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Ratty places – unsettling human-centeredness in ecological inquiry with young people

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Abstract

Posthumanist orientations have underlined the need to foster non-hierarchical relations with other-than-human beings to adequately attend to planetary crises and help life to survive and flourish. Since a posthumanist critique towards natural sciences has mostly leaned on questioning the premise of human subjects making sense of objectified nature, little effort has been made to explore if and how scientific research and posthumanist approaches might intersect and co-exist without abandoning their respective aims. In this paper, we analyse a case of ecological citizen science inquiry on urban rats to explore theoretical and practical opportunities for environmental education that arise from bridging the posthumanist call for attentiveness towards multispecies worlds with ecological research endeavor. We reconceptualize ecological inquiry as sharing *atmospheres* with other animals as well as through its *material aspects* to articulate conceptual tools to disrupt the subject-object division of knowledge creation between humans and other animals.

Keywords: atmosphere; materiality; multispecies worlds; posthumanism; quality education

Introduction

This paper contributes to the call for increasing attentiveness towards multispecies communities (Van Dooren & Rose, 2016) by exploring the intersection and potential synergy of two fields that traditionally have been seen as separate: a posthumanist approach to more than human worlds and ecological inquiry with a natural scientific frame. In the fields of environmental education and research, some scholars have drawn from post humanist approaches to seek ways to challenge human exceptionalism over other forms and materialities of life (e.g., Hecht & Nelson, 2022; Ruck & Mannion, 2020; Spannring, 2017). To adequately attend to the planetary crises and flourishing and survival of life, fostering non-hierarchical relations with other beings is seen as crucial (e.g., Celermajer et al., 2021; Lupinacci & Happel-Parkins, 2016; Saari, 2021). Moving towards this goal requires researchers to move beyond disciplinary boundaries. Such collaborative efforts have already taken place in the emerging field of multispecies studies, which draw from diverse approaches, including posthumanist philosophies and their emphasis on how lifeforms and entities are entangled and connected rather than separate and individual. The collaborative 'critical friendship' between ecologists, biologists and anthropologists has facilitated new understandings, relationships, and accountabilities (Van Dooren et al., 2016). One central stance adopted by multispecies scholars is 'cultivating arts of attentiveness', meaning "attentiveness to the complex ways that we, all of us, become in consequential relationships with others" (Van Dooren & Rose, 2016). This is done by immersing oneself in the lives of particular others (i.e., giving attention to them) while acknowledging that these beings are also attentive themselves (i.e., things matter to them in various ways) (Despret, 2022; Tsing, 2010; Van Dooren & Rose, 2016).

Posthumanist scholarship is a wide umbrella term covering themes from transhumanities and technology, such as artificial intelligence (AI) to more cultural and philosophical themes of critically addressing the legacy of humanism and the cultural reproduction of human supremacy over other beings and more-than-human nature. In this paper we focus on posthumanism as a fairly recent philosophy utilized in environmental educational research. According to this approach, the point of separation of humans from other animals and from nature is located in the developments of natural sciences and the scientific worldview interlinked with eras of enlightenment and humanism in 16th- and 17th-century Europe (e.g., Snaza & Weaver, 2015). The devastating effects of this separation are also elaborated and documented across various other disciplines and fields. These effects include the appealing explanatory power of natural sciences in determining the optimal and normal and the focus on individual bodies and processes often at the cost of increasing

understanding of the cultural and social framings conditioning human and other than human lives (e.g., Kromidas, 2014; Taguchi & Eriksson, 2021). Education scholars have highlighted that the nature/culture division is repeatedly manifested in the tendency to contextualize and reproduce nature as an object to be studied and known by human subjects, themselves separated from this entity (Pacini-Ketchabaw & Nxumalo, 2016; Plumwood, 2005). Beyond a mere critique of humanism and the scientific worldview, posthumanist thinking often materializes in research designs as a quest to flatten various existing hierarchies by taking seriously the active participation of not just human but more-than-human beings and entities in the phenomena studied (e.g., Bennett, 2010).

In light of this critique towards a scientific worldview, researchers face a challenge to combine posthumanist thinking and natural scientific perspectives. The same has been said about environmental education and science education (Gough, 2002). The two tend to have different aims: science education focuses on learning scientific knowledge and skills and environmental education aims to support the capacities of individuals and communities needed to tackle complex socioecological issues (Stevenson et al., 2013). However, it has also been suggested that it is necessary to seek convergence of science education and environmental education to address current fundamental socioecological challenges (Wals et al., 2014). For example, studies have shown that science education, specifically scientific inquiries, can support learners not only to develop knowledge about the environment but also to engage with sustainability (Murphy et al., 2020) and learn about environmental issues in ways that encourage action and decision making (Forbes & Zint, 2010).

The aim of this paper is to explore the theoretical and practical potential of connecting a posthumanist multispecies perspective with ecological inquiry. Since a posthumanist critique towards natural sciences has been based on questioning the premises of humans making sense of nature around them, little effort has been made to explore how scientific research and posthumanist approaches might intersect and co-exist. This might be caused by a tendency to focus on the outcomes and applications of science that are often discordant with a posthumanist orientation (Neimanis, 2014) yet while science is often represented in finalized and objective forms, science and technology studies as well as studies in science learning have suggested that the processes of doing science extend beyond subject-object divisions as they involve material and non-human elements as essential parts (Latour, 1987; Roth, 2021). The question of whether there is space or opportunities within scientific research to reconceptualize the typical subject-object orientation towards other animals in less human-centred ways remains underexplored.

