

Birdwatching in the digital age: how technologies shape relationships to birds

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Abstract

Advances in technologies have affected birdwatching and its popularization through time. To better understand how, we expose ways by which today's digital technology—typically taken for granted—shapes the social practices of birdwatching, which shifts human–bird relationships and has consequences for birds themselves. Starting in the transition from analogue to digital, we highlight how technologies have functioned to enhance human abilities and create connections among people, organizations, and places. We then analyze contemporary digital technologies (e.g., digital cameras, social media, and online biodiversity monitoring platforms), demonstrating how their entry into birdwatching practices reformulates the interests and power of various actors. Such processes affect the experience of birdwatching, its perceived benefits, the organization of birdwatching communities, and how birds are seen. To conclude, we address societal and ethical implications of digital technologies in birdwatching, focusing on their democratizing potential, as well as concerns over privacy, data ownership, and uneven digital engagement.

Keywords: birdwatching, technology, digitization, citizen science, biodiversity recording platforms

Never before have birds received so much attention as now. Wealth, spare time, and environmental concern have allowed birdwatching—a centuries-old interest—to become a leisure activity enjoyed by millions (Moss 2004, Kjølørød 2019, Janeczko et al. 2021). At the same time, birds are a research focus for thousands of scientists, a conservation focus for hundreds of nongovernmental organizations, and a policy concern at local, regional, national, and global levels. This development, we argue, is conditioned by an immensely powerful force embedded in every aspect of our daily lives: technologies. We therefore ask *How do technologies affect relationships to birds?*

To address this question, we look at birdwatching as a set of practices rooted in Western modernity over the past centuries, shaped by a mixture of historical influences (Prior and Schaffner 2011). Birdwatching practices have evolved alongside the rise of natural history, the development of outdoor recreational landscapes, and growing environmental concerns. The term *birdwatching* resonates with bird enthusiasts and the general public, although its meaning differs between communities and countries. We use *birdwatching* as a broad term referring to active engagement with wild birds and focus on how technologies shape the human–bird relationships that arise (box 1).

We start with a brief history of birdwatching tools and practices, from the collection of specimens to an observational approach. We then hone in on the digital age and its technologies that are shaping bird interests in myriad ways. Finally, we consider the wider societal impact of these digitization processes and relations to birds. We rely on ethnographic work into technologies that birdwatchers use and various investigations of digital development, including species recording platforms (e.g., eBird), species

identification apps, biodiversity infrastructure (e.g., Artportalen, the Global Biodiversity Information Facility), and the broader citizen science around birdwatching. From this research, we regard birdwatching technologies as mutually shaped by and shaping societies as coproducers of the various social practices. The historical examples are predominantly drawn from global north countries, where authoritative approaches of interacting with birds were shaped during the modern era, exerting influence on other parts of the world.

How predigital technologies shaped birdwatching

Rarely do we encounter nature unmediated (Jørgensen 2014)—not now and not in the past. Instead, technologies are often in between, brokering (or breaking) connections. The birdwatchers that we see today pick from a vast repertoire of tools, with binoculars being the most characteristic one. However, back in the days, naturalists used guns to come to know birds. Military technology was used, not to hunt or control birds as vermin—a practice leading to long declines of wildlife (e.g., Lovegrove 2007)—but to enable close contact, collection, description, and depiction of specimens and to derive at early accounts of what was there.

Although guns continued to be a tool in ornithological and natural history practices well into the twentieth century, the appearance of new technologies—binoculars and cameras—allowed for the emergence of a fundamentally different approach to birds. Such a shift was actively promoted, with, for example, the North American ornithologist, nature writer, and bird protection advocate Florence Merriam Bailey urging—in

Received: January 27, 2024. Revised: January 18, 2025. Accepted: March 24, 2025

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Box 1. Birdwatching as set of social practices.

Some birdwatching activities that we refer to are well established and delineated, whereas others are more fluid and temporary. More demarcated practices include bird feeding, bird ringing or banding (see box 3), birding as a leisure activity in the sense of going out with a purpose of discovering and identifying birds, and twitching as going out to discover rare birds or see rare birds that others have discovered. These activities can be understood as social practices (Shove et al. 2012) roughly made up of three key components: materials (such as, objects and technologies), competences (including skills, know-how, and techniques), and meanings (symbolic meanings, ideas, and aspirations). The emergence of distinct and recognizable combinations of these elements occur through repetitive enactments over time. Although they constitute delineated entities, social practices are deeply embedded in broader networks or clusters of related practices. They emerge when various elements are interconnected, and evolve as new or existing elements are combined in different ways. The relations among practices can also alter them, because practices are contingent on each other. Elements, including technologies, are both the ingredients of a practice, and points of connection between them. Our starting point, therefore, is that social practices—that lead to certain human–bird relationships and have consequences for birds—evolve and exist together with technologies.

Birds through an Opera Glass, from 1899—her readers to arm themselves with a pair of opera glasses and a camera instead of a gun. This type of advocacy, promoting an observational approach enabled by a new technology, played a significant role in the development of new relationships of care. Raising awareness about the extent of hunting of birds for ornamental feathers ultimately led to protests in the late nineteenth century and the formation of bird protection organizations (Schaffner 2011).

