

Children's Perceptions of Rainforest Biodiversity: Which Animals Have the Lion's Share of Environmental Awareness?

Jake L. Snaddon¹✉, Edgar C. Turner^{1,2}✉*, William A. Foster¹

1 Department of Zoology, University of Cambridge, Cambridge, Cambridgeshire, United Kingdom, **2** Bedfordshire, Cambridgeshire, Northamptonshire and Peterborough Wildlife Trusts, Bedford, Bedfordshire, United Kingdom

Abstract

Globally, natural ecosystems are being lost to agricultural land at an unprecedented rate. This land-use often results in significant reductions in abundance and diversity of the flora and fauna as well as alterations in their composition. Despite this, there is little public perception of which taxa are most important in terms of their total biomass, biodiversity or the ecosystem services they perform. Such awareness is important for conservation, as without appreciation of their value and conservation status, species are unlikely to receive adequate conservation protection. We investigated children's perceptions of rainforest biodiversity by asking primary-age children, visiting the University Museum of Zoology, Cambridge to draw their *ideal rainforest*. By recording the frequency at which children drew different climatic, structural, vegetative and faunal components of the rainforest, we were able to quantify children's understanding of a rainforest environment. We investigated children's perceptions of rainforest biodiversity by comparing the relative numbers of the taxa drawn with the actual contributions made by these taxa to total rainforest biomass and global biodiversity. We found that children have a sophisticated view of the rainforest, incorporating many habitat features and a diverse range of animals. However, some taxa were over-represented (particularly mammals, birds and reptiles) and others under-represented (particularly insects and annelids) relative to their contribution to total biomass and species richness. Scientists and naturalists must continue to emphasise the diversity and functional importance of lesser-known taxa through public communication and outdoor events to aid invertebrate conservation and to ensure that future generations are inspired to become naturalists themselves.

Citation: Snaddon JL, Turner EC, Foster WA (2008) Children's Perceptions of Rainforest Biodiversity: Which Animals Have the Lion's Share of Environmental Awareness? PLoS ONE 3(7): e2579. doi:10.1371/journal.pone.0002579

Editor: Brendan John Godley, University of Exeter, United Kingdom

Received: March 4, 2008; **Accepted:** June 3, 2008; **Published:** July 2, 2008

Copyright: © 2008 Snaddon et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: The authors have no support or funding to report.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: ect23@cam.ac.uk

✉ These authors contributed equally to this work.

Introduction

Natural ecosystems are being converted to agricultural land at an unprecedented rate worldwide [1]. Such devastating loss of habitat has resulted in significant declines in many species and the realisation that the planet is in the midst of an extinction crisis [2,3]. Despite this, there is little public awareness of global biodiversity, with emphasis from the media and conservation organisations focussing on larger taxa such as mammals and birds [3]. In reality, however, the majority of animal species are insects [4] and it is these that carry out the lion's share of ecosystem services [5,6]. Globally, there are estimated to be between 2.5 and 10 million species of insect (approximately 925,000 have been formally named), and despite their small individual size, insects make up the majority of the animal abundance and biomass within ecosystems [7]. Crucial ecosystem functions performed by insects include pollination, decomposition, and biological control, and they are also an important food source for other taxa [4]. Such services are not only important for the healthy functioning of ecosystems, but can also provide significant economic benefits [8]. For example, pollination in agricultural systems worldwide has been calculated to be worth 200 billion US dollars a year [9].

Raising public interest in the conservation of less-publicised taxa is important [10], as without awareness of their disappearance the public is unlikely to donate money to their conservation or governments to grant them conservation protection. Perhaps nowhere is this awareness more important than in reference to tropical rainforests. In recent decades large areas of rainforest have been felled and fragmented [11]. Although forest fragments and logged forests may lose a good deal of their mammal and bird species, such areas can still be important reserves for insects and smaller taxa and should therefore be protected (e.g. Dumbrell & Hill [12]).

