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Biodiversity Knowledge and Conceptions in Latin American: Towards an Integrative New Perspective for Education Research and Practice

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Abstract

Biodiversity plays a crucial role in ecosystem functioning by providing essential benefits to people and improving their well-being, i.e., regulating material and non-material services; especially in cultural and natural rich landscapes, such as those found in Latin-American countries. Nevertheless, in spite of the utmost importance of sustaining human life, biodiversity is not only declining at unprecedented rates, but also this pervasive degradation has revealed both our mutual dependence and interconnectedness, with a profound need for a societal transformative change. To help meet this challenge, the aim of this work is to synthesise pertinent and state-of-the-art knowledge on biodiversity education by utilising a holistic approach and a Latin-American point of view, which will contribute towards understanding and targeting complex socio-ecological issues. The findings have unveiled an abundant number of studies in Latin American countries that have investigated the topic of teachers' and students' knowledge and their conceptions of biodiversity from both conventional scientific knowledge and interculturality. By promoting an integrative dialogue among these categories and their subcategories, several implications arose concerning scientists engaged in public outreach, environmental and sustainable development and science education researchers, those engaged in cultural studies, formal and non-formal education, and school teachers.

Introduction

Under the present scientific rationality, nature has been conceptualised as “the natural world, with emphasis on the diversity of living organisms and their interactions among themselves and with their environment” (Díaz et al., 2015, p. 13). Therefore, although there are other types of knowledge (traditional, ancestral) which conceptualise and experience nature, as expressed in expressions such as the fabric of life, Mother Earth and *Pachamama*, nature is often equated with biological diversity (= biodiversity, BD) in the academic sphere (Gudynas, 2011; Montenegro Martínez, 2011). In this context, with a new emphasis on nature and in spite of it being a term taken from Western Scientific Knowledge, BD has been the object of negotiation and transformation in various ethnic groups, according to their forms of knowledge and cultural practices (Pérez

Mesa, 2019). For instance, rivers, streams and stones are endowed with life and spirit for some ethnic groups, and thus, these are part of the social construct “biodiversity” (Ramírez, 2005).

In Ecology and Science education, BD is often defined as the genetic, species and ecosystem diversity (Yli-Panula et al., 2018), which has been recognised as the “biodiversity trilogy” (Kaennel, 1998). These three levels of expression or components, according to Harper and Hawksworth (1994), were introduced independently by T. Lovejoy and E. Norse and R. McManus in 1980 (Bermudez & Lindemann-Matthies, 2020; Pérez Mesa, 2013a). Since the 1980s, definitions of BD have ranged from “‘the number of different species occurring in some location’ (= species richness) to ‘all of the diversity and variability in nature’ and ‘the variety of life and its processes’” (Swingland, 2001, p. 380). It is worth noting that the term “biodiversity” was coined by W. Rosen while organising the National Forum on BioDiversity, which took place in 1986. However, E. Wilson, who explicitly acknowledged his colleague’s contribution, edited the conference proceedings in 1988 and, as a consequence, he is often recognised for the expression “biological diversity” (Bermudez & Lindemann-Matthies, 2020).

In the political agenda, after the Convention on Biological Diversity [CBD] (1992), the term biodiversity refers to the variability among living organisms, including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species, and of ecosystems. However, according to recent definitions, such as that of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, an independent organism created in the framework of the United Nations) (Díaz et al., 2015), BD includes:

The variability among living organisms from all sources, such as terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part, (...) [which] includes variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems. (p. 12)

Irrespective of the BD definition, human impact has become more significant worldwide since the 1970s. The pervasive flow of material contributions from nature, to the needs and interests of people, has caused the fabric of life on which humanity depends on to seriously unravel at an unprecedented rate (Díaz et al., 2019). In continents such as Latin America, one of the regions of greatest biodiversity, this goes hand in hand with the erosion of ancestral knowledge, propelled by hegemonic processes of power, knowledge asymmetries and unsustainable practices of the civilisation project (Pérez Mesa, 2019). Moreover, the region faces an exporter extractive development model that further consolidates existing social inequalities (Tedesco, 2017) and socio-environmental crises, under mechanisms of appropriation and dispossession of common environmental assets, with the concomitant loss of biodiversity (Escalón Portilla & González Gaudiano, 2017). In this context, socio-economic and cultural disparities cut across environmental issues, in general, and climate change and the loss of biodiversity, in particular, leads to great disadvantages. In this sense, the consequent large impacts on ecosystem processes and, thus, human well-being, are felt disproportionately by the poor, who are the most vulnerable to the loss of nature’s contributions to people (Díaz et al., 2006).

In this regard, the global call of the CBD (1992) is directed at the development of strategies for conservation and preservation, within which is education, as expressed in article 13, entitled “Public Education and Awareness”, by which the contracting parties shall (CBD, 1992, art. 13):

- (a) Promote and encourage understanding of the importance of, and the measures required for, the conservation of biological diversity, as well as its propagation through media, and the inclusion of these topics in educational programmes; and
- (b) Cooperate, as appropriate, with other States and international organisations in developing educational and public awareness programmes, with respect to conservation and sustainable use of biological diversity.

Education constitutes a platform for dealing with and contributing to the knowledge and valuation of biodiversity, and administered by world organisations such as UNESCO, by linking article 13 with that of “Education for Sustainable Development” (ESD), in seeking to maintain the idea of sustainability of nature under a semiotic reconversion that seeks a sustainability of Western culture (Escobar, 1998). In this sense, Navarro-Perez and Tidball (2012) affirm that both environmental education and education for sustainable development (ESD) acknowledge the interdependencies between socio-environmental issues, recognise biodiversity as a relevant crosscutting educational topic, and seek the challenge of transforming society. In this sense, IPBES also claims that “the challenges posed by biodiversity loss, climate change, and achieving a good quality of life, are all deeply interconnected and need to be addressed in an integrative manner -and urgently- from local to global levels” (Díaz et al., 2019, p. 8).

However, these efforts have not inquired about biodiversity education (BDE), neither in formal nor non-formal educational institutions, despite some experiences published in science education (Capraro et al., 2016; Castro Moreno et al., 2021; Erten, 2015; Evagorou & Puig Mauriz, 2017; Kilinc et al., 2013; Lindemann-Matthies et al., 2011; Motokane, 2015; Navarro-Perez & Tidball, 2012; Nyberg et al., 2021; Patrick & Tunnicliffe, 2011; Patrick et al., 2013; Pedrera, et al., in press; Prokop et al., 2008; Sanders, 2007; Santos & Salcedo, 2014; Schneiderhan-Opel & Bogner, 2019; van Weelie & Boersma, 2018), and also in traditional and ancestral practices. Moreover, there is paucity of knowledge in the English-speaking science education arena about people’s conceptual knowledge and alternative conceptions of biodiversity reported from Latin American-based research. This is mainly due to Latin-American publications and database coverage being restricted to regional and national databases, which in spite of these publications often having open access (e.g. <https://www.scielo.org/>, <https://www.redalyc.org/home.oa>, etc.) are rarely considered in English-language publications. Consequently, efforts towards systematic reviews lack strong documentation and linguistic representativeness (Briggs et al., 2018). With this in mind, the aim of this paper is to synthesise and compile current knowledge on BDE in the context of Latin American countries, by taking an integrative approach that includes academic production about traditional and western scientific knowledge regarding students’ and teachers’ knowledge and their conceptions about biodiversity.

Method

We approached the research from a hermeneutic-interpretative approach, through documentary reviews that

sought to configure categories of analysis regarding the approach to biodiversity in educational processes. For this purpose, we followed the guidelines indicated by Pérez Mesa (2013a) and Castro Moreno et al. (2021) regarding the search, selection of bibliographic sources and conceptual developments in science education and intercultural study fields, and considered as the question guiding this research: What is the scientific production related to knowledge studies and conceptions of biodiversity in different Latin American educational contexts?

We conducted a review of scientific articles in the databases *Dialnet* (<https://dialnet.unirioja.es/>), *Red de Revistas Científicas de America Latina y el Caribe, España Portugal* (Redalyc, <https://www.redalyc.org/>), *Scientific Electronic Library Online* (SciELO, <https://scielo.org/es/>), Scopus (<https://www.scopus.com/home.uri>), Google Scholar (<https://scholar.google.es/schhp?hl=es>), and in websites of regionally recognised journals in the area of science education, which sometimes, although they are indexed in well-established scientific portals, such as *Latindex* (<https://www.latindex.org/latindex/inicio>), the article collections were not or only partially included in the above mentioned databases (e.g., *Revista de Educación en Biología*, <https://revistas.unc.edu.ar/index.php/revistaadbia>). Also, we saw the need to include written academic production in conference proceedings related to science education and teacher training research trends, which are published as extra issues/volumes of regional refereed journals, because these authors' efforts rarely managed to be substantiated in scientific articles (e.g. Proceedings of the National Meeting of Experiences in Biology Teaching and Environmental Education - National Congress of Research in Biology Teaching, published in the journal *Bio-grafia: Escritos sobre la Biología y su Enseñanza*, <https://revistas.pedagogica.edu.co/index.php/bio-grafia/index>). Similarly, some refereed books were included in the documentary analysis, according to the same principles. The time frame chosen for the document search was 2004-2020, in order to survey the most recent productions. Findings related to issues such as teaching strategies led to another investigation, whose results are currently in preparation for another publication.

A review of more than two hundred articles was carried out for the current contribution, of which, an initial classification was made and the 63 articles found to be relevant to this research were systematised using the following data: authors and year of publication, country and studied group and main contribution (see Appendix 1). With this in mind, after a dialogical process between authors and the literature, we obtained a system of categories and subcategories that may be characterised as follows as:

- (1) representing, in its broadest spectrum, regional production related to biodiversity education from not only teaching spheres, but also from an intercultural perspective, respectful of the heterogeneity of countries, educational systems and cultural groups;
- (2) reflecting the properties and logistics of academic production of Latin American journals, which typically publish open access and are included in regional and Iberoamerican databases (e.g., *SciELO*, *Redalyc*, *Dialnet*, etc.);
- (3) sharing and establishing innovative bridges with a global audience publications in Spanish and Portuguese, and, in this manner, providing connections and visibility to international networks of researchers and academic journals;
- (4) emerging inductively from the authors' and collaborators' recognition "in the field" of the institutions, traditions and methods of production, communication, circulation and dissemination of

educational and research practices of BDE in Latin America.

Hereinafter, we propose the discussion of trends and critical issues of our categorical system (see Appendix 2). Our findings highlight topics related to teacher (preservice and in-service) understanding of biodiversity, and students' alternative conceptions and conceptual knowledge, both from intercultural and conventional-scientific knowledge perspectives.

Results and Discussion

From Conventional Scientific Knowledge

Students' Conceptions and Conceptual Understanding

Concept of biodiversity (I.1.A). The students' knowledge and conceptions of biodiversity (I.1.A, see details in Appendix 1) are compared with a definition from Western scientific knowledge (WSK), which, generally, is the one provided by the CBD (1992), and which some authors consider to be basic and focused on the variety of species: "diversity and variety of species or living beings on Earth" and "number of species" (Vilches et al., 2018, p. 364); or "set of organisms, living beings, individuals or forms of life, as well as, the variety of habitats, spaces or determined places where these organisms develop" (De La Cruz & Pérez, 2020, p. 6). The causes of biodiversity loss (Barbosa et al., 2019) are less inquired than the concept itself (De La Cruz & Pérez, 2020; Ferreira Fonseca, 2007; Vilches et al., 2018), or its components (I.1.B, C and D).

The findings of the studies conducted in Argentina, Brazil and Colombia (I.1.A) allow us to identify the following critical issues for research and teaching practice. First, the studies are implicitly situated in the teaching of scientific disciplines such as biology, take WSK as a sole referent, and establish coincidences and gaps that are typical of nomothetic studies (see Bermudez & Lindemann-Matthies, 2020). This leads to the conclusion to be drawn that the students' knowledge is poor or basic (De la Cruz & Pérez, 2020; Vilches et al., 2018). In relation to WSK, more recent conceptualisations than that of CBD are not usually utilised (see Bermudez & Lindemann-Matthies, 2020), so these could be updated with the latest scientific contributions and international agreements (Díaz et al., 2015, 2019).

