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NO ROSE ON THIS ONE?

Citizen science field excursion negotiations at the Great Alvar

by Björn Ekström

This study explores how material qualities of tools contribute to shape information practices of observing, documenting, identifying and reporting species in biodiversity citizen science. Through participant observation and trace ethnography, information practices enacted during a field excursion at a World Heritage Site in south-eastern Sweden are investigated in relation to reported data submitted to the species observation system Artportalen. The study, which adopts a theoretical lens comprising the analytical concepts of epistemic objects and inscriptions, finds that the participants' situated questioning, discussion, documenting and comparison of species through tool use establishes the observations as projections of knowledge claims. These projections are subsequently constrained but also appended as they are reported as data via Artportalen. As material qualities are generally made invisible, the reported data are augmented by the observation system when merged with other reports to aggregated data. The study extends knowledge concerning how biodiversity citizen science field excursions are conducted by understanding information practices and their outcomes as entangled activities characterised by negotiations in relation to material tools rather than as streamlined processes. Consequently, the results expand knowledge of the messy practices carried out to produce biodiversity citizen science data.

Keywords: Botany, biodiversity, citizen science, information practices, materiality

Author: Björn Ekström, Doctoral student and Lecturer,
Swedish School of Library and Information Science, University of Borås, Sweden

Introduction

Biodiversity citizen science includes public engagement in identifying, monitoring and recording biodiversity, producing data volumes for scientists which are not otherwise possible to obtain (Dosemagen & Parker, 2019; Peter et al., 2021). Practically speaking, biodiversity citizen science comprises voluntary efforts to monitor and assess the environment through observation of and interaction with nature (Bonney & Dickinson, 2012). While participants encompass a variety of backgrounds and levels of expertise, a shared component among practitioners is the utilisation of tools such as notebooks, field guides, cameras, report systems and image recognition-supported smartphone applications. These tools, in varying extents and forms, are used to observe, document, identify and report species types, numbers and occurrences.

As discussed in previous research, tools such as web portals and information systems can facilitate and simplify the management, processing and sharing of biodiversity data (Chandler et al., 2017). Moreover, participation in biodiversity citizen science has been stated to be made more available and simplified due to technical development (Bina et al., 2021). However, it is important to recognise that such simplification does not equal uniformity of practices. Instead, as seen from a materiality perspective, human *and* nonhuman actors mutually contribute to the production of scientific results (Forlano, 2019). Through such a viewpoint, objects possess qualities that shape practices. From this view, studying participants' use of tools for observing, identifying, documenting and subsequently reporting species, i.e., information practices (Ekström, 2022a, 2023), becomes a key issue for understanding how material qualities of tools shape and control efforts to monitor and overview biodiversity.

Citizen science is an increasingly researched topic, and the scholarly interest concerning environmental and biodiversity citizen science has risen in recent years. While citizen science can approach environmental disasters by addressing locally significant issues (Dosemagen et al., 2022), questions arise concerning how volunteers' information practices occur on-site and what aspects of the practices come to be reported through web-based forms in relation to classification systems. Since biodiversity classification normalises nature into structured, standardising categorisations (Montoya, 2022), volunteers come to depend on established taxonomic systems to make sense of what is found in the field and how to report identified findings to large-scale information systems for data aggregation. Since knowledge, previous research shows, "[…] is temporary, […] validation in the [species observation system] is a never-ending activity" (Hetland, 2020, p. 12). Furthermore, software for tabulating data can be considered organisational tools tangled with structured activities such as talking about, producing and working with data (Dourish, 2017). To understand how tools shape practices of interacting with and in relation to data, careful consideration of the handling of instruments, literature, applications and other material objects during biodiversity field excursions is needed.

An increase in research on material qualities of environmental citizen science projects in general, and biodiversity citizen science in particular, is traceable lately. In a study of birdwatching, field guides were considered media establishing the epistemic community (Lundquist, 2018). Identification activities comprised ongoing negotiations among practitioners during which the birdwatchers attempted to recognise and classify species, which created motivations among the participants (Lundquist, 2018). Another study showed that particulate matter sensors for home air quality measurement were used by participants in an exploratory fashion, testing their limits prior to expert validation (Matz et al., 2017; see also Ekman, 2021). Yet another prominent study placed an educational technology focus on the biodiversity citizen science project *iSpot*, where species reports were shown to structure participation in a community of practice (Scanlon et al., 2014). Drawing on these fruitful research contributions to knowledge production in citizen science, the present study emphasises how tools shape information practices in a botanical citizen science field excursion.

