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OPINION

A students' opinion on the importance of natural history collections and taxonomy in Brazil

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ABSTRACT. Natural history collections (NHCs) contain valuable information that can be used in different fields of knowledge, and aid in the development of society, science, and technology. The role of curators and taxonomists in maintaining and improving biological collections is essential, as these are fundamental for the understanding of biodiversity. However, the role of taxonomists and the importance of NHCs to society have been undervalued in recent years. We, while attending a graduate program on collections at PUCRS, noted a gap in knowledge about scientific collections. Was this gap, which continued from our undergraduate to graduate years, a mere coincidence or widespread in biological science programs in Brazil? We queried 126 Brazilian institutions of higher education to assess the presence of courses related to natural-history collections and taxonomy. A total of 25 private and 37 public universities from 126 institutions searched, have a program of study in biological sciences in the curriculum on their websites. About 16% offer some course related to NHCs or taxonomy, and all of them are public institutions. Despite the budget cutting made by the Brazilian government that make it even more difficult to recognize NHCs and related areas, we believe that there should be more links among researchers from different areas and especially between the levels of basic and higher education, so that students are exposed to this subject early in their education. We, as Brazilian students, believe that more information on NHC-related issues and taxonomic subjects is urgently needed in biological science programs.

KEY WORDS. Biological scientific collections, museums, South America, taxonomic crisis, undergraduate programs.

Natural history collections (NHCs) have an essential role in society, since they make possible to know the past, the present, and make predictions for the future. The information inherent in these collections can be used for a broad range of disciplines, from archaeology and anthropology to biology, biomedicine, earth sciences, and applied fields, such as agriculture and technology (DiEuliis et al. 2016, Gropp 2018). Taxonomists are the scientists who distinguish and classify the biological diversity according to explicit concepts and data-driven hypotheses, and name them according to nomenclatural rules and checking type specimens (Engel et al. 2021). This role is at the basis of knowledge of life sciences. According to Boxshall (2020), it has six main strands: 1) determining identity (diagnostics), 2) establishing and revising taxa, 3) building phylogenetic systems, 4) integrating biological information to build "species biographies", 5) creating identification tools, and 6) training the next generation of taxonomists. All other areas of biodiversity depend on taxonomists' surveys to understand processes, estimate impacts, or even describe new species. Knapp and Boxshall (2010) concluded that "at the very time when the importance of biodiversity has been realized, our capability of describing and documenting it has been eroded to a crisis point."

The community's general view of NHCs is much more related to places that hold ancient things of our culture and biodiversity. Despite the positive perception about the NHCs (Astrin and Schubert 2017), they face enormous challenges. According to Britz et al. (2020), two of the greatest challenges that taxonomy is facing have not changed during the last 25 years, even with the biodiversity crisis moving to the center of attention: (1) inadequate funding combined with (2) the lack of succession planning, training, and recruitment into permanent positions of competent taxonomists. Both challenges hamper the global assessment of biodiversity, especially in megadiverse countries such as Brazil (Paknia et al. 2015). In recent years, the Brazilian

government has cut funding for science and technology many-fold, putting at risk many research projects and higher-education study programs (Escobar 2019, Quintans-Júnior et al. 2020). There is abundant unexplored knowledge in the NHCs; however, there is also a lack of qualified professionals to work in these places, which often can offer only limited training for taxonomists and researchers. NHCs have become key sites for societal engagement with environmental issues and biodiversity (Alberti 2017). However, in developing countries such as Brazil, most lay people are not aware of the value of scientific collections for knowledge and development of science and technology. Part of this lack of interest may be due to the lack of appropriate funding for education, but we think this also may be due to the lack of interaction among the institutions holding the NHCs, the researchers, the collection staff, and society. Even within biological science programs there has been a loss in the importance on the role and the necessity of scientific collections, curators, and taxonomists. We can point to some possible causes: 1) lack of resources for basic science; 2) many environmental problems that force researchers to answer more applied questions such as the effects of climate change, or pesticides, or other anthropogenic variables on communities and populations even before knowing the species or populations; 3) lack of space to publish basic and local research in high impact journals about scientific curation or taxonomy, which may lead researchers to prioritize studies on more applied topics and trends; 4) these surveys take years to achieve any impact, as they sometimes deal with very little-studied groups; and 5) lack of digitization and availability of information from collections.

We as graduate students experienced different periods along our academic trajectory, therefore each of us has had brief contact with scientific collections at different stages of academic life. We had only superficial knowledge of scientific collections and their use and maintenance until we took more specific courses in the graduate program in Ecology and Evolution of Biodiversity at PUCRS (Pontifícia Universiade Católica do Rio Grande do Sul). Also, we had the opportunity to experience a little of the everyday work of curators, taxonomists, and fellow researchers. And we noticed a knowledge gap during our academic career. Was this gap in knowledge from the undergraduate to graduate years a mere coincidence or a widespread situation in Brazilian biological science programs?