Although the students' interest in biodiversity conservation is strong (Barbosa et al., 2019), their independence with their conceptual knowledge may generate an overconfidence or overestimation of their own epistemic capacities to make wildlife management decisions. The scarcity of studies on the recognition of the causes and, in particular, consequences of biodiversity loss, reinforces the focus on species richness and entrenches an additive notion of the ecosystem, where consequences can be predicted, without further ado, by unicausal reasoning or linear causality (Bermudez & Lindemann-Matthies, 2020; Korfiatis & Tunnicliffe, 2012; Sander et al., 2006; Schizas et al., 2018, 2020). Several studies have pointed out the lack of educational materials or textbooks appropriate for teaching biodiversity, and that are relevant to local environments (Bermudez & De Longhi, 2015; Bizerril, 2004; Borges & Simião-Ferreira, 2018; De la Cruz & Pérez, 2020; Ferreira Fonseca, 2007). There are also no studies linking the conceptualisation of biodiversity and ESD.

Components and attributes of biodiversity (I.1.B). Studies on students' understanding of biodiversity (I.1.B, see

details in Appendix 1), carried out mainly in Argentina, Brazil and Colombia, indicate that students possess a variety of conceptual frameworks concerning biodiversity (I.1.B.i), with some of these in agreement with scientifically validated meanings of great relevance and topicality, such as the idea of variety in the number of species (richness, I.1.B.i.a), types of organisms (functional groups, I.1.B.i.b) and trophic relationships (interactions between species, I.1.B.i.c) (Bermudez & Lindemann-Matthies, 2020; De La Cruz & Pérez, 2020; Ferreira Fonseca, 2007; Vilches et al., 2018). However, whereas trophic interactions between exotic animals (predator-prey model) are well recognised, interactions among herbivores, plants and others are disregarded (Arias Santos, 2018). Few investigations have included broader analytical categories than the biodiversity trilogy (species, genes, and ecosystems), especially those that conduct ideographic type studies, which seek to describe the actors' understanding from their own notions rather than categorising their responses from established WSK (Arias Santos, 2018; Bermudez & Lindemann-Matthies, 2020; De La Cruz & Pérez, 2020). Among the conceptualisations and components of biodiversity, students strongly focus on species richness (= number, I.1.B.i.a) (Bermudez & Lindemann-Matthies, 2020; Barbosa et al., 2019; Ferreira Fonseca, 2007; Vilches et al., 2018).

The above findings (I.1.B) have permitted us to identify the following critical topics for research and teaching practice. The undervaluation of scientifically recognised components and attributes (I.1.B.ii: population size, functional traits, species evenness and alpha diversity) calls into question the degree of understanding of biodiversity and how it influences the structure and functioning of ecosystems. In this sense, functional divergence (values and range of functional traits, I.1.B.ii.e) determines ecosystem functioning (nutrient cycling, atmospheric carbon fixation, resilience, pollination, etc.) more strongly than the number of species per se (Bermudez & Lindemann-Matthies, 2020; Díaz et al., 2015, 2019). In addition, the links of biodiversity conservation to the knowledge of biological evolution processes (e.g., regarding interactions and population size, I.1.B.ii.c and d) highlight the need to reconsider the teaching of ecological processes that, from an evolutionary perspective, have their foundations in the theories that justify change, adaptation, selection, drift, and the “bottleneck” effect, among others (Evagorou & Puig Mauriz, 2017; Pérez et al., 2018; Santos & Salcedo, 2014).

The fact of ignoring the plants that serve as food as being part of biodiversity, the so-called vegetables (and also the organisms that have undergone some type of selection, mainly by genetic engineering, GMOs) (I.1.B.iii.b) or those that represent a decrease in biological diversity in terms of genetic composition, is linked to students' views within the framework of broader socio-environmental issues. In this sense, socioscientific issues (SSI) can act as both an obstacle and bridge to understanding the strong imbrications between nature-culture (Evagorou & Puig Mauriz, 2017; Karison & Zeidler, 2017; Minken et al., 2021), especially for examples of traditional artificial selection, as is the case of maize (Bermudez & Lindemann-Matthies, 2020; Escobar, 1998; Gómez Galindo et al., in press; Montenegro Martínez, 2011). Hence, addressing SSI related to biotechnology and food practices may be a gateway to biodiversity understanding in a meaningful and functional way, further linking traditional and academic knowledge (Castaño, 2008; Robles-Piñeros et al., 2020). Moreover, this may be a way of tackling the more general disconnect between formal ecology instruction and daily life activities (Karahan et al., 2017; Wyner & Blatt, 2019).

The low consideration of species evenness (I.1.B.ii.a) for biodiversity conservation highlights a potential difficulty in understanding the effects of biodiversity on the regulation of the water cycle or climate, on the relationships between species (competition, facilitation, etc.), and on the presence and spread of potentially invasive alien species. In line with this, alpha diversity (I.1.B.ii.b) gains importance in an evolutionary context and a multi-scale spatial ecology, so students' disregard for potentially interacting species within a local habitat could prevent them from recognising and valuing species evenness and changes in species numbers and composition, in the face of global environmental drivers such as global warming and the advancing agricultural frontier (Asshoff et al., 2020; Díaz et al., 2006, 2019; Escalón Portilla & González Gaudiano, 2017; Schizas et al., 2020). However, for the above to be addressed, it is necessary to overcome the teaching of ecology as "ecological bytes" (Tunncliffe & Ueckert, 2007) and move towards a comprehensive and thorough understanding of ecological systems' structure and function (Ayotte-Beaudet et al., in press; Korfiatis & Tunncliffe, 2012; Schizas et al., 2020).

The notion of balance in the ecosystem could be a structuring basis for the recognition of food webs as complete, balanced or proportionate (I.1.B.i.c), but more studies on this particular construct are required to determine its influence from broader frameworks on biodiversity conservation decisions and the interpretation of ecosystem processes (Sander et al., 2006; Schizas et al., 2019). Among these frameworks, living in balance and harmony with Mother Earth, which includes ontological, material and spiritual dimensions of people with their community and of the collective with Mother Earth are of interest for including in the dialogue along with academic knowledge (Díaz et al., 2015; Gudynas, 2011; Pérez Mesa, 2019).

The trophic relationships inquired are centred on plants and animals and, within these, herbivore-plant relationships seem to have a lower status than those established between animal-animal consumers (Arias Santos, 2018) (I.1.B.ii.d). Linkages between decomposers and how students' view value nutrient cycling, among other common environmental and ecosystem processes, are currently unknown (Asshoff et al. 2020; Sander et al., 2006). The native and exotic attributes of biodiversity (I.1.B.iii.a), although reduced to the species *taxon*, reveal that the meanings of the everyday terms used ("rare", "out of common", "unique", "proper") are seen as obstacles, incomplete or incorrect (De Souza Proença et al., 2017). Nonetheless, these could represent a starting point to address the history of culture and biogeography, cultural rootedness and worldviews of different groups and cultures, as is the case of maize for the Americas (Gómez Galindo et al., in press), as well as the temporal dimension of ecological processes and affective linkage with levels of biodiversity expression (Bermudez & Lindemann-Matthies, 2020; Robles-Piñeros et al., 2020).

Familiarity with and knowledge of plants and animals (I.1.C). Studies carried out in Argentina, Brazil and Colombia on familiarity with plant and animal species typically ask students for the everyday names of plants and animals (I.1.C, see details in Appendix 1). Later, these names are translated to scientific ones (at the genus or species level) and are added as the number of species or recognised taxonomic categories (Bermudez et al., 2017, 2018; Campos et al., 2012; Torres-Merchan & Medina Peña, 2014). In relation to this, the knowledge revealed of plants is either higher (Campos et al., 2012) or lower (Bermudez et al., 2018) than that of animals, depending on the study (I.1.C).

Inquiries that ask respondents or interviewees for a list of species, which are classified by researchers as native and non-native (I.1.C.i.), normally have very low percentages recorded for known native species; e.g., < 10%) (Campos et al., 2012). However, when recognition is requested using photographs or a free list of species, on the condition that they are native, the “hits” and the proportion of autochthonous *taxa* named increases ($\leq 60\%$) (Bermudez et al., 2017, 2018; Dias and dos Reis, 2018; Schaaf et al., 2018; Schwarz et al., 2012; Zanini et al., 2020).

The prominence of mammals and birds, among animals (I.1.C.ii.a), and of herbaceous flowering plants (phorbs) and trees and shrubs (Figure 1), among the plants mentioned by students (I.1.C.ii.b), points to a strong pattern of recall of nominal categories of biodiversity (Bermudez et al., 2017, 2018; Campos et al., 2012; de Sousa & Freixo, 2020; de Sousa & da Silva, 2017; Schwarz et al., 2012; Torres-Merchan et al., 2018). In addition, there is a generalised trend in the recognition of negative emotions and rejection generated by species categorised as “uncharismatic” (I.1.C.iii), mainly for venomous arthropods and reptiles, and also in some representatives of mammals such as bats (Campos et al., 2012; de Almeida et al., 2015, 2019; de Sousa & da Silva, 2017; Rivera Losada & Amórtégui Cedeño, 2015; Salas, 2018; Schwarz et al., 2012; Torres-Merchan et al., 2018). Gender (I.1.C.iv), place of residence (I.1.C.v) and school sector (I.1.C.vii) are sociocultural factors that have established quantitatively significant relationships with species knowledge and familiarity (Bermudez et al., 2017, 2018; Campos et al., 2012; de Almeida et al., 2015; Eyssartier et al., 2017; Salas, 2018; Schwarz et al., 2007, 2012; Torres-Merchan et al., 2018; Zanini et al., 2020). However, the influence of the school sector (private or state) has been less investigated than the other factors.



Figure 1. High-school Students Identifying Native Trees during a School Fieldtrip in Argentina. Photo credits: G. M. A. Bermudez.

The above trends (I.1.C) have enabled the critical items described below to be identified for research and teaching practice. First, the different methodologies used (drawings, free lists and recognition by photographs) for inquiring about familiarity with and knowledge of plants and animals have produced dissimilar results when applied to different age groups and geographic contexts. Concerning the free listings, some studies ask respondents to mention only native species (Bermudez et al., 2017, 2018; Borges & Simião-Ferreira, 2018), while, in other cases, they are only asked to list or draw species and, thus, in this case the categorisation process of species origin is performed by the researchers (Campos et al., 2012; Schaaf et al., 2018, Schwarz et al., 2012; Torres-Merchan & Medina Peña, 2014; Vilches et al., 2018; Zanini et al., 2020). Therefore, there is a need to systematise and validate the different methodologies through mixed studies, by combining listings, photographs and drawings, for instance.

Everyday taxonomic categories, or *ethnotaxa*, possess an intrinsic value that vanishes in the search for homologation to scientific nomenclature, especially when the former possesses both native and exotic specimens (Bermudez et al., 2018). Invertebrate animals are less known than charismatic ones. In addition, in the case of plants, the taxonomic categories are broad, variable and not very precise (Bermudez et al., 2018; de Sousa & da Silva, 2017; Schaaf et al., 2018), so that translation into scientific language and categorisation according to the origin of the *taxon* is at the discretion of the researcher, and therefore purely arbitrary. Or, as in a few cases, researchers refer to the indeterminacy of origin or a mixed type origin, such as when the named taxonomic category includes species of both native and exotic origin. Consequently, a renewed terminological approach is required that, at least in biology classrooms, avoids the grouping of species using everyday names that include species of mixed origin. For example, Bermudez et al. (2018) point out that “willow”, a highly-mentioned plant category, clusters together *S. humboldtiana*, which is native to Argentina, but there are also other species which are exotic and invasive, such as *S. viminalis* and *S. babylonica*.

The criteria for classification into native or exotic species should consider biomes or ecoregions, in addition to political-geographical demarcations, since species from a given country or district are not necessarily native to the region in which the students’ knowledge is being investigated (Campos et al., 2012; Schaaf et al., 2018; Zanini et al., 2020). The above observation is more evident if we consider that species listings in terrestrial regions (bio-geographic or political) do not usually include, for example, marine animals. However, as the boundaries are not so clear within the different terrestrial ecoregions, it is necessary to have updated, georeferenced and easily accessible information in order to be able to determine the status of a *taxon* at a given time. Adventitious plants named by students as native, i.e., exotics that reproduce spontaneously in an area, represent almost 20% of the species listed as native ones (e.g., pines, eucalyptus, evergreens, etc.). This “adventitious-to-native” figure serves to point out the importance of the construction of collective ideas nurtured in the presence of the flora in the local contexts (home and school yards, etc.) (Bermudez et al., 2018).

