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Methods in Ecology and Evolution

PERSPECTIVE

Introducing a unique animal ID and digital life history museum for wildlife metadata

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Abstract

1. Over the past five decades, a large number of wild animals have been individually identified by various observation systems and/or temporary tracking methods, providing unparalleled insights into their lives over both time and space. However, so far there is no comprehensive record of uniquely individually identified animals nor where their data and metadata are stored, for example photos, physiological and genetic samples, disease screens, information on social relationships.
2. Databases currently do not offer unique identifiers for living, individual wild animals, similar to the permanent ID labelling for deceased museum specimens.
3. To address this problem, we introduce two new concepts: (1) a globally unique animal ID (UAID) available to define uniquely and individually identified animals archived in any database, including metadata archived at the time of publication; and (2) the digital 'home' for UAIDs, the Movebank Life History Museum (MoMu), storing and linking metadata, media, communications and other files associated with animals individually identified in the wild. MoMu will ensure that metadata are available for future generations, allowing permanent linkages to information in other databases.

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4. MoMu allows researchers to collect and store photos, behavioural records, genome data and/or resightings of UAIDed animals, encompassing information not easily included in structured datasets supported by existing databases. Metadata is uploaded through the Animal Tracker app, the MoMu website, by email from registered users or through an Application Programming Interface (API) from any database. Initially, records can be stored in a temporary folder similar to a field drawer, as naturalists routinely do. Later, researchers and specialists can curate these materials for individual animals, manage the secure sharing of sensitive information and, where appropriate, publish individual life histories with DOIs. The storage of such synthesized lifetime stories of wild animals under a UAID (unique identifier or 'animal passport') will support basic science, conservation efforts and public participation.

KEYWORDS
animal passport, biologging, community science, life history, lifetime tracking

1 | INTRODUCTION

Every year, many tens of thousands of individual animals, representing hundreds of species, are observed around the world, in water, on land and in the air, either directly or remotely (Hussey et al., 2015; Kays et al., 2015). Although many of these are one-off sightings, a small but growing proportion represent repeated observations of individually identified animals, some with known histories (Jones et al., 2008). The expansion of image-based animal identification powered by AI, for example (Berger-Wolf et al., 2017), and the democratization of animal observation via community science platforms have made it possible to simultaneously increase the detail and expand the spatial and temporal scales of individual-based data. Much of these data have begun to be stored in community-driven digital databases that allow researchers to archive, analyse and share data, constituting the building blocks of an 'Internet of Animals' (Harcourt et al., 2019; Kays & Wikelski, 2023).

Recently, a framework has been presented to standardize biologging data across different databases (Sequeira et al., 2021), which solves the issue of finding and linking original tracking data. We strongly support this concept and advance it here for individual metadata by developing a globally unique animal identifier (UAID). Such an animal passport is needed to find and preserve the unique metadata and ancillary data (photos, videos, physiological or genomic samples, etc.) of individually known animals. Metadata are essential for any other data to be put into value.

As a service to the animal research community, we provide a free, web-accessible database for the metadata of individually identified animals, the MoMu (Movebank Life History Museum). MoMu offers the assignment of a unique ID to each marked or otherwise individually recognizable animal, which allows to (a) discover and share biologging metadata across data holders and databases; (b) to link ancillary information, like genetic data, human-animal interactions, videos, photos or communications about the animals, as well as nesting phenology, reproductive output or mate/pairing information, to the biologging data; and (c) to enable the public to engage properly with this information, for example, through opportunities for participation in community science initiatives.

A unique animal ID linked to a life-history database has the potential to advance research by enabling data linkages: individual behaviours, life histories and physiologies from birth to death, as well as crucial metadata on the different data collection procedures and methods (Garde et al., 2022; Kay et al., 2019; Sequeira et al., 2018). Such linkages were previously difficult or time-consuming to make (Davidson et al., 2020; Queiroz et al., 2019; Ropert-Coudert et al., 2020; Sequeira et al., 2021). With technological progress and growing needs for environmental monitoring, there are calls to aggregate large volumes of biologging data to serve as new indicators and products, but these efforts, as well as traditional meta-analyses, are hampered by the inability to detect multiple instances of the same animal or data records (Hardisty et al., 2022). At the same time, it is imperative to optimize data availability from animal observations in order to reduce the burden to individual animals and populations (Cockcroft & Holmes, 2008; Cooke et al., 2017; McMahon et al., 2012; Portugal & White, 2018).

