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# Pathways for inclusion and participation of diverse museum audiences in the study and conservation of natural history collections

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**Abstract:** The Citizen Rescuers for Collections (CRESCO) project brings together a team of Belgian biology researchers and curators from the Royal Museum for Central Africa (Tervuren) and the Institute of Natural Sciences (Brussels) with twenty-six citizen scientists for the first time. They join forces to make hidden biological museum collections accessible by taking standardized photos of specimens and by transcribing hundred-year-old handwritten collection labels that cannot be processed using Optical Character Recognition programs. CRESCO has pioneered hybrid, online and on-site, citizen science approaches to public participation in digitizing biological museum collections. The project has strengthened the citizen science community of the two museums by achieving gender equality and by reaching out to Ukrainian refugees. It has delivered quality scientific data that could not have been obtained otherwise. This study analyzes the scientific, social, environmental, economic, and political impact of the CRESCO project and argues that on-site participation has significantly more social impact than online participation. It concludes that, in citizen science, museum staff must reflect on participation with ethical concern and attention, emphasizing the importance of physical presence and dialogue.

Keywords: Participation, Education, Citizen, Science, Community, Crowdsourcing, Natural, Collections

# Introduction

Interaction and participation have become more and more important as today's museums take on a social role that often prevails over their scientific role. The focus lies on the visitor's experience and the learning opportunities created. Moreover, museums combine scientific, educational, communication, and engagement expertise, competences that constitute the backbone of citizen science research. In this sense, museums are ideal spaces for the development of citizen science initiatives (Sforzi et al. 2018).

Museum engagement refers to how museums interact with and include audiences in their educational, cultural, curatorial, and research activities. The Royal Museum for Central Africa (RMCA, Tervuren, Belgium) and the Institute of Natural Sciences (Brussels, Belgium) want to play a social role and, therefore, concentrate on participation. Rather than simply curating collections, they also engage audiences in a participatory manner. Through citizen science activities, the participants

are stimulated to reflect on natural and cultural history and to think critically about the contexts in which these collections came to be.

The Citizen Rescuers for Collections (CRESCO) project has used the citizen science approach to implement participatory actions inside the museums' ornithology, entomology, and wood collections. At its start in June 2023, it was a contributory project, but had partially evolved toward collaborative participation by 2024, according to the scale of participation (Bonney et al. 2009; Simon 2010). The author designed the project together with museum curators and researchers and invited participants, or citizen scientists – members of the public without scientific training - to join. Participation was enabled across several stages of the process. The participants were engaged in digitizing specimens, analyzing the data that was collected, and disseminating the results. They took standardized photos of specimens, which can help researchers describe a specimen without having to visit the museum collection, and they transcribed handwritten labels from century-old collections.

Today, experienced amateur naturalists are still at the core of citizen science. However, simultaneously, a broader, more diverse audience is what any researcher doing participatory research aims for. CRESCO has pioneered hybrid, online and on-site, citizen science approaches to biological museum collections. It is, to the best of the author's knowledge, the first citizen science project implementing wood biology sample analysis. This study evaluates the project's social impact on both the on-site and online participants, as well as the broader scientific, political, environmental, and economic impacts. It argues that hybrid on-site and online participation is crucial in achieving gender balance and the inclusion of harder-to-reach museum audiences.

#### **Theoretical principles**

In the Oxford English Dictionary (OED), "citizen science" is defined as "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions." The terms used to designate participants in a participatory research project largely depend on the field of research, the sociocultural and geopolitical context, and the language. In Europe, citizen science is promoted by universities, research centers, and museums. This is why the terms "citizen" and "science" have become the norm (Eitzel et al. 2017). Throughout this study, the generic English terms "citizen scientist" and "citizen science," as employed by the European Citizen Science Association and widely known in Europe, are used.

Citizen science is often described as a bridge between science and society through which citizens are directly contributing to research in numerous domains and at various levels of participation. It is also seen as an informal means of achieving both scientific and educational objectives (Irwin 1995; Kindon et al. 2007; Bonney et al. 2009). The processes empower citizens to foster perspectives and collect data that would not otherwise be known to science. Being a citizen scientist is no longer for the elite few, but for all those who find motivation and meaning in doing science for and within society (Geoghegan et al. 2016).

Cocreation represents the second highest level of public participation in research (Bonney et al. 2009), below collegial research. Cocreated projects are designed by researchers and members of the public together. These projects require the scientists to accept the participants as peers in multiple stages of the research process, from choosing and defining questions for the study to discussing results and asking new questions.