As scientific research and similarly oriented educational activities are the prevailing ways to build relations with non-human nature, understanding if and how such approaches could better cultivate attentiveness to multispecies communities is all the more important for environmental education. In this paper, we draw from a case of ecological citizen science inquiry on urban rats to explore how natural scientific research might open opportunities for attentiveness that begin to challenge human-centred and hierarchical subject-object premises. We aim to make visible how a natural scientific ecological inquiry necessarily takes place within more than human entanglements. Through examples from our empirical data, we highlight how moments of speculation and orientation towards rats' worlds can be seen as learning to be attentive to complex and dynamic environments that are "continually shaped and reshaped through the sharing of meanings, interests and affects" (Van Dooren et al., 2016). Our goal is not to diminish or evade a posthumanist critique of natural sciences but rather ask whether valuable theoretical common ground can be found between these different premises and what could be the focal points of ecological research process for cultivating attentiveness towards multispecies worlds.

Theoretical background

In this paper, we build on aims of multispecies scholarship to disrupt human-nature division when analysing a cross-disciplinary citizen science project that engaged young people in the study of urban rats. We first employ the concept of atmospheres (Lorimer et al., 2019) to analyse the affective and sensory dynamic between environments and their inhabitants in ecological inquiry, as well as the ways in which other than human beings such as rats, too, can be seen as "atmospheric subjects" (Lorimer et al., 2019). Second, we focus on the materiality of the scientific research by focusing on the "liveliness" (Bennett, 2010) and the event-like nature (Deleuze & Guattari, 1980) of a specific research instrument, a track plate used to capture rats' paw prints in the study.

Animals' atmospheres in ecological inquiry

Atmosphere has lately gained traction as a fruitful analytic when studying the affective intensities and socio-material assemblages of places and spatial events (e.g., Anderson & Ash, 2015; McCormack, 2015; Stewart, 2011). In social sciences and human geography, this concept has allowed scholars to discuss materials, spaces and affect in the same breath and critically examine

the sensory and spatial-temporal complex ways in which various societal phenomena are lived and experienced (see, e.g., Hohti et al., 2021). Atmospheres refer to palpable affective spacetimes that envelop and surround entities thus infusing practices and becoming part of the background of situations (McCormack, 2015). They can be seemingly ephemeral, vague and diffuse; however, they can also be clear to everyone and collectively shared.

Atmospheres do not belong only to the human sphere but they can also be sensed in the total absence of people. Even if studies on atmosphere and its affective intensities have risen to prominence in recent work in geography and helped animate established spatial concepts like territory, place and milieu, there has hitherto been limited work on animals as the subjects or receptors of atmosphere (Lorimer et al., 2019). The range of place-bound experiences differ among individuals and different collectives; particularly, individuals from different species with specific sensory bodies and social structures tend to perceive even the same traits of the environment in completely different ways. Lorimer and colleagues developed the concept of animals' atmospheres, which extends the discussion of atmospheres to animal worlds and on the other hand, expands an understanding of atmospheric geographies beyond the anthropocentric frame. The authors reveal how animals' atmospheres already play a role in humans' culture, for example, in the ways in which 'service animals' are able to tune into shifts in the affective landscapes and the chemistry of their environments has been instrumentalized – shepherd dogs are another example. Our interest in this article is to examine how atmospheres manifest and are essential in doing natural scientific research, in a seemingly objective setting that traditionally has been seen as relatively free from emotions and belonging to the factual world of science. We shall use the concept of atmosphere in analysing how young people use their knowledge, senses, feelings, memories and imagination when pursuing their ecological inquiry.

The vibrant and event-like nature of materiality

Natural and ecological sciences research are material through and through. In a typical narrative of scientific research, the research instruments are viewed as a material extension of researcher's means to carry out the inquiry and as a method to operationalize the research question. Further, these instruments allow the human-subject-researcher to make sense of material and objectified nature. However, material-oriented analyses of science and scientific research show that these processes can be better accounted for when the role of the materiality is understood as *agential*, *dynamic* and *active* part of the research process (e.g., Barad, 2007). Such an understanding

of materiality requires a shift from human tendency and need to "to interpret the world reductively as a series of fixed objects" (Bennett, 2010, p. 58). In her theory of "vibrant matter" Bennett (2010) uses metal and the work of metallurgists as an example to show that what matter is has primarily to do with what matter can do, how it can be transformed and transform life in predictable or often unpredictable ways.

