Concept map for cycliophora: the celebration of knowledge to disseminate about biodiversity

Mapa conceitual para cycliophora: a celebração do conhecimento para divulgar sobre a biodiversidade

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ABSTRACT
This work describes a methodological experience involving a study of the taxon Cycliophora, using a concept map. The methodological pathway included the search and organization of concepts based on a focal question. The resulting map, built with the software CmapTools, encompasses a central and more inclusive concept, linked to several more specific concepts forming propositions aiming at reaching higher-order thinking skills. The investigation explains...
elements about the elaboration of a descriptive concept map about a little-publicized zoological taxon as a learning activity.

**Keywords:** biological diversity, invertebrates, science education, zoology.

RESUMO
Este trabalho descreve uma experiência metodológica envolvendo o estudo do táxon Cycliophora, utilizando mapa conceitual. O percurso metodológico incluiu a busca e organização de conceitos a partir de uma questão focal. O mapa resultante, construído com o software CmapTools, engloba um conceito central e mais inclusivo, vinculado a vários conceitos mais específicos formando proposições que visam alcançar habilidades de pensamento de ordem superior. A investigação explicita elementos sobre a elaboração de um mapa conceitual descritivo sobre um táxon zoológico pouco divulgado como atividade de aprendizagem.

Palavras-chave: diversidade biológica, invertebrados, educação científica, zoologia.

1 INTRODUCTION

Invertebrate animals account for about 96% of the documented zoological biodiversity, featuring a vast array of morphological Baupläne, as well as ecological, physiological, and reproductive strategies (Brusca, Giribet & Moore, 2023). Despite playing a critical role in maintaining ecosystem services in comparison to other groups, such as vertebrates, invertebrate taxa often receive less attention from research projects and have a lower public awareness (Wilson, 1987, Eisenhauer et al., 2019; Wyckhuys et al., 2019; Salvador et al., 2021). Moreover invertebrate animals also face loss of habitat and eventual extinction due to anthropogenic action, and it is necessary to know their diversity and biology, as well as to stress the need for their conservation (Wilson, 1987; Eisenhauer et al., 2019; Engel et al., 2021; Cowie, Bouchet & Fontaine, 2022).

Araújo-de-Almeida et al. (2011) and Di Domenico et al. (2015) highlight that several invertebrate taxa, although relevant for understanding ecological processes and biological evolution, are often overlooked in textbooks and studies about animal diversity and this lack of information also has serious consequences for the teaching-learning process. Such scarce interest may lead to reduced
investments in inventorying and taxonomy-related research about invertebrate groups, reinforcing the taxonomic impediment that may hinder scientific progress and conservation efforts (Araújo-de-Almeida et al., 2011; Engel et al., 2021). One of these groups is Cycliophora, described as a new phylum of invertebrates by Funch & Kristensen (1995), with an uncertain phylogenetic position (Kristensen, 2002; Funch & Neves, 2019, Funch, 2021). They are tiny, marine, sessile commensal metazoans with bilateral symmetry, differentiated cuticle and a complex life cycle with sexual and asexual stages; their solitary feeding stages have ciliated cells in the intestine (Kristensen, 2002; Neves & Reichert, 2015; Neves, 2016; Giribet & Edgecombe, 2020; Funch, 2021). According to Funch (2021), cycliophorans were found in crustacean hosts from localities in coastal areas of the North Atlantic Ocean and the Mediterranean Sea.

The technical characterization of Cycliophora involves unfamiliar, abstract traits, generating a large number of concepts to be apprehended by the student. In order to solve the conceptual difficulties arising from the presence of evolutionary novelties in these animals, it is important to have a didactic instrument to facilitate an overall understanding of this information. Concept maps, as pedagogical tools based on the Theory of Meaningful Learning (Ausubel, 2000), provide clear and concise representations of the conceptual structures that are being taught. As such, they may facilitate learning (Novak & Cañas, 2008; Moreira, 2011). Considering the demonstrated positive impact of concept maps on student learning across diverse disciplinary contexts (Kinchin, Mölits & Reiska, 2019), this paper seeks to chronicle the lived experience of engaging with concept mapping. Additionally, we explore the collaborative interaction between teachers and students in the process of improving the technique of mapping concepts to elaborate an informative synthesis about the Cycliophora.

2 METHODOLOGY

The methodological pathway was carried out within the teaching project “Concept mapping in the learning path of contents in Zoology”, which is being...
developed since 2019 at the Federal University of Rio Grande do Norte (UFRN, Natal, Brazil). Three steps were considered in this methodological pathway: (1) expansion of the experience with the concept mapping technique; (2) development of a participatory process with students of Biological Sciences; (3) use of a collaborative strategy.