On the same note, the Swedish biodiversity citizen science species observation system *Artportalen* (literal translation: the species portal) functions as a node for storing and validating professional- as well as volunteer-reported data of animals, fungi and plants in Sweden (Swedish University of Agricultural Sciences, n.d.). However, while the information system encompasses reports of amphibians, birds, fish, fungi, invertebrates, plants and more, participants with a range of knowledge interests utilise the same standardising tools for registering findings. In line with this, the epistemic culture around *Artportalen*, as the culture that produces and mandates knowledge (cf. Knorr Cetina, 1999), has been described to value "[…] the individual trusted observer for performing particular observations" (Kasperowski & Hagen, 2022, p. 458). Yet another contribution considers, through an actor-network-theoretical approach, how a sighting of a northern lapwing is transferred by an ornithologist from a field observation through *Artportalen* to the large-scale Global Biodiversity Information Facility (GBIF) (Peterson et al., 2022). From this, questions emerge concerning how biodiversity citizen science field excursions incorporating multiple practitioners are conducted in relation to tools used during and after excursions take place.

Relevant prior studies have focused on tool use in environmental and biodiversity citizen science (Ekström, 2022a; Lundquist, 2018; Matz et al., 2017; Peterson et al., 2022; Scanlon et al., 2014). There is, however, a lack of research on how information practices are enacted in practice in relation to material qualities of tools. Studying material qualities of information practices in biodiversity citizen science through observation methods can foster an understanding

of how tools shape information practices in biodiversity citizen science. Consequently, this knowledge can serve to improve the prerequisites for species observation systems to be utilised in environmental monitoring initiatives.

Aim and research questions

This study aims to investigate how material qualities of tools contribute to shape information practices of observing, documenting, identifying, and reporting species in biodiversity citizen science. This is done by exploring how information practices are enacted through the situated use of tools by participants active in a botanical field excursion at a Swedish World Heritage Site. Reported data are subsequently studied in relation to physical observations to understand how the field excursion is translated to biodiversity citizen science data. The study is guided by the following research questions:

1) Which constraints and opportunities do material qualities of tools provide for biodiversity citizen science information practices?
2) What do these constraints and opportunities mean for how data are produced in the given empirical setting?

The empirical material is approached through Karin Knorr Cetina's (2001) theory of objectual practice and Bruno Latour and Steve Woolgar's (1986) concept of inscriptions. These points of departure, viewed through the overarching theoretical approach of sociomaterial practice theory, are explicated after a further description of the research context.

Research context

The empirical setting for this study is a field excursion at the Great Alvar, a limestone plateau part of the Agricultural landscape of southern Öland, Sweden, a UNESCO World Heritage Site. A botanical association in southern Sweden arranged the excursion. Organised regularly, the association organises these types of field excursions to monitor the flora of given geographical regions through inventorying plants at trails. The species observed during excursions or other inventorying activities are subsequently reported to 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.).

The excursion was conducted on a trail from a research station on a slightly cloudy day, the barren landscape stretching out as far as the eye could see. Twenty participants followed the excursion leader with their eyes focusing on the ground, asking questions about the soil, the wildlife, the climate and, most notably, the plants growing in the area. In many ways, the excursion resembled a field biology lecture with pupils following a teacher, inquiring at will about plants discovered. Some participants knew each other from before; others were new to the group. Some were experienced in inventorying the field; others were still adjusting to the practices. Occasionally, participants went about at their own pace, sweeping the bushes with nets in the hope of sampling insects or watching the skies for birds in flight. As the excursion went on, new, smaller groups were formed as extensions of the larger group. When these smaller groups stopped and fixed their gaze upon a specific plant, other members backtracked to the area of interest, intrigued about possible findings. The excursion carried on throughout the trail, circling the area before heading back to the starting point of the research station.

The distinctiveness of the Great Alvar as a World Heritage Site, as the site of enquiry, provided possibilities to the practices enacted in the sense that the participants arrived with preconceived understandings of what went on and how participation was conducted. However, there were also initial constraints to the excursion as the excursion leader's route was more or less expected to be followed. Unspoken rules were followed as the participants would leave the area as it was when they arrived, respecting the World Heritage Site.

Theory

The present study draws on a theoretical approach grounded in sociomaterial practice theory, assuming a stance where people "[…] as they interact with a technology in their ongoing practices, enact structures which shape their emergent and situated use of that technology" (Orlikowski, 2000, p. 404). Practices, from this perspective, "[…] are always sociomaterial, and this sociomateriality is integral, inherent, and constitutive, shaping the contours and possibilities of everyday organizing" (Orlikowski & Scott, 2008, p. 463). Moreover, practices are understood as sets of activities invoking shared understandings, rules, conventions and norms, along with routinised activity, places and material objects (Pilerot & Lindberg, 2018, p. 256). A notable presupposition is that practices are relational, routinised and intertwined in character.

