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Transforming European Taxonomy through Training, Research, and Innovations

Policy Brief 1:
The power of reference collections in biodiversity monitoring

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Revision:

no.	Reviewer	Status	Notes
v01	Ana Casino	Under review	Strategic & policy framework
v02	Iasmi Stathi (NHMC-UOC)	Under review	
v03	Carole Paleco (RBINS)	Under review	
v04	Ana Casino	Approved	

Settings	Value
DELIVERABLE	
Deliverable title:	Policy Brief 1
Deliverable n°:	D8.4
WORK PACKAGE	
Work Package	WP8
Work Package Leader	Michael Magee
Task	T8.2
Taske Leader	Michael Magee
Type:	Document
Lead beneficiary:	NMDK / LUOMUS/ CETAF
Citation:	
Due date of deliverable:	31/05/2024
Actual submission date:	30/05/2024
Deliverable status:	Submitted

Abstract: This document constitutes "*Deliverable 8.4 - Policy Brief 1*", it includes the text that will be formatted into a visually attractive format for its printed and digital dissemination. The topic of this first Policy Brief is the importance of reference collections, for identification and monitoring of species. This policy brief is further supported by the dissemination of "Deliverable 1.1 - Roadmap to set up reference collections".

Document Control Information

Settings	Value
Document Title:	Deliverables Template
Project Title (Acronym):	TETTRIs
Document Authors:	Luc Willemse; Hanna Laakkonnen
Project Coordinator	Technical Coordinator: Ana Casino, CETAF
	Financial Coordinator: Frederik Hendrickx , RBINS
Doc. Version:	V03
Sensitivity:	PU
Date:	30/05/2024

Document Approver(s) and Reviewer(s):

NOTE: All Approvers are required. Records of each approver must be maintained. All Reviewers in the list are considered required unless explicitly listed as Optional.

Name	Role	Institution	Action	Date
Iasmi Stathi	Reviewer	NHMC-UOC	*Review*	24/05/2024
Carole Paleco	Reviewer	RBINS	*Review*	24/05/2024
Ana Casino	Approver	CETAF	*Approve*	30/05/2024

Document history:

The Document Author is authorized to make the following types of changes to the document without requiring that the document be re-approved:

- Editorial, formatting, and spelling
- Clarification

To request a change to this document, contact the Document Author or Owner. Changes to this document are summarized in the following table in reverse chronological order (latest version first).

Revision	Date	Created by	Short Description of Changes

Configuration Management: Document Location

The latest version of this controlled document is stored in <location>.

Introduction

During the past decades, global environmental changes accelerated the speed of biodiversity decline at an unprecedented rate. In the context of the EU Green Deal, the 2030 Biodiversity Strategy and the Global Biodiversity Framework, biodiversity monitoring is a crucial component for observing, measuring and understanding biodiversity changes in our ecosystems and ultimately reversing negative trends. In turn, the success of any biodiversity monitoring schemes is dependent on accurate, reliable and timely available taxonomic data, tools and expertise. TETTRIs, an EU-funded project, is tasked with developing and validating taxonomic knowledge and systems in support of the current biodiversity governance framework needs. In that context, it aims to produce a range of innovative tools for use both among professional and amateur taxonomists, as well as practitioners in the field, involved in biodiversity monitoring, conservation and restoration.

> Taxonomy is the science of naming, describing and classifying organisms and applies to both biological and geological diversity of the world.

This policy brief highlights the importance of reference collections and provides recommendations on how to apply them in European monitoring efforts with a special focus on the EU Pollinator Monitoring Scheme (EUPoMS) as the most recent effort to systematically implement standardised Europe-wide monitoring of biodiversity. A roadmap to build linked virtual and physical reference collections has been developed under TETTRIs and is being tested for further refinement through the so-called Third-Party Projects (3PPs), carried out by local actors in biodiversity hotspots and protected areas across Europe. It underlines the critical relevance of reference collections for harmonised, comprehensive and sustained monitoring endeavours based on species identification in European territory and beyond.

> In this framework, reference collections are a set of specimens with reliable identifications belonging to a defined group, used as a benchmark to identify additional specimens.[1]

Policy context

The discussion on the importance of taxonomic reference collections in biodiversity monitoring is very timely due to the current policy developments, both in Europe and globally. In 2022, Kunming–Montréal Global Biodiversity Framework (GBF) was negotiated at the United Nations Conference on Biodiversity (COP15) as an action plan to protect, restore, sustainably use, manage and finance ecosystems. As part of their commitment to the GBF, each country will need to implement a national biodiversity monitoring programme and harmonise their efforts with the GBF. Among others, a crucial piece of the European Green Deal, the proposed Nature Restoration Law (NRL) would set legally binding targets for EU Member States, thereby providing a renewed momentum for creating a robust monitoring scheme of species and ecosystems across Europe to allow its successful implementation.