A more materially-oriented reading of scientific research allows us to explore whether such materiality could reframe scientific knowledge production as a multispecies entanglement rather than human-driven endeavour. To further articulate how the entanglement of matter, humans and multispecies environment evades subject-object separations,the work of Deleuze and Guattari (1980) on the becoming and event-like nature of (material) life is instructive. Deleuze and Guattari move away from separation of the subject and environment, which they consider to be only abstractions from concurrent lines of becoming (Deleuze & Guattari, 1980). Instead of observing the interactions between self-identical entities, the becoming itself should be understood as a temporal path. It is a

> line of becoming [that] is not defined by points that it connects, or by points that compose it; on the contrary, it passes between points, it comes up through the middle, it runs perpendicular to the points first perceived, transversally to the localizable relation to distant or contiguous points. (Deleuze & Guattari, 1980, p. 293)

A line of becoming (or line of flight) does not connect entities with each other or the environment, but it is an orthogonal description of a "transversal movement sweeping away one and the other" (Deleuze & Guattari, 1980, p. 37). Two lines of becoming intersect and interweave when they share and are part of the same event. But neither such entanglements are reducible to entities, for becoming "is always in the middle" and one can only get it "by the middle" (p. 25). We will analyse a process of an ecological inquiry as an event and *becoming* and articulate how the separation of humans, rats, research instrument is unnecessary.

Methods

The context of this study was a large research project comprising three consecutive phases: scientific, ethnographic and artistic in studying unloved others (Houston et al., 2018) as members

and inhabitants of communities.[1] The project was conducted in collaboration with young Finnish citizens (secondary-school students aged 12-14 years old). The participants were recruited based on their science teacher's willingness to participate in the ecological citizen science inquiry that was advertised in social media. This paper focuses on the first phase of the project the ecological citizen science inquiry, in which students worked in their compulsory science classes with professional researchers and explored the presence of urban rats in their neighbourhood in Helsinki, Finland. The neighbourhoods were located in middle- to low-income areas at some distance from the city centre.

As part of formal education, the objective of the wider project, with all three consecutive phases, was to explore less anthropocentric ways to attend to communities and surroundings as multispecies and to begin to unsettle the automated hegemony of the human species in thought and actions. The aim of the first, ecological inquiry phase[2] of the project was to collect data on rat presence and absence in the city of Helsinki and later link this information to different ecological and environmental variables. The ecological inquiry phase was introduced to the students as an opportunity to participate in an authentic scientific study to ascertain how rat populations vary spatiotemporally in Helsinki and which factors affect these population dynamics. The students were not specifically introduced or guided to posthumanist thinking about multispcecies environmentsbecause the idea of the multiphased project was to first gather experiences of rats from an ecological perspective and later build upon these experiences and extend the thinking towards multispecies relations and tensions in the urban environment.

The focal species of the ecological citizen science study in question is the brown rat (*Rattus norvegicus*), which is a cosmopolitan, synanthropic species. As a highly unloved species (e.g., Bjerke & Østdahl, 2004) yet wholly dependent on humans, the rat poses as an interesting species for study of the relationships between humans and other species (Schuurman & Dirke, 2020). To explore the presence of rats, the student researchers follow a protocol typical to studying the presence of small rodent. They use 20x20 cm white plastic track plates that were painted with lampblack. If a rat walks across a plate, its paw prints are left to be identified and counted by the students. Thus, the students did not encounter rats themselves during the study but there were able to identify the places in which rats had recently moved. At the beginning of the inquiry in each school, the last author, who was also responsible for the ecological research, visited the classroom

[1] CitiRats, https://citirats.wordpress.com

[2] Helsinki Urban Rat project, https://www2.helsinki.fi/en/projects/urban-rats

remotely[3] and presented a30-minute lecture on urban ecology and rats to explain how the students could participate in the research. The students then worked in small groups and were instructed to think of a place where they would like to study rat presence near the school. The task to locate such places unfolded at two spatial levels. First, the students needed to decide on an area where they could place four plates; then, each plate shouldbe placed in the terrain so that if rats were present, they would be likely to walk across it. In the following four days, the students photographed the plates and tried to identify possible rat tracks. They sent the photos of the track plates (with the number of identified rat tracks) to a database through a mobile application, to be checked by professional researchers to confirm the identification. At the end of the four-day inquiry in the school, the findings were shared and discussed with the rest of the research team. The research team responsible for the empirical work in the first phase of the project consisted of a professional ecologist and an educational researcher with a background in biology. Other members of the research group were educational scientists. None of the researchers knew the students beforehand and the teacher in each school supervised the activities, as they were part of the regular science curriculum.

Video and audio recordings and photographs were collected by the first, second and last author during four weeks when closely following altogether nine groups of three to four student researchers (altogether 29 students) while they pursued the one-week inquiry. The selection of groups that were followed was based on their voluntary and informed consent. The data presented in this article is published with the permission of the participants; all names are pseudonyms. We identified episodes in which students were required to think of rats and rat behavior (in the past or future) to make choices necessary for the inquiry. These episodes were analyzed interactionally in joint data sessions (c.f. Jordan & Henderson, 1995) to make sense of the ways in which the students' worlds of ecological inquiry and rats' worlds intertwined during the inquiry.

