

Standards for within-consortia data sharing and database interoperability

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This report is a deliverable for the Biodiversa+ project BIG_PICTURE (Cluster B, WP5, D3).

Introduction

Camera traps have become an increasingly powerful tool for biodiversity research worldwide. This has resulted in the generation of millions of camera trap records. To exploit the full potential of these records, we need effective infrastructure and tools for collaborative data management, harmonization and exchange. A wide range of data management tools for camera trap data are already available, including desktop software and web applications. However, these tools are still relatively disconnected and a significant proportion of the camera trap data are inaccessible to the camera trapping community. There's a strong need to increase the accessibility and interoperability of these tools to maximize the full potential of camera trap data.

The Biodiversa+ project BIG_PICTURE brings together 17 of the leading European research groups and stakeholders involved in camera trapping (Table 1). Together, these institutes manage a large proportion of the European camera trap data. One of the project's aims is to increase the accessibility to and aggregation of these data. To achieve this goal, we need to 1) identify and adopt a common data exchange format and 2) facilitate data export in this format by the infrastructures and tools (hereafter referred to as data management systems or DMS) used by the partners.

Camtrap DP is a recently-developed and well-supported data exchange format for camera trap data. It was presented at the start of the project and all partners agreed to adopt it as the data exchange format. In this report we clarify that decision by providing an overview of the current formats that support the exchange of camera trap data, with their strengths and weaknesses.

A second goal was to identify the different DMS used by the project partners. We gathered this information through an online survey in October 2024. The goal was to identify the current state of the art (*"what system do you use to upload and manage your data?"*) and future plans (*"are you planning to change the data management system you use?"*). In this report we discuss the different DMS and how this affects data sharing and export. As not all DMS support exporting data to Camtrap DP (yet), we identified the partners that need support in transitioning to a new DMS or support in converting their data to Camtrap DP (*"do you need support when migrating your data?"* and *"do you need support and/or extra software tools to convert your datasets into Camtrap DP format?"*). The results of this survey are summarized in table 2.

Table 1: Overview of the project partners

Acronym	Full name	Country
BFNP	Bavarian Forest National Park	Germany
CEFE	Centre for Functional Ecology and Evolution	France
CNR	National Research Council	Italy
FEP	Faculty of Environmental Protection	Slovenia
FEM	Edmund Mach Foundation	Italy
INBO	Research Institute for Nature and Forest	Belgium
INN	Inland Norway University of Applied Sciences	Norway
MPI	Max Planck Institute of Animal Behaviour	Germany
MRI	Mammal Research Institute	Poland
NINA	Norwegian Institute for Nature Research	Norway
SLU	Swedish University of Agricultural Sciences	Sweden
TU	Tilburg University	Netherlands
UCLM	University of Castilla la Manch	Spain
UF	University of Firenze	Italy
UL	University of Ljubljana	Slovenia
UoP	University of Primorska	Slovenia
WUR	Wageningen University & Research	Netherlands

Current exchange formats for camera trap data

We need a common data exchange format to facilitate data sharing, analysis and publication within and outside the project. We identified a number of formats that can support the exchange of camera trap data: Camera Trap Data Package (Camtrap DP), Camera Trap Metadata Standard (CTMS), Darwin Core and Image FAIR Digital Objects (iFDOs).

Camera Trap Data Package (Camtrap DP) ([Bubnicki et al. 2023](#), <https://camtrap-dp.tdwg.org/>) is designed to facilitate the FAIR exchange, harmonization and archival of camera trap data. Under the umbrella of Biodiversity Information Standards (TDWG), its development and maintenance are led by the Research Institute for Nature and Forest (INBO) and the Mammal Research Institute (MRI), both of which are partners of the BIG_PICTURE project. Camtrap DP structures camera trap data in a simple yet flexible data model, consisting of three tables (Deployments, Media and Observations) that supports a wide range of camera deployment

designs, classification techniques and analytical use cases. It builds upon existing data standards such as Data Package, Darwin Core and Audiovisual Core. Camtrap DP is the consensus of a long, in-depth, consultation and outreach process with standard and software developers, the main existing DMS, major players in the field of camera trapping and the Global Biodiversity Information Facility (GBIF). It is developed openly and version controlled. This approach has led to strong adoption. Camtrap DP is already supported as an export format by Agouti and TRAPPER, while Wildlife Insights and EuroCaM have plans to integrate Camtrap DP in the (near) future.

