

2021

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10.1080/13504622.2020.1837081

Gobby, B., Merewether, J., & Nykiel, A. (2021). Extinction, education and the curious practice of visiting thrombolites. *Environmental Education Research*. 27(2), 217-233. <https://doi.org/10.1080/13504622.2020.1837081>

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To cite this article: Brad Gobby , Jane Merewether & Annette Nykiel (2021) Extinction, education and the curious practice of visiting thrombolites, Environmental Education Research, 27:2, 217-233, DOI: [10.1080/13504622.2020.1837081](https://doi.org/10.1080/13504622.2020.1837081)

To link to this article: <https://doi.org/10.1080/13504622.2020.1837081>



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Published online: 29 Oct 2020.



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Extinction, education and the curious practice of visiting thrombolites

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ABSTRACT

The Earth is in the midst of a recent acceleration in the rate of species extinction and the unravelling of ecological communities. The authors think with the emerging field of Extinction Studies to explore educational approaches to ecological endangerment and extinction. Using a notion of visiting as ‘curious practice’, we story encounters between the authors, young children and the endangered Noorook Yalgorup-Lake Clifton thrombolites and their ecological community in south-western Australia. These visits were not intended to teach *about* extinction or the thrombolites. Rather, our aim was to generate pedagogical insights through approaching the threatened thrombolites and their environment with curiosity, openness and attentiveness, and framed by perspectives that trouble human exceptionalism and Western dualisms. Guided by Haraway’s notion of ‘staying with the trouble’, we argue this approach to encountering extinction generates insights into learning and living with ecological crisis in our shared world. Specifically, that for educators and children to relearn the world and their place in it, educators must enable new senses, meanings, perspectives and stories to populate the Earth and for this to occur they should listen with openness to, and think with, children.

ARTICLE HISTORY

Received 16 May 2020
Accepted 9 October 2020

KEYWORDS

Extinction; extinction studies; early childhood; environmental humanities; curious practice; climate

Introduction

*When will we tread kindly here
and gently as ground-water
trickles
between thrombolites
after seeping
through sedge and samphire?*
(Weldon 2014, 200).

Western Australian poet and author Annamaria Weldon spent many hours visiting Noorook Yalgorup-Lake Clifton¹ in south-western Australia, the place of our study (Figure 1). While Weldon asks when humans might tread more kindly in this place, when we visited in 2020, recently made human footprints (Figure 2) were visible on and around the fragile and ancient thrombolites, often referred to as ‘living rocks’. Thrombolites, despite their lifeless appearance,

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Figure 1. The Noorook Yalgorup-Lake Clifton thrombolites, looking south from the boardwalk, late afternoon. All photographs courtesy of the authors.

are complex microbial communities that precipitate calcium carbonate, thereby sedimenting minerals and organic material into a rock-like mass (Moore and Burne 1994; McNamara 2009).² Thrombolites have lived in the internationally recognised (Ramsar 482³) Peel-Yalgorup wetlands system in south-western Australia for thousands of years (Moore and Burne 1994), yet more recently humans have made their mark on the wetlands that support the life of the thrombolites. Land clearing, nutrient runoff and falling water levels (lake and aquifer) threaten their existence (Moore 1987; Moore and Burne 1994; Phillips 2009). Along with changing environmental conditions, human activity has propelled these unique formations onto the critically endangered list (Department of Biodiversity Conservation and Attractions 2018). This unsettling local story is also a global one. Beyond the Peel-Yalgorup wetlands, anthropogenic climate change, industrialisation and globalisation are accelerating species endangerment and extinction, and the collapse of ecological communities (Steffen et al. 2004).

Provoked by the unique thrombolites (Figure 1 and 2), the onrushing rate of world-wide species extinction, and the emerging field of Extinction Studies, we set out to explore new ways of approaching extinction in education. Extinction is commonly understood and taught to children through the discourses of science, particularly the biological sciences. There is a tendency to construe extinction as the biological loss of the last individuals of a species, and to represent extinction through scientific facts. We take the more expansive approach to extinction emerging from Extinction Studies (Rose, van Dooren, and Chrulaw 2017). In these studies, extinction is a 'multi-contextual phenomenon' (viii), a biocultural event involving the unravelling of intergenerational and inter-species relations. Extinction Studies story the complex and entangled relations of specific cases of extinction, and by weaving through cultural analysis that troubles the nature/



Figure 2. Human footprints impact directly and indirectly on thrombolites.



Figure 3. Families visiting thrombolites.

culture divide, it promotes new ways of knowing and being accountable to the complex worlds of others. We view this approach to encounters with extinction as having potential for relearning the world and the human's place in it.