In recent years there has been increasing concern over the *extinction of experience* [13,14]. Coined by Robert Pyle [15], the term depicts a cycle of degradation, where the world's population is increasingly living in human dominated-landscapes, which are expanding at the cost of biodiversity and the natural environment. This leads to people becoming increasingly disconnected from nature, unaware of its importance for ecological processes and apathetic about its value. Analogous with the *shifting baseline syndrome* [16], past experiences of the state of the environment determine peoples expectations of natural environmental conditions. Childhood experiences are the major influential factor that form preferences and perceptions later in life [17,18].

Children's perceptions of animals and the natural environment can be diverse, although their ideas are based around isolated facts and misconceptions are common [19–28]. Forest habitats and definitions of the environment are usually characterised as *wild places* and a *habitat for animals* [20,22,25]. Children also express awareness that humans are part of the environment and that human activities can be detrimental to the natural world [22,25]. The environment in which children live can influence their perceptions. Children living in more rural landscapes have a better understanding of the environment and knowledge of animals and plants [20,26]. Familiarity and aesthetics are important factors governing children's connections with animals [19,29], exemplified by the popularity of mammals and birds [20,28]. Of all animals, invertebrates are least understood, with groups such as spiders and centipedes frequently being classified with insects under the general term of *bugs* [19–21,23,24,27].

In this paper we investigate UK children's perceptions of the biodiversity and ecology of rainforest environments. We evaluate children's perceptions by assessing their drawings of rainforests. We find distinct preferences in the taxa drawn and discuss our results with specific reference to the ages of the children, and to the relative contribution of different taxa drawn to animal biomass in a rainforest and global biodiversity.

Methods

Data were collected in conjunction with a public event '*Forest*' at the University Museum of Zoology, Cambridge, run in association with the Bedfordshire, Cambridgeshire, Northamptonshire and Peterborough Wildlife Trust. The aim of this event, which took place between the 23rd of June and the 11th of August 2007, was to highlight the global importance of forests to biodiversity and people and consisted of a photographic exhibition, a series of talks, and a family event on the 14th of July. *Forest* activities were predominantly attended by people living in and around the Cambridge area. 167 children attending *Forest* volunteered to take part in a drawing competition with the instruction to "draw your ideal rainforest". Entries represented children of both sexes and from a range of primary ages (Table 1). Children taking part in the study can be supposed to be those who are already interested in nature as they were attending the *Forest* event, and therefore would be likely to have a high degree of awareness of natural environments.

The authors inspected the entries received and recorded the number of times different climatic and vegetation components of a forest environment appeared in the pictures. The frequency of different fauna drawn was also recorded in a similar way. Categories included for the climatic and vegetation components of a rainforest were: sun, rain, rainbows, rivers, waterfalls, trees, vines, flowers, fruit, treeholes, deadwood, and fungi. Also recorded

were the presence of any human objects. Faunal categories recorded in the pictures were: mammals, birds, reptiles, amphibians, fish, insects, social insects, spiders, annelids, molluscs, and centipedes. The frequency of different climatic and vegetation components of the rainforests and fauna drawn by the children were compared between three age categories. The three cohorts were: 3–5 year olds (Foundation Stage), 6–7 year olds (Key Stage 1), and 8–11 year olds (Key Stage 2) following the UK National Curriculum [30]. Frequencies were compared separately for climatic and vegetation components and for fauna using Chi-Square tests of association. Deadwood, vines, amphibians, annelids, molluscs, and centipedes were excluded from these analyses, owing to insufficient numbers.

The data for all ages were then summed and the frequencies of different taxa drawn compared to their relative contribution to rainforest biomass and species richness worldwide. Data for the biomass estimates were sourced from Fittkau and Klinge [7] for a central Amazonian rainforest. As this did not include specific data on fish and centipedes it was necessary to exclude these taxa from analysis. An estimate of the total number of species in each taxa was obtained by recording the number of described species from a variety of sources. These were Wilson [31] for the social insects, McGavin [32] for the spiders and centipedes and Wilson [33] for all other taxa. Again Chi-Square tests were used to test for association between the frequency of taxa drawn by children and their relative biomass and total number of described species.

