

## Educational practices and students' ability to differentiate between native and exotic species in schools in Southern Brazil

### Práticas educativas e dificuldade de estudantes na identificação de espécies nativas e exóticas em escolas do sul do Brasil

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**Abstract:** Rising urbanisation and destruction of biomes have alienated humans from native species in their regions, demanding consideration of local ecosystems. The present study aimed to analyse the knowledge of students from public schools located in southern Brazil about native and exotic species, biomes, and biodiversity, and the difficulties that they attributed to these definitions. Research activities included lecture-discussion, fieldwork, and questionnaires, and data were analysed with Chi-Square, Fisher's Exact Test, Binomial Test, Spearman's Correlation and Content Analysis, employing a Mixed Method Research design. Middle School students showed lack of conceptual knowledge and attributed greater levels of difficulty to the concepts in comparison with High School students, while native species and the concept of biodiversity were better defined than exotic species and biomes. Moreover, students associated the concepts of 'native' and 'exotic' to 'known/common' and 'unknown/rare/strange', respectively.

**Keywords:** Middle school; High school; Biology teaching; Native species; Exotic species; Biodiversity.

**Resumo:** A crescente urbanização e a destruição dos biomas distanciaram os seres humanos das espécies nativas, demandando uma maior preocupação com os ecossistemas locais. O presente estudo objetivou analisar o conhecimento de estudantes de escolas públicas localizadas no sul do Brasil sobre espécies nativas e exóticas, biomas e biodiversidade e as dificuldades que eles atribuíram para definições dessa natureza. As atividades de pesquisa incluíram exposição dialogada, pesquisa de campo e questionários. Os dados foram analisados com teste de Qui-Quadrado, Teste Exato de Fisher, Teste Binomial, Correlação de Spearman e Análise de Conteúdo, compondo uma Pesquisa com Métodos Mistos. Os estudantes do Ensino Fundamental apresentaram mais problemas com as definições e atribuíram índices maiores de dificuldade do que os do Ensino Médio. Espécies nativas e biodiversidade foram definidas mais corretamente do que espécies exóticas e biomas. Além disso, os estudantes fizeram uma associação entre 'nativo' e 'conhecido/comum' e entre 'exótico' e 'desconhecido/raro/estranho'.

**Palavras-chave:** Ensino fundamental; Ensino médio; Ensino de biologia; Espécies nativas; Espécies exóticas; Biodiversidade.

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## Introduction

Increasing urbanisation, alienation from the natural environment, and introduced species constitute a severe problem for local biodiversity in many Brazilian regions and worldwide, demanding the development of educational practices to disseminate knowledge about native species, especially as many young people grow up in environments where anthropization disconnects them from the natural environment (FLANNERY, 2012; SIMBERLOFF *et al.*, 2013). Brazil constitutes a mosaic of climatic conditions, relief, and compositions of fauna and flora; however, textbooks present scarce information on local ecosystems, including the Pampas and the Atlantic Forest—the two biomes of the southernmost state of Brazil, Rio Grande do Sul. Considering the country's significant biodiversity, basic education must facilitate students to perceive their surroundings and the biotic and abiotic elements that compose them, so that they can appreciate and value local species (BOLDRINI, 2009; STERN; POWELL; HILL, 2014), and consider the complexity of the intersections between nature and society (SIMBERLOFF *et al.*, 2013).

Located in the extreme south of the country, the state of Rio Grande do Sul features two biomes: the Atlantic Forest, whose degradation of which has reached alarming rates, and the Pampas, consisting of grassy areas with some forests. Estimates have shown that the floristic patrimony of the Pampas is close to 3,000 species, with a high number of native forage plants for livestock production (BOLDRINI, 2009; BUCKUP; BOND-BUCKUP, 2008). However, biodiversity has been directly affected, to varying degrees, by the introduction of potentially invasive exotic species, as has been observed in different locations and with different species in Brazil (PETRI; ARAGAKI; GOMES, 2018).

Knowledge production in the natural sciences has challenged basic education teachers to construct educational practices capable of allowing a didactic transposition of the advances of science in the curricula, including conceptual, social-value, and practice dimensions because activities with children and teenagers related to wild and unknown species can enhance this theme's knowledge and attractiveness (LINDEMANN-MATTHIES, 2005; NYBERG; SANDERS, 2014). However, it is uncommon for educational research to explore students' opinions on difficulties in the learning process.