Mid-1800s technological innovation in the form of Galilean binoculars allowed for birds to be magnified five or six times (Greivenkamp and Steed 2011); this opened pathways to look at birds from a distance, study their behavior and slowly start to work out what birds are where and in which numbers. The early binoculars, however, were available only to the very few. Production of binoculars at a larger scale and for a lower price prompted by investment therein during WWII was needed for greater numbers of people to become birdwatchers. Meanwhile, printing technology had advanced, and this, together with greater use of binoculars, allowed the production of better and relatively affordable field guides, such as the North American Roger Tory Peterson's *A Field Guide to the Birds*, first published in 1934. Bird field guides, as a new mediating technology, did not develop in isolation but at the intersection of science, outdoor life, art, and commercial interests (Dunlap 2011). They provided instructions from natural scientists to a wider audience of amateurs and encouraged practices such as taking notes and listing birds, both indirectly through their form as catalog and, directly, through prepared checklists (Barrow 1998, Lynch and Law 1999). Now that the technologies of the day allowed birds to be brought into focus by small and dispersed armies of enthusiasts and identities of birds could be successfully obtained, the quest for quantification, in addition to mapping bird distributions, was on. Greater mobility through the increasing prevalence of cars (box 2) supported accruing bird observations as quantifiable data, as did the arrival of high-quality affordable telescopes. Telescopes, along with modern field guides, allowed birders to spot and identify “new” birds that were previously difficult to distinguish from a distance.

By the middle of the twentieth century, the greater mobility and—by then well rehearsed—interest in keeping lists led to new extremes for finding rare species: Twitching had become a thing and, with it, a plethora of listing and other behaviors (Sheard 1999). This specific social practice, well known for their often extreme (long-distance travel) commitment to score and cluster around rarities (Prior and Schaffner 2011), has been supported

and shaped by communication technologies to arguably greater extents than other parts of the predigital era birdwatching community (cf. Connell 2009). A cat-and-mouse game unfolded of opportunity, in the form of technologies becoming sufficiently available, and response, an increase in numbers of twitchers and their spatial reach (Liep 2001). Birders used telephone chains to spread news about rarities (Watson 2010). Later on, in the early 1980s, the emergence of answering phone technology enabled the exchange of messages and provided a means for birdwatchers to expand their communication beyond local birding groups. Rare species interest groups, such as the American Birding Association (established in 1969), Dutch Birding (1979), and the Swedish Club300 (1984), emerged and notably assisted in raising the standards of rare bird identification and solidifying practices including the uptake of new technologies when becoming available, such as (radio-wave based) pagers in the mid-1990s.

When looking at the auditory aspects of birdwatching, we also see technologies come and go in rapid succession, typically toward smaller recording and playback devices with greater data-holding capacity and ease of use (cf. Jepson 2011). By and large, what birdwatchers used reflected technological changes in wider society and widened opportunities for them. Switching from vinyl to cassette tapes, for example, dramatically increased the number of bird species covered and allowed birdwatchers to record bird calls themselves and share those with others. The transition to compact discs halted those practices but allowed birdwatchers to rapidly find, replay, and therefore learn calls and songs more efficiently. In addition, some new technologies were actively tailored to birdwatching, such as parabolic microphones, setting new standards and unlocking a far wider spectrum of sounds (Bruyninckx 2019). Similar to the effect of telescopes—where species that were previously difficult to identify became visible—the ability to record and listen to luring calls created new ways of finding and identifying birds.

In addition to the technologies individuals bring with them or keep in their homes, built infrastructures such as towers, signs, hides, and designated paths within nature reserves are part of the arsenal of technologies that mediate relationships between people and birds (Lundquist 2018). These infrastructures that are often arranged with public funds by municipal or regional authorities, instruct visitors on how to move, behave, and direct their attention, with the twofold purpose of facilitating proximity to wildlife while minimizing disturbance. In contemporary birdwatching practices, the ideal is to avoid disturbing birds in their natural habitats, a principle reflected in the ethics and codes of

Box 2. Cars as technology reshaping birdwatching practices.

Binocular and car equipped birdwatchers in southern Sweden ca. 1950 (Photograph: Gunnar Svärdsson). The growing prevalence of cars in the twentieth century significantly reshaped many of the social practices of birdwatching. It expanded the geographic scope of birding, reducing previous limitations and creating hotspots where enthusiasts would gather. No longer restricted to local areas accessible by foot or bicycle, bird enthusiasts could explore distant locations, with cars becoming essential for pursuing rare species. However, in recent decades, the use of cars has faced criticism. This has led to new subpractices such as microbirding, where birdwatchers focus on their immediate surroundings, and ecobirding, which favors bicycles over cars. The dominance of cars as the norm for reaching prime birding sites excludes some, particularly those without cars living in urban or suburban areas, making access to key birding events and locations more challenging. Carpooling within birding groups may, however, serve as a way to foster social bonds and shared learning.



conduct of many birding associations. There is, however, one exception: ringing (or banding), which is more or less the only instance where the birdwatcher actually touches birds, a practice that involves its own specialized set of technologies (box 3). Some birdwatchers regard bird ringing as the pinnacle of their birding experience, seeing it as a valuable opportunity for learning and contributing, through scientific research, to the welfare of birds. However, some birders remain hesitant, concerned that the practice may cause undue stress or disturbance to the birds.