Informed by Donna Haraway's (2015) notion of visiting as a 'curious practice', and the relational pedagogical practices of the educational project of Reggio Emilia⁴ (Edwards, Gandini, and Forman 2012), our study brought groups of young children to the place of the unfolding Noorook Yalgorup-Lake Clifton thrombolite extinction event (Figure 3). The purpose of these visits was not to teach about extinction and thrombolites, although the children did learn about these. Rather, our aim was to explore if bringing children into relation with an extinction event in their local area within a framework of curiosity, openness and attentiveness might generate pedagogical insights for educators. Taking up the call of Extinction Studies to experiment with multiple perspectives and stories as a way to relearn the world (Rose, van Dooren, and Chrulew 2017), this paper uses stories of the child-researcher-thrombolite encounters to think through pedagogies for learning and living with the ecological crises of our shared world.

The wetlands, lake and thrombolites

Emerging from the rise and fall of the ocean tides over thousands of years, the Peel-Yalgorup wetland system includes a large tidal estuary and a string of landlocked lakes that run parallel to the Indian Ocean coastline. This system hosts many plants, animals and microbial life including up to 40,000 migratory shorebirds that visit annually from as far away as Siberia (Hale and Butcher 2007), but like many wetlands in the world, the Peel-Yalgorup system's viability is threatened by anthropogenic activity and climate change (Hale and Butcher 2007; Weldon 2014). One of the largest lakes in this system, the 21.5 kilometre long Noorook Yalgorup-Lake Clifton contains the largest of only two remaining actively growing thrombolite colonies in Western Australia (Warden et al. 2016). This thrombolite colony and its entangled ecological community is the place of our study.

Thrombolites and stromatolites are some of Earth's earliest life forms with their ancestry dating back 3.4 billion years (Allwood et al. 2009; McNamara 2009; Phillips 2009), and they once covered large swathes of the Earth's surface (Moore and Burne 1994; Phillips 2009). As the photosynthesis of the cyanobacteria of the thrombolites and their related stromatolites filled the atmosphere with oxygen (Holland 2006; McNamara 2009, Phillips 2009), they were pivotal to the evolution of aerobic life forms on Earth billions of years ago (McNamara 2009; Phillips 2009). However, having survived previous mass extinction events, there are now very few living thrombolite formations left in the world (Gleeson et al. 2016; Moore and Burne 1994; Ramsar Sites Information Service 2000). Thrombolites have been in long term slow decline since losing their dominance around 500 million years ago (Kennard and James 1986; Moore and Burne 1994; Warden et al. 2016), however their viability in places like Noorook Yalgorup-Lake Clifton is now further exacerbated by human-caused factors (Luu, Mitchell, and Blyth 2004; Smith et al. 2010).

The Noorook Yalgorup-Lake Clifton thrombolite colony is estimated to be 2000 years old (McNamara 2009; Moore and Burne 1994; Phillips 2009). These particular thrombolites rely on the inflow of fresh groundwater (Gleeson et al. 2016; Moore 1987; Moore and Burne 1994) and are therefore susceptible to local changes to land use (e.g. land clearing, forest fragmentation, urban development and groundwater extraction) and a drying climate (Hale and Butcher 2007; Moore and Burne 1994). The human impact in the area which includes the thrombolites does not look to be diminishing; the human population has more than doubled since the area was Ramsar-listed in 1990, and is predicted to continue to grow at around 1.85% annually (Hale and Butcher 2007; City of Mandurah n.d). As a result, the Noorook Yalgorup-Lake Clifton thrombolites have been assessed as critically endangered (Department of Biodiversity Conservation and Attractions 2018).

Extinction and Extinction Studies

There have been a number of mass extinction events on Earth resulting from dynamic geological, chemical and meteorological forces, and the odd astronomical event (Ceballos et al. 2015; Ceballos, Ehrlich, and Dirzo 2017; Chakrabarty 2009; Raup and Sepkoski 1982). Some propose that we are now in the midst of another mass extinction event, and this event's origins are largely anthropogenic (Ceballos et al. 2015; Ceballos, Ehrlich, and Dirzo 2017; Kolbert 2014). Human-induced extinction, brought about by climate change, industrialisation, globalisation, disease, introduced species and changes to land use (Steffen et al. 2004) has led to an estimated one million species being at risk of extinction within the next 25 years (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2019). One hundred Australian endemic species have been listed as extinct since the nation's European colonisation (Woinarski et al. 2019).

These statistics however do not tell the complex and multiple stories bound up in species extinction.

Recently, an interdisciplinary response to extinction has emerged that deepens our thinking about and approaches to extinction. Extinction Studies (Bastian [Forthcoming](#); Chrulew and De Vos 2019; Rose 2011; Rose, van Dooren, and Chrulew 2017; van Dooren 2014a, 2014b), which is grounded in the humanities and positioned within the broader fields of environmental humanities and multispecies studies (e.g. Haraway 2016; Plumwood 2002), emerged from a collective that shares the belief that the 'present time demands considered, lively, and creative responses from the humanities' (Rose, van Dooren, and Chrulew 2017, 2). Extinction Studies avoids reducing extinction to a singular event of the loss of the last individuals of a species, and instead regards it as an unravelling of intergenerational and inter-species relationships over time. Thom van Dooren (2014b, 4) notes, 'life and death do not take place in isolation from others; they are thoroughly relational affairs for fleshy, mortal creatures ... woven into relationships with a diverse array of other species ... These are relationships of co-evolution and ecological dependency'. Extinction, then, is a multi-species event that draws diverse beings into the extinction of others.