The recall of taxonomic categories of biological diversity associated with certain groups of animals (mammals and birds) and plants (forbs, trees and shrubs) (I.1.C.ii.a and b) can be explained not only by the concept of “charismatic species” (Campos et al., 2012; Nyberg et al., 2021; Patrick & Tunnicliffe, 2011; Patrick et al., 2013; Salas, 2018; Schaaf et al., 2018; Schwarz et al., 2012; Yli-Panula & Matikainen, 2014), but could also

indicate the most direct contact pathways present with fauna and flora, as well as the existence of a specific terminology for naming these organisms. In fact, although the least represented groups in the students' free lists, such as grasses (herbaceous plants with a grass-like morphology) and insects, are very abundant in many ecosystems and show an extraordinary taxonomic diversity, the daily lexical repertoire for nominating them is markedly narrow, and include terms such as "grasses", "bugs", "butterflies". Therefore, familiarity and direct contact studies should consider other interpretations of the free listings, and implement new methodologies for recording and analyzing data. Tree-centeredness could be related to the fact that species with large specimens (in mass units, for example) are considered to be the most influential, in terms of dominance and of ecosystem functioning (Bermudez et al., 2018; Lückmann & Menzel, 2014; Villarroel et al., 2018). However, the structuring of the forest as a whole ecosystem is also often associated only to the trees, with the forest as the backdrop for animal life. Consequently, research and teaching interventions should consider a wide range of life forms and functional groups, providing numerous examples of their representatives and their nominations.

Centrism in certain groups has led to a phenomenon referred to as "plant blindness" (I.1.C.ii.c) (Neves et al., 2019; Oliveira & Liesenfeld, 2020), which has been studied in Latin American by considering the prominence of animals in species free lists and also the size, colour and aroma of the flowers and inflorescences as conspicuous ecological characters (Bermudez et al., 2018; Campos et al., 2012). However, this line of research needs deepening to recover affective connections with plants (Amprazis et al., 2021; Kubiato et al., 2021; Nyberg et al., 2021; Pedrera et al., in press; Sanders, 2019). These relationships translate into expressions of beauty, and also symbolic meanings (e.g., associating a plant with a season of the year) and memories of emotions generated by plants, as well as valuing their colour, smell, and size.

The aesthetic appreciation of species as charismatic, friendly, uncharismatic, etc. (I.1.C.iii) is given within the framework of a culture that assigns them meanings and a certain value (including science). Although most of the interpretations of the categories mentioned in the studies surveyed are not culturally based, the few that are demonstrate the wide range of symbolic and affective representations of animals present in the cosmovisions of the peoples of our region (Campos et al., 2012; de Almeida et al., 2015, 2019; de Sousa & da Silva, 2017; Rivera Losada & Amórtegui Cedeño, 2015; Salas, 2018; Schwarz et al., 2012; Torres-Merchan et al., 2018). Research in biodiversity education should direct its efforts at identifying and systematising these representations and the ways in which different cultures have links to biodiversity (Almeida et al., 2020; Ballouard et al., 2015; Beery & Jørgensen, 2018; Bulut, 2021; De La Cruz & Pérez, 2020; Kilinc et al., 2013; Kubiato et al., 2021; Lee et al., 2019; Lindemann-Matthies et al., 2009, 2011; Minken et al., 2021; Özel et al., 2009; Patrick et al., 2013; Patrick & Tunnicliffe, 2011; Pérez Mesa, 2019; Sousa & Freixo, 2020; Torres-Merchan et al., 2018).

Sociocultural perspectives on learning and development can analyze thinking, knowledge and action as mediated by cultural activities. Gender (I.1.C.iv), place of residence (I.1.C.v) and school sector (I.1.C.vii) are factors that influence the students' knowledge and appreciation of biodiversity, although the latter has been the least explored of these (Bermudez et al., 2017, 2018). Considering the differences observed in studies from different countries and with different age groups on the influence of place of residence (I.1.C.v) (Bermudez & Lindemann-Matthies, 2020; Salas, 2018; Zanini et al., 2020), a tendency has been revealed for students from

rural areas to know more species, native and domestic, and to have more positive valuations of wild biota (Campos et al., 2012; de Almeida et al., 2015; Eyssartier et al., 2017). Also, in the framework of conflicting results about the differences between people's gender and their familiarity with biodiversity in studies in our region (Bermudez et al., 2017, 2018; Campos et al., 2012; Schwarz et al., 2012; Torres-Merchan et al., 2018; Zanini et al., 2020), what is in fact relevant and structuring for biodiversity education is that it lacks gender and socioeconomic neutrality (expressed as I.I.C.vii) (Bourdieu, 1984, 2000; Escovedo, 2014; Gessaghi, 2017; Locatelli, 2018; Loughland et al., 2003; Pointon, 2014). In formal contexts, sociocultural factors can begin to be addressed from the expressions and practices of the hidden curriculum, as much as by inviting teachers to consider recognition of their own identity, gender expression, and ascription to a certain social class. The sources of contact with biodiversity, both inside and outside the school, may reflect the influence of sociocultural factors, insofar as, as some studies point out, girls tend to associate more with plants in the garden whereas boys identify more with wild animals (Almeida et al., 2020; Campos et al., 2012).

Perception of biomes and ecoregions (I.I.D). The perception of biomes and ecoregions has been studied in Brazil and Argentina (Bizerril, 2004; Borges & Simião-Ferreira, 2018; de Almeida et al., 2019; de Sousa & da Silva, 2017; Schaaf et al., 2018; Schwarz et al., 2012; Zanini et al., 2020), with these studies indicating that there is a tendency to consider them to be pristine places, to be conserved, although the species or communities that make them up may not be native. The human is conceived to be a threat to the beauty and idealistic view of ecoregions (Schwarz et al., 2012; Zanini et al., 2020), but, at times, the environmental aesthetic qualities are perceived in an impoverished way (de Almeida et al., 2019). Although the influence of gender on familiarity with biomes has been less studied than that for flora and fauna (I.I.C.iv), the students' conception of biomes changes according to their gender (Schwarz et al., 2012). On the influence of the degree of urbanisation of their place of residence, contrasting results have been found (Bizerril, 2004; Zanini et al., 2020).

The above findings (I.I.D) have permitted us to identify the following critical issues for research and teaching practice. For example, the range of biomes and ecoregions studied is very limited (Amazon, Atlantic forest, Cerrado and Yungas) and is focused on terrestrial environments in a mega-diverse country such as Brazil (Bizerril, 2004; Borges & Simião-Ferreira, 2018; de Almeida et al., 2019; de Sousa & da Silva, 2017; Schwarz et al., 2012; Zanini et al., 2020). However, students' appreciations and knowledge of other ecological systems (equally or less biodiverse in taxonomic, phylogenetic and bio-cultural terms) and, specifically, about aquatic environments are unknown. In this regard, some teaching experiences and research on field trips or scientific camps have been developed in coastal areas or wetlands, but the inquiries made do not always systematise the knowledge and attitudes of students towards these environments.

It is a pending task in Latin America to increase the unit of analysis of species in educational research and to consider ecoregions and how these relate to climatic factors such as temperatures and precipitation, or the sets of adaptations of living beings in biomes. This would make it possible, for instance, to associate certain species, such as native ones, to specific communities or ecoregions, independently of the political-administrative limits with which the classifications of native versus exotic are usually made. Furthermore, focusing on the perception and knowledge of ecoregions will enrich the traditional biological perspective, including human activities and

culture as factors that shape the landscape (culture-nature, Montenegro Martínez, 2011). In this sense, it may provide an opportunity to study the dimensions that determine the differences in the classification of ecoregions and biomes, or of ecosystems of more or less equivalent territories, as well as fomenting the comparative appreciation of students from different political-administrative spheres of the same biome or ecoregion.

Teachers' Conceptions and Conceptual Understanding of Biodiversity

Research addressing the knowledge and conceptions of biodiversity of preservice teachers (I.2.A) has been carried out in Argentina (Vilches et al., 2014, 2016) and Chile (Aguilar-Correa et al., 2019), and also of in-service teachers (I.2.B, see details in Appendix 1) in Brazil (Barbosa et al., 2020; Bizerril & Faria, 2003; Ferreira Fonseca, 2007; Seniciato et al., 2009), Colombia (Serrato Rodríguez, 2011; Torres-Merchán & Rojas-Niño, 2017) and Venezuela (Carrero et al., 2011). Among the trends and critical issues for research and teaching practice, it is recognised that studies conducted with in-service teachers are more abundant than those with preservice teachers.

Knowledge and values of biodiversity, its conceptualisation and the benefits or the causes of its degradation have been limited to approaches that are mainly focused on an ecological (species-centred) and anthropocentric view, both in pre- (Vilches et al., 2014, 2016) and in in-service teachers (Seniciato et al., 2009; Serrato Rodríguez, 2011). These observations are in agreement with the findings from other regions (Fiebelkorn & Menzel, 2013), and highlight the need for the teaching of biodiversity to be reviewed and renewed in teacher training, in order to understand it from a holistic view, including cultural, social or economic aspects of diversity and how its loss affects all dimensions (Fonseca Amaya & Martínez Rivera, 2020; Pérez Mesa, 2019; Vilches et al., 2016). A research arena that has been developing in Latin America is the Professional Knowledge of the biology Teacher (PKBT) and the Pedagogical Content Knowledge (PCK) of biodiversity, which has firmly contributed to teacher training through contextualised and action-research studies (Fonseca Amaya, 2018; Fonseca Amaya & Martínez Rivera, 2013, 2020).

We have identified that the main topics that preservice teachers work on when teaching natural science content, such as botany or native ecosystems, include the life cycle of some species, taxonomy, and the general characterisation of the region (Figure 2) (Bizerril & Faria, 2003; Torres-Merchán & Rojas-Niño, 2017), but leave aside other content and expressions of biodiversity. It has been shown that in-service teachers and, in some cases, student teachers, demonstrate a terminological confusion or a lack of clarity about concepts related to biodiversity (e.g., exotic species, ecosystem services, charismatic species, evolution) (Torres-Merchán & Rojas-Niño, 2017; Vilches et al., 2014), which is in line with the findings of studies performed by Fiebelkorn and Menzel (2013), Oliveira and Liesenfeld (2020), Taskin and Ozgur (2019), and Torres-Porras and Alcántara-Manzanares (2019).

The scarce consideration of biological invasions and invasive alien species (IAS) as causes of biodiversity loss, highlights concerns about ecological conceptual formation, the implications of the affective dimension and the ways of understanding sustainable development issues (Bulut, 2021; Büssing et al., 2019; Esteve-Guirao et al.,

2019; Fiebelkorn & Menzel, 2013; Ladrera et al., 2020; Palmberg et al., 2017; Richter-Beuschel & Bögeholz, 2020). Further studies are needed on issues such as teachers' views on the concept of nature (Bulut, 2021), their plant blindness (Neves et al., 2019; Oliveira & Liesenfeld, 2020) and species identification skills, which are more established in other regions and are significant topics in terms of professional knowledge and educational influence on students (Melis et al., 2021; Palmberg et al., 2017; Skarstein & Skarstein, 2020; Yli-Panula & Matikainen, 2014). There is also a gap in knowledge regarding comparative studies on preservice teachers' knowledge and conceptions of biodiversity from different countries of Latin-American (c.f., Lindemann-Matthies et al., 2009, 2011).



Figure 2. Preservice Biology Teachers on a Visit to a Museum to Recognise Native Fauna of Local Environments from Argentina. Photo credits: M. E. Ottogalli.

From Interculturality

Students' Conceptions and Knowledge

It is worth noting that the conceptions of biodiversity constitute explanatory forms of life and its diversity, with differing forms of enunciation used by the different ethnic groups in Latin America. These conceptions refer to biodiversity as life in all its diverse manifestations, in which other entities are also included (water, rocks and air, among others) as a holistic network that keeps the diverse living beings interrelated, and integrates the tangible and intangible, and the human and the non-human, through differentiated representations and practices of nature (Donato et al., 2007; Pérez Mesa, 2013b, 2019). These interpretations of ethnic groups distance themselves from the conceptions and definitions provided by the West, which may be considered to be reduced and exclusive, as they establish a separation between the living and the non-living. In contrast, for different ethnic groups, other entities such as water, rocks, air, or stars cannot be excluded, since they also provide conditions for the possibility of life in its diverse manifestations, which correspond with their worldviews

(Boillat et al., 2012; Cárdenas, 2013; Navia-Imbachí & Tamayo-Alzate, 2020; Pérez Conguache, 2007; Ramírez, 2005).

