

A niche of their own: variations of information practices in biodiversity citizen science

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Abstract

Purpose – Information practices become highly complex in biodiversity citizen science projects due to the projects' large scale, distributed setting and vast inclusion of participants. This study aims to contribute to knowledge concerning what variations of information practices can be found in biodiversity citizen science and what these practices may mean for the overall collaborative biodiversity data production in such projects.

Design/methodology/approach – Fifteen semi-structured interviews were carried out with participants engaged with the Swedish biodiversity citizen science information system Artportalen. The empirical data were analysed through a practice-theoretical lens investigating information practices in general and variations of practices in particular.

Findings – The analysis shows that the nexus of biodiversity citizen science information practices consists of observing, identifying, reporting, collecting, curating and validating species as well as decision-making. Information practices vary depending on participants' technical know-how; knowledge production and learning; and preservation motivations. The study also found that reporting tools and field guides are significant for the formation of information practices. Competition was found to provide data quantity and knowledge growth but may inflict data bias. Finally, a discrepancy between practices of validating and decision-making have been noted, which could be mitigated by involving intermediary participants for mutual understandings of data.

Originality/value – The study places an empirically grounded information practice-theoretical perspective on citizen science participation, extending previous research seeking to model participant activities. Furthermore, the study nuances previous practice-oriented perspectives on citizen science by emphasising variations of practices.

Keywords Citizen science, Information practices, Practice theory, Variation, Biodiversity, Information science
Paper type Research paper

Introduction

Citizen science allows the general public to engage in scientific conduct through data production and analysis, interpretation of results and research question development (cf. Strasser *et al.*, 2019; Haklay, 2018; Kasperowski *et al.*, 2017; Kullenberg and Kasperowski, 2016; Wiggins and Crowston, 2011). Previous studies have found that active participants in citizen science projects bring in data for analysis, conduct the majority of work and discuss issues with less active participants (Rohden *et al.*, 2019). Moreover, rooted in Science and technology studies (STS) theories on learning (cf. Sørensen, 2009), citizen science projects have been found to involve various forms of knowledge including imitation of tested

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knowledge, consensus-building and implementation of prior knowledge (Mugar *et al.*, 2015; see also Jackson *et al.*, 2020). Projects often rely on large-scale information systems providing arenas for participants for engaging with project objectives in line with their own knowledge and interests, which can be expanded by continuous participation.

In the case of biodiversity citizen science projects, voluntary participants engage in collaboratively monitoring the flora and fauna of geographical regions. Data are used to understand and predict natural trends and for preventing environmental issues (cf. Swedish University of Agricultural Sciences, n.d.a). Participation in these settings arguably become more diversified than in single-objective citizen science projects as a multitude of participants with varying degrees of knowledge bases, experiences, interests and motivations are gathered in the vicinity of the very same information system. Distributed, large-scale research projects arguably become complex due to their vast inclusion of participants; information practices shift depending on the discipline and contextual factors (e.g. Pilerot, 2016; Talja and Maula, 2003). As proposed in prior research on participatory biodiversity projects, it has been suggested that notions of participants and the *citizen* in citizen science can be expanded through “an increased sensitivity to the range of practices and knowledge embodied within these different domains” (Ellis and Waterton, 2004, p. 95). Therefore, there is a need for empirically grounded studies of how variations of information practices unfold and what these variations mean for common objectives of producing data (cf. Hui, 2017). The present study is a contribution to this area.

The aim of this study is to contribute to knowledge concerning what variations of information practices can be found in biodiversity citizen science and what these practices may mean for the overall collaborative biodiversity data production in such projects. This is accomplished through a practice-oriented empirical study of participants active in the Swedish biodiversity species observation system Artportalen, which encompasses a range of knowledge interests, backgrounds and motivations for participation. The study focusses on the participants’ information practices through Artportalen and how these vary by addressing the following research questions:

- (1) How do information practices vary in relation to the shared biodiversity citizen science information system?
- (2) What do these variations mean for collective biodiversity data production?

The next section presents a literature review of related research, which is followed by a description of the research setting. The theoretical framework and the method used are then accounted for. The results of the study are then presented. The paper ends with a concluding discussion.

Literature review

Peer production of knowledge comprises a recurring area of investigation both in library and information science and in citizen science research. Library and information science research have been occupied with exploring scholarly information practices through material aspects (Pilerot *et al.*, 2017), reading practices in scholarly work (Late *et al.*, 2019) and co-production of knowledge (Lanoue, 2020). Citizen science research has been particularly engaged with understanding modes of participation and typologies of citizen scientists (e.g. Peter *et al.*, 2021; Eitzel *et al.*, 2017; Haklay, 2013). The connection and demarcation of these strands of research, presented in what follows, are motivated by placing the study in a library and information science practice-oriented research continuum and framing the study in relation to previous research on varying participation in citizen science.