Many wildlife-tracking databases offer automated, near-real-time feeds and storage of sensor data through remote data transfer and coordination with operators of tracking systems (Kays et al., 2022). Similar functionalities do not yet exist for equally crucial metadata information that is collected by fieldworkers who deploy the tags. Proper archiving of metadata such as the exact time of attachment, or body mass, body condition, sex and age of tagged animals is often not possible or forgotten in the frenzy of fieldwork (Kays et al., 2022). Without efforts to extract, organize, automatically correct, connect and explore these materials, they can be lost, along with irreplaceable knowledge (Davidson et al., 2020; Sequeira et al., 2021). No standardized data format or fields exist for many of these types of data (but see, e.g. similar metadata standard for images in GBIF, but also see Sequeira et al., 2021).

Recently, Rutz (2022) suggested that some of these issues related to metadata and data loss could be resolved by establishing a global tag registry, TRACK (Tag Registry for Advancing Conservation Knowledge). TRACK would contain metadata, such as tag type and sensor settings, basic information on the tagged animal, the date and location of tagging, as well as contact details for the data owners and/or stewards, but not the tracking data (these would ideally be deposited in relevant data platforms). We strongly support the establishment of TRACK. Here, we go one step further and argue that the robust identification of individual animals is an essential component of this vision, because references to tags cannot be assumed to match references to individual animals: the same tag can be deployed on different animals over time, individual animals can be equipped with several tags simultaneously or successively, and tags can collect data while not attached to animals. Furthermore, while projects and agencies often assign animal identifiers, they often use multiple naming schemes (e.g. ring numbers assigned by a banding agency, public-friendly names for outreach efforts, and abbreviated IDs referred to in a paper or report), and the same IDs can be used by multiple organizations to refer to different individuals, complicating downstream data quality control and curation analysis (Figure 1).

The UAIDs offer a novel method for linking metadata from individual animals stored in a diverse range of databases such as WildBook (www.wildme.org; Berger-Wolf et al., 2017), ringing data, various biological sample banks, GBIF, animal disease and veterinary databases, Animal Telemetry Network, Ocean Tracking Network, as well as databases on individually identified, habituated animals, GenBank or RhODIS (genetic data of rhinoceri to combat trafficking; Harper et al., 2018).

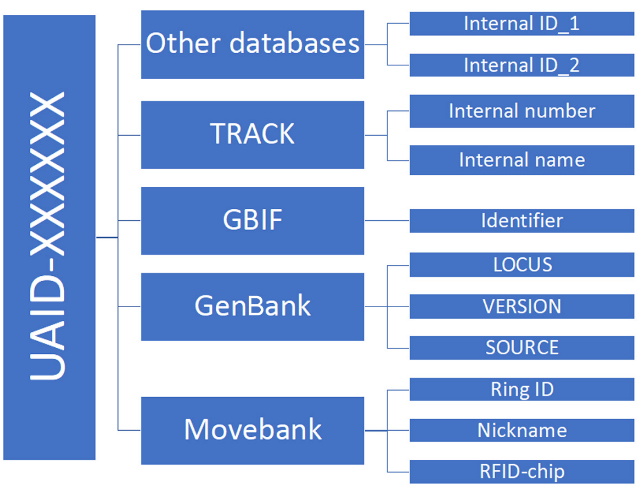

FIGURE 1 Schematic representation of how different databases that store information on individual animals can link to the same animal passport, the UAID_XXXXXX. Introducing the UAID field in these databases will allow the compilation of all data related to individual animals.

2 | METHODS

We introduce a novel, globally unique animal ID (UAID) consisting of 6-digit alphanumeric identifiers, that is UAID_N2Y4NW, deliberately kept short to fit on tiny sampling vials or labels. This UAID scheme will suffice for the first two billion individually identifiable animals and can be extended at any time. All previously tracked animals for which metadata are available could receive UAIDs. Within the MoMu database, the 6-digit UAID is linked to the unwieldy, 36-digit, but essential Universally Unique Identifier (UUID), a 128-bit label (Leach et al., 2005). Using the UUID as background labelling ensures that there will never be two individual animals with the same ID (except if labelling errors occur; see below how to remedy those). The MoMu is hosted on the permanent central server of the Max-Planck Society in Germany and properly backed up (Tables 1 and 2).