A previous study with middle-level students revealed difficulties with the conceptual dimensions related to the origins of species and cultural influence on the construction of such concepts (PROENÇA; DAL-FARRA; OSLAJ, 2017). Thus, the present study analyses students' knowledge about the concepts of 'native', 'exotic', 'biome', 'biodiversity' and species origins to obtain insights for developing basic education practices. Additionally, it addresses the difficulty level attributed by students and possible correlations with the answers linked to each concept, considering the scarcity of this strategy in educational studies.

## Definitions of native and exotic species

Native or indigenous species are those originated in a given area without human involvement or have arrived there without intentional or unintentional human intervention. Exotic or alien species outside their natural boundaries are historically recognised as resulting from accidental or intentional human activity. Invasive species are those that, once introduced, adapt, reproduce, and occupy the place of native species,

causing alterations in natural ecological processes (ABREU; DURIGAN, 2011; MORO *et al.*, 2012; MUSENGUI; ARCHIBALD, 2017; PETRI; ARAGAKI; GOMES, 2018; PYŠEK *et al.*, 2004).

At first, species translocations were intended for agriculture or forestry, and, subsequently, for ornamental purposes. If the new habitat of an exotic species is similar enough to its natural distribution, it can survive and reproduce; however, to become invasive, it must compete successfully with native organisms and increase its population density (BRAZIL, 2009; MORO *et al.*, 2012). Davis *et al.* (2011) asserted that the focus should not be specifically on introduced species but rather on their character and potential to be invasive and damage local species via rapid reproduction and growth, a high capacity for dispersion, and an ability to adapt to new conditions. Ecosystems occupied by exotic species may not present natural predators or even competing species characteristic of the native environment (BRAZIL, 2009).

Invasive alien/exotic species are a leading cause of global biodiversity loss, reducing local diversity, altering community structures and native ecosystem composition, competing with autochthonous species for resources, and changing natives' evolutionary path by competitive exclusion, niche displacement, predation, and extinction (CLUSELLA-TRULLAS; GARCIA, 2017; DECHOUM *et al.*, 2018; PETRI; ARAGAKI; GOMES, 2018). According to the Convention on Biological Diversity (2020), which aims to raise public awareness of invasive alien species, supporting the successful management of this problem is crucial; hence, governments should promote education about the causes of invasion and the risks associated with species introduction. Species knowledge is the first step: the focus is towards resignifying the local environment, providing proximity with the species of the surrounding area, and identifying ecosystems, biomes, and native and exotic species. Educational practices in middle and high school syllabuses provide awareness of species, promoting the conservation of the natural environment and contributing to understandings of the ecological relations of different species and the social implications of environmental issues (DECHOUM *et al.*, 2018; FLANNERY, 2012; LINDEMANN-MATTHIES, 2005; MORO *et al.*, 2012).

## Methodology

Sixth to ninth graders of Middle School (MI) from a municipal school and first to third graders of High School (HI) from a state school participated in the research, which involved lecture-discussion about the species, biomes and biodiversity, application of questionnaires, and fieldwork in the schools' surroundings to observe the plants. A group of 38 seventh graders from a third public school was selected to participate in fieldwork in a zoo inhabited exclusively by native fauna species, and subsequently answered questionnaires. This group was created because plants, animals, and ecological relations are studied during this grade. The activity required written authorisation from parents or guardians, and the study project was previously approved by the Department's Post-Graduation Commission. The choice of schools was defined by convenience sampling with the criterion of being in urban space. All schools are located in middle-income neighbourhoods, and all activities were carried out between 2013 and 2014.

Initially, students were asked to define 'native species', 'exotic species', 'biodiversity', and 'biome', and answers were classified as totally satisfactory (TS), satisfactory (S), unsatisfactory (U), or totally unsatisfactory (TU). These data were gathered using a questionnaire. Subsequently, these definitions were transformed into scores:

TU = 1.0, U = 2.0, S = 3.0, and TS = 4.0. Simultaneously, students attributed a degree of difficulty in defining each term/expression: very easy = 1.0, easy = 2.0, neither easy nor difficult = 3.0, difficult = 4.0, and very difficult = 5.0.

Thereafter, a lecture-discussion was held using a presentation on biodiversity, Brazilian biomes, definitions and examples of native, exotic, and invasive species. Students were shown images of 40 animals and 40 plants along with their scientific and popular names, for them to mark as native (N) or exotic (E) to Rio Grande do Sul. This set of images is the same as in Proença, Dal-Farra and Oslaj (2017), with another set of students. Data on their conceptions of biomes and educational issues were also gathered, followed by a debate about biodiversity, appreciation of native species, and the relevance of invasive species.