Scholarly information practices are a longstanding research interest in library and information science (Palmer and Cragin, 2008). Originating from the practice turn in social

sciences, a certain branch of practice-oriented library and information science studies shares theoretical tenets with STS by emphasising the significance of materiality in the enactment of information practices (Pilerot *et al.*, 2017; see also Huvila *et al.*, 2021; Pilerot, 2014). Growing from a sociologically inclined body of work in library and information science, scholarly information practices have been occupied with the notions of work and domain, domain comparisons, information work processes, collaboration and data practices and digital scholarship (c.f., Palmer and Cragin, 2008; Talja and Maula, 2003). Other related research has been engaged with investigating scholarly reading practices in relation to various publications, disciplines and work responsibilities (Late *et al.*, 2019). Moreover, work process information sharing in archaeology has been problematised in relation to documentational aspects. Work processes are found to be spread out in whole documents rather than through detailed reports (Huvila *et al.*, 2021). The intertwining of multiple information-related activities has also been addressed. In a study of an interdisciplinary design research project, it is concluded that the sharing, writing, reading and seeking of information are embedded in each other and contributes to the enactment of the discipline in question (Pilerot, 2015). Similar perspectives on voluntary efforts of knowledge co-production have focused on knowledge claims and credibility on Wikipedia (Sundin, 2011). Scholarly information practices research is hence occupied with studies on how information is dealt with as science is conducted, and how these intertwined activities constitute practices.

Citizen science research presents a variation of connotations of participation; previous empirical research has explicated intrinsic motivations for participation (Greenhill *et al.*, 2016). A condensed definition of citizen scientists is that the participating individuals are “stakeholders in processes of scientifically informed decision-making” (Kullenberg and Kasperowski, 2016, p. 3). Other discussions of the typologies of citizen science participation include hierarchical levels ranging from crowdsourcing, interpretation as distributed intelligence, participatory science through problem definition and data analysis and so-called *extreme citizen science* involving participants in most of the stages of scientific conduct (Haklay, 2013). Other conceptualisation regard citizen scientists as being one of several epistemic agents: “the citizen”, ‘the volunteer’, ‘the participant’, ‘the crowd’, ‘the activist’, ‘the community’ et cetera – agents that in one way or another perform scientific research without being a professional scientist” (Kasperowski and Kullenberg, 2019, p. 2). In an article on terminology, the *citizens* in citizen science are depicted; amateur, citizen, collaborator, donor, human sensor, local knowledge expert, layman, partner or volunteer (Eitzel *et al.*, 2017).

As there is not one single definition of what entails a citizen scientist, current research on citizen science has been engaged with investigating how citizen scientists operate within certain applied settings and their designated projects. For citizen science projects involving tourists, predefined short-term roles have been suggested to be implemented for providing positive volunteer outcomes (Fischer and Wentz, 2020). Other research contributions have focussed on modelling participation through a normative focus, an epistemic focus and reach, according to which certain citizen science projects can be classified (Schrögel and Kolleck, 2019). Although such a model presents an overarching understanding of the varying degrees of participation in projects, it does not consider how participation and knowledge production can fluctuate within projects. A study on biodiversity citizen science, in particular, however found that participation in biodiversity citizen science led to gaining skills in scientific conduct, increased environmental and scientific interests and motivations as well as “changes in behaviour towards the environment” (Peter *et al.*, 2021, p. 304).

Previous research has furthermore devoted attention to how particularly active participants affect collaborative data production in citizen science projects. A study of a virtual citizen science project found that the most active participants assisted in bringing in new data to be analysed, conducting most of the work, bringing up issues in the discussion forum as well as marking up content for future work (Rohden *et al.*, 2019). Related, in a

biodiversity citizen science setting, one study found that most participants contributed with few records and were active during a very brief period of time. Moreover, plant height as well as species' abundance and ease of identification were factors related to the number of records (Boakes *et al.*, 2016). Regarding participants' abilities to influence their participation, it has been suggested that volunteers ought to be provided more power to make decisions of their own as scientific assistants (Jackson *et al.*, 2018). Lack of clear documentation and centralised databases have been identified as barriers to the usability of citizen science data (Lanoue, 2020). Furthermore, a virtual peer has been found to increase participants' contributions to projects (Laut *et al.*, 2017). Citizen science projects in the natural sciences have also been identified to use a top-down approach to participant activity (Ferran-Ferrer, 2015). In another study, several forms of presence have been noted to exist among volunteers in virtual citizen science projects, where participation has been found to include imitation of already tested knowledge, collective consensus-building as well as creating an outlet for an amateur scientific passion and the prior knowledge that it entails (Mugar *et al.*, 2015; see also Jackson *et al.*, 2020). Birdwatchers have also been studied from an ethnologic perspective with a particular focus on epistemic communities (Lundquist, 2018). While citizen science methodologies in ecological research have been found to be diverse, implicating levels of errors and biases that are not fully understood (Dickinson *et al.*, 2010), practice-oriented, qualitative studies can serve to mitigate these uncertainties. The present study stems from this line of research while especially focussing on variations of information practices through a large-scale biodiversity citizen science information system. Next, the research context of the study is presented.

Research context

Following the participatory turn in international policy-making and decision-making processes (see Saurugger, 2010) as well as ambitions to democratise science and technology (Ottinger, 2010), public participation in science has to an increasing extent been established in the past decades (Eitzel *et al.*, 2017). Such a participative development originates from a shift in the application of scientific studies: "science has itself abolished the boundary between laboratory and society" (Beck, 1992, p. 108; see also Irwin, 1995). It has been argued that although public participation in scientific conduct is not new *per se*, citizen science can contribute to "tackle environmental problems and to achieve some form of 'sustainable development'" (Irwin, 1995, p. 33).