#### Methods

The author used secondary data analysis to summarize citizen science initiatives and perspectives in the RMCA and the Institute of Natural Sciences existing prior to project CRESCO. This comprised a review of the two institutions' annual activity reports and research strategies.

Project CRESCO's impact evaluation was made with the help of the Participatory science toolkit against pollution ACTION, which provides an impact assessment framework (Passani et al. 2022). Two online ante- and post-surveys evaluated the project's social impact on (1) community building and empowerment; (2) knowledge, skills, and competences; (3) changes in the way of thinking, attitude, and values and behavioral change; and (4) health and well-being. The ante-survey was filled in by on-site participants, while the post-project survey was filled in by both on-site and online participants. They were asked ordinal scale questions, such as reading statements and attributing a value from 1 to 5, where 1 was "not at all" and 5 was "very much." The surveys were administrated with the help of the online survey tool LimeSurvey.

While this article provides valuable insights, it is important to note that the survey-based evaluation method is not without limitations. In the event of having more time and resources, other research methods, such as individual interviews, focus groups, and analysis of participants' logbooks, would help provide a more in-depth understanding of the social changes the project has set in motion.

The scientific, environmental, economic, and political impacts were evaluated by the project coordinator using the ACTION impact assessment framework. For each of these aspects, an impact canvas was filled in by the author at the end of the project. The scientific impact assessment canvas considers how the project can influence scientists and research organizations. The author evaluated the generation of scientific knowledge and of new research fields and interdisciplinarity, then assessed to what extent the project had a positive impact in terms of conservation of natural assets, cost saving, and influencing political processes and decision-making.

The trends described in this article concern one specific group of participants and are relevant to Brussels and to Belgium. The author invites the reader to be cautious when extrapolating the conclusions to projects taking place outside the Western European context.

The author has fully taken part in the project as a member of the team and a project coordinator, and has conducted informal, unstructured interviews with the participants. She spent twelve weeks with the participants, following training, discussing results, giving feedback, planning events, and getting to know the participants, who became "colleagues." Trust, respect, and even friendship are the foundation on which the project was built. The author would like to note that these positive aspects may have influenced the participants' assessment of the parameters evaluated. Throughout this article, data deriving from participant observation is indicated accordingly.

#### Why here and now?

The CRESCO project emerged from two contexts, and its intrinsic characteristics are to a certain extent linked to the history and the strategic choices of the two promoting museums. Both the RMCA and the Institute of Natural Sciences are museums and research institutes governed by the scientific policy of the Belgian federal state as implemented by the Belgian Science Policy Office (BELSPO). They host exhibitions and conduct scientific mediation activities as well as research activities. As heirs to important collections in the natural and human sciences, they are required to guarantee access to the research community and civil society. Moreover, the RMCA is not only a museum of natural sciences but also an ethnographic museum displaying colonial collections. In its case, citizen science is an opportunity to rethink the interactions with the African diaspora in Belgium and foster societal dialogue and new perspectives on colonial collections and archives.

Only a small percentage of these collections are presented to the public. The great majority of specimens and objects only live in drawers and behind closed doors. The entomology collection of the Institute of Natural Sciences represents 17,000,000 specimens in 70,000 boxes. The RMCA bird collection boasts 150,000 specimens. Its xylarium, or wood collection, comprises more than 81,000 wood samples from more than 13,500 species from around the world. It is a unique scientific reference collection, and one of the most important in the world. This collection had never been digitized. This is a pressing need in the era where climate change and biodiversity research grows exponentially.

*Cresco, -ere* means "to grow, to prosper" in Latin. The project responds to two crucial needs that natural history museums have. On the one hand, there is little knowledge among museum audiences about the research taking place behind the scenes of a museum's exhibition. There is a need to foster education and awareness about natural history collections and the way they can contribute to solving burning crises like climate change and loss of biodiversity, while increasing the participants' scientific

capital. On the other hand, natural history museums need to offer open access to collections and data on the collections, in accordance with the principles of Open Science (Sforzi et al. 2018). The collaboration with citizen scientists has contributed to making collection data accessible worldwide.

#### Citizen science in Belgium

Since 2004, nature defense NGO Natagora has been organizing a bird census campaign in which citizens are invited to observe, during a winter weekend, the birds that frequent their garden. Natuurpunt, the Flemish-speaking counterpart, organizes a bird-watching campaign entitled "The big bird weekend." Natagora and Natuurpunt are involved in the development of the "Observations.be" online observations platform, where anyone who creates an account can enter naturalistic observations (Hanoteaux 2017).