We acknowledge the role the youth played as co-researchers of the study but for reasons of space and clarity they will be referred to as 'students' in the following sections. In the interviews at the end of the inquiry, most of the young people considered the activity as different to typical classroom activities and reported that it was nice to be part of a research project. Then again, they also reported not to have thought about the larger project that much during the activities. In any case, the students pursued the fieldwork part of the inquiry similarly to how professional ecologists would have accomplished it. They were able to evaluate potential rat movement based on the

[3]Restrictions due to the COVID-19 pandemic prevented researchers from entering school buildings. The face-to-face activities at the schools were organised in the school yard.

observed tracks and choose the spots for the track plates as well as professional researchers would have, based on evaluations of the ecologists involved (Aivelo, 2022). In fact, the students often had better knowledge about the surroundings of their schools than the researchers, for example, they had ideas regarding the potential food sources for rats. Whereas the interpretation of the tracks on the plates was not as easy for students as for experienced rat researchers, the way the students pursued the inquiry was mostly assessed to be consistent with how professional scientists would have acted scientific during a research process; for example, the students argued over their choices and handled uncertainties in ways that are typical to scientific practices (Kervinen & Aivelo, 2023).

Overall, the citizen science project provided an excellent context to explore the question of whether and how opportunities for attentiveness towards multispecies worlds can arise during ecological inquiry. The dual goal of citizen science of pursuing professional science inquiry while extending participation in the scientific process towards the wider societal community also encourages everyone to rethink participation and citizenship in terms of young citizens and non-human animals (Rautio et al., 2022). Whereas similar aspects of inquiry are typical to settings involving only professional researchers, citizen science activities afford both a theoretical and practical venue to explore the non-anthropocentric opportunities for ecological inquiry.

Findings

In the following two sections we articulate and discuss two aspects of the citizen science that we suggest can be seen as bridging both ecological inquiry and the arts of attentiveness to multispecies communities. Drawing on *atmospheres* and *material aspects* of the ecological inquiry, we discuss whether a more affectively and materially oriented reading of the inquiry could reframe scientific knowledge production as a multispecies entanglement, rather than a human-driven endeavour. We present vignettes that have been transcribed according to the conversation-analytic conventions (Selting et al., 1998) to display the tentative and collaborative nature of interaction in which the atmospheres and materialities unfolded during the inquiry. The empirical examples derive from verbal interactions among the students and the visual, material and olfactory interactions between the students and their environment when choosing a potential spot for the track plates and observing the plates in the following days.

Tuning into "ratty atmosphere"

Anna: mmm smells like garbage

Sofia: nice



Group 2

Since the objective of the citizen science research was to learn whether rats move in the neighbourhoods around the schools, the students were motivated to look for places that were feasible for rats to dwell. The opening quote is from a dialogue between students who are looking for a place for a track plate. The dialogue unfolds as they approach a household waste collection point to place their last plate next to its wall. The fragment exemplifies how the objective of the rat research encouraged and required the students to step out of human perspectives to observe and value attributes in the urban environment. Whereas typical human reactions to the smell of garbage might evoke a sense of dirtiness and even aversion (see Horton & Kraftl, 2018), the students acknowledged and appreciated the smell as a sign of a nearby food source for rats and a preferred place for them to live. Indeed, the same group had some moments earlier played with the idea of changing the wording of "*waste* collection point" to "*food* collection point" facilitated by the resemblance of the two words *roska* and *ruoka* in Finnish.

Proceeding in the inquiry required stepping out of accustomed human perspectives. To make sense of the process in which students attuned to their environments as places shared with rats and try to trace their whereabouts, we use the concept of atmosphere (Anderson & Ash, 2015; Stewart, 2011). The opening quote demonstrates how the same material and social characteristics of the waste collection point produces two affectively and materially very different atmospheres for humans and rats. Lorimer and colleagues (2019) suggest a process of *attunement* to be an essential part of knowing animals' atmospheres. Attuning to an animal's atmosphere begins with developing an understanding of the animal's physiology and perceptual mechanisms; that is knowing their *umwelt* or lifeworld or the environment-organism entanglement (Adams, 2016). Whereas a rat perceives the environmental and spatial cues through senses somewhat similar to humans, the intensity and interpretation of sensory cues differs between the two species because of differences in physiology, diet and potential environmental threats. The common characteristics of rats' life

worlds that all student groups employed when thinking of good places for rats were that rats are drawn to food sources from human origin and that rats avoid places that are very open or crowded with humans and tend to seek cover from and move close to the walls and buildings. The students discussed and looked for places where they stated there should be a "lot of trash" but "not too many people" or "not too much noise from the kids" and where rats can move "along the walls" and "stay hidden". Such knowledge derived from what students knew about rat behaviour from their earlier experiences and from the introductory lecture about rats before the empirical inquiry.

The efforts to understand how a rat might make sense of the urban space were multisensory and expanded beyond the vision: the students discussed the excess noise of some places that might make it unlikely for rats to dwell there, the slipperiness or hardness of surfaces that might make it difficult for rats to get a grip or be able to move on them and the smells of food/trash, as discussed earlier. They empathized with rats' ways of moving in and using the material environment by drawing from their own mundane, bodily and imaginary ways of relating to the space. For example, the students discussed whether rats would walk across the plate positioned close to obstacles, whether rats would be "too fat" to fit through some holes, imagined as rats "playing parkour" close to obstacles. These entanglements of humans' and rats' ways of experiencing the space were used to evaluate either the potential spots for the plates or the origin of the tracks when observing the plates (see the next section for more on the interpretation of the tracks). Furthermore, the students pictured other urban dwellers such as dogs, squirrels, cyclists and drunken revelers moving around and potentially affecting the plates. Such an approach is congruent with what Despret (2013) describes as *embodied empathy* with animals. Despret argues that ethological research should involve an affective and immersive learning process in which "the scientist risks being touched/affected by what matters for the animal he/she observes" (p. 57) rather than the human body being separate from and objective towards the research process.