Camera Trap Metadata Standard (CTMS) ([Forrester et al. 2016](#)) is a format to facilitate the exchange of camera trap data. It was mainly designed to facilitate data exchange between eMammal and Wildlife Insights. CTMS classifies camera trap data using 35 terms, grouped across four levels: Project, Deployments, Image Sequence and Image. Although CTMS is an important first step towards a comprehensive data exchange format for camera trap data, it is lacking terms, versioning and most importantly maintenance. As a result, CTMS has become outdated and has gained limited adaptation. Some of its authors (including the lead author) now explicitly support Camtrap DP.

Darwin Core ([Wieczorek et al. 2011](#), <https://dwc.tdwg.org>) is a cross-domain biodiversity standard. It is designed to share information about species occurrence, specimens, and taxa and covers information from a wide range of biodiversity-related topics, including observations made by camera traps. Darwin Core is a community-driven and evolving standard, maintained under the umbrella of TDWG and used by GBIF as the primary standard for sharing biodiversity data. It is globally adopted and a good candidate for exchanging camera trap data. Because it is not specifically designed for camera trap data, it lacks specific terms (e.g. camera settings) and cannot express non-animal observations such as blank sequences or vehicles. Darwin Core is typically expressed in the Darwin Core Archive (DwC-A) format, which star schema structure makes it technically impossible to relate multimedia files and associated metadata to specific occurrences on the one hand, and capture the detailed hierarchical event structure (deployments, sequences) of the camera trap study on the other hand. GBIF, TDWG, INBO and others are currently working on a DwC-A version two, which will resolve these structure limitations. This will make it more suitable for camera trap data, but not as suitable as Camtrap DP.

Image FAIR Digital Objects (iFDO) ([Schoening et al. 2022](#), <https://marine-imaging.com/fair/>) is a format designed for the FAIR exchange of marine image data, such as seafloor and planktonic images. Its development is led by the MareHub initiative of the Helmholtz association. An iFDO file consists of two parts: an image set and image set items. Image set items inherit values from their set if undefined. Terms are grouped into core terms which are mandatory for FAIR data exchange and optional capture and content terms. iFDO was developed openly with data managers, researchers and software engineers, but it is unclear how well it is adopted. iFDO supports a wide range of image capture techniques and can likely express terrestrial camera trap images as well. But since it mainly focuses on documenting image (capture) metadata, it is up to the publisher how to document animal observations (in image-annotations). It is therefore

not a complete solution for camera trap data, for which standardized observation information is critical as well.

Due to its many advantages, the BIG_PICTURE consortium decided to adopt Camtrap DP as the standard format for data sharing.

Data management systems used by the project partners

Most of the partners use a DMS to manage their camera trap data (15 out of 17) (Table 2). Two partners - the Centre for Functional Ecology and Evolution (CEFE) and Tilburg University (TU) - manage their data on external hard drives.

Seven different DMS are used. Four are widely used by the European camera trapping community and within this project: Agouti (used by 6 partners), TRAPPER (4 partners), Wildlife Insights (3 partners) and EuroCam (2 partners). These are mature systems that support the entire lifecycle of camera trap data management, each with their own strengths, priorities and communities of users. They are described in more detail below, highlighting whether they support data export as Camtrap DP (see also [Reyserhove et al. 2023](#) for an overview).

Agouti ([Casaer et al. 2019](#), <https://agouti.eu>) is currently used by six partners. It is a free, full-feature European based service and widely adopted within the European camera trap community. Data is stored on university infrastructure and allows for long-term archival. Open publication of data is encouraged but not required. Agouti offers the ability to export data using Camtrap DP. Agouti is maintained by Wageningen University & Research (WUR) and INBO, both partners in BIG_PICTURE.

TRAPPER ([Bubnicki et al. 2016](#), <https://os-conservation.org/projects/trapper>) is currently used by four partners, although the Inland Norway University of Applied Sciences (INN) is still in the process of setting up the software. It requires installation and hosting, and is a good choice for organizations who want control over the software and where data is stored. It is free to use and is mainly used within the European community. There is no open data requirement. Data managed in TRAPPER can be exported using Camtrap DP. TRAPPER is maintained by the Open Science Conservation Fund, hosted at the MRI, a partner in this project.

Wildlife Insights ([Ahumada et al. 2020](#), <https://www.wildlifeinsights.org/>) is currently used by three partners. It is another, well-known online system for managing camera trap data, that can be used through a subscription model (including a free tier). Data is required to be made public after an embargo of maximum two years and project metadata is always available via a public portal. Data from Wildlife Insights can be exported using a custom format based on CTMS. Wildlife Insights does not currently support data export as Camtrap DP, but is planning to implement this functionality within the lifetime of BIG_PICTURE.