In Flanders, at the initiative of the "Jonge Academie Vlaanderen" (Soen and Huyse 2016) and the science popularization magazine "EOS", an online portal - Iedereen Wetenschapper (translation: Everyone is a scientist) - was launched in 2016. The website is an aggregator of all citizen science projects in Flanders and the Netherlands and is addressed directly to citizens. Flemish-speaking museums also use this platform to reach out to volunteers (Gijsel and Huyse 2019). Such an aggregator does not exist for Brussels or the Walloon Region. There are no traces of such platforms to promote citizen science at the federal level before 2023. In Belgium, citizen science grows mainly through initiatives carried out by regional organizations and universities.

#### Citizen science and the RMCA

The specificity of the RMCA is that it combines research in the fields of the natural sciences (biology, earth sciences) and the human sciences (history, archaeology, anthropology, linguistics), which makes it one of the most important knowledge centers on Central Africa in the world. Its century-old neoclassical museum building was closed from 2013 to 2018 for refurbishment. Over the past decade, the museum has been in the international spotlight not for its research but for its renewed exhibitions and rebranding efforts.

This museum and collection are intimately linked to Belgium's colonial history and, more specifically, to the personal enterprise of Leopold II, who ruled the Congo Free State from 1885 to 1908. The bulk of the collections were taken out of Congo during the colonial period. By commissioning this "Congo Museum" following the 1897 Universal Exhibition, the sovereign wanted to highlight his commercial adventure, whose primary motivation was resource extraction—a goal that resulted in the brutal subjugation of the Congolese.

Interest in citizen science rose after the refurbishment period. Surprisingly, although numerous research projects focus on studying the museum's ethnographic collections, none make use of citizen

science and participatory action as research methods. Involving the members of the African diaspora in citizen science research on the collections is not a common practice. The department of biological collections began experimenting with the online transcription of specimen labels using the online platform DoeDat (Royal Museum for Central Africa 2022). Regarding citizen science in the department of archaeological collections, Els Cornelissen, the former head of the cultural anthropology and history department, explains the main barriers: staff and means, and ethical issues.

The main challenge to working with in-house volunteers is that a good and beneficial reciprocal working relationship is in need of physical presence to follow up on any question they may have. As usual, a matter of staff and means...in human sciences this often relates to personal lives and personal experiences which is more intrusive on the person than observations or counting in nature. (Mitrache 2023, 26)

The analysis of older activity reports of the RMCA shows that citizen science as a research method started to gain ground, although timidly, because of internal interactions between researchers and following collaborations with Belgian universities. Exchanging practices between peers and an interest in Open Science and community science approaches are some of the factors that have favored the development of citizen science inside the research divisions of the RMCA. It began with citizen science research in Africa, with African populations.

From the 2019 annual report (Royal Museum for Central Africa 2019), we find that the Natural Hazards service invested in implementing citizen science for natural risk monitoring in the Great Lakes region in Central Africa. The participants, called "citizen observers," were in two groups. The first involved twenty members of the civil protection teams in North and South Kivu, while the second counted thirty persons from communities in southwestern Uganda. They were trained to use a smartphone app to monitor natural risks affecting their communities.

These citizen science initiatives took place within the ongoing HARISSA project (Natural HAzards, RISks and Society in Africa: developing knowledge and capacities). Its goal is to study natural risks and develop tools to improve their management, thereby reducing the risk of catastrophes and promoting sustainable land use. This project is funded by Belgian Development Corporation (DGD), an agency of the Ministry of Foreign Affairs that runs development projects in the Global South. The RMCA is one of the Belgian actors through which the DGD acts.

Project ATRAP (Action Towards Reducing Aquatic snail-borne Parasitic diseases) follows the same pattern and was also launched in 2019. Citizen scientists in Uganda and the DRC monitor populations of freshwater snails, which spread diseases such as schistosomiasis. In these two projects, not only do the citizens provide crucial data to scientists but also play a role in awareness raising

within their communities. This project is also funded by the DGD. In the context of development cooperation, citizen science is both a solution and an imperative.

#### Citizen science and the Institute of Natural Sciences

Natural sciences museums have a long history of collaboration with amateur naturalists. Over the past decade, the citizen science approach to the conservation and study of national museum collections has gained public attention thanks to projects like "Notes from Nature" (Florida Museum of Natural History and Florida University, 2013–present), "Digitization of the US Herbarium" through the Smithsonian Transcription Center (Smithsonian, 2015–2022), and "Les Herbaunautes" (Musée national d'Histoire naturelle, France), the first European citizen science online platform for herbaria. In these projects, the records were transcribed online, using online platforms. The Musée national d'Histoire naturelle and the Smithsonian developed and used their in-house platforms, while "Notes from Nature" is still active on the world-renowned platform Zooniverse.