A biocultural perspective is an important contribution to the expanded notion of extinction. Extinction events are biocultural (Rose, van Dooren, and Chrulew 2017) not simply because the changing circumstances endangering many species today are tied to human political, economic and cultural practices - which is a part of Extinction Studies' criticism. It is also because the loss of life forms entails the loss of complex webs of lived relations, social practices, languages, arts, and ways of living and being with others that constitute non-human communities (e.g. van Dooren 2014b). Extinction represents 'a *distinct* unravelling of ways of life, a distinctive loss and set of changes and challenges' (van Dooren 2014b, 7, original emphasis) across biological and cultural domains 'long before and well after this 'final' death' (2014b, 58). Therefore, an extinction event is not simply the loss of the species-as-specimen, but the often unacknowledged 'entangled relations that *are* a particular form of life' (2014b, 58). Moreover, these forms of life are entwined with human worlds because humans, like other species, are often 'drawn into the fray as species move towards, and then beyond, the edge of extinction' (2014b, 8).

Encountering these events and seeking to know more with an open and curious mind is one response to the loss of life forms and forms of life. Extinction Studies offers a narrative-based engagement with specific case studies of loss (Bastian [Forthcoming](#); Rose, van Dooren, and Chrulew 2017; van Dooren and Rose 2016). Storying loss is one of many potentially important responses to ecological devastation. Weaving together scientific knowledge, cultural criticism and the aesthetic of storytelling, the narrative approach to fieldwork and documenting extinction events can take us beyond the cold numbers of extinction rates and the reduction of species to biological specimens. As there are multiple stories and perspectives in a single extinction event, a narrative approach can invite us into these '*multiply-storied worlds*' (Rose, van Dooren, and Chrulew 2017, 3, original emphasis), and help us grapple with 'what an extinction means, why it matters, and to whom' (Rose, van Dooren, and Chrulew 2017, 3). The visits in our project

enabled us to explore and contribute to the multiply-storied worlds of Noorook Yalgorup-Lake Clifton. We expand on this approach below.

Extinction and education

Our take up of extinction occurs in the context of education, which is an important site given its transformative power. We suggest that while the task of exploring extinction with Extinction Studies may be challenging given the dominant discourses of Western education, it is needed. Deeply rooted in humanism (Braidotti 2013), its anthropocentric knowledge, curriculum and pedagogical regimes have tended to downplay the co-constitution of the human with non-human Others (Affifi 2011; Jickling et al. 2018; Lloro-Bidart 2015; Pedersen 2010). The human is rendered as exceptional, and 'nature' as an object of human mastery and exploitation. These discourses are exacerbated by the current dominance of neoliberalism, which submits the educational apparatus to economic means and ends, while also objectifying the environment as a resource for human use and management (Bencze et al. 2018; Carter 2015; Gough 2015, 2017). We note that in recent national education policymaking in Australia, the Alice Springs (Mparntwe) Education Declaration (Education Council 2019) foregrounds education's economic goals and excludes any explicit reference to 'climate change', despite its presence a decade earlier in the Melbourne Declaration (Ministerial Council on Education Employment and Training and Youth Affairs 2008).

This absence brings to mind Haraway's observation that in these times of climate crisis, extinctions and ecological collapse, there is an 'unprecedented looking away' (Haraway 2016, 35), a refusal to know and 'to be present in and to onrushing catastrophe in time' (2016, 35). We argue that while others may look away, educators must critically face up to anthropogenic ecological disruption, including extinction, so that current and future generations can grapple with ecological uncertainty and precarity (Jickling et al. 2018; Lloro-Bidart 2015). Educators may be reluctant to turn towards extinction based on the expectation that young children should be distanced, shielded and protected from death and loss (Affifi and Christie 2019). This shielding is seen in early childhood learning settings which, as Iris Duhn (2012) observes, 'are often prime sites where the discourses of protection, vulnerability and innocence create a highly controlled and closely monitored environment ... which can lead to resistance when it comes to addressing potentially challenging, complex topics' (20). This narrative of protection is also political. The Australian Prime Minister recently voiced his worry that the public discourse on climate change, including school student climate change protests, were unnecessarily making children anxious (Glenday 2019). We suggest, however, that turning a blind eye and deaf ear to what confronts us all is a greater threat to children.