While practice theory is employed as an overarching theoretical perspective, the study also draws on adjacent, additional theoretical concepts, which are described in what follows. Seeking to grasp situated information practices enacted during a citizen science field

excursion necessitates the utilisation of theoretical concepts where the tension between situated knowledge and standardised reported data can be unfolded. To achieve this, the study makes use of Knorr Cetina's (2001) theory of objectual practice and, in relation to the current empirical setting, the theoretical notion that epistemic objects emerge throughout participants' information practices. In the present study, species observed in nature are understood as epistemic objects during observation and identification; knowledge is projected upon the species as participants try to identify a plant, a bird or an insect. Or, in the words of Knorr Cetina, "[…] moments of interruption and reflection into the performance of research, during which efforts at reading the reactions of objects […] play a decisive role" (2001, p. 184). Epistemic objects are hence understood as projections of knowledge in lieu of objects clearly defined (Knorr Cetina, 2001). Species in the process of being identified thus open up for questions and interpretations among the participants as work activities are dispersed and distributed among the many actors (cf. Knorr Cetina, 2001). They recurrently change their properties and acquire new ones.

As Beaulieu and Leonelli (2021) describe, "[…] an amateur taking pictures in the woods produces objects through their interaction with the world" (p. 57). These objects can later be utilised by professional researchers, serving as botany data (Beaulieu & Leonelli, 2021). One way to understand the reported data is to understand them as inscriptions, practices of textually naming and noting what has been observed (Law, 2004). Tools used for these matters are understood as inscription devices, i.e., arrangements that enable the conversion of relations from non-trace-like to trace-like forms (cf. Law, 2004; cf. Latour & Woolgar, 1986). Inscriptions can be understood as immutable mobiles, objects maintaining meaning or form in various contexts (cf. Latour, 1986, 1987). However, there are also mutable aspects to inscriptions where information systems can be assumed to be mediators, not only transferring meaning as points of passage but altering the meaning through the very tools used for carrying out the reports (cf. Lammes, 2017). The study of immutable and mutable aspects of inscriptions permits the scrutinisation of how epistemic objects in the field conform to biodiversity citizen science data in *Artportalen*.

Method

It is of great significance in practice-based studies to be able to investigate the empirical setting closely while still being able to consider the setting from afar. Drawing on the methodological approach of combining participant observation and trace data studies (Ekström, 2022b, 2022c), participants' information practices and their reported findings, as uploaded to *Artportalen*, were analysed. In the present study, this coupling of methods invoked the methodological strategy of zooming in and out of practice (cf. Nicolini, 2009) by closely examining the real-time practices of conducting a field excursion and subsequently trailing the reported data as outcomes of the excursion. In turn, the approach enabled the analytical emphasis of geographical aspects of information practices, retroactive understandings of what is made visible from the field excursions and the examination of metadata as traces of information practices, as proposed in previous research (cf. Ekström, 2022b, 2022c). By so doing, it was possible to emphasise and articulate closely investigated aspects such as doings and sayings enacted in the field, bodily movements and the role that material objects play out, as well as considering distantly examined aspects as, for instance, relationships between practices and the effects of the global on the local (cf. Nicolini, 2009).

Data selection and production

The data produced and collected comprised author-produced field notes and photographs during on-site participant observation (cf. Delamont, 2004) of a field excursion as well as species reports exported as trace data (cf. Geiger & Ribes, 2011) from *Artportalen*. Invoking previous studies with participants active in this association (Ekström, 2022a, 2023), the field excursion was chosen on the basis that the participants routinely observe, identify and report species in nature, both on their own and through regularly held excursions. The participants thereby have more or less established routines and know-how concerning observing, identifying, documenting and reporting species for inventorying the flora in the region. Concerning ethical considerations, the participants of the event were informed about and granted permission for the conducted study. Information about and forms of consent to partake in the study were signed by participants or agreed upon verbally on-site. Usernames in the trace data were omitted from visualisations.

Data production was initially carried out during a one-day field excursion in the spring of 2022 through participant observation of members of the botanical association. Twenty participants altogether attended the excursion. The participants ranged from new members to experienced organisers, providing a set of participants with various experiences concerning the inventorying of plants in the Swedish landscape. During the participant observation, field notes and photographs were taken of participants observing, identifying and documenting species on-site in the field, focusing on how tools were used to enact these activities, which were conceptualised as information practices. Occasionally, informal conversations were also held with participants to allow further enquiry concerning the information practices taking place.