Conceptions of biodiversity are closely linked to the knowledge systems of each culture and practices, which seek to maintain a holistic and relational vision of nature, the human being and the spiritual. These conceptions can include contributions in epistemic and ontological terms to provide an intercultural science education (Eimenekene et al., 2013; Pérez Mesa, 2013b, 2019). From the ontological point of view, there is no division between human beings and nature. Thus, the indigenous peoples find themselves forming part of the environment by living in it in a symbiotic way, with a perspective that transcends the material vision taking into account their interrelation with nature and the spiritual, which integrates a principle of reciprocity (da Silva & Ramos, 2019; Donato et al., 2007; Escobar, 2007; Navia-Imbachí & Tamayo-Alzate, 2020; Pérez Mesa, 2019; Ramírez, 2005).

Research on students' conceptions of biodiversity in the school context (II.1, see details in Appendix 1) has been carried out for different school grades, both in primary and secondary school, and to a lesser extent at the university level. Some of these studies have focused on identifying students' ideas about biodiversity in diverse cultural contexts. Under these scenarios, the notion of nature is closer as it forms part of the school content in science teaching, and also as an expression that circulates in different cultures with differentiated meanings (De la Cruz & Pérez, 2020; Molina et al., 2005; Navia-Imbachí & Tamayo-Alzate, 2020; Venegas-Segura, 2013). Comparative studies that have investigated the conceptions of biodiversity in rural and urban school contexts indicate that children and young people from ethnic groups and rural communities recognise various species of flora and fauna from local contexts, while students from urban contexts (school and university) follow school scientific knowledge (SCK), resulting in them having a poorer comprehension of local biodiversity features (González & Contreras, 2013; Molina et al., 2005; Páramo & Galvis, 2010).

Cultural knowledge is recognised as a dimension that forms part of the biodiversity construct, based on the relationships established between human activities and the dynamics of nature. This aspect provides a link between biological and cultural diversity, which is mainly due to the natural conditions of the territories and the practices and customs of the different cultures, as perceived by the students (De la Cruz & Pérez, 2020). The relationship between life and the living emerges as another perspective that addresses the biocultural sphere (Cárdenas, 2013). Research on the intuitive classifications of biodiversity in intercultural classrooms is an opportunity to recognise ways of ordering the world that are related to the knowledge systems of local communities, which are then transmitted to new generations and brought to the classroom. These approaches for classifying biodiversity are of special interest as they offer a criteria that goes beyond rational activity, by linking cultural and symbolic values for recognising and establishing distinctions between “Caatinga animals” (a Brazilian biome), “repugnant animals” and “production animals”, which form part of the local fauna (de Sousa & Freixo, 2020).

The above trends (II.1) have allowed us to identify the following critical issues for research and teaching practices, with investigation concerning the conceptions and knowledge of biodiversity in the school context

having revealed several considerations. On the one hand, the science curriculum's disconnection with the local environment in addressing biodiversity has been highlighted (Castillo-Segura et al., 2019). On the other hand, there is a disconnection between students' traditional ecological knowledge (TEK) with SCK in educational practices (Rocha & Santos, 2013). Finally, for some researchers, the complexity of the biodiversity concept is only understandable through conventional educational intervention (García et al., 2020). The disconnection of SCK and biodiversity with respect to the daily life and cultural contexts in which students develop (Wyner & Blatt, 2019), continues to represent an important challenge for implementing an intercultural and sensitive biodiversity education. Curricular proposals are required that promote a dialogue about knowledge and which take into account the recognition of diversity, differences and points of convergence through an intentional and mediating approach by science teachers (Baptista, 2015; da Silva & Ramos, 2019; Robles-Piñeros et al., 2020; Rocha & Santos, 2013).

The school context in its educational and social tradition constitutes a space to foster SCK. In this sense, it is intended, from a constructivist approach, to recognise initial ideas on biodiversity that are mainly based on the diversity of fauna and flora, and to provide teaching strategies that allow a level of conceptualisation according to the reference definitions (García et al., 2020). However, there are few proposals that have discussed the local knowledge systems that are brought into the classroom by students, the border crossings between knowledge, the negotiations about meanings, and the tensions that can arise in the teaching context (Castillo-Segura et al., 2019; Martínez, 2015; Páez-Rincón & Reyes-Roncancio, 2020).

As for the intuitive classifications made in school contexts, these have been investigated in an initial phase to be contrasted with phylogenetic classifications, which in some cases have been reduced to their being catalogued as erroneous in relation to the norms established in Western science. However, some recent efforts have proposed their integration in order to show the diversity of ways in which cultural groups refer to biodiversity and the classification criteria utilised according to local knowledge systems. These aspects may be of interest in the intercultural classroom by promoting border crossings, negotiation of meanings, and making tensions visible, thereby making it possible to value the plurality of visions regarding the diversity of species and their scope (de Sousa & Freixo, 2020; Robles-Piñero et al., 2020).

Teachers' Conceptions and Knowledge

Research on the conceptions and knowledge of biodiversity of preservice (II.2.A) and in-service teachers (II.2. B, see details in Appendix 1) from a cultural approach in the Latin American context has allowed us to recognise: the diversity of world views about the close relationship between human beings and nature, the body of knowledge that forms part of the history of the communities, and the practices related to various species of fauna, flora and the environment in which ethnic peoples, rural or urban communities develop, as references of the multiethnic and multicultural reality of different nations. This knowledge can provide significant contributions concerning the approach to biodiversity education in the curriculum, and towards the initial and ongoing training of science teachers (Castaño, 2008; Porras, 2017; Robles-Piñeros et al., 2020; Sierra, 2010). Different forms of construction and appropriation of knowledge that are dynamic in the cultural contexts, of

which the future biology teachers are a part, should also be recognised.

Investigation into conceptions of biodiversity has revealed diverse forms of enunciation that can give meaning and significance to the term. In the case of preservice biology teachers belonging to ethnic peoples (II.2.A), the predominance of the knowledge system of their cultures refers to the close link between the human being, nature and the spiritual from a holistic vision of equality with the different entities with which they coexist in the territory on a local scale. On the other hand, investigation of conceptions of biology preservice teachers in the urban context has revealed that academic and scientific schemes predominate in their conceptions formed from more theoretical expressions (Pérez Mesa, 2013b, 2019). The conceptions of biodiversity of teachers with an initial training in disciplines different to biology or natural sciences provide other considerations regarding their potential for promoting interdisciplinary science or in determining the need for training courses with specific disciplinary knowledge in health care and prevention. Research dealing with art preservice teachers has noted the recognition of the existence of the diversity of flora and fauna in a particular territory and the intentionality of establishing different forms of articulation with the artistic field (Castañeda, 2020). On the other hand, an investigation with pedagogy students about the conceptions of biodiversity, especially concerning “poisonous” species, warns about conceptual errors in the identification of snakes and spiders, and the need to provide specific courses with a disciplinary knowledge that promotes personal care and projection in their work, so that as future educators, they can help to prevent accidents occurring with these species (Guerra, 2020).

The study of conceptions in science teaching has been part of a line of research that, over several decades, has focused on recognising the previous or alternative ideas of students and teachers in initial training from a constructivist approach, and with a mono-cultural curriculum that has had a wide deployment of teaching proposals to move towards a school scientific knowledge, such as cognitive change or progression hypotheses, among others. However, in recent years, an attempt has been made to address conceptions from more plural perspectives by not viewing local and traditional knowledge as an obstacle to science learning, but instead as providing an opportunity to conceive an education that is sensitive to interculturality, which combines different visions to contribute to an improved knowledge and conservation of biological and cultural diversity (Pérez Mesa, 2013b, 2019).

In-service teachers’ conceptions (II.2.B) have an impact on their teaching practices. It has been noted that teachers belonging to ethnic groups conceive nature as a “living classroom” and establish relationships between TEK and SCK in their teaching practices (Iyokina Gittoma & Peña Trujillo, 2015; Zidny et al., 2020). On the other hand, although teachers working in rural contexts recognise their students’ TEK and that of the local community, they do not integrate them into biodiversity teaching practices to enable intercultural dialogue (Araujo & Baptista, 2020; Rocha & Santos, 2013).

Research on preservice (II.2.A) and in-service teachers (II.2.B) has been carried out in Colombia and Brazil, with studies performed on the conceptions of biodiversity from a cultural approach. These countries have an important biological and cultural diversity, and their findings offer interesting insights regarding the construction of knowledge and its relationship with biodiversity, which are now beginning to be analyzed from

the perspective of education, especially with regard to the possibilities of the thinking curricula and educational practices that make intercultural dialogue viable (Araujo & Baptista, 2020; Pérez Mesa, 2019; Rocha & Santos, 2013).

The above trends (II.2) have permitted us to identify the following critical issues for research and teaching practice. The conceptions of biodiversity of preservice teachers (II.2.A) who belong to indigenous peoples present a holistic vision of life, by linking nature, the human being and the spiritual as an interrelated whole. From their worldviews, knowledge and practices, these preservice teachers consider the conceptualisations of biodiversity provided by the West to be limited (insofar as life is separated from the spiritual) and fragmented (by maintaining the distinction between the living and the non-living), for which reason, the knowledge system of their base culture is privileged (Pérez Mesa, 2013b, 2019). However, further research is needed to broaden the discussions in the Latin American context.

Research on the conceptions of biodiversity has been mainly conducted with teachers in initial training and with in-service teachers in the areas of biology and natural sciences. However, more recently, studies have been carried out with teachers from other areas of knowledge, such as arts or pedagogy (Castañeda, 2020; Guerra, 2020), which have suggested possibilities for incorporating interdisciplinarity, given the multidimensional nature of biodiversity (Bermudez & De Longhi, 2015; Castro Moreno et al., 2021; Santos & Salcedo, 2014). This may provide other ways to develop more inclusive, enriched and plural educational projects. Some research has focused on the treatment of aspects of biodiversity in textbooks, especially concerning the conceptual, procedural and attitudinal dimensions, and also the existing conceptions that practicing teachers have about this resource for teaching botany in diverse cultural contexts. These studies show how Western scientific content prevails in teaching materials, with evident limitations in practical activities, which poorly integrate the diversity of the local environment and hinder intercultural dialogue (Flores et al., 2020; Odorcick & Wirzbicki, 2018).

Research with in-service teachers (II.2.B) in diverse cultural contexts, especially with bilingual teachers working in indigenous communities, has revealed the relationship between the ways of conceiving biodiversity and teaching practices. When nature is conceived as a “living classroom”, it is constituted as an instance that facilitates dialogue between TEK and SCK, with the participation of savants in an intercultural dialogue involving teachers, students, community and nature (Iyokina Gittoma & Peña Trujillo, 2015). Other research with in-service teachers (II.2.B) working in local communities and who have been asked about TEK and SCK in biodiversity, has shown that although the TEK of the students is recognised, it is not integrated into teaching practices. Hence, ruptures are created between the students’ daily life in the contexts in which they develop, and the contents and didactics for teaching biodiversity at school (Araujo & Baptista, 2020; Rocha & Santos, 2013).

Other Groups’ Conceptions and Knowledge

Indigenous women (II.3.A). Research performed on indigenous women’s conceptions and knowledge of biodiversity (II.3.A, see details in Appendix 1) has revealed the role of women belonging to various ethnic groups of diverse cultures living in Colombia and Guatemala, in terms of their worldviews, knowledge and

management of wild and cultivated biodiversity, as another perspective that in recent years has begun to be linked to studies of science education with a gender approach (Donato et al., 2007). In addition, a distinction has been noted in the ways in which women from indigenous peoples and rural communities conceive biodiversity, identified from their types of knowledge relating to biodiversity. In this case, women are bearers of ancestral knowledge that is transmitted through oral communication and practices that are especially associated with the cultivation of life, and related to their own educational scenarios such as the *chagra* (polyculture) (see Figure 3), where knowledge and practices are passed down to new generations and contribute to strengthening culture and identity, as well as the conservation of biodiversity (Álvarez, 2005; Pérez Conguache, 2007; Ramírez, 2005).