2.1 | How to create a UAID

UAIDs are stored and generated in the MoMu and can be created by anybody registered in the MoMu (https://animaltracker.app), which is open to all researchers, agencies and other entities managing data for animals that can be uniquely identified in the wild by whatever means across the lifetime of the animal (e.g. visual markings, PIT tags or leg bands). The UAID generation algorithm ensures IDs are unique. UAIDs can be created for animals in two ways (Figure 2).

In Workflow 1, a UAID is assigned to an individual that is not tracked by biologging. Creating a novel UAID is easy to do in the field and benefits users by immediately offering an online database option for individual animal metadata and thus streamlining data labelling in the field from the start. Investigators using the Ocean Tracking Network OTN or the Animal Telemetry Network ATN for acoustically tagged animals could link a UAID with OTN or ATN.

Workflow 2 involves an integrated linkage between the established Movebank and Animal Tracker systems (Kays et al., 2022). For animals that already exist on Movebank, UAIDs can be assigned individually or in a batch process. Any number of tracking tag deployments as well as alias names can be linked to a single UAID. Import formats include all common picture formats and pdf, and output formats are currently csv and pdf, but these can easily be changed and adapted to community needs in the future.

2.2 | Researchers benefit from the UAID

Each UAID comes with a unique vCard that can be downloaded from MoMu and entered into the contact card system of mobile devices or computers; a vCard, also known as VCF (Virtual Contact File), is a standard file format for electronic business cards. At the same time, a unique email address is assigned to each animal that has an UAID, in the form of uaid_xxxxxx@inbound.animaltracker.app (Figure 2), which is only available to MoMu registered users, to avoid spamming. Any email sent to this address is directly saved within the data

TABLE 1 Abbreviations of concepts and their explanation.

Term used	Explanation
Animal tracker	Web-based data base and mobile phone app to follow individual animals based on their Movebank location data
API	Application Programming Interface, allowing direct machine-to-machine communication by authorized users with databases
ATN	U.S. Animal Telemetry Network, online portal to view movement and behaviour of tagged marine organisms worldwide
Data dump	Temporary storage for unstructured information (such as photos, PDFs, field notes) about individually UAIDed animals in MoMu
GBIF	Global Biodiversity Information Facility
LITS	UK-based long-term individual-based time-series on animals
MoMu	Movebank Life History Museum
Movebank	Global database on individual animal locations and associated sensor data from electronic tracking tags
OTN	Ocean Tracking Network
Sed card	Visual overview of the available information on individuals, also known as 'model portfolio'
TRACK	Tag Registry for Advancing Conservation Knowledge
UAID	A 6-digit unique animal ID, a short version of the UUID, providing a unique identification for animals globally
UUID	A 32-digit universally unique identifier, a 128-bit label used for information in computer systems
V card	Virtual Contact File, a file format standard for electronic business cards that also contains the email address of an individual animal

TABLE 2 Online guide to enter data into MoMu.

MoMu web resource	URL
MoMu website	https://animaltracker.app/sign_in
Tracking tag deployment info	https://animaltracker.app/animals (create UAIDs here)
UAIDs of animals	https://animaltracker.app/identifiers
Data dumps, Sed cards and V cards	https://www.animaltracker.app/identifiers/UAID_GKYZND (XXXXXX to be replaced by animal ID)
User guide, help and support	https://docs.animaltracker.app/#/momu/what_is_an_uaid https://docs.animaltracker.app/#/momu/data_dumps https://docs.animaltracker.app/#/momu/what_are_sedcards

FIGURE 2 Schematic overview of two possible workflows for creating UAIDs in MoMu. Blue arrows: Available or intended data flows outside of MoMu. Green arrows: Metadata flows in MoMu. Workflow 1 is employed by users who are observing marked, ringed, pit-tagged and/or individually identifiable (by natural marks) animals who are not tracked by active electronic tags. Workflow 2 is employed by users who are tracking animals and use Movebank, or other big (aquatic) databases such as OTN, ATN, IMOS (Integrated Marine Observing System) or GLATOS (Great Lakes Acoustic Telemetry Observation System). A first step could be to disambiguate whether individuals are tracked again by coordinating between the TRACK database (Rutz, 2022) and the other databases. Tracking data then flow from the animal directly into the respective tracking databases, many of which offer downstream applications for visualization (such as Earth Ranger or the Animal Tracker app) and analysis (such as MoveApps). Metadata (such as life-history data) of the tracked animals can be stored in the respective databases or in MoMu. Animal tracking data can also be linked to MoMu from tracking databases. Whenever an individual animal is identified (Workflow 1) or tracked (Workflow 2), an existing or new UAID is assigned. The UAID comes with an inbound email account and a data dump, into which field notes, photos or other digital files can be forwarded via email or dragged-and-dropped. This email account is part of an individual animal website and can be identified by a QR code. Importantly, the direct field observation notes can be added (indicated by the + sign) to the UAID database, either directly or via APIs. MoMu users can also download the contact information of a UAIDed individual into a vCard file, which is then stored in the contact files of a cell phone or computer. The web surface displays an individual animal's Sed card or model portfolio (details in Figure 3), producing a visual timeline of the life history of an individual animal. Excerpts of, or the entire Sed card, can receive a DOI, become public or remain protected. The data manager responsible for an individual animal decides on publication and can invite collaborators.