After participants reported their findings to Artportalen, the reports were exported in Microsoft Excel spreadsheet format. These data, as exemplified in Table 1, were considered documentary traces of participants and their activities in a trace ethnographic vein (cf. Geiger & Ribes, 2011). The trace data comprised 40 entries

of tabulated data. Each of the 40 rows represents a reported observation, with 61 columns comprising metadata variables. The variables selected for this part of the study included species names, scientific names, observation sites, dates, quantities, geographical coordinates, biotope descriptions and age stage. Trace data export was conducted on the 9th of May 2022 and was demarcated to the geographical area of the field excursion. Informed by digital sociology (cf. Marres, 2017), these digital traces were seen as remnants of information practices, the metadata representing bits and pieces of past activities.

TABLE 1.

Species name	Scientific name	Site name	Province	Quantity	Biotope description	Age/stage
Elder-flowered orchid	*Dactylorhiza sambucina*	Station Linné syd	Öland	Noted	Grazed old field	In bloom
European chickweed	*Cerastium pumilum*	Skogsbyalvaret	Öland	Noted	Grazed, tufty alvar	In bloom
Green-winged orchid	*Anacamptis morio*	Station Linné syd	Öland	Noted	Grazed old field	In bloom
Orange tip	*Anthocharis cardamines*	Station Linné SV	Öland	*NA*	*NA*	Imago/Adult

Table 1. Trace data exported from Artportalen (excerpt, translated into English)

Analysis

The analysis drew on an information practices-oriented methodological coupling approach for spatially investigating trace data in relation to traditional ethnographically inclined methods (cf. Ekström, 2022b, 2022c). This approach enabled the investigation of how biodiversity citizen science information practices are enabled and constrained through material objects (Ekström, 2022b, 2022c) by zooming in and out of practice (Nicolini, 2009). Comprising an abductive approach (cf. Pritchard, 2013), the analysis process was conducted in a fashion where field notes and photographs from the participant observation were analysed in relation to the visualised trace data through the lens of the theoretical framework comprising objectual practice (cf. Knorr Cetina, 2001) and inscriptions (Latour & Woolgar, 1986). Occurrences of reported entries and reporting participants were also visualised. The following entities emerging from the empirical data, while overlapping in practice but analytically separated, were in focus:

- Cameras and magnifying loupes for observing species;
- field guides and smartphone applications for identifying species;
- notebooks, GPS devices and Dictaphones for documenting observations and
- the standardising, large-scale information system *Artportalen*.

Compiling and structuring the field notes and photographs, the exported trace data were visualised utilising digital methods (cf. Rogers, 2019) through an author-developed geographical information system (GIS) application (cf. Ekström, 2022b, 2022c). The application was written in the R programming language. It made use of software packages such as *tidyverse* (Wickham et al., 2019), *shiny* (Chang et al., 2020), *leaflet* (Cheng et al., 2019) and *wesanderson* (Ram & Wickham, 2018) along with map data from OpenStreetMap (2022). Qualitatively studying notes, photographs and trace data visualisations alike, the reported observations, seen as outcomes of participants' information practices in the field excursion, were represented as data points on an interactive map.

While the qualitative analysis of field notes and photographs provided close examinations of knowledge claims emerging in situated information practices, the visualisations enabled an overarching understanding of reported observations, filtered by participants, with pop-up labels describing associated metadata entries. Thereby, the species reports that the field excursion resulted in were made visible and understandable in relation to the on-site participant observation during the field excursion. This enabled zooming in on an organised set of sayings and doings observed and zooming out on the traces of information practices by following connections in action (Nicolini, 2009).

Results

In this section, the results of the study are presented. Through a series of vignettes of volunteer data production (cf. Peter et al., 2019, 2021), information practices are in the present section explored with an emphasis on how tools contribute to shape the practices, as seen through the theoretical framework priorly depicted. First, tools used for annotating and magnifying plants are examined as implicating the ongoing establishment of species' features. Second, samples and the tools used for collecting them are investigated as a means for ongoing negotiations on species' identities. Third, the subsection on reported species data provides an analysis of which aspects of the field excursions are made visible in the information system *Artportalen* and which are not.

Annotating and magnifying plants as objectual practices

The participants walk in small groups as part of the larger whole, listening to the excursion leader describing the landscape, the plants living there, the professional research going on at the site and the wildlife animals walking the fields. Occasionally, some of the participants stop at a site to ponder a plant that they find especially fascinating. As this fascination arises, people kneel or lay down on the ground, studying the plants with magnifying loupes, annotating details found with the ambition to identify the species in question.