The particular research setting in this study originates from citizen science activity in the Swedish species observation system Artportalen. Artportalen is developed and maintained by the Swedish Species Observation Centre at the Swedish University of Agricultural Sciences in Uppsala, Sweden, on behalf of the Swedish Environmental Protection Agency (Swedish University of Agricultural Sciences, n.d.a). As a node for reporting observations of plants, animals and fungi in Sweden, Artportalen is a source of knowledge for targeted conservation efforts seeking to understand and predict trends for preventing climate and environmental issues. Additionally, it serves as a database for nature investigations by governmental County Administrative Boards on cases of natural exploitation and tree felling. Volunteers of the general public, organisations and professionals can document species observations which are subsequently transferred to a knowledge bank of Sweden's flora and fauna for common use and long-term data storage (Swedish University of Agricultural Sciences, n.d.b). For the investigation of variations of information practices in the research setting, a common theoretical framework is needed. This is described in the following section.

Theory

This study adopts a sociomaterial practice-theoretical framework assuming how social life consists of interconnected, configured, material components which follow normative,

situated schemes to achieve joint objectives (Gherardi, 2017; Orlikowski, 2010). Placing the theoretical approach in the library and information science subfield of information practices, practices are understood as interrelated, routinized actions and sayings, shared ways of understanding the world, norms, rules, conventions and the material objects and places in which practices are enacted (Pilerot and Lindberg, 2018, p. 256). In this article, information practices are investigated with a focus on how shared meanings are formed through the handling of material tools and how they may vary depending on situations, backgrounds and motivations.

Exploring shared meanings, routines, material and geographical aspects of activities in relation to an information system necessitate a theoretical lens that can place certain emphasis on variations and intersections of information practices. A fruitful way to do so is by embracing a theoretical framework of variations *within practices* and *in relation to the nexus of practices* (Hui, 2017) for unfolding information practices to produce knowledge. Investigations of variations within practices can be understood to relate to the “conceptual distinction between practices as entities and as performances” (Hui, 2017; see Shove and Pantzar, 2007). Variation entails that all practices contain continuous internal differences. For instance, *practice-as-performance* “takes place at a particular space and time when understandings, materials, practitioners and activities come together in a particular way” (Hui, 2017, p. 55). Practices can be performed in many ways while still being regarded as the same unit. These performance variations can still be understood as the very same *practice-as-entity* although consisting of a number of dimensions of the same practice. Variation can also occur through shifts of shared meanings and purposes. This is explicated as a *tolerable flexibility*: “bounding the difference that is understood as still plausible or acceptable for participants” (Hui, 2017, p. 56). Within the compliance of joint understandings in a practice, there might be various degrees through which these meanings might be moulded and diversified due to participants being involved in different ways and with shifting levels of knowledge (cf. Hui, 2017). Variations are “acknowledged and limited in important ways by the shared meanings that are constructed and reproduced by practitioners” (Hui, 2017, p. 56). Sets of material *constituent elements* can vary as “a practice involves different sets of objects that are used in different circumstances” (see Hui, 2012, p. 206, 2017). Material elements can serve a variety of means and uses with consideration to their current utilisations or dependencies, especially relating to participants’ background knowledge (see Reckwitz, 2002; Hui, 2017). They can be obligatory or substitutable depending on the situated meaning or use for a performance.

Next, the variations discussed previously can serve to understand connections and *intersections* of practices. Accomplishing an understanding of intersections between practices in this study is done by inquiring into how *nexuses of practices* are affected by variations (Hui, 2017). That is, how “inputs to one practice are transformed into outputs that may become inputs of another practice” (Hui, 2017, p. 62). Such as theoretical approach can lead to investigations of how variations within practices mean for the assembled information practices as nexuses. The intersections between practices are then traceable through the following inputs and outputs. Material components are here especially significant, as they can be seen as “a form of connective tissue that holds complex social arrangements in place, and potentially pulls them apart” (see Shove et al., 2012, p. 113; Hui, 2017). Practitioners and material components can hence be understood to be “positioned at the intersections of practices” (Hui, 2017, p. 61). The abovementioned theoretical concepts pave the way for empirically driven practice-based investigations of how variations of information practices such as Artportalen occur in relation to information objects and what they imply for the nexuses of practices of which they are a part.

Method

It is highly important for practice-oriented studies to consider how practices can be closely studied, especially when investigating empirical settings where people are geographically

dispersed. In this particular study, the methodological approach of co-presence has been applied to approximate the participants despite the physical distance between the researcher and the participants (Beaulieu, 2010). The notion of co-presence seeks to *achieve* presence in a setting by highlighting shared meanings through interactions with participants. Co-presence diverts attention from the need of being co-located on site with participants. Instead, closeness to the empirical setting is attained by reaching out to participants, signalling a joint understanding of the matter which is under investigation. The approach can be likened to notions of closing in on the empirical data in a practical sense and thereby getting “a feel for the game” (Bourdieu, 1990, p. 66). In this study, the establishment of co-presence has been achieved implicitly through a number of activities. For example, by sharing information about myself and my work to participants prior to data collection. Moreover, it included receiving tips from participants during interviews about how to use Artportalen when reporting species. It also entailed discussing related citizen science information systems during interviews, my prior use of such systems as well as conversing about the flora and fauna of certain Swedish regions with the participants. I also created an account on Artportalen and uploaded species observations I had made in order to understand the functions of the information system.

Participant selection and data collection

Fifteen active users of the citizen science information system Artportalen were chosen as participants for the study through overviewing Artportalen where the initial contact was established via e-mail. Participant selection criteria included that participants had made more than 150 species observations registered in Artportalen between 2018 and 2020. This was motivated by a striving to select a range of participants from the topmost active observers to participants who seldom but regularly document observations. The data selection process also included that the participants were geographically dispersed to enable an investigation of possible geographical differences among biodiversity citizen science information practices.