Results

The frequency of different climatic, vegetation and human components of the environment drawn were not significantly associated with different ages of children (Chi-Square = 25.654, d.f. = 20, $p = 0.178$), although older children in general drew a more even and therefore more diverse coverage of different components of the environment (Fig 1A). In addition, a larger number of older children incorporated human elements into their drawings, often with reference to conservation. The frequency of different taxa drawn differed significantly between different ages of children (Chi-Square = 51.691, d.f. = 12, $p < 0.001$), with older children drawing a more even coverage of taxa with a lower proportion of mammals and birds and a higher proportion of reptiles, fish and insects (Fig 1B).

The frequency of different taxa drawn varied significantly from their relative contribution to biomass in a rainforest environment (Chi-Square = 413.775, d.f. = 7, $p < 0.001$) and to global species richness (Chi-Square = 25841.829, d.f. = 10, $p < 0.001$). Compared to rainforest biomass, children over-represented the importance of mammals, birds and reptiles and under-represented social insects and annelids. Compared to global species richness of different taxa, children over-represented mammals, birds, reptiles and fish, and under-represented insects (Fig 2 and 3).

Discussion

Our results clearly demonstrate that primary-age children have very sophisticated perceptions of rainforests and include a wide variety of different climatic and vegetative components in their drawings. They are also aware that rainforests are populated with a diverse animal fauna. Such perceptiveness by children, the majority of whom have presumably never visited a real rainforest, demonstrates a significant public awareness of what a rainforest environment consists of and what makes it important. Such understanding is a crucial first step in conservation. Although awareness will not guarantee protection, lack of awareness will make achieving conservation of endangered environments and

Table 1. Number of participants in different age cohorts and genders volunteering in the study.

Curriculum stage	Age cohort	Male		Female		Total	
		n	%	n	%	n	%
Foundation stage	3–5 yrs	15	9.0	19	11.4	34	20.4
Key stage 1	6–7 yrs	22	13.2	22	13.2	44	26.4
Key stage 2	8–11 yrs	41	24.6	48	28.7	89	53.3