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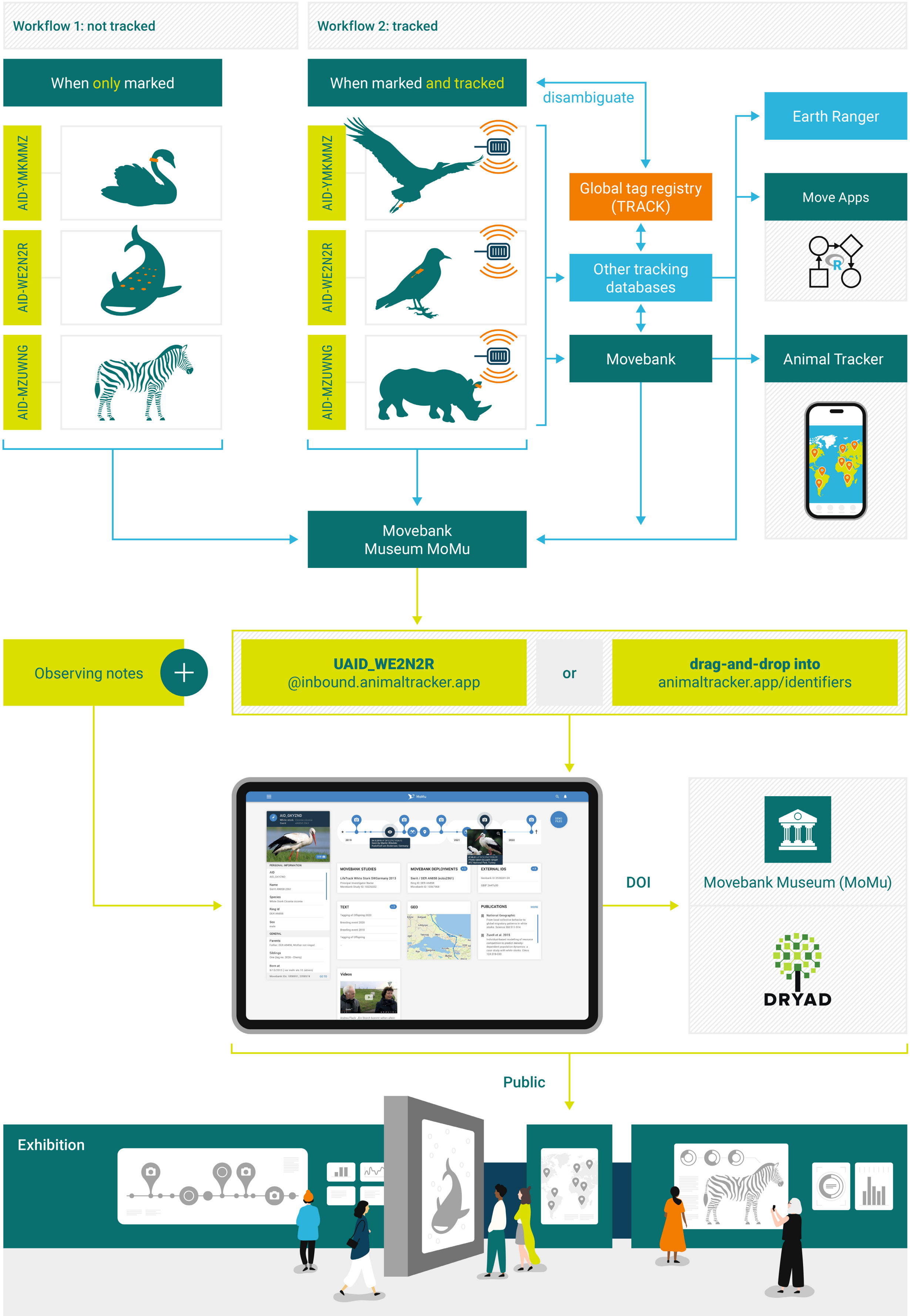