Of course, we don't mean to suggest that extinction is not being taught. Our concern is that some prevalent approaches to science teaching around the environment and extinction may be insufficiently disruptive of Western binaries and insufficiently grounded in the lives of children. We echo a concern of a recent literature review of climate change education that found that top-down, knowledge-focused (science) and didactic teaching dominated, despite the need for participatory, affective and creative pedagogies based in children's local environments (Rousell and Cutter-MacKenzie-Knowles 2020). In our experience, children are often taught about the loss of the dinosaurs and the catastrophic Cretaceous–Paleogene extinction event 66 million years ago. They may also be taught the extinctions of individual species occurring in the recent past, typically on account of their failure to adapt to environmental change (see for example, <https://www.forteachersforstudents.com.au/site/themed-curriculum/endangered-wildlife/>). We suggest that pedagogical approaches could better recognise that extinction and the threat of loss are part of children's present, everyday and future lives, and that life and death are woven together (Affifi and Christie 2019). Moreover, encountering extinction in the sense offered by Extinction Studies invites educators and children to relearn the world as an ongoing entanglement of bio-cultural relations and to trouble their ways of knowing and being.

The scholarship of feminist and posthumanist education researchers and practitioners, such as the Common Worlds Research Collective (<http://commonworlds.net/>), is leading the way by disrupting Western systems of knowledge and practice that undergird our educational, political, economic and other institutions (Blaise, Hamm, and Iorio 2017; Duhn 2012; Lenz Taguchi 2010; Merewether 2018; Nxumalo and Pacini-Ketchabaw 2017; Rautio et al. 2017; Somerville and Powell 2019; Taylor 2013, 2017; Taylor and Pacini-Ketchabaw 2019). This body of research aims to 'stay with the trouble' of learning, living *and* dying on a damaged planet without succumbing to despair or vain hopes for techno-fixes and other heroic and salvific solutions. Experimenting with pedagogies and knowledge-making practices that unsettle human exceptionalism and didactic approaches to education, this research with children generates relational practices of learning that promote responsiveness to our 'inevitable entanglement in the fate of the planet' (Somerville 2017, 399). We are interested in bringing this scholarship into conversation with Extinction Studies (see Taylor and Pacini-Ketchabaw 2019), so as to offer educators perspectives and approaches to grapple with extinction and loss.

Research approach

We now turn to the study at hand. Noorook Yalgorup-Lake Clifton is approximately 100 kilometres south of Perth, Western Australia. During school holidays we met with 51 invited two-to-twelve-year old children accompanied by their caregivers during a series of five two-hour visits to a boardwalk and pathways which allows access to the thrombolites and its surrounds. Participants were recruited through researcher networks and informed that their visits were a part of a research project. We did not inform parents or children beforehand that the thrombolites were endangered, however their rarity, fragility and endangered status were mentioned on their arrival to the site. Most children attended the site with us only once, although a few families chose to repeat their visit. Different local area experts including an artist, scientists, and a local bird observer accompanied each visit. Experts were invited to engage in their area of expertise (e.g. the bird watcher set up scopes to observe birds) and to respond to children's questions and reactions. At the site, following a short group introduction, children were invited to explore the thrombolites via the public boardwalk. Children were offered the opportunity to respond through, for example, conversation, gesture, photography, drawing and other arts experiences (Figure 4). The opportunities offered depended on children's inclinations, ages, the weather and the expert/s present. Researchers acted as participant observers as they engaged with children, and at the same time took notes, photographs, video and audio recordings - to record the children's responses (Hodgins 2019; Merewether 2018). Parents and experts were also invited to notice children's responses and record their observations by taking photos and writing in small notebooks that we provided.

Immediately following each visit, the researchers discussed the theoretical, conceptual and methodological provocations that emerged through our encounters. Co-constructed documentation in the form of fieldnotes and a curated research blog (<http://dialogueswithwaste.climateaction-childhood.net/>), which gathered together aspects of the research as it unfolded, were an important aspect of this study as they provided tools for dialogue. In this sense, '[d]ialogue generates research, research generates dialogue' (Rinaldi 2006, 151). Interpreting, discussing and speculating about our notes and artefacts in relation to Extinction Studies and its wider fields continued throughout the project; 'data' co-emerged in these intra-active practices (Duhn and Galvez 2020).

Visiting: a curious practice

Our study was a modest attempt to engage children and ourselves with extinction by visiting the thrombolites. Our use of the term 'visiting' is inspired by Haraway's (2015) use of visiting as part of what she calls 'curious practice', a reading of Vinciane Despret's research practices.



Figure 4. Children visiting and noticing the thrombolites on a warm Summer's (Birak) morning.