doi:10.1371/journal.pone.0002579.t001

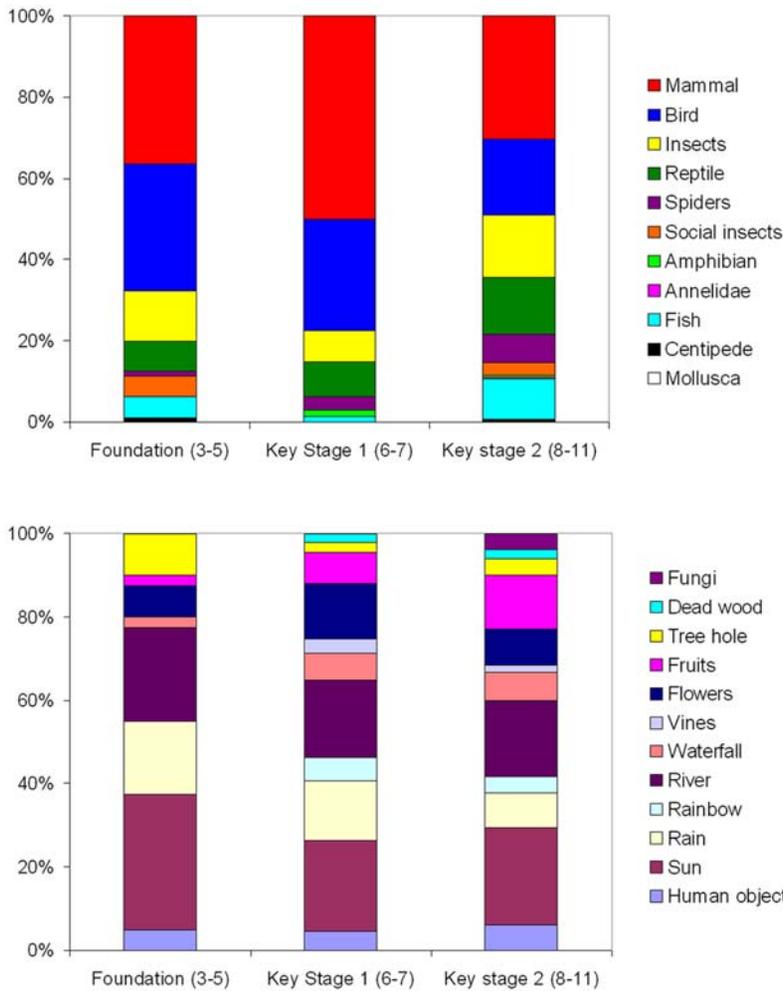


Figure 1. Children's perceptions of the rainforest environment and fauna. (A) The proportion of different climatic, vegetation and human components of a rainforest drawn by different age-classes of primary children (aged three-eleven). To aid interpretation, the frequency at which trees were drawn is not included in the figure, as these were included in all but nine of the 171 drawings. (B) The proportion of different rainforest fauna divided by taxa drawn by different age-classes of primary children. doi:10.1371/journal.pone.0002579.g001

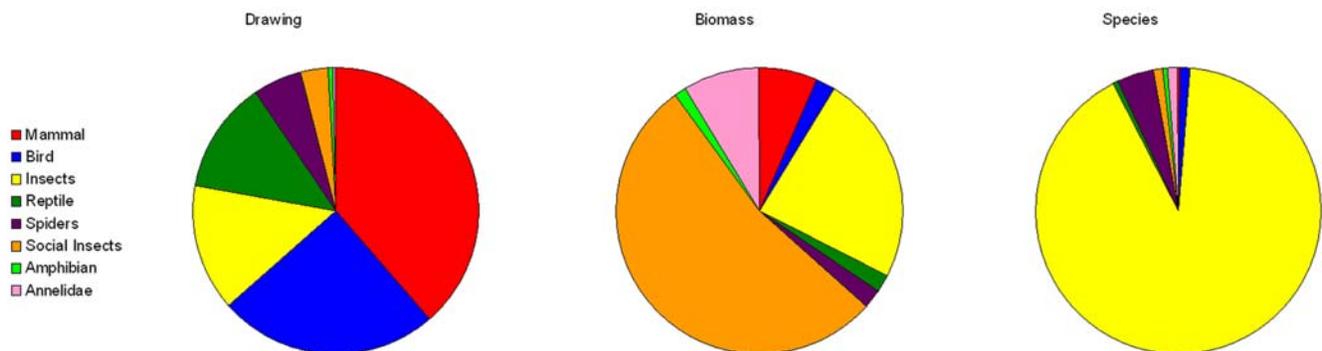


Figure 2. Relative frequency of taxa drawn compared to rainforest biomass and global biodiversity. Pie charts represent the relative frequency at which primary children (aged three-eleven) drew different taxa of rainforest fauna compared to the relative contribution of the taxa to rainforest biomass (following Fittkau & Klinge [7]) and global biodiversity (following Wilson [31] for the social insects; McGavin [32] for the spiders and centipedes and Wilson [33] for all other taxa). doi:10.1371/journal.pone.0002579.g002



Figure 3. Species scapes representing the relative importance of the different rainforest faunal taxa. (A) Species scape representing the relative frequency at which primary children (aged three–eleven) drew different taxa and (B) the relative contribution of the taxa to rainforest biomass (following Fittkau & Klinge [7]). Size of the drawings represents the relative contribution of each taxa with the animals each representing: leopard – mammals, toucan – birds, butterfly – non-social insects, lizard – reptiles, spider – spiders, ant – social insects, frog – amphibians, and worm – annelids. doi:10.1371/journal.pone.0002579.g003

species difficult [10]. Knowledge of the diversity of species and of the natural world is also important in recruiting the next generation of naturalists and conservationists [10,14].

Despite children's awareness of rainforest biodiversity, several taxa, particularly social insects, insects and annelids, are still under-represented compared to their contribution to rainforest biomass and global biodiversity. Such a finding supports previous studies [19,20,28], and may be driven by a variety of factors. Two likely explanations for this are that children are more aware of larger taxa or that children prefer larger taxa. An additional factor in the latter point could be that children drew larger taxa because they felt that this would give them a better chance of winning the

competition (perhaps because they deem them to be prettier). Either of these explanations reveals that children's perceptions focus on mammals and birds and undervalues the true importance of invertebrates.