Overall, the various technologies used for watching birds are there to enhance the biological capacities of the human body and let people tune in on birds, while also connecting them to other people, organizations, and places. In recent decades, the advent of new digital technologies has significantly reshaped these connections, altering existing bird-related social practices and cocreating new ones, a phenomenon that will be further explored in the following sections.

Digital technologies and the watching of birds

Digital technologies promise better, faster, and more (Arts et al. 2015, Kellner 2021), and that is what they seem to have brought

to birdwatching practices. Surely, binoculars (and, to an extent, telescopes) continue to be the prime technology, but an increasing number of traditional tools turn digital, and a spectrum of totally new ones have arrived, forming a landscape of connected technologies bringing far-reaching change. This development redefines how societies interact with birds.

Tools that have turned digital in recent decades include field guides, cameras, rare bird alerts, and notebooks, all being adopted in a rapid fashion (Watson et al. 2018). Broadly speaking, these analogue-turned-digital tools are used in similar ways to their predecessors, but their design and capacity bring new possibilities for the pursuit of birds. Unwittingly, this transition influences birdwatching practices, because such technologies are integrated at all levels of birding activity, be this planning, learning, recording, or sharing observations.

The camera turning digital has been most influential (figure 1), redefining what to expect in terms of looking at and documenting birds and, together with new communication technologies, scaling up the sharing of pictures of birds as evidence, discussion, and (birdwatcher) mobilization material (Slater et al. 2019). Moving from analogue (24 or 36 exposures) film to memory card also expanded the role of the camera as an extra eye that supports longer-term memory. Because of the importance of all those

Box 3. Technological change mediating strength of relations between volunteers and professionals—the practice of bird ringing.

Bird ringing is a method of studying birds by capturing them in nets and attaching a small ring with a unique number to their leg. If the bird is later recaptured or found deceased, researchers can track its movements and lifespan. Ringing reveals different agency of technological advance, notably influencing strength of relationships between volunteers and professional scientists connected to this birdwatching practice. Here, small numbers of often highly dedicated people are trained and endorsed, by extant structures, to catch birds and ring them—procedures stemming from ornithological research and therefore science. Deployment of metal rings mostly addresses traditional naturalist questions around bird migration and overwintering, and often concerns relatively low sample sizes because of the requirement of retrieval. For a while, this practice did not serve current academic aspirations well, leading to reductions in funding from universities and their sponsors for this practice. The arrival of color rings, typically deployed by professional scientists interested in the movement or demographics of specific species, reinvigorated their relationship to volunteers, because it had to and indeed did mobilize birdwatchers across large geographies to include into their practice the scanning for and reading leg color rings and neckbands, and submitting that information. This allowed the niche practice of metal ring reading to expand and generate much larger volumes of data. But over time, scientific interest waned again, leading to difficulties finding homes for these large observational databases that needed considerable (verification and wider) effort. More recently, however, scientific interest and funding for structural investment in ringing resurfaced, and therefore relationships between volunteers and professionals in this practice to strengthen again, in no small part because of digital innovation bringing capacity to data handling, storage and exploitation to address questions about rapid environmental change.

aspects in birdwatching practices, the tool itself has become a must-have for many. At the same time, widespread use of digital cameras in society means that for novices this tool becomes an increasingly common entry point to the world of birds. Both routes generate a fundamentally different kind of birdwatcher: one who is first and foremost armed with a camera rather than with binoculars and a scope and who is out to create tangible rather than mental representations or enumerations of birds (Watson 2011). The growing reliance on digital cameras and intersecting technologies and services for birdwatching does reinforce the idea that specialized equipment is required to enhance observations, confirm identifications, and document experiences (Schaffner 2011).

A new tool starting to shape birdwatching practices is automated species identification, through apps such as Merlin Bird Id and BirdNET, which assist in identifying bird calls and songs and automatically transmit resultant observation records to various platforms and programs (Kahl et al. 2021). Interestingly, by taking over the process of bird identification, these digital newcomers directly challenge one of the most fundamental aspects of being a birdwatcher. Also, it raises the question how well environmental knowledge is acquired by users of such technologies (Truong and Van der Wal 2024).

New digital technologies that have already transformed birdwatching practices—but also continue to do so—are social media apps and data submission platforms, such as eBird, Observation.org, Artportalen.se, and iNaturalist.org, notably affecting practices around communication and registration. In combination, these change the immediacy, volume, and circulation of bird data, in turn influencing the reputation of birdwatchers (Randler and Großmann 2022) and birdwatching organizations (Verma et al. 2016). Social media platforms have also led to new multidirectional communication, among both longtime birders and those who have just begun to pay attention to birds (Liberatore et al. 2018, Ma et al. 2021). There are, for instance, Facebook groups focused on advanced species identification that require a comprehensive preunderstanding but also groups where anyone can post pictures of common bird species and get identification from others. Some of these groups have emerged as initiatives from new actors, whereas others, such as those focused

on garden bird counts and feeding, are backed by established birdwatching associations. Through active groups on social media centered around this theme, combined with data submission platforms, hundreds of thousands of garden bird counters and feeders can be mobilized each year.