Participants were distributed over Sweden in 11 regions. Eight of the participants were female, and seven were male [1]. Two of the participants (Adam and Karl) are or were previously employed by the Swedish University of Agricultural Sciences which hosts and maintains Artportalen. Two (Christian and Joanna) are or were previously employed at Swedish County Administrative Boards. Four (Eric, Felix, Gabriel and Molly) work or have worked with reporting species observations through Artportalen in their capacities as professional biologists. One (Olivia) is employed at the Swedish Forest Agency, using Artportalen as a part of her work. Six (Beatrice, Daniella, Helena, Isaac, Lisa and Nora) were engaged in Artportalen solely on a volunteer basis. Three (Beatrice, Christian and Helena) have been appointed roles of validating data due to experience and species knowledge. All participants reported species observations via Artportalen during their pastime.

The empirical data were produced over a course of one and a half months, from the 22nd of February to the 12th of April 2021. Semi-structured interviews were conducted by seeking to obtain the participants' descriptions of their information practices while interpreting the meaning of what was described (cf. Brinkmann, 2015). Such an approach included an “openness to changes of sequence and forms of questions in order to follow up on the specific answers given and the stories told” (Brinkmann, 2015, p. 150). The interviews followed an interview guide concerning views on biodiversity monitoring, species foci, preparations prior to fieldwork, everyday practices of reporting observations, collaboration and changes of practices over time. The interview guide included several types of interview questions, from introductory and follow-up questions to probing and structuring questions (cf. Brinkmann, 2015, pp. 160–162). Nine interviews were conducted through a video conferencing software, whereas six were conducted by phone. All interviews were carried out in Swedish, followed

an interview guide and were recorded. The duration of the interviews ranged from approximately 30 min to 1.5 h. Transcribed quotations were translated from Swedish to English by the author.

Analysis

Keeping a focus on the variations of information practices through Artportalen, a multitude of information practices were identified by qualitatively coding interview transcripts through a coding scheme using ATLAS.ti 9.0.7. The coding scheme was developed by iteratively focusing on information practices found in the empirical data such as observing, reporting, identifying, collecting, curating and validating species observations as well as making decisions based on such observations. This enabled an analysis of the empirical data where descriptions of participant statements about their activities could be interpreted through the theory; foci were especially placed on the concepts *practice-as-performance*, *practice-as-entity*, *tolerable flexibility*, *constituent element*, *intersection* and *nexus* (Hui, 2017). The analysis process hence entailed an interpretative stance seeking to go “beyond what is directly said to work out structures and relations of meanings not immediately apparent in a text” (Brinkmann, 2015, p. 235). This strategy of delving into participants’ statements about their information practices gave rise to understanding of how practices were interrelated. The analysis process thus comprised an abductive approach in order to make “the unpredictable conversational world of human beings” (Brinkmann, 2015, p. 225) understandable. From a practice-theoretical point of view, focussing particularly on sayings about practices invoked the immanence of sayings and doings (Bourdieu, 1990). The abductive approach led to forming a gradual understanding of the empirical data by analytically moving between the data and the theoretical framework (Brinkmann, 2015).

Results

In what follows, the results of the analysis are presented, through which the variations of biodiversity citizen science information practices are investigated in relation to the concepts accounted for in the theory section; *practice-as-performance*, *practice-as-entity*, *tolerable flexibility*, *constituent element*, *intersection* and *nexus*. Firstly, the variations of information practices are untangled. Secondly, the implications that these variations have for collaborative data production are described.

Untangling variations of information practices

Artportalen’s large scope entails multiple areas of interest. Several participants express their views of Artportalen in a collective way, as exemplified by participant Karl: “Artportalen is an infrastructure. It is public. It is not made for one specific purpose, but it is made for many, many different activities”. The multiple and diverse occurring activities originating in the vicinity of Artportalen is a notion which Gabriel shares: “I think everyone creates a little niche of their own”. While Artportalen instigates a number of interrelated information practices, they are difficult to fully distinguish from each other. Even still, six information practices have been analytically identified from the empirical data. The following sections explicate these and the variations within them.

Observing species. Observing species is identified as a common information practice for all participants in the study. While the activity encompasses seeking for species in nature and works as a practice-as-entity, variations in the practice-as-performance occur. A common trait between several participants is to observe species in one’s close surroundings, in the backyard or when performing everyday tasks:

I have family and children and a lot of other things, so there are not that many planned excursions but [there is] a lot of ad-hoc [observing]. Then you have not planned it but [you observe] what you see when you pick up the children from school, and you see a strange plant at a roadside (Christian).

Others use a more stringent and standardised way of observing species as they engage in fieldwork: “I will walk and my eyes always scan the ground and the sky and the ears are open for birds and insects” (Adam). This variation of observation involves a number of tools and material aids as constituent elements:

If I go out to see what I can find, I always keep binoculars and a [magnifying] loupe around my neck. I have some tubes in my pockets with labels and alcohol. [. . .] But then I can stop at a spot and use my net as a beat net. I will beat around the vegetation among plants without seeing what is there. Then you will find quite a lot of insects and then you have to kneel and see what you have captured in the net (Adam).

Yet, other participants engage in fieldwork observation as professional biologists on behalf of County Administrative Boards. Co-operation is of certain importance in these settings, where the participants take part in various types of observational modes.

If we go out to a pasture, for example, people look for different things. I might be looking for flowers, but the next person may be looking at what the area looks like and its' history. When we get back to our cars and put the cards on the table, I think we have the whole story (Gabriel).