The student's previous experience with the concept mapping technique, developed in curricular components of Zoology at UFRN, was considered in the effectiveness of research in teaching with concept maps. It is a narrative emphasizing the student's experience of learning zoological taxonomy following phylogenetic reasoning (see Araújo-de-Almeida et al., 2019a). This process involved elaborating concept maps and writing reports about the journey experienced, as described in Araújo-de-Almeida et al. (2019b), Araújo-de-Almeida & Santos (2021), and Aciole et al. (2022, 2023). The reports produced are intended for publication, so that they can be returned to the classroom, as informative texts to promote teaching and support studies on the topics covered. By emphasizing the creativity of students and collaborative work involving teachers, researchers, and learners, experiences with concept maps envision the perspective of Morais et al. (2023). In this aspect, science, when reinforced in the teaching process, encourages learning.

Some titles in the specialized literature were also recommended to the students in order to provide them with a theoretical background about concept mapping and technical information on the animal taxa. As basic sources for understanding the concept mapping technique, some papers were considered relevant, such as Novak & Cañas (2008), Kinchin (2011), Moreira (2011), Aguiar & Correia (2013), Åhlberg (2013), Cañas, Novak & Reiska (2015). For topics on zoological diversity, we selected: Ruppert, Fox & Barnes (2004), Brusca, Moore & Shuster (2016), and Fransozo & Negreiros-Fransozo (2016). The concept mapping tasks emphasized the criteria for the production of good concept maps expounded by Cañas, Novak & Reiska (2015). The mapping of concepts on the Cycliophora was influenced by the standardization of some propositions presented in the translated version of the original concept map on Entoprocta by
Aciole et al. (2020). The focal question proposed was: “Which morphological, taxonomic, phylogenetic, and ecological traits characterize the Cycliophora?” The concept map was built with the software CmapTools (IHMC, 2019).

3 RESULTS AND DISCUSSION

The concept map “CM-CYCLIOPHORA” graphically organizes concepts about the cycliophorans (Figure 1), and displays a set of ecological, physiological, and morphological features that can be diagnostic for the taxon Cycliophora, such as the presence of an adhesive disc, buccal funnel with cilia, layered cuticle and complex life cycle with Pandora, Prometheus and chordoid larvae. The map also indicates Spiralia as the taxon to which the Cycliophora is currently assigned, and differentiates the subgroups of Cycliophora down to species level. The concepts mapped follow a hierarchical structure, showing the levels of generality at which the characters are phylogenetically informative.
Figure 1: “CM-Cycliophora” answering the focal question “Which morphological, taxonomic, phylogenetic, and ecological traits characterize the Cycliophora?”.


It is noteworthy that the concept map built for the Cycliophora clarifies issues related to the textual description of this lineage. This is accomplished by conveying a visual representation of the interconnections between these descriptive characteristics. The representation may help students and teachers outline the morphology and biology of these animals. The concept map also illustrates general aspects in the classification of Cycliophora, thus making biological taxonomy more perceptible for the student, as pointed out by Araújo-de-Almeida & Santos (2018). In this way, the CM-CYCLIOPHORA represents an additional element to broaden the understanding of the cycliophorans, and provides an example for the construction of improved graphic schemes for the dissemination of knowledge about biodiversity, as discussed in Araújo-de-Almeida & Santos (2018, 2021), Dias-da-Silva et al. (2019a, b), Lima et al. (2022), and Aciole et al. (2023).

In order to reach a wider audience, the present study group on concept maps published some papers in English dealing with little-publicized taxa such as Gastrotricha and Nematomorpha (Araújo-de-Almeida & Santos, 2018), Rotífera and Acanthocephala (Bezerra, Santos & Araújo-de-Almeida, 2019), Entoprocta (Aciole et al., 2020), Tardigrada (Xavier et al., 2020), and Priapulida
(Filgueira et al., 2021). Some publications by the same group of researchers, available in Portuguese, address the taxa Loricifera (Lima et al., 2018), Onychophora (Paiva et al., 2019), Cycliophora and Kinorhyncha (Cunha et al., 2021), Gnathostomulida (Lima et al., 2022), and Micrognathozoa (Cunha et al., 2022).

This perspective underscores a path that allows for the formation of scientific educators, making them more actively engaged in the construction of knowledge. Ruhl, Posner & Ricketts (2019) point out the need to transmit science information to society in order to illuminate and foster policy-making, and according to them: “Leaders could celebrate policy up-take as much as number of academic publications or citations” (Ruhl, Posner & Ricketts, 2019, p. 8).

4 CONCLUSIONS

Mapping concepts related to overlooked and less-publicized animal groups, such as Cycliophora, serves as an innovative tool for outreach and undergraduate teaching, facilitating a deeper understanding of zoological taxa. Additionally, these concept maps offer a valuable resource for classroom exercises.

Recognizing the significance of concept maps in skill development, regular practice in creating them provides reflective examples that can be applied across various fields of knowledge.

As an illustration *per se*, the concept map (which may be contextualized in a written narrative) constitutes a product that, by involving dynamic learning, communicates information and may pique the curiosity of the target audience. Hence, concept maps have the potential to divulge knowledge about zoological groups and underline the need for their conservation. This aligns with the provisions of Article 13 of the Convention on Biological Diversity (Araújo-de-Almeida & Santos, 2021) and is in harmony with the United Nations Sustainable Development Goals numbers 14 (“Life below Water”) and 15 (“Life on Land”), as well as the ocean literacy movement.
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REFERENCES