dump area of the UAID, akin to a field drawer, for later review, before the information contained in the email (e.g. photos, videos) is moved to the main animal page. Perhaps the most helpful feature of this email system is that photos on mobile phones can be selected directly during or shortly after fieldwork and forwarded to the UAID email address, thus preventing data loss and confusion ('which picture belongs to which animal tagged?').

Notes can also be manually added, and photos can be dragged and dropped into the individual UAID window in MoMu, where they are also first stored in the data dump. From the data dump, information can be linked to an individual's life history. Whenever photos are linked, their metadata (e.g. location, time, camera type) will be extracted automatically (Figure 1).

2.3 | Extended life-history data in the MoMu and UAID verification

Based on the entered metadata, an overview of the available information is displayed as a Sed card, or 'model portfolio' (Figures 1 and 2), highlighting the UAID and its aliases in linked databases. Video or sound URLs, such as those stored in public databases (such as www.youtube.com, www.xenocanto.com, and others), can be linked by UAID. The long-term preservation of YouTube videos is currently being discussed, and the outcome will be included in the data preservation strategy of MoMu. Access to data stored in MoMu can be tailored by data managers, under the data owner's instructions, authorizing selected users for specific features, opening parts or all metadata to the public or keeping them private. Data managers, conservation managers, permitting agencies, researchers, community scientists or members of the public can check MoMu for UAIDs to validate which animal it is (if the data are public), and whether the UAID is real (and not a made-up UAID_XXXXXX string), and see which other researchers or institutions have registered an UAID or find linked data using an UAID. As a next evolutionary progress for the MoMu, in discussion with future users, we will implement a platform that encompasses all the steps for the direct upload of metadata info using R-scripts.

2.4 | Input from community scientists and resolving individual animal identities

The public can already contribute individual animal observations through the Animal Tracker app Sighting function. Community scientists using the app for reporting observations are asked to provide a description of the location where the individual was sighted, of the behaviour of the animal, and ideally some images. These observations are curated by a professional. Initial stages of curation could also be crowd-sourced (Cheeseman et al., 2017) before being curated by a professional to reduce individual effort. In the near future, AI could support such activities, both reducing the need for professional curators and increasing the ease with which observations can be added to the database. Similar situations exist for camera trapping networks, for example, that start to rely upon AI to take over most of the initial data curation. The photos and descriptions in MoMu will help determine which individual animal this is, for example, by using markings that can potentially be identified. This would be beneficial when someone takes a photo of an animal with a collar or is re-tagging an animal that had been collared years ago but no longer carries the collar at the time of handling (Parham et al., 2018).

2.5 | Data output to the public

Data owners or museums can create exhibits based on life histories or lifetime tracks of individual animals (such as https://myriad.earth/). Museums may benefit from the UAID initiative: When an UAIDed animal dies, it can be collected and entered into the museum collection where the specimen and its associated tracking data can be accessed in perpetuity, used in future research and included in exhibitions. This is particularly relevant for species that are tagged and tracked for conservation purposes but not collected as museum specimens due to their threatened status.

2.6 | Data security concept

Ideally, all data should be open. But data for sensitive species might be abused for poaching or increase disturbance for popular individuals. In MoMu, we structured the data access such that data managers, who are the guardians of individuals, can either invite trusted individuals as data co-managers or only output certain types of (nonsensitive) information to the public. The security status of a UAIDed animal can change over time and data managers can adjust data access immediately in response. An individual animal can also have a mixed status, such that parts of its data, especially sensitive ones, can be off-limits to the public. The MoMu is set up to serve these needs of data managers to protect parts of the individual information.

3 | IMPLEMENTATION

Using both manual assignment of UAIDs directly within MoMu, as well as metadata feeds from studies set up in the Movebank database, users have already created thousands of UAIDs ('animal passports'). Many thousand additional UAIDs can be added easily building upon the live data feeds from research groups who currently track animals, but also for historical tracking data. In the case of data already existing in Movebank, data managers can simply assign UAIDs to their tracked animals; MoMu then allows them to compile and create 'Animal Sed Cards', that is, compilations of information of individual animals, such as that shown in Figure 2.