The first collections made publicly available were herbaria, followed by entomological collections. The reason behind this lies in their incomparable profusion. In the case of the Smithsonian collection, the action resulted in 2,800,000 labels of plants transcribed and 3,800,000 images digitized in seven years (National Museum of Natural History 2022). That is the entire US herbarium collection. In 2023, "Notes from Nature" celebrated ten years of existence and more than 4,700,000 specimens transcribed (Denslow and Pinson 2023).

In comparison, the Institute of Natural Sciences has not yet implemented a large-scale crowdsourcing campaign. By looking at how citizen science is presented in its annual reports, we conclude that it is not an established research goal of the institute, but more of an exception related specifically to biodiversity monitoring activities and to science dissemination or education activities.

The analysis of the activity reports reveals that citizen science inside the institute is a term applied to the relationship it has been maintaining with amateur taxonomists and paleontologists for over a century. It is also applied to education and outreach projects in general, when these are derived from scientific research, but not systematically. No formal federal or internal scientific policy or strategy stimulates the institute to carry out citizen science initiatives. Instead, these types of initiatives have grown organically over the years.

The first mention of citizen science is made in the 2015 activity report, when referring to an educational project in schools in the field of taxonomy (Institute of Natural Sciences 2015). In the 2018 to 2022 research strategy of the institute, citizen science is mentioned once in relation to its education department and to its museum (Institute of Natural Sciences 2018).

We observe that citizen science is associated with monitoring activities in the 2022 activity report, under the title "In Citizen Science We Trust." Some examples of nature observations made by citizen

scientists are given. An observation of a rare cuttlefish far from the beach was made by a volunteer through the platform Marine Mammals. In another project, Objectif 1,000 Jardin Massart Brussels, we learn that the citizens involved have helped identify over 4,000 species of insects, revealing one of the hotspots for biodiversity in an urban environment (Institute of Natural Sciences 2022).

#### Towards a hybrid online and on-site approach

In 2023, when the time came to design a brand new participatory program for the two museums, it was clear that two different approaches were necessary: a virtual and an on-site approach (Wiggins and Crowston 2011). The RMCA had little experience with on-site participants, whereas the Institute of Natural Sciences had no experience with virtual actions and online platforms for biological collections. We then chose to work in two different ways and appeal to different social categories.

The first package of tasks consisted of transcribing and annotating data on the mite collection of the Institute of Natural Sciences, using the online platform DoeDat. To do this, we were expecting to engage with the existing community of transcribers already active on the platform. At the time, DoeDat had over 1,000 registered users.

The second task package involved taking pictures of the birds in the collections and preparing, scanning, and describing wood samples from the xylarium of the RMCA. The on-site approach was adopted, as participants had to be physically present in the museum to manipulate the specimens. The calls for participants were published on all the digital channels of the museum, and a targeted communication campaign was directed at Ukrainian refugee groups on Facebook. The participants filled in a form and attended an Information Day before applying for the program. A total of fourteen citizen scientists were selected for the three-month program, five for the wood biology collections and nine for the ornithology collections. The selection was based purely on motivation. All fourteen candidates who attended the initial training, out of the sixty who had registered, were selected.

#### Community building and empowerment

In March 2023, prior to the start of the CRESCO project, the author carried out a survey to learn more about the motivations of participants already involved in research projects in the two institutions. One DoeDat online volunteer explained what motivated them to participate, in the following way:

Working as an internet volunteer through DoeDat is a "PAUSE" moment for me during my work as a planner/coordinator/scheduler. By concentrating on the data to be transcribed, the thinking pattern in my coordinating tasks is interrupted. When the actual work resumes afterwards, it is more easily done from a neutral position. As a result, I do not remain stuck in a fixed pattern of thinking and I find new, alternative solutions and ways to bottlenecks more quickly. So you could say that I do this volunteer work mainly in order to be able to do my actual work more smoothly. (Translated from Dutch, Mitrache 2023, 55)

When asked about what would make them feel more appreciated for their efforts, the same person replied as follows:

Perhaps an appreciation moment or action for internet volunteers? Suggestion: behind-thescenes tour so that a volunteer (who has no/little background) gets an idea of the collections for which he is transcribing data, gets an understanding of the process/methods necessary to maintain or build a collection, gets a general idea of how a museum works as a scientific and/or public institution. (Translated from Dutch, Mitrache 2023, 33)

When asked about the factors that could prevent from contributing to these projects, another volunteer replied, "Nothing. As an internet volunteer, you decide what and when you do something" (translated from Dutch, Mitrache 2023, 55). The motivating factors are contributing to science, learning, and spending free time in a fun way. These results align with other studies on participants' motivation (e.g. Jordan Raddick et al. 2013).