The current targets for conserving biodiversity and indicators for monitoring species loss similarly over-look the small invertebrates that represent most of the biodiversity within ecosystems [34]. The taxonomic and ecological information of the small invertebrates is relatively sparse, yet it is essential that they are incorporated into conservation planning in order to conserve biodiversity and ecosystem functions [2]. It is important that this imbalance is addressed by raising the profile of these taxa through

organisations devoted to their conservation, documentaries and public events aimed at reconnecting people and children in particular with the natural world. Previous publications have highlighted the importance of children actually visiting natural environments to improve their understanding of the natural world [35,36]. In addition, insects represent an extremely useful tool in studying the natural environment, as they are found in large numbers in nearly every habitat, including the most built-up environments, and can be readily kept as pets [19,37].

Significant steps have already been made in raising the profile of invertebrates in the UK. In recent years a charity [38], and a journal [39] devoted to invertebrate conservation and dissemination of research have been founded. In addition, public events such as National Insect Week [40] have been set up with the aim of informing the public about invertebrates and invertebrate conservation. It is up to scientists and naturalists to continue to champion these lesser-known groups to ensure that public appreciation of their importance continues to grow and to guarantee their conservation protection in the future. This should focus on more activities to reconnect children with the world

around them, allowing them to appreciate more fully the complexity and importance of the natural environment.

Acknowledgments

We would like to thank the University Museum of Zoology, Cambridge for hosting *Forest* and, together with the Bedfordshire, Cambridgeshire and Northamptonshire Wildlife Trust, for running the *Forest* event. We would particularly like to thank Julie McArthur, the Museum Outreach Officer. We would also like to thank Ellen Argent, Georgia Cundy, Harvey Dibden-Angus, Chloe Humphreys, Nathan Morley, Andrey Nezhentsev, Francesca Sharman and all of Class 9, Bar Hill Community Primary School for drawing the forest and forest animals. Thank you also to everyone that helped on the day and Ria M Cooke, Tom Fayle and Russell Stebbings for their helpful comments on the script.

Author Contributions

Conceived and designed the experiments: ET JS WF. Performed the experiments: ET JS. Analyzed the data: ET JS. Contributed reagents/materials/analysis tools: ET JS. Wrote the paper: ET JS WF.