The activities carried out were predominantly about presenting the species to the students and answering their questions while recalling the concepts previously approached in the classroom. Their answers were examined to generate sets of qualitative and quantitative data. Content Analysis was performed on open questions by constructing categories that represented the most relevant aspects found (BARDIN, 2011). A portion of the data received quantitative treatment using descriptive and inferential statistics. Content Analyses were applied to obtain the main themes mentioned in relation to each concept and generate the percentages of answers organised by meaning, with the semantic criterion compounding the answer categories for 'native', 'exotic', 'biome', 'biodiversity'; other aspects included referred to 'types', 'qualities' and 'distinctions' for each concept.

In the quantitative component, Binomial test—a non-parametric tool used when data are dichotomous, as with the answers 'native' or 'exotic'—was employed. To compare data from each MI and HI year, non-parametric Chi-Square and Fisher's Exact tests were used; thereafter, the data were transformed into scores and analysed by a non-parametric Kruskal-Wallis test since they did not show normal distribution. Spearman correlations between scores and the difficulty index attributed by the students were obtained. By integrating the collection and analysis of qualitative and quantitative data, the study uses a Mixed Methods Research (CRESWELL; CLARK, 2011).

## Results and discussion

A set of 110 MI students and 74 HI students participated in the classroom and fieldwork in the schools' surroundings to observe the plants, while 38 seventh graders carried out fieldwork at the local zoo. The MI students were aged 11 to 15; 56.4% were female and 43.6% were male; 20.9% had lived in rural areas, and 50.9% had visited these places before. The HI students aged 14 to 18 years; 70.3% were female and 29.7% were male, and 14.9% had lived in rural areas, while 56.8% had previously visited such areas. Thus, urban, female students predominated, in an age considered appropriate to their grades. **Table 1** shows the percentages of responses obtained from the MI and HI.

**Table 1** – Students' definition

Answers	native (%)		exotic (%)		biomes (%)		biodiversity (%)	
	MI	HI	MI	HI	MI	HI	MI	HI
Totally unsatisfactory (TU)	60.9	25.7	92.7	60.8	81.8	64.9	63.6	33.8
Unsatisfactory (U)	8.2	9.5	0.9	4.0	6.4	6.8	9.1	9.5
Satisfactory (S)	10.9	16.2	-	9.5	3.6	16.2	20.9	48.6
Totally satisfactory (TS)	20.0	48.6	6.4	25.7	8.2	12.1	6.4	8.1

Source: prepared by the authors.

In both MI (30.9%) and HI (64.8%), students defined 'native species' more accurately than other concepts, considering the total of TS plus S answers. These results were 27.3% and 56.7% for 'biodiversity', 6.4% and 35.2% for 'exotic', and 11.8% and 28.3% for 'biomes'.

Amongst HI students, in the TU category, the 'best known' (9.5%) and 'common species' (9.5%) expressions were the most frequently used for native species. Amongst MI and HI students, the S answers categorised were similar to those categorised as TS, although students ignored the question of the species' local origin. 'Exclusive to a specific place' (8,1%) for native species in S category (HI) was confounded with endemic species (SIMBERLOFF *et al.*, 2013).

Concerning exotic species, students had even more difficulty (93.6% for TU+U in MI), reporting definitions such as, 'rare species/difficult to find' (21.8%), 'unusual species/unknown' (21.8%), 'different/stranger appearance' (28.2%) and 'animals and plants that are not part of our everyday lives' (3.6%). TS answers were dominated by 'they originate from another location' (25.7%) in HI. However, the word 'exotic', according to the Brazilian dictionary (MICHAELIS, 2016), also expresses synonyms such as 'tasteless', 'clumsy', 'weird', and 'extravagant', which may have led to confusion with this definition since they are meanings commonly observed in contemporary culture.

For 'biomes', S responses in HI were considered those that related abiotic aspects with the characteristic fauna or flora, alluding to the 'geographic space and the living beings that inhabit it' (10.8%) and are different regions such as 'Cerrado' or 'Caatinga' (5.4%).

The percentages of TS/S responses for 'biodiversity' were low (27.3% and 56.7%), despite the term's media prevalence. Responses such as 'various species' and 'many species' were mentioned in S category for MI (20.9%) and HI (48.6%), while 'living beings' was most common among the U answers. Understanding the definition of biodiversity is extremely important for the systemic recognition of environmental issues. The term represents the variability of living organisms of all origins, comprising terrestrial, marine and other aquatic ecosystems, and the ecological complexes that they are part of, as well as diversity within and among species and ecosystems (CONVENTION ON BIOLOGICAL DIVERSITY, 2006). In defining invasive species, 21.6% of HI students presented S/TS answers related to their potential to overrun native species. Some TU responses referred to them as 'parasites'.