According to Haraway, curious practice requires us 'to venture off the beaten path to meet unexpected, non-natal kin, and to strike up conversations, to pose and respond to interesting questions, to propose together something unanticipated, to take up the unasked-for obligations of having met' (2015, 8). This avoids the functional sense of visiting as a practice for achieving pre-determined and specified ends. We did not anticipate how the children's encounters with the thrombolites would unfold. We did not seek to fill the children with pre-ordained scientific facts about thrombolites beforehand; nor did we seek to do this while we were visiting. This is not to say we avoided what Latour (2004) refers to as 'matters of fact'; indeed, many matters of fact made themselves known, one way or another. But our primary intention was for the children and ourselves to approach the uncharismatic and seemingly inert thrombolites as polite, attentive and curious visitors; visitors looking at the world with the thrombolites, rather than merely looking at them as dispassionate observers. Visiting as curious practice invites us to approach non-natal kin with openness and without preconceptions about what we might find, and therefore to potentially find others interesting. This visiting also takes a critical perspective that, as Extinction Studies shows, troubles modernist binaries and systems of thought that privilege the human. By visiting the thrombolites with a critical ethos and of being open to the possible-but-not-yet, we wanted to explore what bringing children into an entangled extinction story could add to pedagogies. This, as it turns out, is a very demanding practice, especially when the inquiry involves inert, rock-like microbialite formations. It required 'method alert to off-the-beaten-path practices' (Haraway 2015, 6). Children were encouraged to explore, to verbalise their sensing, to speculate, to reach out to the thrombolites by creating drawings and taking photos, and to ask questions of listening and attentive adults, who were themselves becoming-with the children and thrombolites. Duhn and Galvez (2020, 3) call this 'a curious practice approach to thinking with "data" as these intra-actions 'cultivate perceptions of the materialities of tentacular becoming with the world' (3).

Storying our visiting

As mentioned above, our approach was to discuss our observations and notes, and then collaboratively journal these in the form of blogs using the concepts and theories from our readings of extinction. Those events that provoked the children and the adults, or made us think, hesitate and stutter made their way into our stories. This process, of *storying* the encounters with thrombolites - ours and children's - was a way into the complexities of children's encounters with ancient and fragile life on the edge of extinction. Storytelling is crucial to the practice of thinking and world-making (Haraway 2016; van Dooren and Rose 2016; Bastian Forthcoming). It is a mode of attentiveness and responsiveness through 'which multispecies players, who are enmeshed in partial and flawed translations across difference, redo ways of living and dying attuned to still possible finite flourishing, still possible recuperation' (Haraway 2016, 10). Haraway's point is to eschew salvific meta-narratives and the logics of reducibility, unifying reconciliation and the universal, which she construes as 'the dubious pleasures of transcendent plots of modernity' (Haraway 2016, 41). Instead, we must multiply attention to differences, multiply the differences that count, and write different stories as part of a commitment to 'the modest possibilities of partial recuperation and getting on together' (p. 10). Storytelling can intrude on the categories and binaries of our thoughts, trouble human conceits, de-colonise by multiplying the stories from different perspectives (e.g. children's). In this sense, 'a story can allow multiple meanings to travel alongside one another; it can hold open possibilities and interpretations and can refuse the kind of closure that prevents others from speaking or becoming' (van Dooren and Rose 2016, 85). Of course, storytelling as a means of 'staying with the trouble' (Haraway 2016, 10) is a modest endeavour unlikely to change on its own the course of global events. But, rather than throw our hands up in despair, or turn away in what Haraway calls 'cynical quietism' (2016, 38), we use stories of child-researcher-thrombolite encounters as a generative world-making practice. It is a practice of noticing and attentiveness (van Dooren and Rose 2016), a means to expand our ways of knowing and being, to enact what was not there before, to insert ourselves into the lives of others, and generate and experiment with multiple ways of knowing and being-with others on the edge of extinction. A story is a mode of visiting.

Thinking with thrombolites: Curious practices

The lake breathes

On our first visit, we (Brad, Jane and Annette) make our way along the short path that leads us to the boardwalk on the edge of Noorook Yalgorup-Lake Clifton. It is Birak, the Noongar first Summer (December-January). The branches of Melaleuca (paperbark) trees that arch across the path shelter us from the morning sun. We pause to marvel at the peppering of shiny black spots that float around us on our walk. These Christmas spiders (Austracantha minax) have spun their large orbed webs across the path, netting small flying insects ... and us! These webs visually and physically remind us that everything, including us, is connected to something else. We cannot make our way through these webs without disturbing multiple others. As van Dooren (2014b, 60) observes, 'everything is connected to something, which is connected to something else...' As the Melaleucas and their resident golden whistlers, blue wrens and spiders recede behind us in our approach to the boardwalk, an expanse of glassy water opens before us. Spread across the landscape like an elongated blue iris gazing up to the sky, the lake glows in the light of the ancient sun. The gentle, warm breeze feels like the lake breathing in and out, in and out.