References

- Green RE, Cornell SJ, Scharlemann JPW, Balmford A (2005) Farming and the fate of wild nature. *Science* 307: 550–555.
- Thomas JA, Telfer MG, Roy DB, Preston CD, Greenwood JJD, et al. (2004) Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science* 303: 1879–1881.
- Dunn RR (2005) Modern insect extinctions, the neglected majority. *Conservation Biology* 19: 1030–1036.
- Grimaldi D, Engel MS (2005) *Evolution of the insects*. Cambridge: Cambridge University Press.
- Wilson EO (1987) The little things that run the world. *Conservation Biology* 1: 344–346.
- Samways MJ (2005) *Insect Diversity Conservation*. Cambridge: Cambridge University Press.
- Fittkau EJ, Klinge H (1973) On biomass and tropic structure of the central Amazonian rain forest ecosystem. *Biotropica* 5: 2–14.
- Lossy JE, Vaughan M (2006) The economic value of ecological services provided by insects. *Bioscience* 56: 311–323.
- Kearns CA, Inouye DW, Waser NM (1998) Endangered mutualisms: The conservation of plant-pollinator interactions. *Annual Review of Ecology and Systematics* 29: 83–112.
- Balmford A, Clegg L, Coulson T, Taylor J (2002) Why conservationists should heed Pokémon. *Science* 295: 2367–2367.
- Sodhi NS, Koh LP, Brook BW, Ng PKL (2004) Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution* 19: 654–660.
- Dumbrell AJ, Hill JK (2005) Impacts of selective logging on canopy and ground assemblages of tropical forest butterflies: Implications for sampling. *Biological Conservation* 125: 123–131.
- Miller JR (2005) Biodiversity conservation and the extinction of experience. *Trends in Ecology & Evolution* 20: 430–434.
- Cheesman OD, Key RS (2007) The extinction of experience: a threat to insect conservation? In: Stewart AJA, New TR, Lewis OT, eds (2007) *Insect conservation biology: proceedings of the Royal Entomological Society's 23rd symposium*. Wallingford; Cambridge, Mass: CAB International.
- Pyle RM (1993) *The Thunder Tree: Lessons from an Urban Wildland*. Boston/Massachusetts: Houghton Mifflin.
- Pauly D (1995) Anecdotes and the Shifting Base-Line Syndrome of Fisheries. *Trends in Ecology & Evolution* 10: 430–430.
- Measham TG (2006) Learning about environments: The significance of primal landscapes. *Environmental Management* 38: 426–434.
- Bixler RD, Floyd MF, Hammit WE (2002) Environmental socialization - Quantitative tests of the childhood play hypothesis. *Environment and Behaviour* 34: 795–818.
- Prokop P, Prokop M, Tunnicliffe SD (2008) Effects of keeping animals as pets on children's concepts of vertebrates and invertebrates. *International Journal of Science Education* 30: 431–449.
- Strommen E (1995) Lions and Tigers and Bears, Oh My - Children's Conceptions of Forests and Their Inhabitants. *Journal of Research in Science Teaching* 32: 683–698.
- Barrow LH (2002) What do elementary students know about insects? *Journal of Elementary Science Education* 14: 51–56.
- Greaves E, Stanistreet M, Boyes E, Williams T (1993) Children's Ideas About Rain-Forests. *Journal of Biological Education* 27: 189–194.
- Shepardson DP (1997) Of butterflies and beetles: First graders' ways of seeing and talking about insect life cycles. *Journal of Research in Science Teaching* 34: 873–889.
- Shepardson DP (2002) Bugs, butterflies, and spiders: children's understandings about insects. *International Journal of Science Education* 24: 627–643.
- Shepardson DP, Wee B, Priddy M, Harbor J (2007) Students' mental models of the environment. *Journal of Research in Science Teaching* 44: 327–348.
- Barraza L (1999) Children's drawings about the environment. *Environmental Education Research* 5: 49–66.
- Snaddon JL, Turner EC (2007) A child's eye view of the insect world: perceptions of insect diversity. *Environmental Conservation* 34: 33–35.
- Chen S-H, Ku C-H (1998) Aboriginal children's alternative conceptions of animals and animal classification. *Proceedings of the National Science Council* 8: 55–67.
- Tomkins S, Tunnicliffe SD (2007) Nature tables: stimulating children's interest in natural objects. *Journal of Biological Education* 41: 150–155.
- Qualifications and Curriculum Authority, <http://www.qca.org.uk> (03 February 2008).
- Wilson EO (1990) Success and dominance in ecosystems: the case of the social insects. *Federal Republic of Germany: Ecology Institute: Oldendorf-Luhe*.
- McGavin G (2000) *Insects, spiders and other terrestrial arthropods: Dorling Kindersley Handbooks*.
- Wilson EO (1992) *The diversity of life*. Cambridge, MA, USA: Harvard University Press.
- Fontaine B, Bouchet P, Van Achterberg K, Alonso-Zarazaga MA, Araujo R, et al. (2007) The European Union's 2010 target: Putting rare species in focus. *Biological Conservation* 139: 167–185.
- Tunnicliffe SD, Reiss MJ (1999) Building a model of the environment: how do children see animals? *Journal of Biological Education* 33: 142–148.
- Tarlowski A (2006) If it's an animal it has axons: Experience and culture in preschool children's reasoning about animates. *Cognitive Development* 21: 249–265.
- Matthews RW, Flage LR, Matthews JR (1997) Insects as teaching tools in primary and secondary education. *Annual Review of Entomology* 42: 269–289.
- Buglife - The Invertebrate Conservation Trust, <http://www.buglife.org.uk> (03 February 2008).
- Leather SR, Bassett Y, Hawkins BA (2008) *Insect conservation and diversity - a new journal for the Royal Entomological Society*. *Insect Conservation and Diversity* 1: 1.
- The Royal Entomological Society National Insect Week 2008, <http://www.nationalinsectweek.co.uk/> (03 February 2008).