"They are horrible", one participant exclaimed, "those white flowers, they all look the same!". Identifying plants on an excursion simply by eyesight was, quite literally, not a walk in the park, especially when the flowers were not yet in full bloom. However, with tools, guidance, and a large portion of patience, the identity of the plants could, in many cases, be at least partly settled. In cases when the distinctiveness of a single species was not directly determinable, the identification was negotiated collectively among participants in the excursion. In order to establish an adhocratic consensus of species' identities through negotiations, participants took turns comparing details, habitats, and other circumstances, such as time of the year for the observation. As seen through the lens of the theory of objectual practice, definitions of the species were looped through the species as knowledge objects temporarily constructed (cf. Knorr Cetina, 2001).

Annotating plant details brought up in discussion with other participants became crucial for species identification, the practices intermingling so as to indicate which taxon the species should be labelled. The excursion leader, who had extensive experience and expertise regarding the region's flora, suggested some ideas on what to look for and how to identify almost every species found throughout the excursion. Several of the other participants relentlessly scribbled annotations in their notebooks, functioning as analogue inscription devices (cf. Latour & Woolgar, 1986; Law, 2004). One participant described signs necessary to document and keep one's eyes open for: "well... species, circumstances and conditions, recognisable features". The notebooks served as instantaneous checklists regarding things to keep in mind during the excursion.

During the time of identification, the species started to take the shape of epistemic objects in the sense that they opened up for questions, fostering further inquiry (cf. Knorr Cetina, 2001). A prominent example of this was the effort to identify dandelions, of which there are more than 900 microspecies in the Nordic countries. Being able to describe and identify a dandelion by eyesight was, hence, no easy task, but the utilisation of a magnifying loupe enabled this practice to a greater degree. In Figure 1, both the loupe and the notebook are visible as tools used by the participants for trying to make sense of the flower in question, establishing an epistemic object. The leaves, the buds and the details provided indicators that can be recognised either by field guides or via the experience-based knowledge shared between participants.

Figure 1. Two participants are kneeling on the ground, trying to identify a dandelion

As the participants, throughout the excursion, realised that there were several types of dandelions blooming in the area under scrutiny, the epistemic object pended between mainly three species: *Taraxacum intercedens, Taraxacum rubicundum* and *Taraxacum suecicum*. Several dandelions were seen during the day, and each provoked further questioning among the participants, questions that turned the species into epistemic objects. Subsequently, a participant called the excursion leader over, asking, "but there is no rose on this one?" and "what characterises this one?". As discussions and negotiations took place, the epistemic objects unfolded, inquiries and identifications swaying to and fro until consensus was reached or could not be established.

Kneeling or lying down on the ground, loupe in hand, comprised the usual procedure for a participant engaged in this kind of excursion. However, there were cases where rigorous notetaking intertwined with that which was seen through the magnifying loupe. In the instance of one particular dandelion, a discussion took place among the participants regarding which types have smooth leaves. Notes were compared, and friendly discussions were held among the participants. Loupes were brought out, and the flower in front of the group was determined to be a *T. suecicum*. Up until the point of establishing the species, the notebooks and the loupes fostered the epistemic objects, enabling previous annotations to be circled through species observed and participant notions to be coiled through iterated use of the loupes.

Samples as epistemic objects

After some further walking along the trail, various participants make use of tools for capturing species. A few participants assist each other in putting insects caught in a sweeping net into a sample tube. Others utilise image recognition-supported smartphone applications to be able to identify plants of which they are unsure. The species, whether as physical samples in the tube or as digital representations on the smartphone screen, provide means for further study and subsequent possible identification practices.

About halfway through the excursion, the participants rested for a bit by a set of stones and a stretching field of orchids. Using a

walking stick, the excursion leader pointed towards the orchids, describing three types growing on the site: *A. morio, Orchis mascula* and *D. sambucina*. The excursion leader went on to show and discuss the plants' characteristics, mentioning also how some of the orchids have been taxonomically reclassified. Such a reclassification of species implies that identified species could be understood as epistemic objects as their definitions were reconsidered (cf. Knorr Cetina, 2001), the taxonomic trees being shifted and rearranged over time. As the walking stick directed the attention of the participants to a specific flower, knowledge about the flower could be shared among the group.