These developments create a digital landscape in which different actors compete for attention (Verploegen et al. 2021). Consequently, information about birds is becoming increasingly abundant and at the same time fragmented and difficult to oversee. For example, rare bird observations were communicated through lucrative bird alarm systems run by twitching clubs. These systems are now being challenged by free apps (e.g., Band) and accessible platforms (e.g., eBird). Ironically, the digital turn and superb ability to swiftly gather and convey information of such systems seems to have made twitching almost too easy, leading some birders to operate outside national borders (working on their world lists) or to move to observing different nonbird species groups and for twitching as a specific subculture to dwindle. Another interpretation, however, would be that the digital has allowed elements of twitching to become part of the ever-changing practices of mainstream birding.

Visual portrayals of birds have been with us through the ages, through art and artifacts (e.g., stamps, money). The digital has amplified exposure to such visuals. As a result, not only birdwatchers but anyone can explore—and is likely to be exposed to—the world of birds by engaging with closeup imagery on mainstream forums including social media sites such as Instagram (figure 2), YouTube, and TikTok. These birds are often colorful, or otherwise charismatic, shaping the image of what is a bird to a rather narrow spectrum (cf. Truong and Clayton 2020, Stouder et al. 2022). This has opened opportunities for notably conservation actors to connect people to digital birds in real time, through, for example, nest cams, remote-control live cameras, and websites portraying migration routes of satellite-tagged birds (Searl et al. 2023), providing glimpses into formerly hidden aspects of birds' lives, as for the common cuckoo, to science (Hewson et al. 2016) and society (<https://www.bto.org/cuckoos>). The scientific community saw possibilities for gathering additional data, at large geographic and fine temporal scales, by launching crowdsourcing initiatives on digital platforms such as Zooniverse. And, as we will see in the

Introduction of new digital technologies induced changes in:

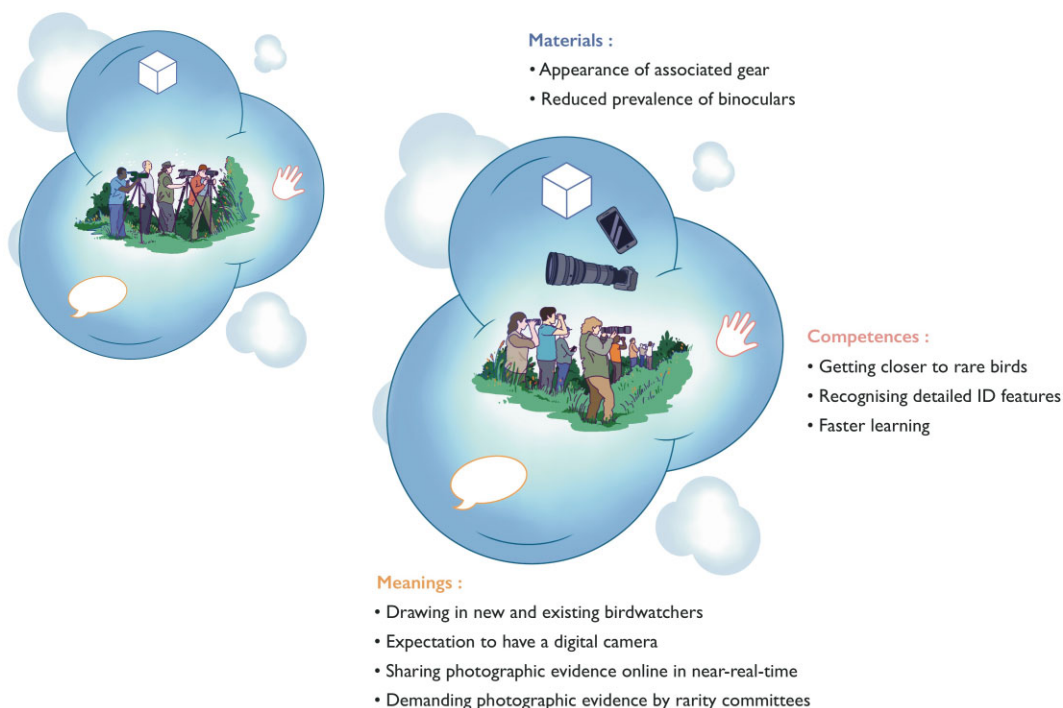


Figure 1. How new digital technologies change a birdwatching practice. (a) Taking the practice of twitching, as an example, social practice theory stipulates it emerges at the intersection of specific sets of materials, (📷) meanings (💬), and competences (🧠) (see also box 1). There are many other birdwatching practices it relates to and intersects with, in stronger or weaker ways, which are drawn as constellations in the background. (b) The introduction of new digital technology, here the digital camera and smartphone, transforms the entire practice by requiring new skills and reshaping its meanings and competences. A selection of concrete changes is listed to illustrate. The practice as a whole became more mainstream and therefore larger—that is, closer to the more widespread birdwatching practices. This shift also altered participant composition by lowering the threshold for involvement through changes in ideas and aspirations (i.e., meanings). Illustration: Sacha Berna.

next section, it also responded to the presence of large volumes of data, by aggregating, providing access to and visualizing notably distributions (birdcast.org, <https://eurobirdportal.org/>) and movement patterns (Kays et al. 2022; <https://www.movebank.org/>) of birds at national and global scales. By redefining what is possible, the digital has allowed for the emergence of a rich online landscape drawing in producers and consumers that connect to each other and to birds in often new ways (Turnbull and Adams 2022). Another profound influence is made with this point: Such digitally mediated operations bring in new audiences and challenge the notion of what birdwatching can or is allowed to be.