The digital vCard system widely facilitates the immediate forwarding of data, such as photos or scans of field data sheets, into the UAID database of the individual. Most researchers may want to save or backup their data as soon as they return from the field. Many of

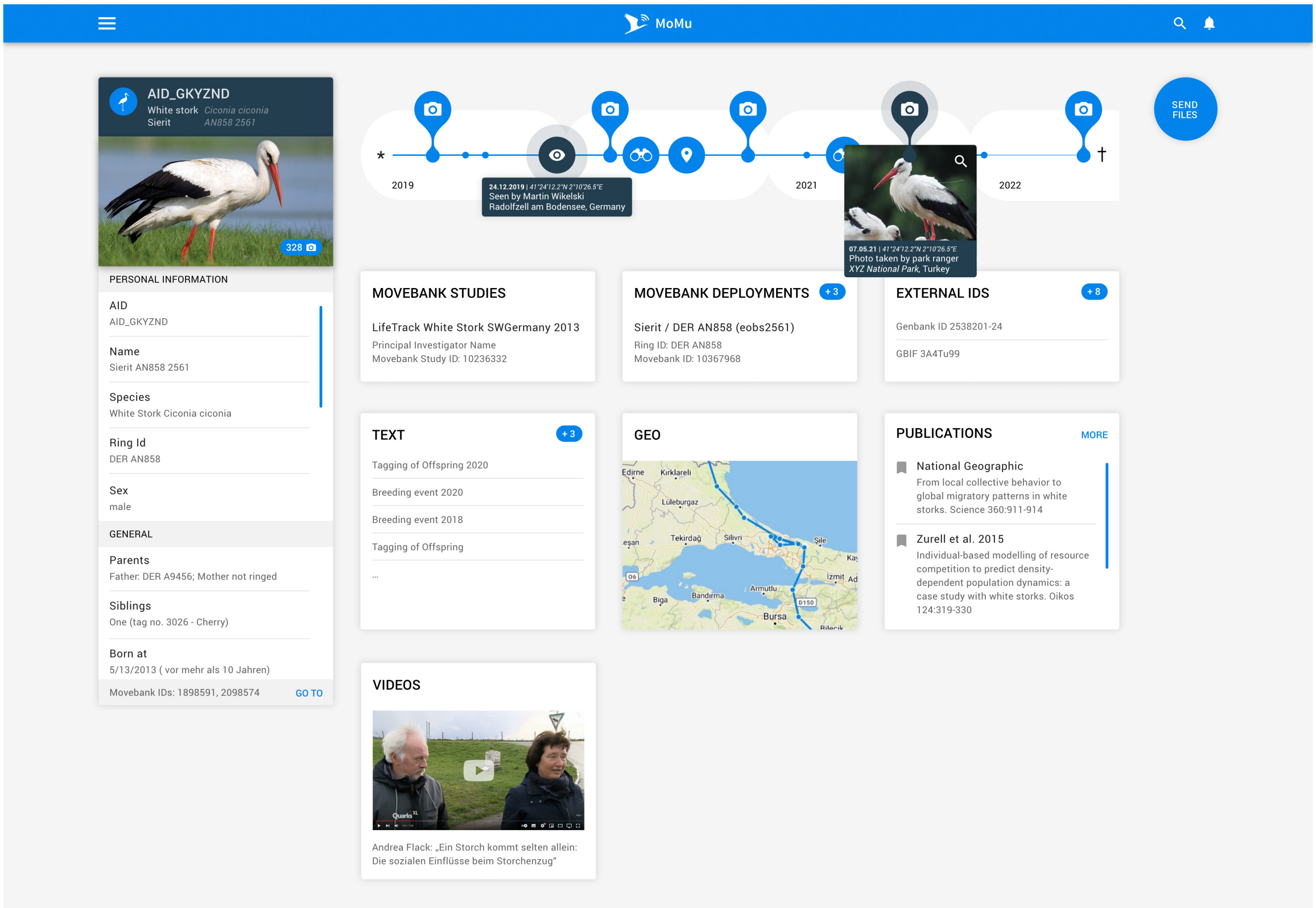

FIGURE 3 A compilation of some of the most important events during the lifetime of an individual animal—the white stork Sierit, who was tracked from birth onwards for most of her life (Berthold et al., 2004; Flack et al., 2016, 2018). Sierit's Sed card features its various alias names and external IDs (links to other databases, some currently as placeholders only). This individual is known by at least three different common names in four different languages, has performed at least eight migrations and has successfully bred many times. Its Sed card links to the UAIDs of Sierit's tracked offspring, providing a network of social relationships. Sierit's tracking data feature in at least five scientific publications. Data from Sierit's life can be protected from public viewing or selected for public viewing and published as an individual public Sed card. Public viewing can be stopped immediately if security concerns arise. Currently, the standardization of individual metadata is in progress, and once finished, a DOI-referenced information for MoMu metadata will be established. Importantly, through a unique UAID, all data streams for this one animal have now been linked and streamlined to ensure an accurate lifetime record.