Aiding the group guidance, the excursion leader was in possession of several other tools that helped shape the practices, as is visible in Figure 2. To ensure that all participants could hear the description of the flora and the milieu, the leader wore a vest with patched-on loudspeakers, amplifying the statements uttered through a headset. This, in turn, provided a way to sonically follow the events of the tour even if a participant lingered and was not at all times physically located in direct proximity to the leader or the site currently under scrutiny. Species documentation was primarily conducted through a Dictaphone, recording the species mentioned by the leader and the questions coming from the association members. Another device used was a GPS tracker, tracing the path that the leader took throughout the site. Both the Dictaphone and the GPS tracker were analytically understood as inscription devices (cf. Latour & Woolgar, 1986; Law, 2004); the Dictaphone recorded speech to digital audio files and the GPS tracker converted the trail from non-trace-like to trace-like form. Altogether, these tools shaped the temporal and spatial aspects of the identified species through digital stamps in the recorded sound file and through geographic positions in the GPS tracker, respectively.

Figure 2. The excursion leader points with a walking stick towards an orchid, directing the participants' attention. Other equipment includes a Dictaphone (top), a GPS tracker (on the waist) and a wearable loudspeaker system

While the association walking the site had a botanical focus, not only plants were observable on the limestone ground of the Great Alvar. As many of the participants were engaged in investigating the flora, one participant with a sweeping net joined them, showing his findings. The net functioned as a way to capture species that the participants could seek to identify, i.e., a trawling device through which one could pull the net through the vegetation and hope for serendipitous encounters with insects. After several attempts to sway the net in the bushes near a stone wall, the participant encountered another excursion partner, leading to the following conversation described in the field notes.

> The other participant looks into the net, "a tick, is it the big one?" he asks. No answer is given, my impression is that the participants do not want to expose any possible lack of knowledge. "That one is a click beetle, but that one I do not know off the top of my head", says the man with the net. The interested participant takes his smartphone from his pocket and starts searching the web for answers about the tick. "There are ten kinds of [tick] species in Sweden". The participant keeps searching the web for tick character features but concludes that "it is not *Hyalomma marginatum*, the big one".

Discernible from the conversation snippet, the net here served as a container of species through which the knowledge of the participants, as well as the web search queries conducted on the spot, were circulating the species observed and sought to be determined (cf. Knorr Cetina, 2001). While the click beetle was almost immediately identified, the tick proved more challenging to determine. Nevertheless, the sweeping net shaped the practices, and the identity of the tick was re-evaluated up to the point that the participant could deduce that what they had in front of them was not the *Hyalomma marginatum*. The tick, however, remained unidentified.

Yet other tools were utilised during the excursion for capturing species samples. Returning to the participant with the net, who was highly inclined to show his findings, he resumed his bug-catching endeavours by finding butterflies in the vegetation. Standing beside an ancient monument site, where several other participants were in the midst of observing obtuse sedge growing on a tumulus, he was once more helped by another participant getting two butterflies into the sample tube. When asked about the findings, the man with the sample tube became slightly perplexed: "I am not quite sure what this is; you have to look at the antennae, the wings…". Twisting and turning the tube, as seen in Figure 3a, the participants looked for clues regarding character details. The sample tube holder, still unsure of the species' identity after negotiating, finally reverted to having to bring the samples home for further analysis: "I do not know at this point. I have to consult my books".

Figure 3. (a) Two at the time unidentified insects sampled in a tube from a sweeping net and (b) a strain of Sesleria uliginosa identified through the image recognition application Google Lens

Another tool used for sampling findings at the excursion, albeit in a slightly different form, was that of the image recognition-supported smartphone application Google Lens, integrated into the official Google search app. Through such an app, primarily used by two participants in the excursion, it was possible to identify species on the fly with the aid of deep learning technology. As seen in Figure 3b, two participants identified a strain of *Sesleria uliginosa* using the smartphone application. The identification was not unproblematic as it depended on human-nature alignment. The participants described how hands shivering when holding the strain of grass made it difficult for the application to parse the image seen through the camera. Likewise, the wind blowing on the little strain made it flutter, and the need for good lighting was considered crucial for the image recognition to be correctly conducted. Apparently, the application mistook an *O. mascula* for a *Muscari botryoides*, implying another instance of classificatory negotiations. Through continual use, the epistemic objects emerged in relation to the image recognition app.

Reported species data as mutable mobiles

Following the field excursion, some of the participants report the findings to the species observation system Artportalen. By entering metadata through the forms, fields and checkboxes in the user interface, the species found during the excursion are transformed to structured representations comprising fine-grained metadata. The representations that comprise the data conform, but also expand, the field excursion practices through translations conducted through the Artportalen information system.

Returning to the research station after the excursion, the participants concluded and compared their findings, informally conversing about the day. Since the findings would be subsequently reported to the species observation system *Artportalen*, the excursion leader asked to be notified of which of the participants would like to be described as co-observers in the reports. Co-observation was valuable for many of the participants, considering that the reports would appear in their observation lists, denoting participation. Such an enquiry by the excursion leader provided a conforming, yet welcoming, collaborative aspect to field excursion, indicating which of the participants were present when the *O. mascula*, for instance, were observed.