How records mediate connections between people and birds

Many of the aforementioned technologies would not be possible without large-scale adoptions of digital networking technologies and infrastructures, such as servers, databases, and APIs, along with protocols and software applications that support mass collections of digital bird records (Lepage et al. 2014, Van Horn et al. 2018). These tools provide unparalleled access to individual birds, as well as bird populations (figure 3). As such, they increasingly mediate relationships between amateur and expert birders, as well as other specialized communities including ornithologists, conservationists, and policymakers. These tools become another seeing glass through which people develop connections with birds.

Such connections depend on who uses these technologies and for which aims. For birdwatchers, these technologies enable them to realize highly specialized relationships that often suit individual users. Access to eBird and most other bird recording applications provide the ability to create and curate personalized lists. They also provide access to a large-scale community that shares information that birders can act on, including the aforementioned notifications regarding rare bird sightings. Because the data is open, users no longer need to subscribe or pay fees to services or organizations for access to this information. Therefore, these digital platforms supplant the use of bird atlases or become integrated with digital ones. Because these recording applications are set up to take data from individuals, what data gets shared often becomes a personal decision that may or may not take into account what observations currently are being made or already exist in the database, what the observer thinks is worth reporting, what is not, and what the user wishes to report but also conceal from other users (Ganzevoort et al. 2017). By developing digital birding platforms to accommodate a wide range of functionalities, bird data providers give users ways to modulate how these platforms work according to their own needs, as well as the users' needs.

Indeed, beyond the birdwatchers who use these tools, there are the IT professionals and data scientists who build, operate, and maintain them. Their institutional affiliations with universities and commercial enterprises rather than birding clubs highlight how watching data about birds has become professionalized