Observations occur embedded in everyday life, as something which just happens in the midst of mundane activities. During excursions, what is found is done by chance, but at the same time entails material objects through which the practice-as-performance is conducted. The serendipitous encounters of several participants are significant for getting, as Gabriel put it, the whole story of the excursion and for understanding not only the species but also the biotope and the history behind it. These variations are accepted within the practice: “some people only want to see what can be found where you live, that’s also an important part of life” (Gabriel). There is hence tolerable flexibility regarding how observations should be performed (cf. Hui, 2017), echoing notions of participants creating niches of their own.

An information practice related to observing is identifying species, which is described in the subsequent section.

Identifying species. In order to make sense of the species observed, they have to be identified. The practice of identifying species can also be seen as varied. Continuing the description of the variations of observation activities described in the above section, identifying species can be done with the assistance of a number of material components. Joanna is one of the participants who is engaged in observing species in her near proximity. Sometimes, however, she travels a bit further for targeted expeditions:

In those cases, you may prepare yourself by bringing your binoculars or some kind of field identification guide so that you do not stand there and not know which flower you’re looking at (Joanna).

Field guides and tools such as binoculars are deemed important objects for identifying species *in situ*. Another key way to identify species is to make use of Artportalen itself outside the fieldwork. Artportalen’s image bank, comprised of previous observations, is used for identification purposes:

There are a lot of photos in Artportalen that I make use of. I might be curious about what a certain species actually looks like, a species that you do not know that well. [. . .] Instead of googling images, you can search in Artportalen. [The photos in Artportalen] are often of better quality, there’s a greater chance that they are correctly identified (Christian).

Through these cases, various tools for identifying species relate to whether they are done on-site or after the observations have been completed. There is flexibility in identifying species

which can vary depending on whether it is done through imparted knowledge by simply viewing a species through binoculars, with the aid of literature or by tracing other people's contributions in Artportalen's image bank. The variations of performances are intertwined with the variations of material elements adopted in the information practice (cf. Hui, 2017). For participants lacking knowledge regarding certain species groups, unable to identify species on-site, comparisons can be drawn between the sighting in question and uploaded photographs, where photographs play a role for investigatory purposes.

Another significant method of identifying relates to interactions with fellow participants. Social media, and especially Facebook, are significant when receiving assistance for species identification:

It can be about helping each other to identify species or guide each other but also to actually join up to do things together. The social aspect and the possibility to both get and share knowledge, the evolution that has happened with all the possibilities to find and reach out to each other there, has enormously increased the desire to do these things (Eric).

This quote from Eric illustrates how social media are important for receiving assistance when identifying species. This co-operation is also noted to increase the desire of participation, extending motivational aspects of engagement. Collaborative identification indicates a function common for distributed layman research while also extending the practice beyond the vicinity of Artportalen. Similar to observing species, there are multiple ways in which species identification can be done, providing another aspect of tolerable flexibility of practices. The next section explicates the various ways in which observed and identified species are reported.

Reporting observations. Throughout the participants' sayings, a recurring theme illustrates that reporting vary in thoroughness throughout the participants' sayings. Some participants noted that their carefulness has increased since they started using Artportalen. Others describe that thoroughness fluctuates: "sometimes I will report everything I see during one day if I'm out birdwatching, even [...] chaffinches and common species, but sometimes I will only report specific species" (Molly). The carefulness and frequency of reports relate to time limitations, occasionally causing rare species to be reported to a greater extent than common. The lack of a smartphone application has been described to be a hindrance for easy-to-use reporting:

There are a lot of discussions in the field when you meet other watchers, if there was a good app so that you, in a smooth and easy manner, really could report directly in the field. [...] Because now, it may be that you only enter what is interesting and that is not what the real fauna is. [...] Maybe that would be more of value for Science (Nora).

Lack of time and easy-to-use reporting tools, such as a smartphone application, are stated to limit reporting. The lack of a full breadth of reported observations is bearable, but flawed, since they do not show the whole picture of the Swedish nature, speaking of tolerable flexibility of report outcomes. In line with this, several participants highlight motivations related to preservation in the practice of reporting species. Preservation consists of both the actual activity itself and functions as the motivation behind other activities. As for the first aspect, observation reports can be understood as an act of preservation in itself in the long-term storage of collaboratively collected biodiversity data.

I am passionate that grand forests should not be cut down. It is very, very important that there is data on what is living in the forest. [...] If there is a [tree] felling case in a place where an interesting species has been noted, they get a ping in their computer, "you have to check this, someone is about to cut a forest with interesting species". [...] It is an activism of sorts, although on a small scale (Joanna).

Reports as preservation are thus considered a notable cause for engagement in biodiversity citizen science. The participant Isaac describes yet another variation of the performance

related to physical preservation. Reporting observations is here done outside the immediate context of Artportalen by assisting in safeguarding physical species samples for long-time storage:

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Usually, if I have received material in addition to what I have collected, when it comes to mushrooms, I dry them and make a collection of them which I send to UPS, a herbarium at the Museum of Evolution in Uppsala (Isaac).

In sum, reporting species observations through Artportalen vary in relation to the material tools and applications at hand. However, tools are also chosen based on the purpose and the context which encompasses the observation. Thoroughness and frequency of reports vary depending on purposes, experience and time. A certain motivation relates to reporting species for preservation means, although these practices also differ in relation to preservation as digital data or physical specimens transferred to herbariums; niches of their own. Collecting documented species is further explored in what follows.