Figure 3. The *chagra*, a Scenario for Learning for the *Uitoto-Muruy* Ethnic Group of La Chorrera-Amazonas (Colombia). Photo credits: M. R. Pérez Mesa.

The above findings (II.3.A) have identified the following critical issues for research and teaching practice. First, the conceptions of biodiversity held by women belonging to indigenous peoples or rural communities propose a dynamic relationship between nature and the human being. As nature represents life, each entity that integrates it is considered to be a constituent part of biodiversity. Society and nature here form a unity that is expressed through their worldviews, knowledge systems and practices, which maintain a relationship of reciprocity rather than that of domination, as present in the dominant culture (Álvarez, 2005; Boillat et al., 2012; Pérez Conguache, 2007; Ramírez, 2005). As women and men from different cultures establish differentiated relationships with the territory and biodiversity, we seek to visualise the role of women as participants in the processes of cultivating the life and sustenance of communities that form part of a historical process and a cultural base that provides a plural perspective, both epistemic and ontological. This can become a reference

point for discussion in policies and strategies for biodiversity conservation and environmental sustainability (Álvarez, 2005; Donato et al., 2007; Pérez Conguache, 2007; Ramírez, 2005).

Other settlers (II.3.B). Studies have been performed on the perceptions of biodiversity and the conservation practices of other people in local communities (II.3.B, see details in Appendix 1) that have some degree of relationship with protected areas, or with areas of interest due to the wild diversity of their territories. A plurality of visions has been noted, especially with regard to the issues that compromise the diversity of some species and ecosystems (Martínez & Manzano, 2016). Investigations about the perceptions of biodiversity of local communities is a way to assess their knowledge and practices, permitting the identification of epistemic dimensions and their degree of involvement in the processes and strategies utilised for the conservation of wild species and species in captivity in protected areas. Therefore, better results can be obtained by integrating local knowledge and scientific knowledge through workshops on species management, through developing balanced diets for captive animals, and by the identification of important wild forage species for animal nutrition in the environmental management unit (Martínez & Manzano, 2016; Sandoval Rivera, 2018). Intuitive classifications of biodiversity made by local communities are based on the system of TEK for grouping animal and plant species, in which the symbolic, ontological and use values that form part of their cultural values in relation to the territory they inhabit are decisive (Correa et al., 2012). The classification systems of different cultural groups include a series of criteria associated with the knowledge and symbolic aspects of representations of the fauna and flora, which respond to the complex relationships between the social systems and the ecological systems that form part of the dynamics of the territory (Millán-Rojas et al., 2016).

The above trends (II.3.B) allow us to identify the following critical issues for research and teaching practice. In a study on perceptions of biodiversity associated with protected areas, or with areas of interest due to the presence of wild species, a dichotomy in the relationship between nature and society is evident, an aspect that needs to be considered when establishing conservation strategies that enable joint and effective participation with local communities (Martínez & Manzano, 2016). Educational proposals that link local communities, their worldviews, knowledge and practices from participatory processes can contribute to ecosystem and wildlife conservation processes in a better way than when they are established unilaterally by researchers and academics using so-called expert knowledge and policies. These proposals can become a model for the dialogue of knowledge in an exchange of experiences and practices that articulate interculturality and sustainability through collective reflection, and which can contribute both to the conservation of species and address the problems of local communities and the transformation of realities (Martínez & Manzano, 2016; Sandoval Rivera, 2018).

Finally, intuitive classifications of biodiversity permit us to recognise the knowledge systems of local communities that express the criteria of use, aesthetic value or medicinal properties, among others. These types of classifications operate using different logic to those established by WSK, in which rationality predominates, separating the moral dimension from feelings and emotions. For local communities, however, they form part of a whole in their ordering of the world, as highlighted in these classifications (Correa et al., 2012; Millán-Rojas et al., 2016).

Conclusions and Final Remarks

Considering the panorama of scientific production on biodiversity education, it can be concluded that there is a wealth of topics in Latin America that could contribute to the formulation of research and practice agendas, both in the region and in other regions of the world; in particular, concerning people's (students, teachers and inhabitants) conceptions and knowledge of biodiversity. However, the particularities of the realities and dynamics of local contexts must be recognised in order to avoid the formulation of reductionist educational agendas on this topic and applicationist teaching.

The study of the conceptions of biodiversity has begun to be considered a strategic issue to be addressed in the field of science and biology education, but it is only just starting to appear as a subject of research and reflection in teacher training programmes (mainly for preservice teachers). In these areas, a predominance of classical views from conventional scientific knowledge (with a variable degree of updating between CBD and IPBES) can be observed, and in which alternative conceptions and knowledge of biodiversity are considered to be "poor" or "basic". However, because of the importance to science education, the growing interest in SSI (Evagorou & Puig Mauriz, 2017; Karahan et al., 2017; Minken et al., 2021), such as biodiversity loss, protection and management, may act as a vehicle to promote students' understanding of a contextualised nature of science (NOS) (Karisan & Zeidler, 2017).

Moreover, the disconnection with the cultural context and the diversity of cultures in many of the studies surveyed is in agreement with processes of loss of biocultural diversity in the region, within a framework of increasingly accentuated processes of displacement and marginalisation of ethnic, Afro-descendant and peasant groups (Pérez Mesa, 2013b). Hence, the erosion of ancestral knowledge, the violation of peoples' identities and the ignorance of local biodiversity (from the most inconspicuous components to the biomes) require relevant educational proposals that are sensitive to intercultural dialogue, in relation to the contexts and realities of Latin America, which is one of the most biologically and culturally diverse, as well as unequal, regions on the planet. The natural environment, through its diversity, offers an ample source for the development of indigenous thought, and also TEK, especially if one considers the systems of ordering, classification and relationships with nature, which are part of their millenary knowledge and cultural practices (Martínez, 2015; Millán-Rojas et al., 2016; Páez-Rincón & Reyes-Roncancio, 2020; Robles-Piñero et al., 2020).

Therefore, it is important to recognise that science education and teacher training require proposals that contemplate the complexity of the configuration of conceptions from cultural perspectives, as well as the opportunity to envisage science teacher training that is sensitive to cultural contexts, diversity and difference (Marques & Xavier, 2021; Molina et al., 2014; Pérez Mesa, 2019; Yuen, 2010). All these elements pose important challenges for research, with the generation of public policies and the configuration of contextual educational proposals, in a framework in which environmental realities and issues challenge humanity, in order to protect biodiversity and climate. We urge international and national government agencies to take advantage of the academic educational production on biodiversity, which can contribute to the question of which biodiversity we will conserve and for whom, given that its extinction is also (previously) expressed in

alternative conceptions, social representations and ancestral knowledge.

Finally, we wish to stress that teachers should not reduce the intercultural perspective of biodiversity when addressing the origins and worldviews of students, and in this way forgetting that teachers' experiences and perceptions are also shaped by their cultural origins. Moreover, while teacher training does not usually pay explicit attention to the recognition of cultural identities and roots, we believe it is necessary to consider biodiversity as a structuring axis of biology education, and to contemplate the different epistemologies and interrelationships between cultures and the diversity of life, which implies an openness to other epistemologies and exchanges of knowledge that involve a decentring of conventional science (Pérez Mesa, 2013a). Towards the aim of this being achieved, this article may represent a significant contribution for teachers and environmental, sustainable development and science education researchers in order to help them encounter a broad, detailed and intercultural description of conceptions and knowledge of biodiversity, which will enrich their teaching and learning sequences.

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Appendix 1. Source (Authors and Year of Publication, Country and Studied Group) and Main Contributions of a Selection of Academic Productions on Biodiversity Conceptions and Knowledge in Latin America

Source	Country and Studied Group	CODE	Main Contribution
Barbosa et al. (2019)	Brazil, 3 rd Grade High-School Students	I.1.A	Importance Of Biodiversity For Animal Survival, With An Anthropocentric Perspective. The Most Perceived Ecosystem Services Provided By Biodiversity Are The Supply Of Fresh And Potable Water And Food. Some Others Less Recognised Include Temperature Regulation And Pollination. The Causes Of Biodiversity Loss Are: Deforestation And Fires, Pollution, Improper Waste Disposal, Use Of Pesticides, And Wildlife Trafficking.
De La Cruz And Pérez (2020)	Colombia, 9 th Grade Students	I.1.A	Biodiversity At A Basic Level: Variety Of Organisms.
		I.1.B.i.a, b and c	Recognition Of Several Life Forms, Genetic Composition, Ecosystems And Relationships Between Living Beings.
Ferreira Fonseca (2007)	Brazil, 3 rd Grade High-School Students	I.1.A	Biodiversity As Variation In The Species Number. Recognition Of The Causes Of Biodiversity Loss (Destruction And Fragmentation Of Habitat, Exploitation And Pollution). Textbooks And Curriculum Materials Are Not Related To The Amazon Region.
Vilches et al. (2018)	Argentina, High School Students (Aged 15-19)	I.1.A	Biodiversity As A Set Of Species, As Variety And Diversity Of Life.
		I.1.B.iii.a AND I.1.C.i	Students List The Tiger, Elephant, Giraffe, Polar Bear, Gorilla, Panda, Kangaroo, And Ostrich As Alien Species. The Deer Is Named As An Exotic Species, Although There Are Also Native Deer Species In Argentina, As Well As Those Introduced.
Bermudez and Lindemann-Matthies (2020)	Argentina, High School Students (15-19 Years Old)	I.1.B.i.a, b and c	Ideas About “Variation” Such As “Number Of” And “Divergence In” Were Used For Species, Species Types And Interactions Between Species.
		I.1.B.ii.a, b, c, d and e	Undervalued Components For Conserving Biodiversity: Species, Alpha Diversity, Population Size, Trophic Relationships, And Range Within A Functional Group.
		I.1.B.iii.a	Corn Is Valuable For Conservation As Long As It Is Considered To Be Native.
		I.1.B.iii.b	Edible Plants (E.G., Vegetables), Or Their Parts, And Genetically Modified Organisms (Gmos) Are Not Part Of Biological Diversity.
		I.1.B.iii.c	Preference For Conserving The Species Whose Organisms Are Large.
Arias Santos (2017)	Colombia, High School Students (Aged 16-18)	I.1.B.ii.d	Trophic Interactions Between Animals (Predator-Prey Model) Are Recognised, Unlike Those Between Herbivores And Plants. Models Of Species Interactions Only Have Non-Native Representatives (Foreign Species).
De Souza et al. (2017)	Brazil, Students From 5 th To 8 th Grade (13 Years Old, On Average)	I.1.B.iii.a	Occurring Species That Are Easy To Find Or That Can Be Found At Home Are Recognised As Being Native. Exotic Species Are Those Difficult To Find, Such As Rare Ones.
Bermudez et al. (2017)	Argentina, High School Students (15-19 Years Old)	I.1.C.i	65% Of The Listed Animal Taxonomic Categories Are Native Species, As Well As 4 Out Of The 5 Most Cited Animals (With The Exception Of The Hare, Which Is A Naturalised Exotic Species). Exotic Animals Represent 26% Of Those Mentioned By Students, With The Majority Consisting Of Domestic Animals, Such As Horses, Dogs, Cats, Etc. (7% Of The Listed Species). Only 2% Are Non-Domestic And Non-Naturalised Exotic Animals, Such As Lions, Zebras, Etc., And Only 9% Of Listed Species Are Of Mixed Origin.
		I.1.C.ii.a	Most Of The Animals Listed Are Native Mammals (Approx. 54%).
		I.1.C.iv	Boys Name More Animals Than Girls.
		I.1.C.vii	Students From Private Schools Mention More Native Animals Of The Regions Of Argentina Than Those Who Come From Public (State) Schools, With The Latter Naming More Domestic Animals And Native Ones From The Local Area.