In order to determine whether this was a local or nationwide pattern, we conducted a survey using the list of biological science programs in Brazilian institutions that are evaluated and recognized by CAPES (Coordination for the Improvement of Higher Education Personnel –Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) at the Sucupira Platform, which is used for collecting information to the evaluation of Brazilian graduate programs (CAPES 2021). Based on the CAPES list, we searched for courses in the curricula of undergraduate programs in biological sciences that comprised exclusively scientific collections (NHCs) and taxonomy. We considered only the name of the courses to carry out the survey, since most of them did not have the description available. We accessed the websites of 126 universities/colleges, representing all Brazilian regions, of which 68 have programs in biological sciences in the curricula. We analyzed 62 universities that make the curricula available on their websites (Table S1), 25 of which are private and 37 are public universities. Only 10 (about 16 %) have any course related to NHCs or taxonomy, all of them are public universities. Comparing private and public institutions, we see a tendency in public universities to offer biological science programs more than private universities (Table S1). Currently, the courses that we found are the following: Curation of Collections in Natural History Museums (Universide de São Paulo – USP), Biological Collections (Universidade Federal de Pernambuco – UFPE, Universidade Federal de Ouro Preto – UFOP, and Universidade Federal de Mato Grosso – UFMT), Methods of Preparing Specimens For Collections (Universidade Federal do Pará – UFPA), Animal Taxonomy and Morphology (Universidade Estadual de Santa Cruz – UESC), Science Museum and Biological Collections and Teaching Applications (Universidade Federal de São Paulo – UNIFESP), Zoological Collections (Universidade Federal da Bahia – UFBA), Biological Collections and Taxonomy (Universidade Federal do Paraná – UFPR), Bird Collections and Taxidermy and Biological Collections Curation (Universidade Federal do Rio Grande do Norte – UFRN), and Museology and Management of Collections (Universidade Federal do Mato Grosso – UFMT). Nonetheless, only at the Universidade Federal de Pernambuco – UFPE this subject is mandatory and required as part of the curriculum. In all the other universities the subjects are electives. The low number of programs that include any course focused specifically on taxonomy or scientific collections demonstrates the lack of incentives to train new taxonomists and, consequently, to create and maintain NHCs, further devaluing the area and creating an important gap in the basis of many areas of biology. Also contributing to this devaluation are the frequent budget cuts that the Brazilian federal government has been imposing on scientific research. Therefore, we found that our limited experience with NHCs and taxonomy as undergraduate students seems to be common in the majority of higher-education programs across Brazil.

We believe that recognition of the value of taxonomy and NHCs by society and the financial investment can be improved in a few ways that we summarize next. 1) Continuing and improving financial investments in the area by the government, such as the Taxonomy Training Program – PROTAX, created in 2010 (CNPq 2012), with the objective of capacity building in taxonomy aiming the management and knowledge of Brazilian biodiversity. 2) The sciences that provide fundamental biological knowledge needs to be more highly valued by journals, journal editors, and even researchers in other areas. Since taxonomy is the basis for many of the biological sciences, researchers who use taxonomy and scientific collections data must cite the original papers and the collections consulted. 3) Educational institutions must include in their curricula a program on taxonomy and scientific collec-

tions and encourage dissemination of scientific information to society by their researchers. Contact with taxonomy and NHCs should be introduced at the beginning of the studies on biological science programs or even other related programs, allowing those interested in the subject to have the opportunity to go deeper into this study. 4) In addition to higher educational institutions, elementary and high schools should teach about NHCs and their importance to society and researchers. By this means, the general population would begin to understand the real importance of them. Many believe that collections and museums are merely attractions, and we need to rebuild this vision. 5) Increase networking and partnerships among institutions holding scientific collections, schools, and universities, to connect them, as well as increase the number of studies related to biodiversity and scientific collections. 6) Taxonomist researchers should invest in expanding the dissemination of their work results, making it more accessible to society. Appropriate dissemination of scientific information has the power to reduce the distance between the scientific community and society.

We believe that achieving those goals will lead to a higher number of qualified taxonomists, which will improve our knowledge about global biodiversity and its use in conservation, applied sciences, and other fields. With more taxonomists and proper funding, the value of the NHCs will increase and their future as safekeepers of biodiversity will be more assured. Involving society will bring to the surface their value and crucial importance for dissemination of science. The low offer of courses related to NHCs and even their absence in Brazilian universities and also the lack of capacity building as undergraduates regarding taxonomy, reinforce how few professionals are currently being prepared to work in the areas of collections and taxonomy.

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Supplementary material 1

Table S1. Universities or Colleges that have the list of courses of their undergraduate programs in Biological Sciences published online and the availability of courses related to Natural History Collections or taxonomy.

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