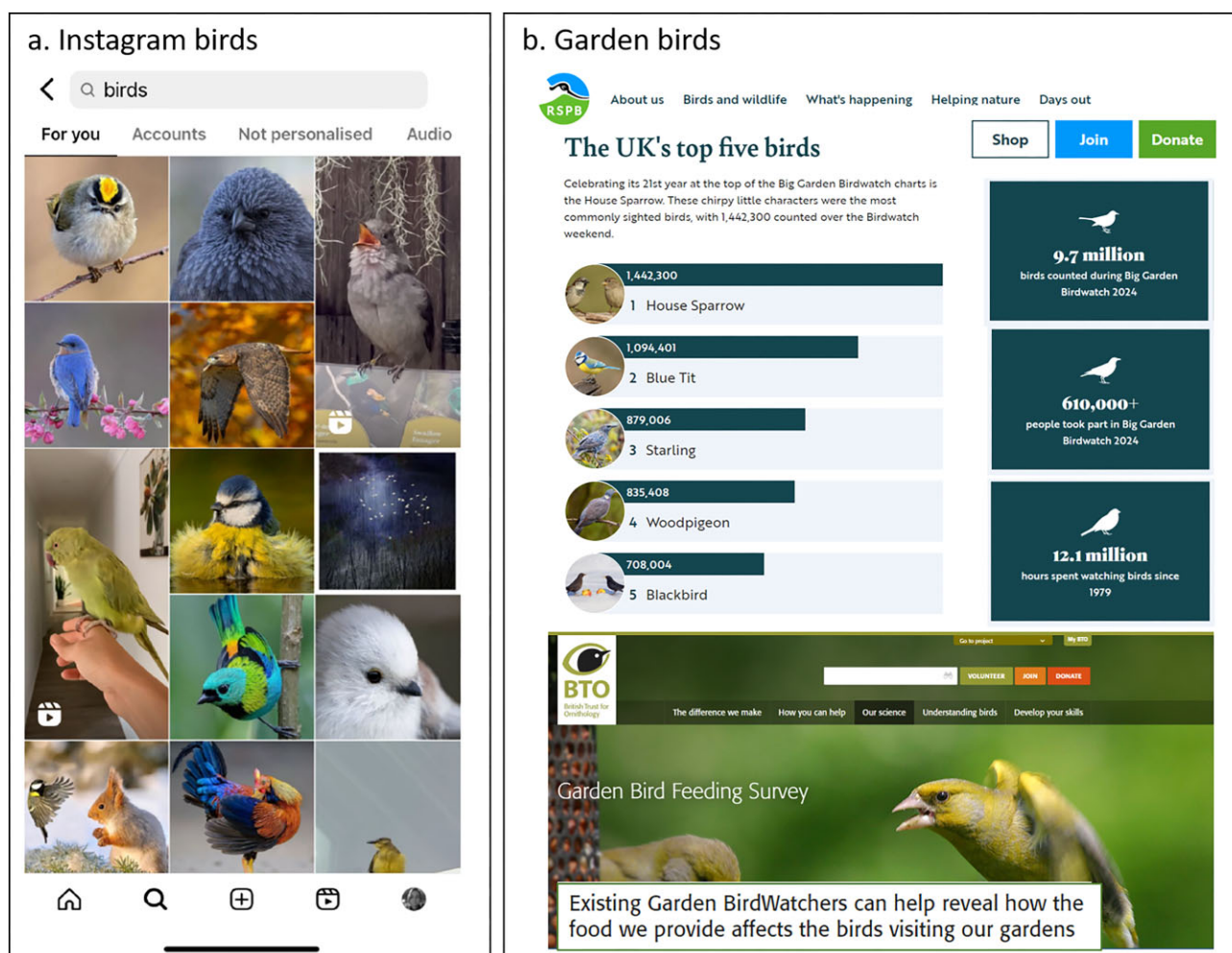


Figure 2. Social media and web pages popularizing (certain) birds. Social media and the watching of images of charismatic birds. (a) A search of the term birds on Instagram brings in vision closeups of mainly colorful and endearing birds, shaping the image of what a bird is (conducted on 13 December 2023). (b) Two UK bird nongovernmental organizations (the Royal Society for the Protection of Birds [RSPB], and the British Trust for Ornithology [BTO]) using the digital to attract attention to garden birds (and bird feeding) through citizen science. The highly popular RSPB's Big Garden Birdwatch—a one-off event—draws people into everyday birds, such as the house sparrow, and to the charity itself. It made a careful start already in 1979, using TV (Blue Peter) as medium. Social media and digital submission routines allowed it to become the single most popular birdwatching event in the country, particularly effectively addressing families with young children, showing them what birdwatching can be and feel like. The BTO has run its year-round, much smaller and more scientific equivalent (Garden BirdWatch) since 1995 and, in conjunction, an even smaller scheme, the Garden Bird Feeding Survey, which commenced in 1970–'71 to “examine the increasingly popular activity of providing food for birds in gardens during winter and is the longest-running study of its kind in the world.” Also, the aforementioned digital tools and the visibility they gave to garden birds were key ingredients behind this program's longevity.

(Sullivan et al. 2014, Zhou et al. 2020). As records about birds become centralized in these sectors, influential organizations, such as eBird, become possible and others, such as Birdlife International, strengthen. Such reformulations in the birdwatching world allow for different strategies and powers for wielding influence on society than local birding clubs previously could muster (Rands 2000). Moreover, the digital has enabled organizational realignments that feed back into birding communities. For instance, in Sweden, birdwatchers were not informed that their sightings of vulnerable species were being shared with commercial companies, often hired by municipalities to do environmental assessments, which has led users to stop recording data for a time (Hansson 2014). Nevertheless, having such data potentially affect development or conservation goals generally motivates birdwatchers to contribute records to these networks (Verploegen et al. 2021). In addition, because records about birds aggregate in the

hands of professionals and their organizations, these records become subject to aims and agendas that may be of peripheral interest to birdwatchers and birding clubs. For example, a main aim of digital recording applications, whether they are focused exclusively on birds (e.g., eBird) or not (e.g., Observation.org), is to gather as many observations as possible while controlling for data quality (Sullivan et al. 2014). That is, they have been developed with the specific aim of accumulating scientifically usable records. They rely on individual users to provide data with the ambition to make this data relevant to nonusers, such as those working in policy and science. That is, these technologies not only mediate connections to individual birds but also to populations through, for example, using models to estimate species distributions (Johnston et al. 2021). Scaling up relations from the individual bird to the species alters relationships by broadening the scope of how to manage birds.