In the context of monitoring, the most concrete policy developments on EU level are currently found in the area of pollinators, given their dramatic decline which threatens the survival of nature, human wellbeing, secure agriculture and economic growth at large. The EU 2030 Biodiversity Strategy and the 2018 Pollinators Initiative (revised in 2023 under the name "A New Deal for Pollinators") formulate the commitments towards halting and reversing the decline of pollinators, with a key pillar dedicated to improving knowledge of pollinator decline, as well as its causes and consequences. Once in force, the NRL would impose a legally binding target for the recovery of pollinators by 2030.

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In 2021, a proposal for an [EU Pollinator Monitoring Scheme](#) was prepared and published by a leading group of experts gathered within the [STING](#) project, which was mandated by the European Commission (the Joint Research Centre). The proposal elaborates a methodological framework for the systematic monitoring of pollinators across the EU, with an emphasis on closing the existing knowledge gaps in relation to their status and trends. The EUPoMS methodology was trialled through several projects and initiatives in order to obtain a comprehensive picture of the needs, supported by the Expert Pollinator Working Group under the Governance of the EU Biodiversity Platform. Notably, the [SPRING](#) project was launched with an aim to strengthen taxonomic capacity with regard to pollinators, support preparation for the implementation of EU-PoMS and pilot the scheme in the field. Several other projects, such as [ORBIT](#) and [Taxo-Fly](#), are developing resources for species inventory and taxonomy for European bees and hoverflies in support of the monitoring scheme, to provide up-to-date and accurate information on pollinators (abundance and richness) in Europe.

Present available resources for identification

Under the joint framework of all these initiatives, a set of resources, including taxonomic capacity and other tools and mechanisms in support of taxonomists' work, stands as a critical component for effective and sustained (pollinator) monitoring implementation anchored on species identification.

Role of taxonomists in the species identification process

Identification of species is at the basis of any monitoring activity. Once collected, assigning a name to specimens is the single most important step. This requires taxonomic expertise and it allows us to have a solid reference enabling us to communicate unambiguously about species across the world. Adequately identifying species allows us to manage biodiversity by determining the species to preserve, remove (e.g. invasive alien species) and restore, in order to foster the healthy functioning of natural ecosystems.

Supporting tools for species identification

Taxonomic expertise is mostly linked to collection-holding institutions[2] where taxonomists conduct their research. These professional taxonomists may rely on their own expertise and on the collections on which they work to understand, describe and document biodiversity. However the task of identifying biodiversity is substantial and specialised taxonomists are scarce. Para-taxonomists, amateurs and citizen scientists at large may complement the taxonomic work, critically in hotspots and protected areas. However, they need to be adequately trained, have access to the necessary tools to contribute meaningfully. There are several categories of tools that can be used to identify species like AI apps (e.g iNaturalist), field guides, and research papers or natural history collections. These categories are inter-complementary, each with its own target audience, and differ in their degree of accessibility, reliability (of the result), and taxonomic expertise required for their use and setting where it can be used (indoor or outdoor).

When used without the taxonomic knowledge, algorithms of the AI apps or images of the identification guides are relevant to certain groups or species. Phenotypes are not always obvious and they may require closer examination with scientific equipment. For example, among hoverflies, only about 30% can be identified based on a general dorsal image. Similarly, for many groups of bees, such as cuckoo bumblebees, blood bees and mason bees, a mere dorsal image will not be sufficient for correct identification of the species. Furthermore, individuals display variations within the species in colour and shape, not to mention the differences of sexes and individuals of different castes. Identification of species may rely on non-professional experts to do some actual taxonomical work, but in addition to this, surveys and monitoring programs need highly qualified personnel with identification skills. At the present, there is a lack of both and the reliance on

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[2] Museums, botanic gardens, biodiversity centres, etc.

para-taxonomists often results in erroneous or ambiguous identifications. Due to this, we often do not know which species are threatened. Currently biodiversity is under threat due to several human induced factors: habitat destruction, fragmentation, pollution, invasive alien species and species are disappearing before taxonomists can even describe and provide the scientific knowledge necessary to protect them.