One of the most striking features of Noorook Yalgorup-Lake Clifton lies at its shallow eastern edge; the thrombolites, which the local Indigenous Binjareb Noongar people describe as noorook (eggs) of

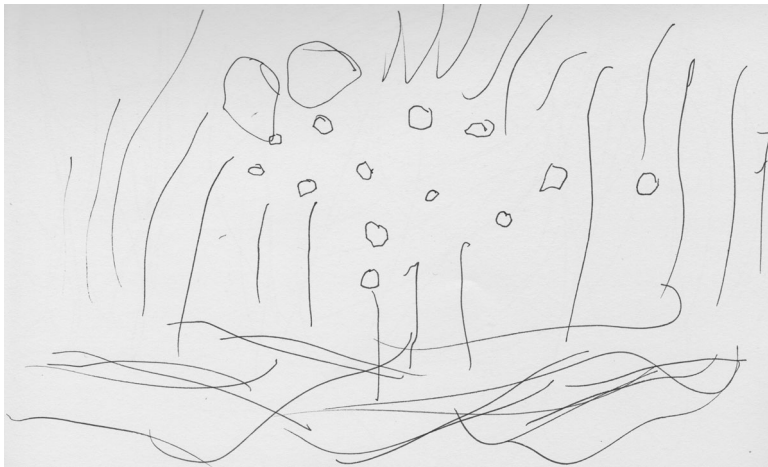


Figure 5. Spaghetti and meatballs drawing by Anna (3 years).

the *Waugal*, the creation snake which is giver of all life. Standing on the wooden boardwalk, we look towards these rock-like domes that form a limestone-coloured reef stretching into the distance.

Anna's⁵ meatballs

Some weeks later, we return to this place with a group of children and their parents who are encountering the lake and these rocky protrusions for the first time.

'Ooo ooo! Look! It's the sea! It's the beach!'

Three-year-old Anna spots the water through the trees and dashes toward it along the boardwalk. As she reaches the thrombolites, she suddenly stops and exclaims excitedly, 'Meatballs! Spaghetti and meatballs!' (Figure 5).

While we have often heard thrombolites referred to as rocks, this is the first time we have heard them called meatballs. We don't know if Anna thinks thrombolites really are meatballs. It would be easy to simply dismiss her naming of thrombolites as meatballs as a naive substitution in the face of the lack of another word, but we wonder if thinking about thrombolites as meatballs helps Anna and us think differently about thrombolites and their environment in our 'collective world-making' (Rooney 2018a, 2).

'It's hot,' says Anna looking at the giant 'meatballs' below her.

It is indeed an uncomfortably warm day and the group is ready to head for the shade of the tuarts (*Eucalyptus gomphocephala*) on the edge of the lake.

'Do you think the thrombolites like it hot?' asks Anna's mother.

'Meatballs like it hot,' Anna replies.

We have come to this research informed by the pedagogical research practices of Reggio Emilia, practices that call us to listen to children with openness and without preconceived ideas about what is 'right' (Rinaldi 2006). Listening to young children with openness, then, is part of our curious practice. We are curious to know where thinking of thrombolites as meatballs might take Anna and us. So we resist our urge to tell her that thrombolites are not meatballs. We know from previous experience that doing so could risk quelling her enthusiasm for this moment. Instead, we ask if she'd like to draw what she can see in the notebook we have given her (Figure 5). Anna takes this invitation very seriously.

As we watch Anna gazing intently at the thrombolite-meatballs we notice it is not just her eyes that are doing the sensing. Her whole body seems to be alive to her surroundings; her attentiveness in this new situation is palpable. We notice the other children are similarly alive to their

surroundings as they sit and lie on boardwalk peering through railings and gaps in the boards. None of them scoff at Anna's meatball theory; we researchers wonder later if in fact it offered them another way of encountering the thrombolites. We cook meat to kill the microbes in it. We decide to use this story to help children and adults imagine thrombolites, complex microbial communities, as slowly poaching in the increasingly saline and warming waters of this lake.

In describing Vinciane Despret's curious practice in her animal studies work, Haraway (2015, 5) notes that Despret 'trains her whole being, not just her imagination, 'to go visiting''. As adults we may need to train ourselves to go visiting using all of our senses, but when three-year-old Anna encounters the thrombolites, she is visiting with her imagination and her whole being; no training is necessary. Anna is teaching us the art of curious practice. And she reminds us that as adults who work with young children, if we are to 'cultivate the wild virtue of curiosity' (Haraway 2015, 5) we need to be careful not rush children into separating fact from fiction.

Enchanted animism

Children's animist responses to the thrombolites are another feature of every visit to the site:

'Some are joined up—maybe it's a mum and baby.'

'They don't like all the people here. They can't sleep.'

'They are like turtles and their legs are tucked up underneath. They go walking at night.'

Children's 'enchanted animism' (Merewether 2019), or their playful attribution of liveliness to what might otherwise be considered 'inert' or 'passive' 'things' make us aware that 'matters of fact' can be a cage for our adult imaginations. Enchantment is an agential and affective way of being with the world (Pyry 2017). As conscientious researchers, we have come to the site armed with knowledge about thrombolites' geology, hydrology and microbiology. Could it be that this knowledge constrained the way we related to the thrombolites? What might change, for example, if like the children, we see thrombolites as lively and as having intentions and desires of their own?

'They are rocks but not rocks! Look, you can see their faces!' a child exclaims peering intently over the boardwalk edge.

