native animals raising cause for concern. The causes must be identified and rectified. IEs may have specific, contextually-dependent factors that exert indirect effects on knowledge. For instance, it is quite common for adults to accompany children on their excursions, particularly in the capital city, due to safety and other societal concerns, thus restricting free-choice explorations. Parental involvement as a primary deterrent to nature experiences has been reported in other countries including the United States (Larson et al., 2011), China (Zhang et al., 2014), Australia (Laird et al., 2014), Norway (Skar et al., 2016), New Zealand (Freeman et al., 2018). Being on a scheduled lifestyle dictated by adults may be a barrier in the Maldives. These factors need to be investigated to determine nuanced differences in the frequency of DNEs to strategize optimal experiences. The findings underscore the importance of facilitating DNEs as a necessary tool to promote biodiversity knowledge. In the cultural contexts and constraints of the expanding cities of the Maldives, it is necessary to find ways that schools, parents, and organized bodies can contribute to these experiences in safe spaces. Scholars emphasize the increasingly central role of cities as significant contributors to curbing the biodiversity crisis in innumerable ways, including biodiversity stewardship, planning, restoration, integration of nature and culture, and providing accessible nature (Oke et al., 2021).

Despite the undeniable significance of DNEs on biodiversity knowledge, one must acknowledge that today's children are growing up in a world where their experiences and interests are increasingly shaped by technology (Truong & Clayton, 2020). Meanwhile, vicarious experiences can influence biodiversity knowledge (Genovart et al., 2013), and complement hands-on activities with virtual realities (Çelik et al., 2020; Ishak et al., 2021; Sarioğlu & Girgin, 2020; Yildiz et al., 2018) result in active learning of biological concepts. Hence, interactive technology-based pedagogical methods that augment DNEs may be particularly useful in situations like that in the Maldives, which pose tremendous challenges to facilitating routine DNEs for children in many islands due to urbanization and the loss of indigenous biodiversity. Although, exploring ways in which the virtual world could complement DNEs and lure people's interests toward seeking real-world nature experiences and supporting conservation may be necessary in current times (Truong & Clayton, 2020), the emphasis on meaningful DNEs cannot be overstated. However, to obtain a clearer picture of how children may be associated with biodiversity conservation, other variables such as attitudes towards biodiversity and conservation need to be investigated as well.

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