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Collecting documented observations. Collecting documented observations of species is a key information practice by which participants engage in biodiversity citizen science. An intrinsic common ground is the routinised activity (cf. Pilerot and Lindberg, 2018) of accumulating and tracking species for enriching knowledge. Building a collection of observations can be traced to remembrance purposes “as it may otherwise be difficult to remember ‘have I ever seen a bog forest?’” (Joanna). Another reason for trawling observation lists relates to “gaining your own understanding and perception of ups and downs and trends and waves of nature which we are so dependent on” (Daniella). Collection provides both documentational and predictive modes of monitoring nature, both one’s own and others’, posing variations of practices-as-performances related to purposes and ambitions (cf. Hui, 2017). Endeavours of collecting species can, however, dominate the will of contributing for experienced participants:

The citizen scientist part has [for me] to some extent been replaced by this collector’s desire, to use Artportalen as a small bag where you put various [species] and hope that [the bag] will become big and large, which is a purely personal driving force (Eric).

Collecting species gradually come to inspire a sense of competitiveness and is likened to a game of assemblage, creating a feeling of reward experienced “when you see numbers [of observations] get larger” (Lisa). Such activities of competing for collected observations are legacies from activities such as birdwatching in the sense that “you tick off birds and try to see as many as you can” (Felix). While species observation competition is primarily done annually, some participants have driven this competitiveness further, both monthly and daily: “competition has been a success concept to get a lot of data to Artportalen” (Adam). Species observations here include competitive means by exhibiting one’s observations through information objects, increasing data quantity. In what follows, this will be explicated further by delving into a practice interconnected with the collection, which is that of data curation.

Curating lists of reported observations. In the previous section, Eric saw his collection activities in the vicinity of Artportalen through a metaphor of the information system as a bag, in which number of observations grow larger as one tries to see and report as many species as one possibly can, implies that competition is mediated through Artportalen. However, other modes of competition are explicated, relating to specific areas, which align with the intention to curate lists of observations by filling white spots on a map. Such activities are not necessarily directed towards others but towards oneself for accomplishment purposes:

Many of those who are interested in nature are engaged in a kind of competitive collector’s desire. [...] I can be triggered by the fact that I have to look at a red-crested pochard in [a] harbour so that

I can get it on my parish list. It does not matter that I have previously seen that species in many other places. It's missing in some little list where I am stockpiling things, and I have to fill that gap (Eric).

Curating lists of species can thus be understood also in terms of fulfilling personal achievements. It can also be motivated by a desire to broaden one's knowledge and skills in identifying species: "I try to trigger myself to become more capable [of identifying species] by competing with myself" (Joanna). The variations entail several ways in which the performance of curation is conducted through variations in relation to tolerable flexibility of shared understandings and in relation to produced data having a variety of inherent meanings as information objects. As described previously, the species observations collected and curated are utilised in decision-making activities, which are further explicated as follows.

Decision-making based on species observations. Monitoring species distributions for certain geographical areas is a key course of action through which biodiversity data is used by government officials for administrative cases: "If someone wants to build a road, we will make a search in Artportalen if there is [...] something unusual that has been reported there, something you have to take into account" (Christian). Targeted on-site inventorying presents other means by which distribution counts of certain species are conducted:

"How many horned grebes are breeding in this lake this year?" I'll travel there and try to observe that. It's on a more advanced level than pure birdwatching. And it's the same thing with plants. We try to map all the plants in the county. Searching is done in a targeted manner where no one has been before, in an attempt to fill white spots on the map (Christian).

County Administrative Board officials hence use Artportalen for both monitoring and producing biodiversity data, which are subsequently used in decision-making processes. The advanced level of operation mentioned by Christian implies that there is a professional, decisive touch to the decision-making, which eventually comprise the data produced. The research data that have already been reported to Artportalen serve as information objects, setting up guidelines for future work and decision-making in related practices. The data become constituent elements, differing from how they are understood in the above section on collection and curation; what is regarded as simply an entry into a database when participants collect and curate species reports here become a point of reference for decision-making purposes.

County Administrative Boards also appoint specifically responsible individuals for inquiries on species data, which is a position that Joanna has held previously:

One is mainly engaged with administrating governmental accounts and authorisations but it also includes decision-making for authorisations. There are various degrees of secrecy for various observations and I have been deciding who should get what access, but also [acting as an advisor] when questions arise regarding protected species (Joanna).

The information practices accounted for in this section have in common that they regulate cases of nature exploitation while also ensuring the preservation of protected and rare species, invoking variations of how research data as constituent elements are perceived (cf. Hui, 2017). The long-time storage of data for decision-making purposes requires validation, which is further explored as follows.

Validating observations. While Artportalen presents standardised procedures for data input, the broad range of participant interests, backgrounds and knowledge call for validation practices. Some participants receive a validator role in Artportalen, enabling features of affirming data quality. Validating others' reports serve to confirm their plausibility and substantiality:

Especially when it comes to something more unusual, some rare species, it is important that they are correctly identified and that this point, this [geographical] coordinate, is correct and that it is not placed in the incorrect milieu and another part of [the] Öland [region]. (Helena)

Validation is conducted in relation to the accuracy of the geographical metadata as well as the correct species identification. Helena describes the validation further: “sometimes it’s dull, you will not receive a reply but then you can make a threat and say ‘if you do not reply now I will reject your observation’ and they cannot credit it on their lists” (Helena). A certain tension is noticeable from this passage, where reporting and validating citizen science data are interconnected; various information practices occur in the vicinity of Artportalen, sometimes in dispute. Occasionally, however, these information practices intertwine and intersect (cf. Hui, 2017), as in the following case where the validity and credibility of the data are considered crucial also for a participant without validation authorisation:

I strive to be very correct in my reports. If I find out that something is wrong with my reports, I change it. I have become my own validator. If it happens to show that something is incorrect, in the occasion that I am in contact with someone more knowledgeable, then I think you have to change it. After all, it is a database which will be used indefinitely by scientists (Isaac).