These testimonials guided several decisions that helped maximize CRESCO's social impact. Inclusion was the project's main goal. To achieve this, we launched an open call for participants translated in three languages: French, Dutch, and English. Equally important was reaching out directly to a Facebook group of Ukrainian refugees, giving regular feedback to participants during project meetings, and organizing networking and public dissemination events.

A total of twenty-six citizen scientists participated in the project: fourteen were present on-site, and twelve contributed from home on the platform DoeDat. All fourteen CRESCO on-site participants were active during the twelve weeks of the program, and eight continue to collaborate with curators of the RMCA in 2024. Today, five analyze the anatomical characteristics of wood, achieving an even higher degree of participation and becoming true project collaborators (Bonney et al. 2009; Heinisch 2017), while three continue to digitize the bird collection. Since June 2023, the citizen scientists have been involved in various stages of research. They have collected, processed, and curated data and created dissemination material such as videos and presentations.

Twelve of the on-site and six of the online citizen scientists, six men (33%) and twelve women (67%), completed the impact evaluation surveys on which this study is based (Figure 1). Of these, eight (44%) are aged 25 to 49, three (17%) are 50 to 64, and seven (39%) are 65 to 79 (Figure 2); five (83%) online and eleven (92%) on-site participants have a university diploma.



Figure 1: Percentage of Survey Participants, According to Their Gender (No. = 18) Source: Figure by the author



Figure 2: Percentage of Survey Participants, According to Their Age Category (No. = 18) Source: Figure by the author

One in two participants was between 25 and 49 years old (Figure 3), and two out of three were women. The majority of on-site participants were women, nine out of twelve (Figure 4). This is partly explained by the communication campaign targeted at Ukrainian refugees living in Belgium. This invites reconsideration of the typical contemporary naturalist amateur involved in citizen science in the two museums. According to the results of a previous survey at the Institute of Natural Sciences, 80 percent of on-site volunteers were male and 48 percent were retired (Mitrache 2023). However, these volunteers were not selected following a targeted outreach and communication strategy. Word-of-mouth and previous work connections had played an important role in volunteer recruitment at the Institute of Natural Sciences.



Figure 4: Comparison of Number of On-Site and Online Participants Per Gender Category (N° of Survey Participants =18) Source: Figure by the author

Thanks to its community engagement strategy, based on inclusivity, two-way communication, and training, CRESCO was successful in including diverse participants. Half (six) of the on-site citizen scientists had a migrant background. Conversely, there were no migrant online participants (Figure 5). We achieved diversity among participants by communicating the project in French, Dutch, English, and partially Russian. A total of five nationalities were represented on-site: Belgian, Italian, Spanish, Ukrainian, and Nigerian. Four French-speaking and two Dutch-speaking Belgian nationals were involved on-site.



Figure 5: Proportional Representation of the Number of Speakers Per Native Language Source: Figure by the author

Language is a major barrier to participation. Sticking to Belgium's official languages—French, Dutch, and German—would have ruled out all social groups of residents who speak other languages. Brussels alone is one of the most diverse cities in Europe. In 2023, 287,590 European residents and 170,562 people with a non-EU nationality lived in the Belgian capital. In total, they accounted for 181 different nationalities and a quarter of the city's population (Brussels Institute for Statistics and Analysis 2023). To enlarge the impact of the project, we designed communication in English and Russian, specifically designed to reach Ukrainian refugees in Belgium. This choice was justified by the fact that one of our team members was Russian. Multilingual communication proves to be one of the crucial success factors for inclusion in the heart of Europe. Olha, a Ukrainian participant, joined the project to "do something meaningful and give something back to the Belgian people." I have a genuine interest in nature, history and research. I dreamed to be a scientist when I was a kid and now I tend to connect myself with nature on daily basis. I see it as a great opportunity to contribute and do something valuable and meaningful for the community and museum itself.

Olayemi, a young Nigerian student, says he wanted to "contribute to scientific advances that have the potential to shape a more sustainable and greener future." He is helping researchers create artificial intelligence models to find protected wood species entering Europe through the port of Antwerp. Illegal logging is a burning matter in his native country.

By becoming a member of the Tree Squad, I aspire to be part of a dedicated team committed to making a meaningful impact on our environment. Moreover, I am eager to contribute to scientific advancements that have the potential to shape a more sustainable and greener future.