Post reporting, the identifications made during the excursion were visible in *Artportalen* along with details such as species name, quantity, activity, discovery method, observer(s), accuracy, geographical coordinates, date and time of observation. Exported and visualised, the reports produced following the field excursion were made visible, each inscription being conformed to comma-separated values. In Figure 4, the results of the excursion and the negotiations taking place are visualised on a geographic information system map. The pop-up field denotes the metadata entered for one of the daffodils, the *T. suecicum*, as seen and identified by the participants. Visible in Figure 4, the reports of observations sprawl the field site. The colours of the data points indicate various reporting users and the blue nodes represent reports made by the excursion leader.

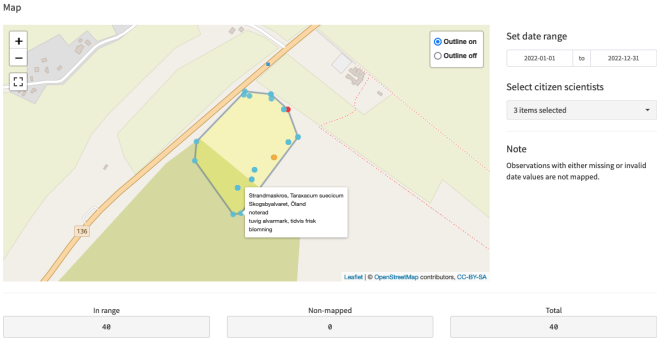

Figure 4. Visualisation of reported species observed at the field excursion. The pop-up field describes metadata affiliated with a report of the observed T. suecicum. Marker colours represent the reporting participant

The metadata of the selected data point indicates species type in Swedish ("Strandmaskros"), Latin name ("*T. suecicum*"), site of observation ("Skogsbyalvaret, Öland"), quantity (translation: "noted") biotope description (translation: "tufty alvar ground, occasionally healthy") and age stage (translation: "in bloom"). While the context surrounding the emergence of the daffodil as an epistemic object was lost in translation from the Dictaphone and the notebooks to the information system, meaning being translated between inscription devices (cf. Latour & Woolgar, 1986), granularity was added to the metadata entries of the report. This granularity, in retrospect, has been achieved by the loupes, notebooks, and cameras utilised during the field excursion. However, it is also regulated as per the reporting interface and data structure invoked by *Artportalen*.

As *Artportalen's* interface influences the participants to discipline when reporting observations, the data produced are regulated but also appended through the data tabulation occurring when storing the reports in the information system. Understood as a mutable mobile (cf. Lammes, 2017; Latour, 1986, 1987), an observation changed shape when translated from the species documentation

tool to the report tool. Conversations held, bodily movements carried out, observation tools used, and knowledge produced collaboratively in the field were restricted in the report as a data point, among others. However, the entering of metadata such as geographical coordinates as well as date and time stamps, as assisted by the GPS tracker, allowed for the visualisation of reports through interactive map tools, fostering further enquiry into volunteer-produced metadata such as biotope, age stage and quantities. Moreover, one participant also noted the use of the sweeping net as a method for sampling the insects found. Observations as data points contain details regarding the circumstances of sight, enabling data aggregation but becoming confined knowledge-wise.

While the actual bodily movements of the participants in terms of kneeling or lying down to visually examine the plants were lost, the GPS tracker provided traces of where the practices were enacted, as represented by the data points. As such, some intricate knowledge relating to the particular observation got lost in the translation. At the same time, the standardising function of the information system enabled observations to be spatiotemporally aggregated, allowing researchers, civil servants and volunteers to read and analyse the accumulated data eventually. In other words, the local knowledge enacted by volunteers during the field excursion became altered into standardised fields but allowed for visualising a snapshot of the Swedish flora and fauna.

Concluding discussion

This study has served to explicate how the material qualities of tools contribute to shape information practices of observing, documenting, identifying, and reporting species during a botanical citizen science field excursion at a Swedish World Heritage Site. Information practices enacted through a botanical field excursion were analysed through the theoretical concept of epistemic objects (cf. Knorr Cetina, 2001) to understand the emergence of situated knowledge. The concept of inscription devices (cf. Latour & Woolgar, 1986) and immutable mobiles (Lammes, 2017; Latour, 1986) were adopted to understand how the knowledge produced in situ is translated to biodiversity citizen science data.