these still use analogue data sheets that are being filled out on-site when an animal is being handled and tagged. Under time pressure and challenging field conditions, digital data entry may not always be feasible. The new vCard system offers researchers, at least in areas with Wi-Fi or cell phone connectivity, a convenient way for forwarding and immediately saving their field photos, scans of field data or other information on a safe, backed-up and managed database that is accessible by all project collaborators.

3.1 | Curation procedures and how to manage errors

Errors in the creation of UAIDs will certainly occur. For example, registered users may create UAIDs and never link them to individual animal metadata. Or, the same individual—perhaps because it migrated between hemispheres and is observed by different research teams unbeknownst to each other—is being assigned to two different UAIDs. To remedy such errors, as part of the metadata curation process, UAIDs can be deleted, or information from various UAIDs can be merged or purged. However, such processes can only be done in consultation with a professional MoMu curator, similar to established workflows in natural history museums.

Similarly, individuals can lose their permanent markers, such as a pit tag. For these situations, we envision a feedback loop from the Workflow 1 (Figure 1), including a filter check for previous evidence of marking in the area or for a similar territory/nest/den or for similar-looking individuals.

4 | DISCUSSION

Unique identities are essential in biology, as the individual is the unit of selection. Similarly, globally unique digital individual identifiers for wildlife that has been tracked, observed and sampled repeatedly over its lifetime will greatly facilitate research in the increasingly interdisciplinary scientific world. Some individual-based studies have already pioneered excellent data repositories like LITS (Jones et al., 2008).

Museum collections of animal specimens have proven extremely valuable to science and society for hundreds of years (Clavir, 2012; Suarez & Tsutsui, 2004). Part of this value is the meticulous metadata that are standard around these specimens, even if they were not necessarily important initially. Thus, standardizing the fundamentally collected metadata is of great benefit. Museum collections provide insight into several topics, including climate and global change, epigenetic and phenological responses, microevolution or the rise and fall of populations (Suarez & Tsutsui, 2004). Often, the value of the accumulated information became clear only after decades or centuries (Casas-Marce et al., 2012; Schmitt et al., 2019). We expect a similar expansion of information in individual life-history information from field observations, video recordings and data collected by wildlife drones (Corcoran et al., 2021), camera traps (Burton et al., 2015; Santangeli et al., 2020) and even satellites (Duporge et al., 2021). The UAID system will allow us to connect behavioural observations and physiologies of live animals to the 'extended specimen concept' (Carbillet et al., 2022; Lendemer et al., 2019).

The UAIDs can be linked to databases featuring samples or other records of the identified individuals, such as GBIF (Flemons et al., 2007), physio-bank or GenBank (Benson et al., 2012) and align well with the envisioned development of a tag registry (Rutz, 2022) and a digital extended specimen network for physical specimen collections (Hardisty et al., 2022). Currently, such linkages are implemented via web-links or respective database identifiers. In the future, a system of permanent ID associations is envisioned via the joint link towards the UUIDs underlying the UAIDs.