Eleven on-site participants filled in the post-project survey. Citizen science activities had a considerable impact on community building and empowerment. Of the participants, 91 percent (ten) said that, by participating in the project, they had met new people who differ from them in terms of age, level of education, or social status; 64 percent (seven) said that they would keep in touch with the new people they had met during the project; 64 percent (seven) said that the project increased their trust in their local community; and 91 percent (ten) said that the project increased their trust in the RMCA.

The six online participants were a different social group in terms of age and ethnic background (Figures 3–5). Of them, 50 percent (three) were women (Figure 4), which means that gender equality was achieved in both online and on-site actions. None of the online participants said that they met new people or felt that they were part of a new community during the project. Despite being invited to on-site events, only one participant among the six attended one event; 34 percent (two) said that the project increased their trust in the Institute of Natural Sciences.

The following data was gathered by the author through participant observation and informal, unstructured interviews. Two on-site project participants confessed to the author that receiving a volunteer stipend for their participation was a positive surprise and reenforced their prior motivation to participate in the project. A total of eight (57%) out of the fourteen on-site participants continued their collaboration with the museum in 2024, without a stipend.

The reasons the other six (43%) ended their participation in the project were finding a job (three), finding an activity more in line with their competences (one), and unknown (two). Five out of the six participants who ended their participation in CRESCO in 2024 were between 25 and 49 years old and three out of six were Ukrainian nationals. This data, although not significant enough,

seems to suggest that younger participants and participants with a migration background are more likely to put an end to their participation sooner. However, this creates opportunities for other candidates to join, which will continue to enhance inclusion and diversity.

Data gathered from the participants through informal, unstructured interviews implies that social events, museum guided visits, and filming a video clip all played a role in community building. Raymonde and Philippe, two on-site participants, expressed their feelings about the social events organized in the following way: "It was very nice to meet volunteers from Meise, to discover the missions of the Meise botanical garden, to follow the guided tour of the Royal Museum for Central Africa" (translated from French by the author).

Another on-site participant reacted to the video clip of the project, in which all the on-site participants played a role. His opinion was shared by other on-site participants following the release of the video clip. "Very good script, excellent director, very good music, excellent filmmaker, not to mention the actors. To be sent to the Cannes Film Festival! Will be awarded. Congratulations! And thank you for sharing your enthusiasm with us" (translated from French by the author).

It can be concluded that on-site activities succeeded in attracting a more diverse audience than the online activities, while having a greater impact on community building and empowerment.

#### Changes in way of thinking, attitude and values, and behaviors

Eleven on-site participants testified to changes in the way of thinking, attitude, and values; 27 percent (three) said that thanks to the project, they had changed their ideas on environmental issues such as pollution or climate change; 45 percent (five) stated that they would change some of their behaviors in order to reduce their impact on the environment (reduce pollution, emission, waste, etc.); 55 percent (six) said that CRESCO increased their participation in the life of their community; and 55 percent (six) considered pursuing a scientific career.

The impact on the online participants was quite different. None said that they had changed their ideas on environmental issues such as pollution or climate change thanks to the project. Just one participant said that he would change some of his behaviors in order to reduce his impact on the environment. Participation in the life of their community did not increase thanks to the project. Only one online participant thought of pursuing a scientific career.

#### Science education

All (eleven) on-site and 50 percent (three) of online participants say that CRESCO increased their interest in science. CRESCO was the first citizen science project for all of the on-site participants, whereas 50 percent (three) of online participants had already taken part in citizen science projects on the platform DoeDat, and 67 percent (four) of them had previous experience in digitizing collections;

82 percent (nine) of on-site participants said that the project increased their understanding of content, process, and knowledge of what science is, and 50 percent (three) of online participants shared this opinion. At the end of the project, 64 percent (seven) of on-site participants said that, thanks to the project, they learned more about collections management. This was the case for 50 percent (three) of online participants. Of the on-site participants, 73 percent (eight) said that the project had increased their skills of science inquiry, such as data gathering, data curation, data analysis, and data interpretation, an opinion shared by only one online participant.

#### Well-being

One participant started a part-time job while working on the project. He said that participation in CRESCO gave him a structure and an occupation while looking for a job. Other participants came in contact with museum personnel, either by presenting their work during internal seminars or by attending meetings and networking events. By so doing, they broadened their professional network. This was an important achievement, as 50 percent of on-site citizen scientists were under 49 years old and active in the employment market.