The use of reference collections

In the field of identification, natural history collections are the foundation upon which other identification tools are built, the repositories of the name-bearing individuals (types) used to describe new species and a benchmark for confirming or assessing the identity of new specimens. In this context reference collections stand as an instrumental component of the identification process. Reference collections are widely recognised as an important resource for the proper implementation of EUPoMS. The 2021 proposal highlights the need for each country to build a comprehensive national reference collection for training both experts and amateur taxonomists, managed by institutions such as natural history museums, and harmonised and coordinated through centralised hubs such as CETAF. Moreover, reference collections are seen as an important component in innovative approaches to monitoring such as automatic image analysis and sound recognition for species identification, as it is being developed under TETTRIs and other related EU-funded projects (e.g. MAMBO).

Information and expertise shortage

To overcome the shortage of tools and other resources, the CETAF community has developed under the TETTRIs project a roadmap for building reference collections (both virtual and physical) that can be used to improving resources for accurate identification, help enlarge capacity in the process and ultimately ensure quality implementation of the species monitoring programmes. This is the first time this issue is addressed with special contributions made by the taxonomic community. In this context, natural history collections form a stable benchmark, which can be used to confirm or assess identifications, especially for taxa that are difficult to distinguish or for groups that have been less studied.

The *Roadmap for building reference collections* outlines the definitions and features of benchmark collections both in their physical and virtual (digital images) format. It lists the specific steps for setting up and developing such collections in the collection-holding facilities and identifies the measures to improve the international infrastructure connected to them. Additionally, reference collections of pollinators are being built to be used as replicable models for other taxa groups. This work is undertaken, tested and validated with the help of practitioners working in the field.

With the help of digital indexes of reference collections, the stakeholders will know where they can find identified benchmark representatives of the taxon groups of their interests. Digital species index is recognized as the most important tool to raise awareness and attract interest and increase accessibility to collections, both by the researchers associated with collections and other stakeholders. However, digitization is a slow process and a minor section of zoological collections are digitised, furthermore not all collection-holding facilities dispose of a digitisation lab. A complimentary way of making the collections available for stakeholders are the virtual reference collections (high quality images of collections specimens identified by experts). However, moving from current image libraries (with only dorsal images) towards virtual benchmark collections, the images should portray diagnostic morphological traits that can be used for taxon identification (often images from other parts of the body, or close-ups of certain characteristics). In the framework of TETTRIs, reference collections and their species indexes are considered critical to allow reliable recognition of species. All the information about the collections and their species composition along with complementary virtual data, such as links to

genomic data and identification keys, needs to be made easily accessible by allocating it on open access platforms, well curated and maintained.

Similarly to the current lack of good reliable reference collections and indexes, the results extracted from the work developed under TETTRIs and confronted with other sister initiatives in relation to pollinators monitoring activity (e.g ORBIT, Taxo-fly, MAMBO, and the Red List of Taxonomists for insects at large) clearly indicate that the field's shortage of experts and resources continues to persist. The contributing factors include the siloed knowledge with limited interaction between interested actors and across the multiple layers of taxonomy. Physical access to taxonomic infrastructure at local, regional, national, and global dimensions is also limited and subject to request. There is an urgent need for a transformative change in the field of taxonomy to improve and optimise the taxonomic research capacity. For this, essentially three actions have been identified to be spearheaded to ensure the necessary increase of taxonomic capacity and provide researchable tools to facilitate and scale up their work:

- **Access**: in order to optimally support all activities that include identifying individual organisms, natural history collections and information about their collections (e.g. a species index) should be easily findable and openly accessible. By doing so, the use of collections as benchmark for species identification will revert back in support of increasing taxonomic capacity and leveraging on efforts made across borders.
- **Innovation** to develop supporting systems: it is worthwhile to direct international collaborative efforts towards further developing AI tools to share taxonomic expertise using image and sound recognition. The metadata obtained by using these tools will enrich reference collections and enlarge the set of features to record and track over time to avoid misidentification and facilitate aggregation of results at national, European and global level.
- **Education, training and capacity building:** all measures that broaden and deepen taxonomic expertise at local, regional, national and international levels across Europe will, in the end, contribute to more and better benchmark collections. Such measures may start by raising interest in entomology among the youngest generation and run via various training courses targeting all levels of education, including the promotion of a European-wide centre for taxonomy training the Distributed European School of Taxonomy (DEST)[3].