Similar to the case with Helena above, social exchange with peers are deemed crucial for ensuring data validation. The difference in Isaac’s case is that he himself strives towards validating his reports by monitoring them and ensuring their correctness with other, more experienced and accomplished people. Validation thus differs in terms of appointed and adopted roles and as an implicit motivation for providing reliable data.

Implications for collaborative data production

The practices accounted for above comprise the nexus of information practices taking place through the collaborative production of biodiversity data in the vicinity of Artportalen. As can be seen throughout the presentation of the results, the information practices of citizen scientists display a multitude of variations. The following section depicts intersections of information practices that spark how “inputs to one practice are transformed into outputs that may become inputs of another practice” (cf. Hui, 2017, p. 62). Several implications can be noted; not least how material objects impact mundane data production, competition influences data comprehensiveness and that there are variations in apprehending validated data.

Mundane data production enacted by material objects. As is discernible from the prior section of the article, there are variations of coverage in relation to what is reported to Artportalen. Some participants describe that they have become more thorough by standardising their reports through Artportalen’s interface and report system. Others describe that the thoroughness of their reports has fluctuated. While Artportalen contributes to standardisation of data production through the various methods of reporting species observations, variations of practices-as-performances (cf. Hui, 2017) occur when these methods have been comprehended and normalised into participants’ lives. Everyday reports of common species are affected by this normalisation. One related aspect has to do with time limitations when reports are done in relation to targeted species inventories: “maybe I will add it for egoistic reasons [. . .], but I will not report everything since you make such careful protocols anyway” (Nora). Only certain species are hence deemed valuable enough to report for these self-proclaimed selfish causes, whereby notions of importance varies from participant to participant. Another aspect concerns reporting species during one’s spare time, in which a similar priority is implied. Yet other participants note that the reports may not be as extensive as they would like them to be. However, the participants note that this could be facilitated by a smartphone application rather than the current web-based, mobile-friendly application. While such technical features provide several material variations relating to reporting species, they could also alleviate everyday on-site reports which in turn might provide a more complete picture of the Swedish flora and fauna.

Competition impacting data comprehensiveness. The collection of species observations is regarded as a prominent part of engagement in Artportalen. Despite this, the activities that connote collecting reports of observations to lists can pose another issue for the coverage of species in the Swedish nature: “it is a good way to get a lot of reports and to get people engaged and involved to contribute, but of course it affects the content of Artportalen a lot” (Eric). Connections can also be traced to motivations of reporting novelties: “I know myself that I do not report everything I see, but rather ‘oh, I have not seen this one before so I will report that’” (Felix). Collecting and competing for species observations as well as curating lists of species might hence lead to providing a large set of species while compromising the diversity of the data. The following quote further explicates reporting species as a competitive intention rather than a noble cause:

I think it is quite similar to those who do geocaching or Pokémon [Go, the augmented reality mobile game]. It is very similar in that collecting and finding are a driving force and motor, and the social context around it creates a jealousy of each other and triggering each other to look for something at the same place. If someone has observed something, you want to remake that achievement. It’s like a hobby, it is a spare time interest rather than that you walk around feeling like you are morally correct because you contribute. (Eric).

Seeing other participants’ sightings can hence function as a motivation for remaking accomplishments. While such activities also function as validating observations and thereby forming intersections between practices (Hui, 2017), they provide multiple sightings of the same species. This is not an issue relating to the data it entails, but the practice directs attention to the surroundings, compromising other sightings. However, another form of competitive drive, as stated by Joanna and described in the prior section, also includes a motivational function for learning new species. The various forms of competition, either directed towards oneself or others, have implications for what is observed and where thereby influencing the exhaustivity of species reported to Artportalen.

Variations in apprehending validated data. In this final results section, the focus is placed on what the information practices and their variations imply for making sense of the data. Between participants occupied with validation and decision-making, disputes sometimes occur. Knowledgeability and understandings of validation activities can generate disagreements regarding how to apprehend collaboratively produced data. This is exemplified as follows:

There are those [among the County Administrative Boards] who are not familiar at all with Artportalen and how it works or birdwatchers, botanists, entomologists, how they work. Then it is harder to assess whether a report is unreasonable or not (Christian).

Variations in apprehending participants’ work routines and the many activities reported to Artportalen pose issues when assessing the validity of the data, providing another intersection between practices, which Beatrice further explains as,

What I miss is the knowledge at the County Administrative Board, the Swedish Forest Agency, municipalities, to use the facts that we report. They do not understand if it’s validated or not. [...] We [volunteers] are learning [to use] a system that is supposed to be accessible for Sweden in all kinds of contexts, but the beneficiary cannot really assimilate that yet (Beatrice).