# Scientific impact of citizen science on museum biological collections

When we talk about biological collections, we often talk about quantities, but rarely about the people in contact with these collections. Over the six months of the project, citizen scientists photographed over 3,000 birds and 1,288 wood samples; 2,300 mite tags were transcribed from home, using the crowdsourcing platform DoeDat. Without citizen participation, these specimens would have remained invisible for much longer.

#### New knowledge resources

CRESCO generated knowledge that would have been impossible to produce without the citizen science approach. In only twelve weeks, the project helped digitize three collections and create three new datasets consisting of more than 6,600 biological collection items. The data quality was controlled before publication by the collection managers. The data is FAIR. It is findable online and accessible through reports generated by the online databases DaRWIN and Virtual Collections. The participation of citizen scientists is acknowledged for each specimen published online.

The 1,288 wood samples prepared and scanned constitute a crucial step toward digitizing the RMCA's reference wood collection, which will be the basis for training AI models to identify protected wood species (De Blaere et al. 2023). The Tervuren wood collection is the third most important worldwide and the most important collection of African wood on the planet. The digitization of this extraordinary knowledge resource will have an impact on international

cooperation in the field of wood biology. In 2024, five citizen scientists continue to produce and analyze data on this collection.

# New research fields and interdisciplinarity

The project has stimulated interdisciplinarity by enabling experimentation with new methods for digitizing microscopic slides to achieve the right quality for online crowdsourcing. The mite slides were digitized with a webcam with 4K resolution and a backlit custom-made plate. This inexpensive and efficient setup is innovative for museum collections as it delivers high-quality pictures, suitable for online transcription projects. Without this new digitization system, online transcription would not have been possible.

The same type of innovation was necessary for participants to digitize the Tervuren wood collection. To the author's knowledge, this is the first time wood samples were prepared by participants with no scientific training, using affordable machines in the form of a tiny sanding tool and a hand-held microscope. The mini sanding tool efficiently creates a high-quality, flat sanded surface, ideal for detailed anatomical assessments, allowing a quick transition from rough to high polish in under two minutes. It simplifies the digitization process immensely. For capturing detailed images, the participants used a hand-held microscope. Featuring high magnification, the microscope increases the accuracy of wood anatomical assessments.

# Environmental impact of citizen science and artificial intelligence

In the long term, the project will have an impact on ecosystems. The 1,288 photos of wood samples taken by the citizens will help train AI models. The AI identification tool created with the help of the wood dataset will help reinforce wood importation regulations, which will have an impact on forests worldwide. Illegal logging has long been a major problem, but enforcement is challenging because of the difficulty of identifying the kind of wood being traded. To solve this problem, fast and accurate means of wood identification are needed (De Blaere et al. 2023). According to the researcher in charge of the citizen science program inside the wood biology division, 95 percent of the data produced by the participants was of high quality and could be imported directly into databases.

# **Economic impact**

The work of the citizen scientists during project CRESCO generated a cost saving of at least 26,800 EUR in total for the two museums involved. Moreover, these activities would have been impossible to perform in the absence of additional personnel. The tasks performed by the citizen scientists would

not have been performed by researchers or collection management personnel, or they would have been considerably delayed.

The work performed by the citizen scientists on-site (670 hours = 88 days) is worth 17,600 EUR, the reference being a collections technician's salary. If we consider a postdoctoral researcher's salary, their work is worth 34,000 EUR. The on-site citizen scientists received a 10 /day volunteer stipend, while online citizen scientists received a free annual subscription to the Institute of Natural Sciences.

The time investment by online volunteers was not evaluated. However, a collection technician can transcribe fifty mite labels in one working day. It would have taken forty-six working days to process the 2,300 labels transcribed by the citizen scientists. In that time, the technician would have earned 9,200 EUR. However, we should consider the fact that a technician would transcribe the labels directly into the collection management database, whereas after transcription using the platform DoeDat, the data is standardized by the curator and batch imported by the online database manager, which constitutes extra work.

To avoid commodification, museums should offer on-site participants sufficient rewards and benefits. Wherever the legal framework allows it, a volunteer stipend or a flat-rate reimbursement of expenses should be seriously considered depending on the available resources. Moreover, in order to offer equal opportunities to participants who present higher occupational or employment mobility, such as younger participants and participants with a migrant background, museums should adapt themselves by renewing their citizen science actions on a regular basis and organizing regular recruitment sessions at times that are convenient for the target audience.

### **Political impact**

CRESCO has reached out to policymakers in two ways. It informed regional, national, and international policymakers in the field of wood regulation about the outcome of the digitization of 1,288 specimens in the wood collection. Additionally, it informed the BELSPO about the impact of citizen science research in the two federal museums.