However, knowledge about rat behaviour and ecology was not sufficient to make the choices needed for setting the plates. When choosing the exact spots to set the plates, the students needed to figure out how a rat would move in the area. To do this, they worked towards what Lorimer and colleagues described as attunement *with* animals—gaining "a sense of the animals' atmospheres so as to better understand particular situations and environments" (p. 34). It was not enough to attune *to* animals' atmosphere but the students also had to become aware of how the rats' atmospheres rather intertwined with human ways of knowing and experiencing the urban space. This is exemplified in the following fragment, in which the researcher group tries to choose spot for their fourth track plate. While trying to attune to a rat's bodily and affective lifeworld, human everyday worlds are also engaged.

Fragment 1.

1 Tomas: let's put it there ((points at something; Fig. a))



a

2 Pauli: there (..) where

3 Tomas: under the tree

4 Pauli: why

5 Tomas: [under the tree]

6 Pauli: [why why] would rats go that way

7 Leo: why would rats [go there they're not]

8 Tomas: [I don't know they want if it's raining and] they want to go under a tree

9 Leo: [we're studying ra-

10 Pauli: [well then they go there under the roof

11 Leo: we're [studying rats not birds]

12 Tomas: [well what if] they don't get it or what if they go to that vent and vent away ((points at a vent on the wall; Fig b))



b

13 Pauli: ((laughter)) [vent away]

14 Leo: ((laughter)) [I guess now you know] we're studying rats [not birds

15 Tomas: [then we know that rats are impostors



c

16 Leo: ((laughter))

17 Tomas: or there for example (.) there at the wall ((points at the wall, Fig c))

The group first discusses a proposal by Tomas to place a plate under a tree. The rationale for the proposal stems from the idea of taking cover from the rain, something that make sense from typical human perspective of behaving. In turns 6-11, other students argue against the proposal by suggesting that rats would prefer going under a roof close to the wall and that birds might prefer tree as a cover whereas rats do not. Tomas then points to a vent (turn 12) suggesting that rats might "vent away". This is treated with laughter, suggesting that others accept the idea as humorous for some reason. Tomas further continues that the rats would then be "impostors", reacted again with laughter by others, before making a suggestion of a plate placement beside the wall. "Impostors" and "venting" are references to a social online game called Among Us.

Thinking about places and events in terms of atmospheres foregrounds a dynamicity, in which atmospheres both have effects not only on what can happen but also on events themselves (McCormack, 2015). The atmosphere that unfolds in the students' discussion shapes the decisions as to where the plates are set. The scientific purpose of the research is negotiated (how the inquiry will manage to produce knowledge about rat presence). However, atmospheres also are generated during the inquiry that cannot be reduced to mere scientific goals. In the case demonstrated above, what is at stake in the atmospheres is an open-ended assemblage of multiple factors (c.f., Stewart, 2011): former experiences, cultural scripts of video games, imaginary scenarios involving rain, shelters and vents. These human-originated atmospheric factors entangled with the need to attune to how a rat would perceive the environment differently from humans.

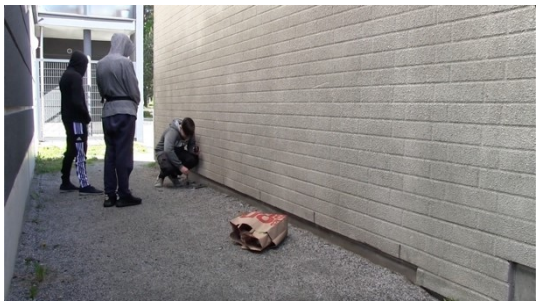
Human ways of knowing and dealing with animals' atmospheres always involve biopolitics of human-animal relations with respect to human engineering of animals' atmospheres (Lorimer et al., 2019). In the case of rats, the "rat" seemed to be entangled with cultural and counter cultural productions as much it is with students' ethological knowledge. In parallel to how unruly raccoons disrupted the nature/culture divide embedded in educational practice (Pacini-Ketchabaw & Nxumalo, 2016), the plurality of rats and "rattiness" set challenges to carrying out ecological inquiry for which (some of the) the cultural rattiness might be misleading. This was well demonstrated in several examples when the student researches were seeking and finding "*ratty places"* in which to place the plates.