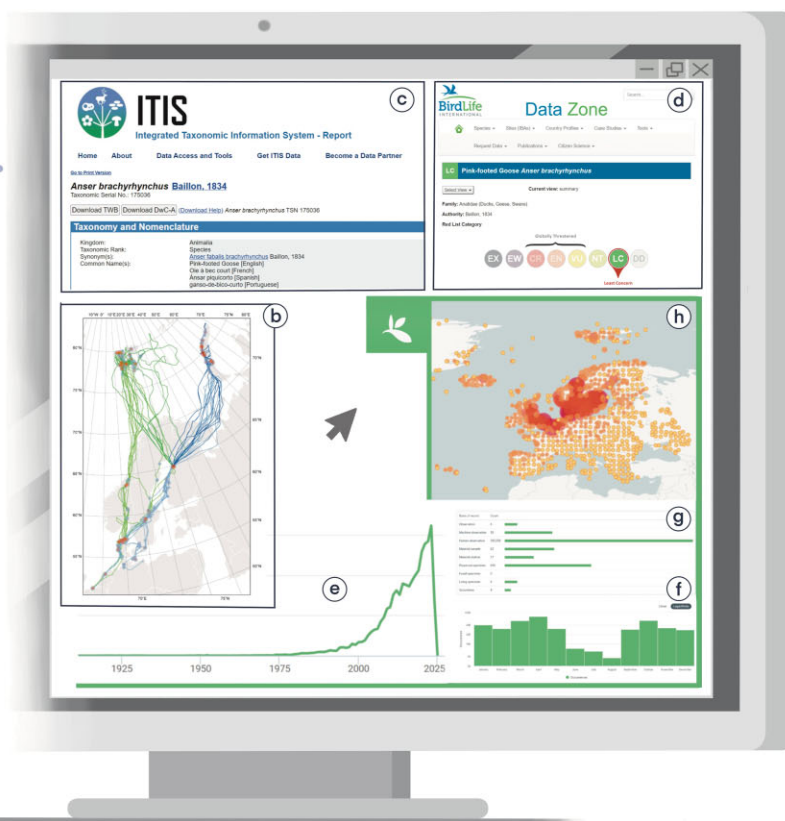


Figure 3. The making of a digital bird: Pink-footed geese from the field to the screen. (a) Pink-footed geese on a prebreeding site near Longyearbyen, Svalbard (Photograph: Christiane Hübner). (b) Spring migration routes of satellite-tagged birds from their winter quarters in Belgium and the Netherlands to their high-arctic breeding sites (Madsen et al. 2023). (c) Taxonomic information system that allows *Anser brachyrhynchus* to turn into a digitally traceable object (<https://www.itis.gov/>). (d) BirdLife International declaring the conservation status of the species on the basis of the available data (least concern; <https://datazone.birdlife.org/species/factsheet/pink-footed-goose-anser-brachyrhynchus/summary>). (e–h) Global Biodiversity Information Facility data outputs, displaying the abundance of the species across months (www.gbif.org/species/2498024/metrics; e), over the years (f), the nature of the data (primarily human observations—by birdwatchers; g), and mapping the records across Europe (h). Turning this population of pink-footed geese into a digital bird allows for census data to be used to estimate population size and set hunting quota, and to maintain a population size of around 60,000, within a range to prevent the population to collapse or irrupt, respectively—following the Agreement on the Conservation of African–Eurasian Migratory Waterbirds (https://www.gbif.org/occurrence/map?has_coordinate=true&has_geospatial_issue=false&taxon_key=2498024). Illustration: Sacha Berna.

Watching birds this way provides highly abstractable relations to be enacted through intimate encounters with data about birds. In order to become a recorded observation, birds must be subjected to digital vivisection. That is, the activity of reporting sightings of birds must follow protocols that require the input of various forms of metadata. Such metadata includes observations and other digital information about birds (e.g., behavior, sex, age) but also information about the observer (e.g., date, time, location; Hall et al. 2021). It is only through this coming together of multiple bits of information that the bird as digital observation begins to cohere together as a valid, objective scientific object. As a summation of different bits of metadata, these digital birds can then be taken apart again to customize, reassemble, or modulate how bird observations (and the observers) get analyzed and represented (Peterson et al. 2022). Not only are occurrence records infinitely divisible in theory, these records provide grounds for (but not empirical evidence of) estimating entire populations of birds. For instance, the total number of birds worldwide is currently estimated at 50 billion birds (Callaghan et al. 2021). Digital bird records, therefore, provide means for not just representing individual observations of this or that bird but for analytically producing other bird-like representations—such as indicators (e.g., farmland bird index) or entities (e.g., popu-

lation size, bird density, likelihood of occurrence; Cardador and Blackburn 2020)—which (for the most part) are unobservable by birdwatchers. In this way, birds have been digitally extended and become a new entity to which people can connect both culturally and politically (Webster 2017). As a result, people's connections to birds no longer reduce to how birds look or what they do in their immediate surroundings but are more often about seeing birds when they move beyond the purview of binoculars as an ecological actor at a planetary scale. Watching data about birds has become a defining activity in birdwatching in the twenty-first century.

Where does this leave us? Impacts on human–bird relationships

We show that the various social practices of birdwatching are intertwined with and shaped by technologies. This means that technological changes, from guns to binoculars and digital cameras, from field guides to smartphone apps, and from notebooks to data centers, all influence the conditions of how we can or do relate to birds (figure 4). Technologies as cocreators of bird-related social practices also shape wider connections, to and between



Figure 4. Digital technologies shaping birdwatching practices and relations to birds. This illustration presents various relationships to birds formed in social practices shaped by digital (and wider) technology. The portrayed human–technology–bird compositions lead to certain birds coming in focus and others becoming less (or even in) visible. In one scene, a recorder, guided by a digitally presented bird forecast, spots migrating razorbills through a telescope, whereas in another, a drone operator detects black-tailed godwit nests in farmland. Elsewhere, a bird watcher engages with birds on his smartphone through social media, creating virtual communities and shared meanings. Another image shows twitchers, summoned by digital bird alert systems, gathering around a dusky warbler. A hunter, informed by digital bird records and quotas, manages the Egyptian goose population. Finally, a birdwatcher engages with cuckoo migration routes from satellite-tagged birds, being drawn into the lives of these birds, places they seem to visit and pressures they may encounter. Illustration: Sacha Berna.

people, places, and organizations. The adoption of technologies in birdwatching practices has been and continues to be related to a plethora of societal factors. Because birdwatchers as a group historically have been relatively affluent (Moss 2004), commercial factors in combination with birdwatchers' curiosity and motivations to expand their knowledge and gain new and altered experiences have been drivers in the process. Beyond the development of tools, science has played a major role in all of this through its ability to instruct, organize, and set norms. When it comes to digital technologies, these processes are heightened, because of the rapid succession of tools, the speed they generate and their capacity to interconnect functionalities, data streams, and social relationships. Even though digital technologies are designed to be used in certain ways, their interconnectivity makes them also get used in unintended ways, such as databases developed for scientific purposes being used by land developers (McCarthy 2006) and environmental activists (Kasperowski and Hagen 2022) to renegotiate and relocate influence and power.