Bermudez et al. (2018)	Argentina, High School Students (15-19 Years Old)	I.1.C.i	Students List Fewer Taxonomic Categories Of Plants Than Of Animals (165 < 216). Most Of The Mentioned Native Plant Categories Are, In Fact, Exotic To Córdoba (63%) Or Argentina (50.6%), Of Which 33.8% Are Adventitious (Naturalised Exotic Plants Such As Pines And Privets), Representing 17% Of The Mentions. The 20 Most Named Plant Species Are Mainly Native, Such As Mezquite (<i>Prosopis</i> Spp.) And <i>Espinillo</i> (<i>Vachellia Caven</i>).
		I.1.C.ii.b	Most Named Plants Are Trees And Shrubs, Although The Most Representative Life Form Within The 165 Plant Taxonomic Categories Are Herbs (Forbs + Grasses = 38%; Trees = 32%; Shrubs = 24%; Others = 6%).
		I.1.C.ii.c	Size, Colour And Floral Aroma Are Defined As Conspicuous Ecological Characters (Cec). The Highest Cec Values Are The Least Represented In The Students' Plant Free-Lists For Native And Exotic Species, With The Exception Of Adventitious Ones. Listed Native Plants Have Moderate And Low Cec Values (E.G., Mezquite, Roman Cassie And Silk Floss Tree). The Most Frequently Named Exotic Species Are Pines (No Flowers), Eucalyptus And Roses, Whereas The Most Salient Adventitious Plants Are Privet, Mulberry And White Cedar (Medium Cec Values).
		I.1.C.iv	No Gender Differences Occur Between Girls' And Boys' Free-Lists Of Plants (Considered To Be Native).
		I.1.C.vii	The Proportion Of Listed Plants And Listed Native Species Of The Local Area (Córdoba) Is Higher In Students From Public Schools Than From Private Schools. Students From Private Institutions List A Higher Proportion Of Plants Native To The Country (Argentina) And Of Adventitious Species.
Campos et al. (2012)	Argentina, Students From 7- To 18-Years-Old	I.1.C.i	Students List More Plants Than Animals (257 > 220). Only 3 Of The 10 Most Named Plants Are Native (10% In Total). The Remaining 7 Are Ornamental And Have An Exotic Origin, Such As Rose, Jasmine Or Daisy. Only 2 Of The 10 Most Mentioned Animal Species Are Native (5% In Total), While Domestic And Exotic Species Prevail In Students' Lists (E.G., Horse, Dog, Etc.).
		I.1.C.ii.a and I.1.C.iii	No Uncharismatic Animals And Only A Few Invertebrates Are Listed By Students.
		I.1.C.ii.c	The Most Named Plant Species Are Ornamental Ones With Prominent Floral Characters, Such As Roses, Jasmynes And Daisies.
		I.1.C.iv	Girls Mention More Ornamental Plants Than Boys, While The Latter Name More Wild Plants Than Girls. Boys List More Native Species Than Girls.
		I.1.C.v	Rural Boys Name More Native Species And More Birds, Insects, Reptiles And Amphibians Than Rural Or Urban Girls.
		I.1.C.vi	Young Children Learn About Plants And Animals Through Non-Direct Contact, Such As In Books, On Television, Or The Internet. However, The Countryside Is An Important Place For Students To Become Acquainted With Animals In Rural Contexts.
Schaaf et al. (2018)	Argentina, Students Aged 12 And 13	I.1.C.i	More Than 60% Of The Students Consider Pines, Poplars And Eucalyptus To Be Native Trees Of The Local Ecoregion (Yungas), Although They Are Exotic Species. Among The Native Ones, They Correctly Name The Cockspur Coral Tree (<i>Erythrina Crista-Galli</i>), Jacaranda (<i>Jacaranda Mimosifolia</i>) And Creole Oak (<i>Amburana Cearensi</i>). Students Correctly Identify Charismatic Species Of Animals Such As The Toucan Or The Jaguar, But With Less Success For Other Organisms, For Which They Even Assign Indeterminate Names Such As "Parrot".
		I.1.D	Most Students Consider That Native Forests Are Complex Ecosystems That Develop Naturally And That Are Formed By Species That Have Adapted To Local Conditions Over A Long Time. Half Of The Respondents Perceive That Native Forests (Yungas) Are Important For Providing Ecosystem Goods And Services, As Well As For Providing A Habitat For A Large Number Of Species.
Schwarz et al. (2012)	Brazil, 1 st To 8 th Grade Students (6-14 Years Old)	I.1.C.i	Only 1 Of The 10 Most Named Species Of Plants Is Native (Orchid) To The Local Biome (Atlantic Forest), With The Rest Of Them Being Ornamental Plants Or Food, Such As Rose, Daisy And Royal Palm. 77% Of The Named Animal Species (Belonging To 97 Different Taxa) Are Native To The Atlantic Forest, While The Remaining Species Are Iconic Exotic Fauna, Such As The Tiger, Lion And Elephant.
		I.1.C.ii.a	Non-Charismatic Animals And Invertebrates Are Rarely Mentioned In Students' Free Lists.

		I.1.C.ii.b	Trees And Grasses Are Prominent In Students' Drawings. The Palm Tree Frequency Is The Same As The Representation Of Shrubs In Students' Drawings.
		I.1.C.iii	Children Experience Significant Difficulties When Answering Questions About Microorganisms. Children Are Aware Of The Existence Of These Organisms, But Cannot Classify Them Easily.
		I.1.C.iv	There Is No Gender Difference Between Girls' And Boys' Free-Lists Of Species Considered To Be Native To The Atlantic Forest.
		I.1.D	The Atlantic Forest Is Depicted As An Ideal And Beautiful Place. The Younger The Child, The Better Preserved The Atlantic Forest Is In The Students' Drawings. Girls Depicted More Natural And Unspoilt Landscapes Than Boys.
Zanini et al. (2020)	Brazil, 16- And 17-Year-Old Students	I.1.C.i	Native Animals And Plants Are More Frequent In Students' Drawings Of The Atlantic Forest Than Exotic Species.
		I.1.C.iv	Girls Draw More Native And Exotic Animals Than Boys.
		I.1.C.v	The Number Of Mentions Of Native And Exotic Animals And Plants Does Not Differ Significantly With Respect To The Degree Of Urbanisation In The Students' Place Of Residence.
		I.1.D	Drawings Of The Atlantic Forest Reveal That Students See This Biome As An Unspoilt And Distant Place For Human Beings, With The Latter Only Being A Destructive Agent. This Representation Decreases As The Percentage Of Urbanisation Of The Students' Place Of Residence Increases.
Borges and Simião-Ferreira (2018)	Brazil, 7 th -Grade Elementary School Students	I.1.C.i	Students Name Exotic Taxa (From Other Biomes) As Native Faunistic And Floristic Representatives Of The Cerrado Biome.
Dias and Dos Reis (2018)	Brazil, 8 th -Grade Students Of Elementary Education	I.1.C.i	The Percentage Of Success In Identifying 50 Photographs Of Animals Native To The Cerrado (A Biome) Is Lower Than That Of The Exotic Species, With Maximum Identification Scores Obtained For Lion, Giraffe And Elephant.
Salas (2018)	Colombia, 12-Year-Old Students (From 4 th To 9 th Grade)	I.1.C.i	Native Species Of The Local Environment, Such As The <i>Machaca</i> And <i>Pava Hedionda</i> (Smelly Turkey), Are Considered To Be Exotic Animals By Students.
		I.1.C.ii.a and I.1.C.iii	High Familiarity With Mammals, With The Panda, Spectacled Bear And Koala Topping The Students' Lists Of Animals To Save From Extinction. Most Of The Listed Species Are Known As Charismatic Ones.
		I.1.C.v	Recognition Of Animal Photographs Is Similar Between Students Attending Rural And Urban Public Schools. The Students' Preferences For Animal Protection Are The Same In Rural And Urban Contexts.
Torres-Merchan and Medina Peña (2014)	Colombia, Students Between 8- And 13-Years Old	I.1.C.i	Preference For Domestic And Exotic Animals. Students Base Their Preference On Species Aesthetic Qualities And The Assumption That Domestic Species Are "Good".
De Sousa And Da Silva (2017)	Brazil, 8 th - And 9 th -Grade Students Of Basic Education	I.1.C.ii.a and I.1.C.iii	High Familiarity With Mammals. Invertebrates And Reptiles Are Mentioned In Second Place. Fish Are The Least Named And In A Nonspecific Manner.
		I.1.D	Students Associate The Caatinga Biome Mainly With Abiotic Factors, And Are Less Inclined To Perceive It In Terms Of Its Rich Biodiversity. However, Students Are Able To Name A Number Of Species From The Caatinga Biome, Especially Mammals.
Torres-Merchan et al. (2018)	Colombia, Students Aged 7-13 Of Basic Education	I.1.C.ii.a	High Familiarity With Mammals. Birds Are The Second Taxa That Received The Most Citations By Students.
		I.1.C.iii	Ophidians, Bats, And Arachnids Are Known To Cause Fear And Disgust.
		I.1.C.iv	Boys Like Reptiles, Arthropods And Amphibians More Than Girls. With Age, The Percentage Of The "Nice" Option Increases For Reptiles, Birds And Mammals. Girls Have A Greater Preference For Brightly Coloured Species Such As The Hummingbird, Chameleon And Butterfly. Boys Tend To Show A Greater Affection For The Coral Snake, Tarantula And Red-Eyed Frog Than Girls.

		I.1.C.v	Students From Urban Places Of Residence Tend To Consider Mammals As Being More Pleasant Than Their Rural Peers. Conversely, Reptiles, Arthropods And Amphibians Are More Pleasant For Children In Rural Contexts.
		I.1.C.v and I.1.C.vi	In Both Urban And Rural Areas, Television And The Internet Are The Main Sources For Fauna And Flora Identification (Mammals, Reptiles And Birds, Mainly In The Case Of Exotic Species).
De Sousa and Freixo (2020)	Brazil, 7 th - And 9 th -Grade Students Of Elementary Education	I.1.C.ii.a and II.1	High Familiarity With Mammals. Birds Are The Second Most Cited Taxonomic Group. Students' Intuitive Classifications Of Animals Were, For Example, "Caatinga Animals", "Disgusting Animals" And "Production Animals". These Classifications Reveal The Symbolic And Cultural Values That Students Assign To The Native Or Exotic Fauna Of The Environment Where They Live. Through A Dialogue Of Knowledge, Students Were Encouraged To Establish Similarities And Differences Between The Ways Of Grouping Animals, As A Way To Link Intuitive Classifications With Phylogenetics (Cladograms, Common Ancestor, Monophyletic Groups, Etc.).
De Almeida et al. (2015)	Brazil, High School Students	I.1.C.iii and I.1.C.v	The Jaguar Is Valued In The Rural Context. However, Even In Students From The Same Region, This Animal Is More Associated With Danger And Terror By Those From Urban Settlements.
Rivera Losada and Amórtegui Cedeño (2015)	Colombia, 8 th Grade Students (13-16 Years Old)	I.1.C.iii	Bats Are Referred To As "Nocturnal Birds" By Students And, Despite Being Able To Identify The Animal's Fingers, Students Disregard Other Morphologies, Adaptations And Ecosystem Roles. Bats Are Perceived As Having A Bad Reputation.
De Almeida et al. (2019)	Brazil, Secondary School Students (14-18-Years-Old)	I.1.C.iii	Students' Appreciation Of The Cerrado (A Biome) Plant And Animal Representatives Is High, Whereas Negative Attitudes Prevail Towards Fungi, Bacteria And Protozoa.
		I.1.D	The Amazon Rainforest Is The Most Appreciated Ecosystem By The Students. The Aesthetic Consideration Of The Cerrado Biome (I.E., Where They Live) Is That Of Deserts.
Schwarz et al. (2007)	Brazil, Students From 1 st To 8 th Grade Of Basic Education (6-14- Years-Old)	I.1.C.iv	Girls' Drawings Of The Atlantic Forest (Biome) Are Richer In Flowers And Butterflies Than Those Of The Boys, Whose Pictures Show More Trees, Birds And Other Animals, As Well As The Human Presence.
Eyssatier et al. (2017)	Argentina, Students Of 11- And 12-Years-Old	I.1.C.v	Students' Plant Knowledge In Northern Patagonia Show Similarities Between Those Inhabiting The Same Type Of Socio-Ecological Environment (Urban, Semi-Urban, And Rural). Children From Rural Contexts Mention A Greater Number Of Plants (Including More Trees And Herbs), More Native Ones And More Species With Medicinal And Alimentary Use Than Children From Urban Or Semi-Urban Areas.
Bizerril (2004)	Brazil, Students With An Average Age Of 13	I.1.D	Some Students Think Of The Cerrado As The Xeromorphic Vegetation Found In Arid And Desertic Regions. Students Describe The Cerrado As A Dry Landscape Where Animals Suffer Because Of The Dry Conditions. However, Favourable Opinions On The Cerrado Prevailed, With No Differences Among Students' Place Of Residence (Urban, Semi-Urban And Rural Landscapes). Textbooks Have Not Developed Contents Related To The Cerrado Biome.
Borges and Simião-Ferreira (2018)	Brazil, 7 th -Grade Elementary School Students	I.1.D	Students' Pictures Of The Cerrado Biodiversity Showed A Completely Preserved Natural Environment. There Is A Lack Of Information About The Cerrado Biome In Textbooks.
Vilches et al. (2016)	Argentina, Undergraduate Teachers Of Biological Sciences And Geography	I.2.A	Undergraduate Teachers Have A Simplified Concept Of Biodiversity, Reduced To An Ecological And Anthropocentric Perspective. The Main Causes Of The Loss Of Biodiversity Are Human Population Growth And The Loss And Degradation Of Habitat. The Introduction Of Exotic Species Is Neglected.