Individual-level digital resources need not only to be stored but also carefully curated (Jones et al., 2008), similar to physical museum specimens (Curry et al., 2010)—the data are only as good as their curation. In many cases, photos of animals show their tracking tags or other markers, and with machine or observer-aided assessment, these individuals can be connected with their various aliases in other databases (Tuia et al., 2022; Vidal et al., 2021). The intended permanent preservation of MoMu data will also support long-term individual-based studies, such as those conducted on populations of many ungulates, carnivores, primates, birds, teleost fish, elasmobranchs and cetaceans (Anderson et al., 2011; Beaune et al., 2013; Chapman et al., 2010; Clutton-Brock et al., 1996; Jones et al., 2008; Kappeler & Watts, 2012; Kranstauber et al., 2020; Kumbasli et al., 2010; Sheldon et al., 2022). These intensive field studies have shown the importance of collecting and linking individual-based data (e.g. physiological or reproductive state, rank, body mass and condition), and other life-history events (birth, maturation, reproduction and senescence) and movements throughout the lives of individual animals until their death (Berthold et al., 2004; Froy et al., 2018; Pemberton et al., 2022). The information stored in the MoMu will allow future scientists to revisit studies and compare them with newly collected data in a way similar to these long-term studies. This will be extremely valuable for monitoring wildlife populations and habitat management in our changing world. For example, Shuert and colleagues (Shuert et al., 2022) demonstrated that only through collating all satellite-tagged narwhal data were they able to address the question of how this species react to climate change by modifying its migration timing from summering grounds.

The open structure of MoMu creates the potential for the general public, skilled amateurs and community scientists to play a huge role in curating individual animal data (Koelzsch et al., 2022), engaging with individual animals (Acácio et al., 2023; Wilkinson, 2023) and connecting various databases and/or error-prone observations similar to the approach in iNaturalist (Van Horn et al., 2018). Ultimately, it will be up to the respective data managers of individual animals to protect or publish (e.g. with a DOI) the information of animals over their lifetime. As with natural history museums, MoMu will require a statement from the current data manager on how the data under his auspices will be curated in the future, for example when a data manager retires. We envision that a permanent institution should then inherit the guardianship over these data, and if no guardian can be found, the MoMu management will take on responsibility for such orphaned data sets. The ease with which data managers can curate individual metadata, share them with the wider community, or introduce novel analysis ideas is one of the main strengths of MoMu. Moreover, a key advantage for conducting large-scale comparative studies is to make metadata available so that analysis questions can be well-crafted based on accurate information.

MoMu can also be productively linked with the global tag registry proposed by Rutz (Rutz, 2022), or other existing or planned platforms, accelerating the development of an efficient, fully integrated digital ecosystem of tools for the curation, management and analysis of whole-organism data. Although there are standardized marking schemes for the worldwide identification of birds and a few other taxonomic groups exist (EURING-The European Union for Bird Ringing, 2020), in practice, not all tagged individuals receive such markers and for many taxa coordination is lacking. Individual identifications may also overlap between, or be repeated within, regions of the world, thus necessitating a globally unique ID system. The UAID system allows for identification of unmarked individuals as well as linking of tracking data and other information for marked individuals, no matter which marking scheme is used.

The combined life-history information of individual animals could also provide an essential data input for the Earth BioGenome project (Lewin et al., 2018), especially if the metadata including behaviour of sequenced individuals is known. Imagine a dataset where the decisions of many individuals of a species are known in their wild environment over their lifetime and brought together with the in-depth knowledge of their genomic architecture (Poelstra et al., 2014; Wolf et al., 2010).

In the future, the Internet of Animals will grow and provide input into many global earth information systems (Kays & Wikelski, 2023). Data from wildlife may help with direct earth observations (Bartlam-Brooks et al., 2011; Ellis-Soto et al., 2023), the prediction of global zoonotic disease dynamics (Weber et al., 2015) or climate conditions (Bohrer et al., 2014; Gurarie et al., 2019; Wikelski & Tertitski, 2016), assessments of reforestation (Estrada-Villegas et al., 2023) or nature-positive environmental planning (Rutz et al., 2020; Wilson et al., 2016). The Internet of Animals depends on unambiguous, permanent and secure linkages of data, which in turn rely on individual identification systems, such as the unique identifiers introduced here, issued and curated by MoMu. As discussed previously (Kays et al., 2020), it is critical that organizations such as those within the biodiversity community facilitate the long-term storage and availability of digital animal data. It is envisioned and under discussion that a governmental institution that will exist in perpetuity (such as natural history museums) will take over the MoMu in the long term. As such, the MoMu, administering the UAIDs, will serve a global community of people working with information of individual animals. However, only institutions that are expected to persist in perpetuity can ensure that animal data are preserved for future generations. Using both UAIDs and MoMu will enable individual researchers to aid in this goal.

AUTHOR CONTRIBUTIONS

The entire team conceived the ideas and designed the methodology. Julian Hirt and Michael Quetting designed and wrote the code. Martin Wikelski led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

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DATA AVAILABILITY STATEMENT

All UAID data available in https://animaltracker.app. Beyond these animal metadata, this manuscript does not contain any data/code.

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