Several groups articulated that a place that would be "comfortable for rats" and where rats "can chill out" would be optimal place for track plates. Such ratty places were not limited to traits that would satisfy a rat's needs for food and shelter; the ratty places were equally and perhaps more defined by their contrast to and conflict with the places that would be appreciated by humans. For example, one group placed a plate in an alley that they described as a "dark, drug-dealing alley" (Figure 1a) and another discussed whether they would find "only drug needles" in another alley

(Figure 1b). The latter group also considered taking the plates to places where poor or unemployed people would go to receive social insurance allowances, making a joke about "allowance rats". Another was a place referred to as "a potato cellar", which was a small, partially underground one-room construction, located next to a recreational forest area a few hundred meters from the school (Figure 1c). The students described the place as a "fusty cellar" and "probably having four [dead] children inside", "stinking" and potentially " full of snakes". Such discussions tied the *ratty places* with the material and social unpleasantness and referenced a dark side of human life (c.f., Horton & Kraftl, 2018). Afterwards they reflected on how a potato cellar is "the only place where we can get a rat" and that it would be "a pleasant place for them", highlighting the assumed and culturally constructed contrast between human-friendly and rat-friendly places.



a



b



c

Figure 1. Ratty places: a) a "dark drug dealing alley", b) an alley where there are "perhaps only drug needles", and c) the "potato cellar".

Despite the difference of ethologically-oriented ratty atmospheres and cultural productions of "ratty places", the above examples show how the students moved smoothly between these two registers. On the one hand, while tracing the rats the young people altered their commonplace ways of perceiving their near environments, paying attention to atmospheric qualities important to rats. On the other hand, sometimes cultural trajectories seemed to take over the atmosphere. For instance, when they explored the potato cellar and considered it as 'ratty', considerations on how

the place might offer food, shelter or nesting possibilities for rats were rendered imperceptible. Sometimes what was perceived as 'ratty' involved enacting social prejudices, geographies of fear or anxiety, related to young peoples' livelihoods, thus producing a (troubling) atmospheric resemblance that underprivileged humans and unloved rats share.

To conclude, successful implementation of the ecological inquiry involved an entanglement of ethological considerations, embodied empathy and everyday experiences related to *ratty atmospheres* and negotiating the cultural productions of "ratty places" which at times contradicted ethological accounts. The students were required to consider and try to attune to rats' atmospheres by negotiating the differences between human and rat ways of living in the city rather than merely reflecting on their own intentions and experiences. The scientific goal of knowing about rat presence, which entails the subject-object underpinning, was only one element in shaping this process. When the preliminary results of rat presence and the impact of these results were discussed at the end of the inquiry with the professional researchers, the students discussed ideas such as where the rats are problematic and if they could be relocated away from humans. The attunement to rats' atmospheres that was required during the inquiry might have had impact on raising such thoughts that consider rat's perspective to some extent yet, these ideas were based primarily on the human perspective, which suggests that it is not easy to disrupt the human cultural atmospheres as the primary way of thinking about rats. Overall, attunement to *ratty atmospheres* and negation of *rattiness* during the inquiry contrasts the objectifying supposition of scientific research by giving primacy to the socio-material process that involve rats and potentially other urban species as subjects rather than only humans. Next, we shall further focus on the materiality of the research process and how it further creates space for multispecies attentiveness.

The (living) materiality of the research in reconceptualizing subject and object

1 Elias: this is quite exciting are those
leaves or what are these kinds of
((photo of the plate in Fig. a))
2 Oliver: I don't know
3 Elias: [you can see]



a

4 Oliver: [or some] rat have jumped there and slided from there haha
5 Elias: cause that's pretty downhill

6 Leevi: [yeah yeah it could be just tsssssh ((a sibilant sound))
7 Elias: [no
8 Oliver: [well okay hardly that is hardly the case but
9 Leevi: but it looks like someone had scratched it anyway
10 Elias: yeah scratched ((makes gestures of scratching with his hand; Fig. b))
11 Oliver: hmmm



b

Learning about rat presence was made possible by and embodied in the physical research instrument: the plastic plate that was painted with lampblack and set on the ground. However, it was not only the students' hands that modified the plate but markings were made on the plate by other animals, plant parts and a range of urban phenomena. When the students were observing the tracks on the plate and trying to make sense of what had happened, a process of interpretation and argumentation unfolded as demonstrated in the opening fragment. The dialogue shows how the students came up with alternative explanations that could explain the transformation of the painted surface and evaluated their likelihood. Before the articulation of knowledge of rat presence could happen, entanglements of humans' and rats' actions and transformations of the research instrument had to take place.

The use of research instruments could be conceptualized as a material extension of a researcher's means to carry out the inquiry and as a method to operationalize the research question. Such narrative is typical to the accounts of scientific research as an endeavour of the human-subject-researcher to make sense of nature. However, a more materially oriented reading of the opening fragment could focus on the transformed track plate as an agent that enables through its transformation (or in Barad's terms, through agential cut) the production and sensemaking of knowledge about possible rat presence. Drawing from Deleuze's and Guattari's (1980) approach to focus on lines of becoming—events—rather than separate subject and environment, the whole process of rat inquiry can be considered as becoming-to-produce-knowledge-about-rat-presence. Such an event is not reducible to separate entities but the researchers, rats, track plates or the environment are all in the process of becoming: the researchers are in the process becoming to know about rat presence and the rats are becoming to make their presence/absence available to be known by moving around and on the plates. A material manifestation of this event is in the track

plates' transformation and becoming to contain traces of past events in the environment (Figure 2). During the four days of painting, setting, walking on and interpreting, the plates are constantly changing. Indeed, just as the Great Pyramid (Whitehead, 1920) or Italy (Bakhtin, 1993) can be theorized as events, the track plates are events rather than fixed objects. As an entanglement with the becoming of student researchers and rats (and other events), they constitute the possibility to know what has happened in the environment. In an *event* of the track plate, the interweaving lines of becoming involve painting/being painted, walking/being walked on and interpreting/being interpreted, which might in the end be abstracted as a knowledge of rat movement in the area (Figure 2a).