Vilches et al. (2014)	Argentina, Undergraduate Teachers Of Biological Sciences At A Non-University Educational Institute	I.2.A	Undergraduate Teachers Have No Difficulty In Defining The Concept Of An Exotic Species, But They Describe Exotic Taxa As Being Rare Or Endemic Species. There Is A Simplification Of The Concept Of Biological Invasions, Since It Is Limited To The Introduction Of A Large Number Of Specimens Of Exotic Species. Only The Ecological Consequences Of Biological Invasions Are Taken Into Account.
Aguilar-Correa et al. (2019)	Chile, Undergraduate Teachers	I.2.A	Undergraduate Teachers' Perceptions Of Ecosystem Services Are Linked To The Concept Of Goods Provisioning And Non-Material Services. Associations To Environmentalism Are Made, Such As Following The 3r-Approach (Reduce, Reuse, Recycle). Some Students Consider That Ecosystem Services Are Guaranteed By Government Institutions. Native Forests Are Considered As A Valuable Pedagogical Learning Scenario.
Ferreira Fonseca (2007)	Brazil, Teachers And 3 rd Grade High-School Students. Analysis Of Textbooks And Curricular Proposals	I.2.B	Biodiversity Is Conceived By Teachers As The Variation In The Number Of Species. Recognition Of The Causes Of Biodiversity Loss (Destruction And Fragmentation Of Habitat, Exploitation And Contamination). General Aspects Of Biodiversity, Of The Amazon Biodiversity And Sustainable Development Are Poorly Founded On Scientific Information.
Barbosa et al. (2020)	Brazil, Teachers Attending A Distance Training Course	I.2.B	The Most Important Topics Taught About Botany Are The Environmental Importance Of Plants, Photosynthesis, Classification And Taxonomy, And Life Cycle. Biodiversity Is One Of The Least Mentioned Topics. The Most Used Strategies And Activities Developed By Teachers Are Lecture Classes With The Use Of Slides Or Figures, And The Blackboard.
Bizerril and Faria (2003)	Brazil, Directors And Teachers From 5 th -To-8 th Grade Primary Schools	I.2.B	A General Characterisation Of The Region (Climate, Relief, Distribution Of The Biome) Is Taught In A Descriptive Manner, With A Reduced Analysis Of The Biological And Cultural Diversity Of The Biome And Of The Negative Impacts Caused By Anthropic Actions. Difficulties In Teaching Are: Lack Of Awareness And Knowledge Of Teachers, Reduced Communication Between Research Organisations And Schools, Lack Of Educational Material, Budget And Time, And Lack Of Interest.
Seniciato et al. (2009)	Brazil, Ecology Teachers At The Higher University Level (Bachelor's Degree Program In Biological Sciences)	I.2.B	Development Of A Proposal With Biodiversity Teaching Perspectives Focused On Aesthetics, Referring To What Guides And Influences Feelings About Natural Environments, Which Goes Beyond Emotions. Ecology Instructors Tend To Valorise Scientific And Objective Criteria, Demonstrating A Certain Embarrassment On Including The Aesthetic Dimension In Their Teaching. However, They Recognise The Relevance Of The Aesthetic Dimension For Ethical Implications On Teaching And For The Conservation Of The Natural Environment.
Torres-Merchán and Rojas-Niño (2017)	Colombia, Teachers Of Rural Primary Schools	I.2.B	Non-Charismatic Species Are Not Taught As A Specific Topic By The Teachers. Instead, These Species Are Implicitly Taught In The Framework Of Other Contents, Such As Reproduction, Ecosystems, Living Beings, And Conservation Of Biodiversity. Teachers Affirm That The Importance Of Invertebrate Conservation Is Not Studied In A Meaningful Way In The Classroom.
Serrato Rodríguez (2011)	Colombia, Teachers Of Biology, And Of Biology And Chemistry	I.2.B	Botany Is Approached From A Taxonomic And Biological Viewpoint (Taxonomic Classification Of Plants, Physiology And Medicinal And Industrial Uses), With Emphasis On The Value Of Classification For The Recognition Of Biodiversity. Some Teachers Are Able To Improve On Visions Of Botany Linked To Taxonomy, And Cover The Interactions Of Plants With The Environment (For Example With Environmental Conditions Or With Other Organisms). Botany Is Conceived By Teachers As A Pretext That Contributes To Developing Scientific Skills (Inferring, Drawing Conclusions, Data Analysis). Field Trips And Visits To Green Areas Of The Educational Institution Are Proposed To Aid The Students To Obtain A Better Understanding Of Botany.

Carrero et al. (2011)	Venezuela, Primary School Teachers	I.2.B	Teachers Recognise National Parks As Areas Rich In Biodiversity, Which Are Protected By The State, With Touristic And Educational Value. Identified Benefits Provided By Parks To Human Beings Are Recreation, Water And Oxygen Production. However, Only A Few Teachers Highlight Carbon Sequestration.
De La Cruz and Pérez (2020)	Colombia, 9 th Grade Students From Montería, Córdoba	II.1	The Findings On Conceptions Of Biodiversity Include Cultural Knowledge As One Of The Typologies Of Knowledge In The Construction Of The Concept Of Biodiversity. The Influence Of Humanity And Its Activities On The Development Of Nature Is Analyzed. This Representation Includes Customs And Cultures, As Referenced In The Student Response: “Our Country Has A Variety Of Races, Such As Indigenous People And Blacks; Cultures, Customs And Traditions Change Depending On The Region. I Think This Is Very Important In Our Country, Which Also Makes It Unique And A Megadiverse One” (P. 12).
Páez-Rincón, and Reyes-Roncancio (2020)	Colombia, 8 th Grade Students	II.1	Students Identify 17 Plants To Which They Attribute Medicinal Properties. This Knowledge Has Been Provided Thanks To The Oral Transmission Of Knowledge Or Family Traditions.
Cárdenas Toro (2013)	Colombia, With The <i>Inga</i> Community And An Educational Institution	II.1	Through A Comprehensive Pedagogical Practice Project That Aimed To Identify The Content Of Social Representations About The Living And Life In The Knowledge Of The <i>Inga</i> Community, It Was Found That The Living And Life Are Two Inseparable And Interconnected Categories, And That Their Understanding Of The World Is Articulated With A Group Of Representations That Become Meaningful With Their Own Worldview As A Central Focus Of Practice. For The <i>Inga</i> , Life And The Living Represent The Fact Of Being Able To Work The Land, Which Represents A Living Element Of The Territory That Provides Them With Sustenance And A Possibility Of Survival In Physical, Cultural And Biological Ways.
Venegas (2013)	Colombia, Children Of The <i>Sikuane</i> Ethnic Group	II.1	In Her Work With The <i>Sikuane</i> Children Of The Eastern Plains Of Colombia, The Author Presents The Expression “Mother Earth”, Which Allows One To Refer To Nature. This Idea Corresponds To The Worldview Of These Peoples, And To Their Natural Environment, And Their Geographical And Mythical Location. The Ideas Of Nature Expressed By The <i>Sikuani</i> Boys And Girls In A Science Class Are Highly Oriented In Their Traditional Knowledge And Culture. However, They Use Scientific Terms, Such As Oxygen, With Different Connotations From Western Ones.
González and Contreras (2013)	Chile, High School Students Of <i>Mapuche</i> Origin And Students Starting University Studies	II.1	By Examining The Botanic Taxonomy In The <i>Mapuche</i> Language, The Importance Of Vegetable Diversity To The <i>Mapuche</i> People And Their Traditions And Vision Of The Cosmos Are Revealed. The Comparative Study Revealed That <i>Mapuche</i> High-School Students Have Much More Knowledge Of Vegetable Biology Than College Students At The Beginning Of Their Studies In Forest Engineering And Agronomy.
Páramo and Galvis (2010)	Colombia, Children From Different Cultural Contexts; From Regions Where The Majority Of The Colombian Society Live And An Indigenous Community From The Colombian Amazon	II.1	This Study Was Oriented In Identifying The Bonds That Children Develop Toward Animals Through Their Personal Constructs. The Findings Highlight That The Children Of The Majority Colombian Society Follow Academic Or Scientific Schemes, Whereas The Indigenous People Base Their System Of Constructs On Direct Experience With Animals And A Broad Knowledge Of Animal Diversity.

Navia-Imbachi and Tamayo-Alzate (2020)	Colombia, Indigenous Students Of The <i>Nasa</i> Ethnic Group, In A Middle School Of Cauca	II.1	The Characterisation Of Mental Models About The Environment Can Be Fundamental For The Intervention Of The Teaching And Learning Processes, Since Students' Mental Models Influence Their Environmental Behaviour. The Identified Mental Models Are: The Environment As A State Of Natural Things, The Environment As A State Of Natural Relations (Which Was The Most Frequent In The Sample Of Students), The Environment As A Human Being-Nature Relationship, And The Environment As A Planetary Whole At The Service Of Human Beings.
García et al. (2020)	Cuba, 7 th And 8 th Grade Students From An Urban Secondary School In Granma	II.1	When Addressing The Idea Of Biodiversity, The Students Only Make References To The Diversity Of Animals And Plants Existing In Ecosystems. After A Teaching And Learning Sequence, It Is Appreciated How They Then Interpret The Meaning Of Biodiversity, Which Goes Beyond The Approaches Initially Expressed By Recognising That It Represents Life In All Its Manifestations, I.E., As Expressed In Genes And Species (Including Humans And Their Cultural Diversity).
Castillo et al. (2019)	Costa Rica, Students From Rural High Schools	II.1	The Main Results Show That Students Have Limited Knowledge About Marine And Coastal Ecosystems - A Worrying Aspect, Given That Teachers Must Contextualise Education And Take Advantage Of The Richness Of Their Environment. The Concern About This Lack Of Knowledge Is Highlighted (81% Of The Students), Considering The Role That Ecosystems Play In The Different Communities.
Molina et al. (2005)	Colombia, Students (8- 13-Years-Old) From Two Primary Schools	II.1	Ideas About Nature And The Degree Of Importance Of Living Things In Students' Explanations Are Revealed. In The Immigrant School, The Students' Idea Of Nature Refers To The Animal And Vegetable Explicitly: "(...) Where There Are All Kinds Of Trees And Many Plants And Animals." They Denote The Natural As Referring To Spaces Outside The City: "Nature Is Trees, Fields, Forest" (P.55). For The Boys And Girls Of The City School, Although Nature Continues To Imply The Animal And The Vegetable, It Is Observed In Their Statements That Their Descriptions Are Expressed In Terms Of School Knowledge, I.E. "(...) Animals Have A Cycle, First They Are Born And Grow, Then They Reproduce, And Then They Die" (P.55). However, Priorities, Criteria, Values And Beliefs Are Mostly Shared Among The Boys And Girls Of Both Schools: The Dynamics And Descriptions Of These Dynamics As Naturalistic Criteria, The Useful, The Utilitarian, And The Awareness Of Humanity's Dependence On Nature, The Beauty Associated With The Variety And Quantity Of 'Natural Beings' And Nature Considered As A National Emblem. On The Other Hand, The Assessment Of The Contrasts Could Focus On A More Subtle Description Of The Categories In Terms Of The Differences Found, When The Narratives Of The Boys And Girls From The Two Schools Are Compared.
Pérez Mesa (2013b)	Colombia, Undergraduate Teachers Of Biology From Two Different Cultural Contexts: Bogotá And La Chorrera- Amazonas	II.2.A	The Notion Of Biodiversity Changes, In Both Studied Cases, To Become More Authentic In Terms Of Each Culture. In Sara's Case, The Ways Of Understanding Biodiversity 'As Variability, Relationships Of The Living' Allows Us To Find Elements Of The Western Vision. Also, The Way Fernando Speaks Of 'Mother Nature' As A Representation Of Abundance And The Creative Production Of Life, Shows That Both Conceptions Are Closely Related With The Ways Of Living And Connected To Nature, In The Cultural Frameworks In Which These Conceptions Are Built. These Are Fundamental Topics As Objects Of Analysis And Problematisation In The Biology Teachers' Training Processes.
Pérez Mesa (2019)	Colombia, Undergraduate Teachers Belonging To The <i>Uitoto-Muruy</i> Of The Chorrera Amazonas Ethnic Group	II.2.A	The Undergraduates' Ways Of Enunciating And Signifying Biodiversity Are Provided, In Relation To Their Worldviews. <i>Mother Nature</i> : The One That Engenders Life. <i>Monifue</i> : Abundance Of Life. <i>Baile Del Yua</i> +: A Ritual That Represents The Diversity Of Life As A Holistic Network That Seeks To Harmonise Relationships As An Interrelated Whole.
Guerra (2020)	Brazil, Undergraduate Teachers From The Federal University Of Rio Grande Do Sul	II.2.A	After The Application And Quantitative Analysis Of Questionnaires, It Was Observed That Most Of The Workshop Participants Made Conceptual Errors About The Identification Of Poisonous Animals, Mainly Snakes And Spiders. According To The Author, The Topic Of Poisonous Animals Needs To Be Worked On In Training Courses For Pedagogy Teachers. In This Way, Future Teachers, As Well As Personal Carers, Can Become Sources Of Correct Information As A Means Of Accident Prevention.