### Discussion

This article examines how project CRESCO has pioneered hybrid citizen science approaches, integrating both online and on-site participation, to enhance public involvement in the digitization of biological museum collections in Belgium. This initiative has strengthened the citizen science communities within the two participating museums by promoting gender equality and reaching out to Ukrainian refugees. Furthermore, the project has successfully delivered high-quality scientific data that would have been unattainable through other means. Preliminary analysis of the data indicates that on-site participation exerts a significantly greater social impact compared with online

participation, underscoring the importance of physical presence and dialogue in community engagement and data collection processes.

These lessons learned from the biological collections can be transferred to the object collections. Researchers and curators in the humanities agree that there is still a lot to learn about citizen science from the natural sciences (e.g. Smith 2014). However, the participatory methods developed in the natural sciences need to be reconsidered when applied to the human sciences. Photographing a plant or transcribing data on an insect does have different social implications than studying an object that has existed in a social context and fulfilled multiple functions.

Objects acquired during the colonial period raise ethical concerns because of the historical context and the way in which they were acquired. Applying citizen science methods to the study of these collections must involve critical thinking strategies and cocreation or codesign with a diverse, non-Western audience. Taking the time to explore the questions the object raises and, in doing so, sharing leadership and power with the communities requires a transformation of the way interactions are conceived between museum professionals and the public.

Museum staff must reflect on the forms of participation with ethical concern and attention, and not hesitate to think outside the box. Sometimes, dealing with colonial collections requires stepping out of the purely scientific approach and delving into alternative methods that foster dialogue in a safe environment, one that does not recreate preexisting power structures. Artistic exploration through film is an alternative approach used by Museum X, an experimental museum celebrating Black British history, art, and culture (Puddle and Katwala 2023). In this project, open conversations with African diaspora groups revealed the importance of understanding both the historical and cultural significance of museum collections.

# Conclusion

The impact of a citizen science approach for museum collections goes well beyond producing new data and saving money. The on-site and online activities carried out in the CRESCO project have had an impact on the inclusion of social groups that would otherwise not have had physical access to museum collections in a research context. The data produced was of high quality, despite the lack of academic training in the fields of entomology, ornithology, and wood biology for both the on-site and online participants.

The interactions between participants, researchers, curators, and museum workers in general have an important transformative effect on museum practices and should not be underestimated. In the short term, in the immediate aftermath of CRESCO, other curators in the RMCA have expressed

interest in opening up the collections to volunteers through open calls and communication targeted at underrepresented groups. In addition to the zoological and the wood biology collections, the archaeological, geological, and ethnographic collections will also soon benefit from such forms of collaborations.

Change from inside must come in the form of internal decision-making that allows public participation to grow, for example, by allocating time and resources to collection curators to learn about participatory research methods. The collections department should collaborate with an internal participation officer, who should play an active role in liaising with local communities. Bringing collections outside the museum through citizen science becomes as important as bringing communities inside the museum. The majority of participants in project CRESCO had a university diploma. For citizen science to touch participants without academic training, a deeper collaboration and exchange with community organizations, schools, cultural centers, and NGOs is necessary. Only then can new perspectives on museum collections and, ultimately, a new type of socially engaged research emerge.

The concept of knowledge cocreation is not new to the museum setting (Simon 2010). However, cocreation has most often been part of exhibition, mediation, and communication practices. In Belgium, it has rarely been utilized as a tool to formulate research questions and transform the research, which serves as the basis of museum narratives. Museums are gradually embarking on the citizen science path, which catalyzes long-term institutional changes. Redistribution of power comes in different forms, from giving participants a voice to giving them the possibility of making decisions (Arnstein 1969). Museum narratives would be different if research on collections would be designed in cocreation with social groups that are external to the museum's setting. Each group is different, which means that the participatory approach should be adapted to the group in question.

Cocreation may be a big step for natural history museums. Through crowdsourcing and limited participation, museums do create an entry point for harder-to-reach audiences and transform their relationship with the public. In the future, interdisciplinary collaboration is essential to pave the way for full participation and true cocreation with the participants (Hecker et al. 2018). Natural history and ethnographic museums must strengthen the collaboration between internal services and actively involve curators, researchers, educators, communicators, and exhibition officers in interdisciplinary projects, by designing institutional projects of longer duration and oriented toward social change (Kindon et al. 2007) and broad engagement of the public in research (Miller-Rushing et al. 2012).

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The author declares that generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete essential authoring tasks in this manuscript.

# **Informed Consent**

The author has obtained informed consent from all participants.

# **Conflict of Interest**

The author declares that there is no conflict of interest.

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