The data-centric nature of digital technologies raises ethical and societal concerns, where privacy implications for individual users and data security are the main aspects. When birdwatchers share their observations on digital platforms, questions about data ownership, control, and potential use arise, including by political or commercial stakeholders, such as advertisers and action groups (Lawrence 2010, Peterson et al. 2022). The digital turn also comes with other challenges for users, such as the pressure of being up to date and having to learn and adapt to new tools, leading some to believe that one needs to be an expert to use recording platforms. Birdwatchers may embrace the digital technologies available but do, in some cases, also see them as distractions that cause feelings of detachment from birds and the environment (Lundquist 2018). Going out birding, without too many gadgets in hand, is therefore a means to escape the fast-paced digitized reality of today.

Digital technologies, however, also bring new possibilities in creating, storing, moving, disseminating, and communicating

data and images of birds, and now with AI, even identifying birds for their users. Embracing the digital can therefore facilitate learning about birds and create communities of care and has the potential to democratize birdwatching in some respects. Social media, readily available cell phone cameras, access to images of birds on the Internet, technologies for automated species identification, and free digital recording platforms that can be used worldwide are all examples of technologies that may contribute to a process of lowering the threshold to start noticing, learning, and caring about birds. But who is participating? Even the users of the largest databases, such as eBird, do not represent equal global coverage (La Sorte and Somveille 2020) and Black, Indigenous, and other people of color remain underrepresented (Rutter et al. 2021). Digital technology in the form of social media is actively used by actors in society to try and change this (e.g., Black birders week). However, despite increased participation through in-house information and communication tools development, gender, and age inequalities remain a prevailing issue in, for example, Sweden's Artportalen (Jönsson et al. 2023). These persistent disparities in participation highlight the need for more inclusive strategies to ensure that biodiversity data collection reflects the diversity of people (Grade et al. 2022, Ellis-Soto et al. 2023) and of ecosystems worldwide (Chapman et al. 2024).

The great popularity of birds means that numerous conservation and other actors use digital technologies to benefit birds and their habitats. However, other uses of digital technology can also harm the lives of birds. Besides the environmental backside of consumerism (e.g., carbon footprint of data storage, harmful mining of metals for cell phones), recording platforms and social media have, for instance, increased the visibility of certain bird species, making them vulnerable to disturbance (cf. Verploegen et al. 2021). Twitching, digital photography, and playback of bird sounds can lead to pressure on some birds (Şekercioğlu 2002). Ease of access to bird records delineate birding hotspots, which can lead to other places no longer receiving due care because of, for example, a lack of records being misinterpreted as the absence of birds (La Sorte et al. 2024). Bird feeding, actively promoted through large digital citizen science programs and social media, influences the lives of birds both positively (greater populations of some birds) and negatively (through reduced breeding success and disease transmission in other birds; Plummer et al. 2019). Contributions of bird data to digital platforms means that birds become governable; birdwatchers thereby become implicit in processes that lead toward which birds get cared for and which birds get persecuted (e.g., species perceived to be overabundant, nonnative, or otherwise undesirable; Bradbeer et al. 2017, Crowley et al. 2019, Clancy 2021).

Although digital technologies are often taken for granted, we show that they inevitably influence practices and outcomes. How this unfolds, however, is down to what we do with them and allow them to do. Because of the pervasive nature of digital technologies and sheer scale at which they influence practices—of birdwatching and otherwise—we call for their use and implementation to be done with our eyes wide open.

Acknowledgments

The ethnographic material was produced as part of the EU-funded project EnviroCitizen (2020–2023) in which the authors of this article collaborated with partners in Cyprus, Estonia, the Netherlands, Norway, Romania and Spain. As part of the project, four short videos with the main title “How does

digital technology connect people to birds?” were produced. These are available on youtube.com (<https://www.youtube.com/@envirocitizen-ze6bt>). The script of this video series formed the basis of this research article. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 872557. The illustrations for figures 1, 3, and 4 were created by the artist Sacha Berna.

Author contributions

Elin Lundquist (Conceptualization, Methodology, Resources, Visualization, Writing - original draft, Writing - review & editing), Jesse Peterson (Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review & editing), Minh-Xuân Truong (Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review & editing), Gabriel Gumucio (Conceptualization, Resources, Visualization), and René van der Wal (Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing - original draft, Writing - review & editing).

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Received: January 27, 2024. Revised: January 18, 2025. Accepted: March 24, 2025

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