Castañeda (2020)	Colombia, Undergraduates Of The Bachelor Degree Program In Music	II.2.A	When Inquiring About The Ideas Of Biodiversity, It Was Observed That The Responses Were Divided Into Three Main Categories: 18% Of The Eleven Students Defined Biodiversity As The Existence Of Plants And Animals, Another 55% Considered That Biodiversity Is Determined By The Existence Of Animal And Plant Species Associated With A Specific Territory, Whereas The Remaining 27% Recognised That Biodiversity Also Includes The Relationships Established Between These Species. Cultural Diversity Research Has Found That The Conceptual Constructions Are Of Greater Complexity, While Undergraduates Understand Culture As A Human Characteristic, Others Understand It As Social Constructions. The Former Associates These Characteristics To A Specific Territory (45% Of The Participants), With The Latter Being Divided Into A Majority That Considers Culture As The Social Constructions Associated With A Territory (36%), And The Remaining 9% Mentioning That Such Cultural Constructions Are Not Necessarily Associated With A Specific Region, Since They May Correspond To Global Or Virtual Phenomena And The Conception Of The Human As A Species.
Iyokina Gittoma and Peña Trujillo (2015)	Colombia, Bilingual Teachers Of Two Community Schools In The Amazon	II.2.B	Nature Is Seen As A Symbolic Setting; It Becomes A Living “Classroom” And A Place From Which To Learn And Teach Through The Experience And Guidance Of Knowledgeable People. Among The Scenarios For Teaching And Learning About Life Care, The Following Stand Out: The <i>Chagra</i> (Material And Symbolic Space For Cultivation), The <i>Maloka</i> (Assumed As A Traditional House Of Knowledge), The River, The Beach, The Pipe, And The Medicinal Plants. The Biocultural View Of The Relationship Between Man And Nature In The Amazonian Indigenous Contexts Is Specified From The Integration Of Nature And Culture In Their Symbolic Expressions, And Is Dynamised In The Knowledge (<i>Corpus</i>), Practices (<i>Praxis</i>) And Beliefs (<i>Kosmos</i>) That Are Typical Of These Original Groups.
Rocha and Santos (2013)	Brazil, Teachers Of Natural Sciences	II.2.B	In The Investigation About Teachers' Traditional And School-Scientific Knowledge Related To Biodiversity Of Fishing Communities, The Results Indicate That Traditional Knowledge Is Important For Scientific Teaching And Learning, Since It May Facilitate The Establishment Of Relationships Between Scientific Content And Knowledge Experienced By Students Both Inside And Outside The Classroom. However, Despite Its Importance, Teachers Often Neglect Teaching Strategies That Make Intercultural Dialogue Possible.
Odorcick and Wirzbicki (2018)	Brazil, High-School Biology Teachers	II.2.B	From Interviews About Science Textbooks And Approaches To Botany, Teachers' Conceptions, In General, Are Established With The Limitations Imposed By Textbooks. There Is A Need To Understand The Limitations Inherent In The Conceptual Approaches To Botany Used In Textbooks.
Donato et al. (2007)	Colombia, Women Researchers And Book Editors Of The Proceedings Of The Second International Seminar Of Indigenous Women, Territoriality And Biodiversity	II.3.A	It Is Recognized That, In All Cultures, Women And Men Establish Very Different Relationships, Not Only With The Rest Of Society, But Also With Their Territories And Resources, Or With Their Biodiversity. This Implies Having To Take Into Account Their Differentiated Knowledge, Perceptions, Representations And Practices With Nature, As Well As The Organisation Of Their Knowledge And Its Transmission In Dissimilar Ways.
Pérez Conguache (2007)	Guatemala, A Woman Belonging To The Mayan Culture	II.3.A	The Traditional Mayan Knowledge In Guatemala Starts From A Knowledge System That Is Transmitted Orally, Based On The Principles And Values Of Mayan Spirituality And The Sacred <i>Tz'olkin</i> Calendar. This Traditional Knowledge Is Closely Related To Biodiversity, And The Community Has Contributed To Its Conservation. One Of The Concepts Related To Biodiversity Refers To Life Itself On Earth, Including Human Life And The Sustenance Of The Vital Processes That Maintain It. In This Way, The Bond Of Guatemalan Indigenous Women With The Earth Is Productive, Reproductive, Social And Spiritual, With Both The Forests And The Land Being Sacred To Them.

Ramírez (2005)	Colombia, A Woman Belonging To The <i>Wayúu</i> Culture	II.3.A	The Author Discusses The Limits Established By The Definition Of Biodiversity Stated In The Convention On Biological Diversity From A Western Context, Which Contrasts With The Worldview Of The <i>Wayúu</i> People. For Instance, For <i>Wayúu</i> People, “All The Components Of Nature Are Endowed, The Stones, The Streams, The Winds, The Earth, Everything Has Spirit” (P.40). For This Reason, It Is Difficult To Say What Belongs To Biodiversity And What Does Not, Because Everything Is Part Of Biodiversity For The <i>Wayúu</i> People.
Álvarez (2005)	Colombia, Women Belonging To The <i>Zenú</i> Culture	II.3.A	<i>Zenú</i> Women Know And Make Use Of The Local Biodiversity, As Expressed Through The Sowing Of 28 Species Of Plants For Horticultural Use, 30 Fruit Species, More Than 50 Species Of Medicinal Plants, And 28 Species Of Plants For Construction, Dyes, Ornamentation, Firewood And Handicrafts. The Role Of Women’s Knowledge And Management Of Biodiversity For Food Sovereignty, Medicine And Material Culture Is Highlighted.
Martínez and Manzano (2016)	Argentina, Perceptions Of Local Communities In Three Protected Areas Of Córdoba	II.3.B	There Is Evidence Of A Plurality Of Perceptions Related To Environmental Problems And The Importance Of Biodiversity And Its Conservation, As Well As Species Control And Retraction. Perceptions Of The Environment And Its Conservation Are Rooted In The Particular Villagers’ Worldviews Regarding The Relationship Between Nature And Culture, In Which Society Is Generally Placed Outside Of Nature.
Sandoval Rivera (2018)	Mexico, Peasants From Veracruz	II.3.B	An Educational Project That Sought To Recognise Knowledge And Cultural Practices Towards The Strengthening Of Community Processes In Favour Of “Conservation”, From A Wider Point Of View To That Proposed By International Conservation Policies And Scientific Academic Knowledge. In This Sense, Collaborative Work Was Based On Action Research Methodology, With The Purpose Of Identifying Local Practices And Knowledge That Could Be Included In A Participatory Process For Wildlife Conservation. The Case Study Shows The Complexity Embedded In The Development Of Educational Projects Aimed At Sustainability, In Contexts Of Cultural Diversity Permeated By Historical Processes That Have Led To Structural Inequality In Rural And Indigenous Contexts. The Findings Highlight The Importance Of Including Horizontal And Participatory Educational Processes Based On Local Knowledge And Practices.
Correa et al. (2012)	Colombia, Fishermen Of Two Coastal Areas	II.3.B	Local Ecological Knowledge On Marine Ecosystems Of Inhabitants From Three Colombian Coastal Areas Accounts For Most Of The Species With Common Names In Widespread Use In The Colombian Pacific. The Sea Is A Source Of Food And Economical Resources, But It Is Also The Sphere Where The Male Personality Is Forged. Fishermen Establish Their Own Classification Systems By Assigning Other Names According To The Colour, The Sound An Animal Makes, Or Its Shape. They Also Recognise Species By Their Behaviour, To The Point That They Know If An Animal That Is Approaching Or Is Being Looked At From A Distance Is “Bad” Or “Good”, “Brave” Or “Silly”. Within The Same Taxon, They Distinguish Genera, Species And Varieties. The Snapper, For Example, Can Be Spotted Or Red, And Tuna Can Be Yellowish Or Yellowtail. Intelligence Level Is Also Commonly Used To Classify Animal Species. Local Ecological Knowledge Studies Should Be A Starting Point For Environmentalist Actions.
Millán et al. (2016)	Mexico, <i>Matlatzinca</i> Indigenous Group From Central Highlands	II.3.B	The <i>Matlatzinca</i> Community Has A Shared Knowledge Of Nature, Which Has Been Transmitted And Preserved For Generations And Is Reflected In The Recognition Of The Species, In The Oral Tradition Regarding Its Uses (Whether Current Or Not) And The Value Of Domestic, Religious Or Ritual, Medicinal And Economic Uses As Classification Criteria. Fauna Represents An Ontological Value For The Inhabitants, Since: (I) It Is Part Of An Ecosystem Or “Part Of Nature”; The Animals That Inhabit The Forest Have A Reason For Existing; And (II) It Influences The State Of Mind And Allows A Gratification Of The Senses; Being A Repository Of Joy And Beauty, Such As In The Case Of Butterflies, Rabbits, Deer And Birds.

Appendix 2. System of Categories and Subcategories Concerning Knowledge and Conceptions of Biodiversity

Category (I, II)	Subcategory (1-3)	Subcategory (A-D)	Subcategory (i-vii)	Subcategory (a-e)		
I. From conventional scientific knowledge	I.1. Students' conceptions and conceptual understanding	I.1.A. Concept of biodiversity				
		I.1.B. Components and attributes of biodiversity	I.1.B.i. Positively valued for its conservation	a. Species b. Types of species c. Trophic interactions		
			I.1.B.ii. Undervalued components to protect biodiversity	a. Species evenness b. Alpha diversity c. Population size d. Species relationships e. Range (variety of values) within a functional group		
			I.1.B.iii. Other attributes for biodiversity conservation	a. Native versus exotic b. Vegetables and GMOs c. Organisms size		
		I.1.C. Familiarity with and knowledge of plants and animals	I.1.C.i. Native flora and fauna			
			I.1.C.ii. Centrism in specific groups	a. Mammals and birds b. Trees and shrubs c. Plants with conspicuous floral characters and plant blindness		
			I.1.C.iii. "Non-charismatic" animals and groups I.1.C.iv. Gender I.1.C.v. Rural-Urban contexts I.1.C.vi. Contact sources I.1.C.vii. Public / state and private schools			
			I.1.D. Perception of biomes and ecoregions			
		II. From interculturality	I.2. Teachers' conceptions and conceptual understanding	I.2.A. Preservice teachers		
				I.2.B. In-service teachers		
II.1. Students' conceptions and knowledge						
II.2. Teachers' conceptions and knowledge	II.2.A. Preservice teachers					
	II.2.B. In-service teachers					
II.3. Other groups' conceptions and knowledge	II.3.A. Indigenous women					
	II.3.B. Other settlers					