a b c d

Figure 2. Transformations of the track plates

Before coming to an end, an event is inherently in the state of becoming and passing over into an unknown future, which produces novelty (Whitehead, 1919). During the rat inquiry, the unpredictable transformations of the track plates led to students interpreting and becoming to know a number of other events than merely rat movement. For example, when they found a paw print that might belong to a dog (Figure 2b, Group 1), they continued to discuss the potential dog walkers moving close the plates. Another group of students (Group 7) found small shoe prints (Figure 2c) and very regular triangles (Figure 2d) from the plates set in the vicinity of a kindergarten, the students went on to speculate how small kids could have been playing games or making drawings in the area (as a more probable explanation than "rats wearing sneakers" or signs of "illuminati"). The unpredictable material transformations of the plates to contain signs of past urban life were interwoven with the students' becoming-to-know-about-the-rat-presence so that a new becoming unfolded: the students began discussing if they have "just awful research", if "others have had any results" and ask if they could "just change this research like into something under eight-years old next to plates". Within the event (becoming) of producing knowledge on rat presence, new events of producing knowledge on human presence around the plates as well as reflecting on the successfulness of the study arose.

The above examples demonstrate the unpredictable entanglements of different becomings and movements around the track plate. Analysing the research instrument as a line of becoming, inseparable from and interwoven with those of researchers and rats, proposes an alternative to a natural scientific account of the human subject as knowledge producer. Following Deleuze's and Guattari's (1980) proposal of life as becoming and the "flow of matter-movement" (p. 406), it becomes apparent that the materiality of the research instrument and the rats have as much to do in the production of the new knowledge. The track plates, given the numerous other than rat traces, allowed paying attention to the near environment as multispecies events: ratty atmospheres are entangled with more than rats and more than humans. Material traces became matter of speculations on the possible happenings on and around the plate. Sometimes the speculation on these other traces was transformed into speculation about rat intentionality. Other times they allowed for questioning the research question or track placing manoeuvres.

The students themselves acknowledged the rats' role in the process to be not only important but even as actively making choices. Several groups discussed during plate placement and after the inquiry whether the rats would have walked on the plates if they had noticed the plates. When asked about the rat's role in the research, one group (Group 7) formulated it as "kind of announcing themselves that they are not here […] that we are not here". However, the same group also left open an alternative explanation: "or then there are just rats that don't step on our plate". However, we did not find any further elaboration on the collaborative role of rats and materiality, suggesting that more input from the educators would have been needed for such a perspective to be properly acknowledged and discussed.

Discussion

We have explored the possibilities of realizing and affirming posthuman perspectives and unsettling the human-centredness within ecological inquiry in urban spaces, within school science activities and within the ethos of Western modern science in general. Whereas connecting posthuman and Western science and education traditions in ways that lead to learning of multispecies attentiveness is by no means a simple task, this study articulates potential conceptual tools that can be used for rethinking ecological inquiry and designing environmental education activities in ways that unsettle the human-centredness of scientific research.

Ecological inquiry as multispecies collaboration

We suggest that, despite the seemingly incompatible premises, a posthumanist-oriented reading of ecological inquiry could reveal an interesting and valuable venue for both reconceptualizing natural scientific inquiry as more-than-human endeavour and operationalizing attentiveness towards multispecies worlds in tangible and viable ways.

Our analysis of ecological citizen science inquiry on urban rats suggested that whereas the result of the inquiry appears as humans knowing of rat presence or absence, the process emphasizes a more distributed sense of subjectivity. First, the goal of the inquiry may require attunement to more-than-human atmospheres and acknowledging other animals as atmospheric subjects, which enables learning from the shared environment and its possibilities. Acknowledging how tensions between cultural productions of animals and non-human animals as atmospheric subjects might contravene with the scientific goal of the inquiry appears to be important for attuning to more-than-human atmospheres. Negotiation of such tensions between human cultural atmospheres and rats' atmospheres is needed to find the common ground that fits the scientific need to know about rat movement and rats' needs to live and move around.