EuroCaM is an online data management platform specifically developed to address the needs of the EUROMAMMALS community. Access is granted via password and managed by the platform administrators. The community is open to all those who request and sign the terms of use. Soon, the data managed within EuroCaM will be available for export using camtrap DP.

Three of the partners have developed their own DMS. These systems are not developed for widespread use and are specifically tailored to the needs of their projects.

The **Norwegian Institute for Nature Research (NINA)** had developed an online platform to manage data for the [SCANDCAM](#) project, which monitors medium and large mammal species in forests across Scandinavia. The platform is by the SCANDCAM project partners. Data are not shared openly. Export as Camtrap DP is not supported yet, but this feature is under development.

The **University of Firenze (UF)** combines the use of Wildlife Insights with another, custom made platform named **Wild.AI**. Wild.AI is specifically tailored to serve the needs of park professionals and researchers in Italy for systematic monitoring. It is not developed for widespread use. The export format aligns with the export format of Wildlife Insights (CTMS). There are currently no plans to support export as Camtrap DP.

The **University of Ljubljana (UL)** also developed a DMS to cover the specific needs of their current projects. However, the platform is very basic and does not support many other functionalities, it only covers the few requirements needed. Data can be exported as CSV or DBF, not as Camtrap DP.

Almost all partners (15 out of 17) are satisfied with the DMS they currently use. Only UL (own DMS) and CEFE (no DMS) consider a change of DMS in the (near) future.

Table 2: Summary of the responses of the partners to the survey. It includes information about the data management system(s) in use by the partner (“DMS”), if that DMS currently allows export as camtrap DP, if the partner has any plans to change their DMS, and if support is needed for (1) migrating data to the new DMS. Column or (2) converting data to camtrap DP.

Partner	DMS	Export as camtrap DP	Plans to change DMS	Support needed for migrating data to new DMS	Support for conversion to Camtrap DP
BFNP	TRAPPER	yes	no	no	no
CEFE-1	no system	no	no	no	no
CEFE-2	no system	no	no	no	yes
CEFE-3	no system	no	yes	yes	no
CNR	Agouti	yes	no	no	no
FEP	Agouti	yes	no	no	no
FEM	EuroCam	planned	no	no	yes
INBO	Agouti	yes	no	no	no
INN	TRAPPER*	yes	no	yes	yes
MPI	Wildlife Insights	planned	no	yes	yes
MRI	TRAPPER	yes	no	no	no
NINA	own system	no	no	no	no
SLU	TRAPPER	yes	yes	no	no
TU	no system	no	no	no	no
UCLM	Agouti	yes	no	no	no
UF	Wildlife Insights, own system (Wild.AI)	planned (Wildlife Insights)	no	no	yes
UL	own system	no	maybe	no	yes
UoP	Agouti	yes	no	no	no
WUR	Agouti, EuroCam, Wildlife Insights	yes (Agouti)	no	no	no

Recommendations and next steps

The BIG_PICTURE partners agreed to adopt Camtrap DP as the common format to share data within the project. This format is maintained openly, which allows us to suggest changes to the standard if needed. If those changes are not adopted (e.g. because they are too specific for the standard), then the extendible nature of the standard allows us to adopt them within the project, while ensuring interoperability with other projects.

With Camtrap DP as the common format, partners need to be able to transform the data they manage locally to this format. The next step for WP5 is to support partners in this process. Luckily, the DMS Agouti and TRAPPER already support export as Camtrap DP export, so no further assistance is needed there. These systems are used by the majority of the partners (10 out of 17), who are satisfied by their choice.

Wildlife Insights and EuroCam do not yet support Camtrap DP as an export format, but both DMS are in the process of integrating this option. This is useful for the afterlife of the project, but these features might not be ready for data exchange during the project. WP5 should therefore investigate how to support transformation to Camtrap DP for the 3 partners using these DMS: Edmund Mach Foundation (FEM), the Max Planck Institute of Animal Behaviour (MPI) and UF. Note that WUR also uses Wildlife Insights and EuroCam as a DMS, but they have sufficient in-house expertise to export their datasets as Camtrap DP.

Finally, WP5 should provide assistance to partners without a DMS (CEFE, TU) or their own DMS (NINA, UF, UL). Either by supporting a transition to a DMS (CEFE, UL) or providing technical guidance in how to implement export functionality to Camtrap DP.