We look again. Many of these 'rocks but not rocks' do seem to have faces and many are 'cuddled up' to each other', as another child puts it. It is hard for us adults to see the thrombolites in such terms because we carry with us lifetimes of resisting these so-called 'childish' ways of seeing and ignoring the wonder of 'thing-power' (Bennett 2007) affected by the seemingly inanimate. Indeed, as Karen Barad points out:

The inanimate-animate distinction is perhaps one of the most persistent dualisms in Western philosophy and its critiques; even some of the most hardhitting critiques of the nature-culture dichotomy leave the animate-inanimate distinction in place. It takes a radical rethinking of agency to appreciate how lively even 'dead matter' can be. (2007, 419)

Provoked by these very young children, we can imagine thrombolites living as active participants in the lake-forest-sky-human assemblage we are part of, each taking from and contributing to the others for their very being, disrupting the nature-human/culture dichotomy (Rautio et al. 2017; Taylor 2017). Could such lively visions open us up to the shared vulnerability of all those in the assemblage, not just the humans? We are inclined to think so.

Shared vulnerability

Two-year-old Max is also very excited by the thrombolite-water assemblage that lies before and beneath him. He rushes along the boardwalk, dashing from one side to the other with his father,

Josh, valiantly trying to stay in close proximity. Even though the water is less than 1.5 m deep, Josh knows that water and young children can be a dangerous combination. His concern is palpable and several times he grabs the back of Max's shirt as Max leans over the edge of the boardwalk.

As we watch Max's exuberant interactions with the thrombolites we are reminded not just of his vulnerability but also the vulnerability of thrombolites and the precariousness of the whole thrombolite-assemblage, of which humans are a part. Max's safety is ensured by his father's vigilant presence, but it would not take much to change the situation; other children have drowned in this lake (Weldon 2014). Thrombolites are complex microbial communities, but they do not live in isolation. They are situated in entangled relations of water, land, rocks, and reeds, to name but a few. The holding-togetherness of the thrombolites depends on these. Max's falling into the lake might be frighteningly rapid but the thrombolite assemblage is equally precarious, albeit within different temporalities. In other nearby lakes, thrombolite assemblages have succumbed to the complex interactions of a threatened and fragmented ecosystem; forests and wetlands have been replaced by houses and pavement, fresh aquifers suck in sea water rather than recharge with rain, and changing lacustrine nutrient loads favour other photosynthetic microbes (Smith et al. 2010). Like Max, thrombolites are dependent on those around them. Like thrombolites, we are all dependent on those around us, human and non-human. As Tsing (2015) notes, precarity 'is the condition of being vulnerable to others. Unpredictable encounters transform us; we are not in control, even of ourselves' (2015, 20).

Care & extinction

Making sense of where he is, eight-year-old Charlie eagerly shares with us his impressive knowledge of the geological and biological history of planet Earth stretching back to its molten past. He is attentive to more-than-human timescales and how the thrombolites came to be in the story of the ancient Earth. This provokes Brad (Author 1) to say to Charlie, 'these thrombolites have been here for around 2000 years, but thrombolites have been around for over three billion years. That's a long time. We don't know how long these will live for, or if they will die soon. The water is becoming too salty'. Brad's words become an invitation to think through another temporal frame by bringing to mind imaginings of the yet-to-become of the thrombolites as they approach the edge of extinction. For Charlie, the death of the thrombolites matters: 'I hope they don't die until after I die. I'd bring my child here too.' Thinking with different temporal frames, in relation to a specific context, enables the exploration of our accountability in terms of our inheritances, legacies and how we could live differently (Pacini-Ketchabaw and Kummen 2016; Rooney 2018b).

Brad then asks Charlie provocatively, 'Why should we care about them? They're only 'rocks' – not cute and cuddly animals like koalas.' Brad's question emanates from his own curiosity about how humans can cultivate a collective care for entities that don't appear immediately affiliated, useful, or sensible. However, building shared worlds means putting into play hierarchies of value so as to recognise entangled and lively co-becomings. It is also about learning 'to proceed in the presence of those who are mute, or who present no argument which protagonists with a voice are able to take into account' (Stengers 2017, np.). Brad's question positions Charlie as someone who may create new futures through speculative thinking. Charlie ponders and then responds with:

'We should care because they are so old.'

'Because they make oxygen,' says another child listening in.

The children's responses echo in our ears as we ponder how humans can make kin with their earth others. Extinction Studies provoke us to find ways to live in situations of precarity and destruction, and to look for 'the ongoing practices of living in the ruins... to explore the ruins that have become our collective homes' (Haraway 2016, 37). When this topic of caring for thrombolites emerges, one child says, 'We could take stuff out of the water, like the hats, thongs and rubbish'

and another child comments: 'By not putting rubbish in the water, and not stepping on them. One of my friends lives near. She comes here to check on them.' The children do not offer grandiose ideas or plans, and they avoid instating the human as the master, caretaker and steward of the Earth. Instead, they offer modest, tangible and situated ways humans can live in this place, respectful of our entangled realities and what is significant to thrombolites and as well as to humans.