Second, understanding the materiality as an active, dynamic part of the research process creates space to alter the subject-object setting of the natural science. The research instrument can be re-conceptualized as a living and transforming part of the becoming-to-know-together rather than a method used by the human researcher. Drawing from Smith's (1960) analysis of how a craftsperson works with metals, Bennet (2010) suggests that the two work in collaboration rather than either being a subject or an object. Whereas such analysis of the research instrument dismantles the subject-object distinction between human and material, the case of the rat inquiry with track plates brings in rats as a third collaborator. The process (event, becoming; Deleuze and Guattari, 1980) of collaborating towards production of knowledge on rat presence in the surroundings have material, animal and human aspects (phases) that cannot be separated. Only at the end of the inquiry, was the result of rat presence/absence abstracted in such a fixed and objectified form that can be *known to* or *possessed by* human subjects. However, at that point, new events and becomings begin to unfold that bring together new entanglements of human, animal and material life. Just as different parts of flux relate only when one part arises from or have something in common with another (Whitehead, 1919), what follows from the result of rat presence/absence makes sense only as a phase in the continuum from the original research question to analysing and applying the knowledge in the future.

Future directions for environmental education

Viewing ecological inquiry through a multispecies lens offers valuable directions for environmental education. Both reconceptualizations proposed in this study—the non-human animal as atmospheric subject and the dynamic role of materiality in the research process—encourage researcher to consider the other-than-human species as collaborators in the production of new knowledge rather than as mere objects to be known. Natural scientific inquiry and posthumanist attentiveness to multispecies entanglements can intersect without compromising their respective aims. For such an intersection to happen, human actors such as researchers and educators need to make an effort to rethink the subject-object setting of the research. In our empirical case, such rethinking did not become visible among the youth during the inquiry activities but was only touched upon in the discussions after the inquiry and left to be revisited in the later stages of the multidisciplinary project. However, building conceptual understanding how natural scientific learning and the posthumanist ethos can be bridged is the pivotal first step towards challenging the human-nature dualism. In this regard, the study presents an approach to dismantle peculiar 'educational humanism', which is identified as persistently holding the fort of the enlightenment era, keeping humans and other animals as distinct and separate categories (Lloro-Bidart, 2018). Such an approach can support the important goal of connecting science education and environmental education in a meaningful way (Wals et al., 2014).

From the natural science perspective, focus on atmospheric entanglements and the materiality of the research highlights how the process of inquiry entails and requires openness to other animals as active subjects who collaborate (or not) in the more-than-human process of knowing and producing knowledge. Whereas research reports tend to present the final state of acquired knowledge and reproduce the subject-object setting, shifting focus to the dynamic and collaborative process of knowing is equally characteristic of natural scientific inquiry (Latour, 1987, Roth, 2021). Such a perspective can create space for attentiveness to the more-than-human world. What is then produced in these spaces or whether they remain engaging curiosities, is a point for further reflection and inquiry. They do not produce transformation by default and as our study showed, might not be nearly enough on their own. This calls for words of caution regarding the danger of overly romanticizing the currently popular theoretical and methodological lines of posthumanism as straightforwardly non anthropocentric endeavors. Peter Kraftl (2020), for one, notes that we can become enamoured with a continual search for newness on a conceptual level and fail to produce transformation in the here and now (see also, Tammi, Hohti & Rautio, 2020). Whereas the focus of the current study is in developing the conceptual tools for rethinking of

ecological inquiry as a multispecies endeavour, future studies should investigate the implications of such educational activities for students learning and thinking.

It is important to consider additional critical perspectives on the potential pitfalls of post- and materially oriented scholarship as limitations of the theoretical frameworks employed in this paper. Scholars have pointed out the danger of disregarding social injustice between humans when the focus is on the nonhuman or material (Lupinacci & Happel-Parkins, 2016). For example, our findings show how the students negotiate cultural and social aspects of "ratty places" but these considerations can be distant or even contradictory to the ecological and material focus of inquiry activity. Further, posthumanist theories are not unique in criticizing the cultural reproduction of human supremacy over other beings and more-than-human nature but indigenous knowledge recognizes more-than-human thought before posthumanism entered the scholarly debate (Todd, 2016). Whereas other theoretical framings might have highlighted different important non-anthropocentric aspects of the ecological inquiry activities examined in this paper, it does demonstrate that there are promising opportunities in attempting to bridge two seemingly incompatible approaches.

The present study, despite its limitations, contributes valuable insights for environmental education on how ecological inquiry could be a potential approach to understand the world in meaningful ways (c.f., Forbes & Zint, 2010; Wals et al., 2014). Our more-than-human exploration of ecological inquiry provides much needed understanding on how present science education practices could be reconceptualized as opportunities for teaching and learning *with, for* and *from* other animals and the natural world (Dinker & Pedersen, 2016), highlighting interdependence and the intrinsic value of all forms of life. Searching for common ground between ecological research in a natural scientific frame and the outlined approaches that highlight attentiveness to multispecies worlds can help to create new post-anthropocentric knowledge practices for environmental education in the time of our human-induced ecological crises. For example, future studies might explore how students are encouraged and guided to *think about the atmospheres* of and *find out ways to collaborate* with more-than-human actors to co-create knowledge, and in doing so critically reflect on the exclusive subjectivity of human researchers. Consequently, acknowledging more-than-human dimensions in the processes of ecological inquiry could contribute to recontextualizing natural scientific inquiry as a collaborative task among other species and, thus, further explore posthumanist-oriented environmental education. At the same time, ecological sciences could provide fruitful ground for pursuing non-anthropocentric understandings within environmental education and on a wider societal scale.

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There are no conflicts of interest to disclose.

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