The study showed that participants' tool use when partaking in a botanical field excursion was considered not to be stable but redefined as per their current use (cf. Knorr Cetina, 2001). On-site classification work by participants was understood to be enacted through discussions held, and questions asked, as well as through repeated observations made through loupes. These results are comparable to previous studies focusing on epistemic objects emerging through birdwatching, where the ongoing identification of birds motivates participants (Lundquist, 2018). However, the present study also demonstrated that the attempts to identify botanical species fostered discussion and practices of seeking information intuitively and informally, leading to adjacent attempts to identify species that were not found on site.

Particularly important for this collaboration to occur was the comparison of notes made through inscription devices (cf. Latour, 1986) such as notebooks or image recognition applications, as well as practices of sampling species through tubes. Practices of documenting and collecting species were hence understood as distinctly entwined with observing, as is perhaps most notable through the participant examining a daffodil and simultaneously asking, "but there is no rose on this one?". Taking notes, discussing the correct taxon or viewing a sample through Google Lens offered room for interpretation, providing an opening for the knowledge to emerge and take shape through the practices. The volunteer production of inscriptions played a distinct role in the collaborative establishment of epistemic objects. Similar to previous studies (Matz et al., 2017), these tools were used in an adhocratic manner where species identities as epistemic objects emerged through repeated tool use.

On the other hand, some aspects of the tool use narrowed or closed the negotiations, most notably in relation to the directedness of the excursion leaders' use of a walking stick and loudspeakers. Nonetheless, the informal setting paved the way for participants with varying knowledge backgrounds (cf. Ekström, 2022a) to partake in the collaborative production of botanical citizen science. While species reports have previously been described to structure the community of practice (Scanlon et al., 2014), the botanical field excursion studied arguably shaped practices in a more situated sense as the collaborative negotiation and classification attempts were centred on the emergence of species as epistemic objects.

Drawing on previous research where *Artportalen* has been understood as an inscription device (Kasperowski & Hagen, 2022), the constraints and opportunities of situated tool use for information practices could be unfolded. Echoing previous research on material qualities of information systems for organising work (e.g., Dourish, 2017), *Artportalen* was understood as being a tool of reports, systematisation, arrangements, and exhibitions, part of the messy apparatus through which botanical information practices take place. In particular, this perspective opened up to foster further understandings of how nature becomes normalised into standardising categorisations in relation to established taxonomy (cf. Montoya, 2022), but also how information systems invoke the visibility and invisibility of situated information practices as translated to reported observations. From this, it can be concluded that further situated biodiversity knowledge would be possible to gain as data points should information system stakeholders consider opening up for data inconsistencies.

The present study moreover found that some material qualities of tool use, such as the site of observation, quantity, biotope and age stage, were directly translated to the reports as metadata. However, other aspects, such as the variety of tools and participants' negotiations, became invisible in relation to species reports. Inscriptions, as shown in the visualisation of the *T. suecicum* (Figure 4), were not considered immutable but mutable mobiles (cf. Lammes, 2017) since the observations changed shape as they became translated from documentation tools to report tools. In other words, when observed species were reported to *Artportalen*, the individual aspects of the methods used for collecting species were, in many cases, the first to disappear, streamlined to standardised, tabulated reports through forms, fields and checkboxes. One exception included that a participant entered the method for sampling insects, i.e., the sweeping net, as metadata for the report.

Much in the same way that scientists conduct laboratory work, participants in biodiversity citizen science were considered to organise and systematise the field to transform species into digital representations, i.e., inscriptions (cf. Latour & Woolgar, 1986). By doing so, the information practices enacted to produce botanical citizen science data could be understood in terms of ongoing negotiations in relation to material tools. Rather than the data being produced in a streamlined, rationalised manner, information practices related to classifying wildlife organisms are messy and entangled, sometimes open and sometimes closed (cf. Peterson et al., 2022). As such, material aspects of tools, whether physical or abstract, are constitutive in shaping the information practices in terms of the enquiry and annotation of species, the capturing of samples as well as the reports of identified species. Future research on citizen science field excursions could benefit from this and neighbouring studies in the investigation of temporality. This could foster new knowledge concerning how the participants' information practices change throughout projects, improving material prerequisites for environmental monitoring. A methodological approach focusing on both the situated field excursion and the outcomes of this field excursion, as conducted in the current study, would be feasible for answering such questions.

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Competing interests

The author has no competing interests to declare.

Author description

Björn Ekström is a Doctoral student and Lecturer in Library and Information Science at the Swedish School of Library and Information Science, University of Borås, Sweden. His main research interests include information practices, citizen science and digital methods. Björn Ekström can be contacted at: bjorn.ekstrom@hb.se.

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