Recommendations:

While TETTRIs is significantly contributing to identify issues related to the identification of species, and specifically related to pollinators monitoring, the solutions to those challenges will require prompt action in the near future, our recommendations focus on a combination of two key components, namely knowledge creation and availability of expert taxonomists, as well as tools for species identification, supported by two other cross-cutting dimensions: funding availability and sustainable governance schemas.

Instrumental components

Human resources:

1. **Fostering taxonomic recognition** through communication initiatives[4] and raising awareness of the role and the importance of taxonomic work in the species identification towards different audiences can have a positive impact on taxonomic capacity in support of future monitoring activities.
2. **Facilitation of training and capacity building** in a centralised manner offering a dynamic catalogue of material with: a) a multilingual environment to customise

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[3] DEST is an important initiative run by the taxonomic community coordinated by CETAF, into which the Pollinator Academy (resulting from the SPRING initiative) is also being incorporated.

[4] For instance, the Taxonomy Recognition Day launched under TETTRIs.

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European initiatives to local needs; b) a multi-level system to address different capacity requirements, from advanced to beginners; and c) a "train the trainers" model to scale up and ensure sustainability of the programme would ensure a standardised, yet flexible approach to efficiently tackling the shortage of experts needed for species monitoring.

3. **Promoting citizen scientist involvement** should be continued and ramped up as citizen scientists play an important role when it comes to benchmark collections. Dedicated efforts are needed (also in terms of GDPR) to increase the exposure of citizen scientists, especially the ones with private collections.

Supporting tools:

4. Despite online access to an ever-growing amount of biodiversity data, species-level information of the collections - a crucial entry point for a lot of research and identifications - needs to receive greater attention and be made more accessible. The **species indexes** across European collection-holding facilities should be prioritised in this regard.

5. Virtual images of accurately identified specimens, curated by taxonomic experts, should be fostered to increase the access and usability of collections. Investments in detailed **images of species** portraying specific characteristics needed for identification, identification keys and species descriptions are needed to make benchmark specimens (along with standardised nomenclature) easily available for the stakeholders.

6. The **use of interactive maps** and the development of a tool for pinpointing the locations of natural history collections across Europe (such as the CETAF Registry of Collections), preferably also including private collections, could immensely help facilitate their ease of use in the context of monitoring. Additional information at the species level is essential to assist prospective users.

Cross-cutting dimensions

Funding

7. It will be imperative to **secure long-term funding** in order to sustain, curate and reinforce reference collections as essential tools for species identification, while avoiding soft funding prevents the creation of a standardised, comprehensive and consistent map of resources necessary to aggregate data from local, national and European levels.

8. Increasing the amount of explicit **references to taxonomy in the EU Framework Programmes**, is a sound way to ensure that this fundamental science is supported sufficiently enough to bring maximum impact to the field of biodiversity monitoring. Supporting strategic partnerships among organisations will similarly foster the advancement in the provision of sustainable taxonomic resources.

9. To develop reference collections, it stands critical to overcome the shortage of taxonomic experts through the implementation of **stable and systemic schemes** in support of a strategic understanding and long-term combined action to open revised education paths, allow expanded professional careers, and foster multidisciplinary integration of taxonomists in stable jobs (in museums and biodiversity centres, and other taxonomic facilities).

Governance

10. The **creation of a European portal for reference collections** (e.g through the CETAF Registry of Collections) will help to avoid overlap and create added value from joint actions, such as streamlining of protocols, sharing expertise and best practices.

11. The production of reference collections needs to be linked to the maintenance and expansion of updated **training platforms for capacity building in the field of taxonomy** to ensure the continuation of this endeavour beyond projects' time frames and the engagement of new generations of experts, professionals and amateurs, in biodiversity monitoring.

12. Efforts should be made towards the **formation and development of focused working groups to build reference collections** across Europe, with the involvement of taxonomic facilities, associations of interested parties (entomological societies) and citizen Science (CS) initiatives.

Final statement

Development of reference collections is critical for the identification of species to ensure effective implementation of monitoring schemes in Europe and to achieve the major targets identified in the Global Biodiversity Framework. A centralised European platform of benchmark collections can provide harmonised protocols, support the use of common standards and facilitate cross-fertilisation across borders. Yet, this effort cannot be attained in isolation, but needs to be accommodated to the (sufficient) taxonomic expertise required for the provision of reliable, comprehensive and harmonised data.

APPENDIX 1

ID	Reference or Related Document	Source or Link/Location
1	*Roadmap to set up Reference Collections*	LINK