Home away from thrombolites

After the children leave the lake, some parents email us. They send photos they have taken and comment about their children's responses to their visit. Mary relayed to us that her son Jacob said he was 'really glad I got to see the thrombolites before they went extinct.' She continued, 'He has been intensely interested in our 'earth' resources at home. Playing with a globe that shows the layers of the earth and reading books about the earth's beginnings.' Cultivating attentiveness to and curiosity about our local ecological communities should be central to contemporary education.

Conclusion

Onrushing extinctions and ecological precarity should compel us to forge new ways of living with a damaged planet. Haraway's (2016) call to 'stay with the trouble' invites us to invent and discover new sensibilities, concepts and practices for living with our non-natal kin for multispecies flourishing. As we are increasingly surrounded by the unravelling of life, this study turns towards ecological precarity and our Earth others. Moving beyond the narrow orthodoxies of formal education, we brought young children into presence of an extinction event close to their lives: the Noorook Yalgorup-Lake Clifton thrombolites. Visiting the thrombolites with politeness, attentiveness and curiosity, and framed by a critical reading of anthropocentric Western systems of knowledge, our approach departed from more conventional pedagogies that focus on imparting knowledge and learning *about* things, like thrombolites as specimens and extinction as a biological fact. The curious practice we adopted invited ourselves and the children to encounter the thrombolites as polite, inquisitive, attentive, and speculative meaning-making visitors of others' worlds. Crucially, to generate pedagogical insights around young children's relationships with non-human worlds we need to be attentive to rather than overlook children (Taylor and Pacini-Ketchabaw 2019). We needed to listen and to think with them with openness and curiosity, to enable their curious practice to trouble our and their worlds. In doing so, we (as researchers and educators) opened ourselves to new compositions of shared worlds, new ways of sensing, knowing and being. We see value in this curious practice with children as 'part of the critical work of decolonizing Western boundaries around knowledge and expertise' (Rose, van Dooren, and Chrulew 2017, 4) because it broadens who is authorised to speak about 'nature' as each of us crafts shared lives in multispecies communities.

We noticed on our visits curious children attentive to the shimmers of our shared worlds. The children's encounters with the thrombolites generated multiple ways of sensing, knowing and being in relation to them, which we did not discourage, and which is not typically enabled by narrow factual accounts or instrumentalist forms of education. Such encounters with loss and extinction provide opportunities to recompose the relationships between humans and more-than-human others (Affifi and Christie 2019; Russell 2017; Taylor and Pacini-Ketchabaw 2019). Our stories of the children's encounters not only bear witness to the thrombolites and their slow disappearance, but also 'witnesses for the possibility of other ways of doing that could possibly be "better"' (Haraway 2016, 31). The curious practice of visiting, which we recommend, drew the children into the worlds of the thrombolites as they speculated about these worlds, storying themselves into the thrombolites' lives. We read in their encounters the making of new ethical relations and potentialities for both the children, educators and thrombolites. Through the

children's encounters and our stories, we hope to actualise the potential for treading more kindly and carefully on the planet.

Notes

1. Although this site is commonly known as 'Lake Clifton', we respectfully preface this colonial name with the local Indigenous name, Noorook Yalgorup. Noongar is an Australian Aboriginal oral language consisting of 14 different dialects which pronounce similar words differently. As an oral language, spelling may be approximate and variable; for example, Noongar may also be spelled Nyungar, Nyungar, Nyoongar, as well as a number of other ways. Yalgorup is sometimes spelled as Yalgorap. Therefore, in this article spellings may vary from those used elsewhere.
2. Thrombolites and stromatolites are microbial structures (Kennard and James 1986) or microbialites (Burne and Moore 1987) formed by benthic microbial communities. Both microbialite structures form in a complex relationship between cyanobacteria and algae which results in the excretion of aragonite (calcium carbonate) in clotted structures (thrombolites) or laminar structures (stromatolites) (Luu et al. 2004; Moore and Burne 1994). Some scientists (e.g. McNamara 2009) describe thrombolites as a type of stromatolite. Others (e.g. Aitken 1967; Kennard and James 1986) argue thrombolites and stromatolites are distinct types. Stromatolites have a layered internal structure and are generally formed in marine environments, while thrombolites have a clotted internal structure and are formed in lakes (McNamara 2009). The Noorook Yalgorup formations are known locally as thrombolites; this is how we refer to them in this paper.
3. The Peel-Harvey wetland system is designated under the Ramsar Convention (<https://ramsar.org>) as a Wetland of International Importance <https://rsis.ramsar.org/ris/482>.
4. The educational system of infant-toddler centres and preschools run by the municipality of Reggio Emilia in Italy has attracted international attention since its inception in the 1970s. An ethic of research is a dimension of the everyday practice of teachers and children in this system. The co-participated research is enabled through a process of 'pedagogical documentation' which deploys multimodal and multiperspectival strategies that include but are not limited to note-taking, audio and video recording, drawing and painting.
5. All children's names are pseudonyms.

Disclosure statement

No potential conflict of interest was reported by the authors.

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