The knowledge discrepancy mentioned above is arguably related to the distributed setting and associated practices of Artportalen as data are produced decentralised but monitored by County Administrative Boards. A person responsible for species data inquiries at the County Administrative Boards, as previously described by Joanna, could serve to facilitate such an intermediary knowledge position, enabling co-ordination between the knowledge attained through validating and the knowledge practiced through decision-making.

Concluding discussion

The present study shows that volunteer participants in Swedish biodiversity citizen science engage in heterogeneous, occasionally interlinked, sets of information-related activities. What at first glance may be understood as a relatively cohesive set of practices contains a number of different, although related, information practices with varying motives. This also entails a variety of consequences for collaborative research data production. Information practices enacted through and in the vicinity of Artportalen are both unified and varied, complicating previous models of citizen science participation (e.g. [Schrögel and Kolleck, 2019](#)). They are joint in the sense that all participants are occupied with observing, identifying and reporting species. Several participants are involved in collecting observations, curating lists of species, validating others' observations or decision-making based on aggregated observations. Information practices do, however, vary due to motivations for preservation, technical know-how, knowledge production and learning as well as the reporting of species. As such, participation in Artportalen entail a variety of interests to co-operate for the collaborative production of biodiversity data; participants are engaged in forming a niche of their own in the vicinity of the information system in question. Observing species vary depending on whether species are sighted in everyday situations, as part of field excursions or as part of professional biologists' work assignments. Identifying species shift as information practices are enacted through material objects; by the aid of binoculars and field guides, trawling Artportalen's image bank and with the assistance from peers through social media.

Thoroughness in reporting species has been found to vary depending on participants' time at hand and on preservation motivations. Collecting observations and curating lists has, moreover, been found to be a principal motivation for participation. Collection vary based on the will to assemble observations, competing with others or to deepen ones' knowledge on species or species groups. Decision-making based on species observations is done both in relation to monitoring and producing research data. Validating is done as an assignment both by certainly appointed volunteers but also as an implicit internal motivation among participants for assuring reliable data. What is more, participant engagement in the vicinity of Artportalen has been found to lead to knowledge production, individually as well as collaboratively. Collecting species produce knowledge about the species witnessed, as well as serve remembrance purposes through the individuals' backlog of species reports. These past reports are in turn used as a way of understanding trends of species occurrences. The practice of curating lists broadens participant knowledge as the lists are used to enhance skills of identifying species with competing with oneself, as one participant describes it. Such skills can also be strengthened by tracing other participants' contributions in Artportalen's image bank, comparing a new sighting with photographs previously uploaded by other participants.

There is a reason to remark that this study has met research requests seeking to increase sensitivity to the information practices which unfold in biodiversity citizen science ([Ellis and Waterton, 2004](#)). In turn, the study also problematises typology understandings of participation in previous citizen science research (e.g. [Kasperowski and Kullenberg, 2019](#); [Eitzel et al., 2017](#); [Haklay, 2013](#)); rather than being placed into one particular volunteer category, participants engage in a number of information practices through which participation shift depending on current knowledge interests, the time at hand, reporting tools utilised and experience. Varying information practices are thus encouraged as a contribution to, and in a decentralised perspective setting the stage for, the citizen science practice at large.

As for what these variations entail for the collective production of biodiversity data, information practices such as observing, identifying and reporting species occur in situated settings on a day-to-day basis. Similar to previous research on natural science citizen science

projects (Ferran-Ferrer, 2015), a top-down approach to participants' information-related activities has been noted with regard to how participant activities are utilised by decision-makers at County Administrative Boards. The study has, however, found knowledge and interpretation discrepancies between the validation practices and the decision-making practices; there is no clear consensus of how to apprehend data validity. Intermediary participants can serve to minimise the distance between variations of positions in Artportalen, resolving issues of unclear documentation reported in previous research (Lanoue, 2020). Contributing to scholarly information practices research on materiality (e.g. Huvila *et al.*, 2021; Pilerot, 2014), the material objects through which identifications and reports are done have, moreover, been found to be of high importance for both the quality and quantity, but also the diversity, of the data. Similarly, time limitations of observing and reporting species lead to simplified, non-detailed reports as well as prioritising reports of rare species. This is especially notable as one of the main objects of Artportalen is to monitor biodiversity. Moreover, the competitive driving forces of several participants can have negative implications for data diversity, risking a certain data bias. However, competition can also serve to enrich individual knowledge about particular species. Another aspect relates to how species are reported, where performances of the same practice entity vary depending on the mode of reporting. One way to answer the participants' needs for simplifying everyday reports relate to the development of a smartphone application to be used in fieldwork. While this would lead to further variations of information practices, it could serve to mitigate data bias, increasing both environmental interests and motivations for participation (cf. Peter *et al.*, 2021).

Adopting a practice theoretical framework focussed on variations to the study of citizen science enables understandings of diverse, distributed and assorted information practices – niches of their own – taking place under the shared roof of a large-scale information system. The present study has arguably posed nuanced understandings of participants' information practices, complementing previous studies on practices based on epistemic cultures (e.g. Kasperowski and Hillman, 2018; Lundquist, 2018) and forms of presence (e.g. Jackson *et al.*, 2020). Future research on variations of information practices in citizen science could benefit from diverse perspectives on matters such as the mutual constitution of valid and reliable data or further explorations of the possibilities and limitations of technical information systems and tools. Empirically grounded information practice studies provide a suitable way through which such questions, in relation to the decentralised settings of citizen science projects, can be answered.

Note

1. As part of the participant recruitment process, all participants received information of, and gave their written permission and consent to, being included in the study and having personal information collected. All participants were pseudonymised.

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