Allochthonous species are those whose introduction, reintroduction, or dispersion represent a risk to society, the economy or environment, including ecosystems, habitats, species, and populations (BRAZIL, 2009). Therefore, identifying the invasive

potential of exotic species and developing means to control their expansion remains crucial (MUSENGUI; ARCHIBALD, 2017; PETRI; ARAGAKI; GOMES, 2018).

The comparative analyses of the percentages of correct MI and HI answers resulted in significant differences from Chi-Square and Fisher's Exact tests; however, the interpretation of the results was performed with greater depth through transforming the data into scores and obtaining an average for each year, followed by the respective average difficulty indexes (DI) that students attributed to each definition (**table 2** and **table 3**).

**Table 2** – Average scores and difficulty index attributed by MI students

Year of Middle School	native (%)		exotic (%)		biome (%)		biodiversity (%)	
	A*	DI**	A*	DI**	A*	DI**	A*	DI**
6.º	1.38c	3.32a	1.00b	3.07a	1.06b	3.71a	1.00c	3.64a
7.º	1.42c	3.17a	1.00b	3.00a	1.17b	3.66a	1.61b	3.41a
8.º	2.69a	3.25a	1.73a	3.37a	1.96a	3.91a	2.19a	2.86b
9.º	2.10b	3.16a	1.10ab	3.45a	1.42ab	3.88a	2.13ab	3.53a
<b>Average</b>	1.90	3.22	1.20	3.23	1.38	3.79	1.70	3.39
<b>Correlation A/DI</b>	<b>-0.06 (NS)</b>		<b>0.11 (NS)</b>		<b>-0.38 (p&lt;0.01)</b>		<b>-0.44 (p&lt;0.01)</b>	

\*A = average score. \*\*DI = difficulty index. Different letters in the same column indicate significant differences. Source: prepared by the authors.

**Table 3** – Average scores and difficulty index attributed by HI students

Year of High School	native (%)		exotic (%)		biome (%)		biodiversity (%)	
	A*	DI**	A*	DI**	A*	DI**	A*	DI**
1.º	2.56b	2.38b	1.56b	2.84ab	1.44b	3.44ab	2.12a	3.22a
2.º	2.43b	2.68ab	1.11b	3.43a	1.25b	4.11a	2.43a	3.50a
3.º	3.86a	3.14a	3.71a	2.38b	2.81a	3.24b	2.38a	3.14a
<b>Average</b>	2.86	2.81	1.97	2.97	1.75	3.68	2.32	3.37
<b>Correlation A/DI</b>	<b>-0.31 (p&lt;0.01)</b>		<b>0.37 (p&lt;0.01)</b>		<b>-0.42 (p&lt;0.01)</b>		<b>-0.18 (NS)</b>	

\*A = average score. \*\*DI = difficulty index. Different letters in the same column indicate significant differences. Source: prepared by the authors.

Eight graders scored higher than other MI students, likely because they studied 'living beings' throughout seventh grade significant differences in the answers were found just for 'native' when compared with students in ninth grade. The average scores were low in both MI (1.2-1.9) and HI (1.75-2.32), except for 'native' in HI (2.86), and the difficulty index was lower than other definitions (2.81). The negative correlations between scores and indices of difficulty for 'biome' and 'biodiversity' in MI indicated that students perceived greater difficulty in defining these themes, hence obtaining lower scores. HI students had a more accurate perception than MI students for native and exotic species whose negative correlation (-0.31, -0.37, and -0.42 for biomes) demonstrated that students' higher scores were associated with a lower DI, except for biodiversity. Paradoxically, although the MI score was inferior to HI for 'biodiversity' (1.70

and 2.32, respectively), perception of the difficulty was similar (3.39 and 3.37), likely because the possible different interpretations of the word 'biodiversity' cause student misconceptions. **Table 4** presents the percentage of correct answers obtained from asking students to indicate 'native' or 'exotic' when shown animal pictures and names.

**Table 4** – Percentage of correct answers regarding animals from MI and HI students

<b>Exotic domestic animals</b>	<b>MI (%)</b>	<b>HI (%)</b>
Buffalo – <i>Bubalus bubalis</i>	70.9**	73.0**
Turkey – <i>Meleagris gallopavo</i>	59.1	75.7**
Cow – <i>Bos taurus</i>	20.0**	36.5*
Rooster – <i>Gallus gallus domesticus</i>	20.0**	21.6**
<b>Native mammals and birds</b>		
Quero-Quero – <i>Vanellus chilensis</i>	95.5**	94.6**
João-de-barro – <i>Furnarius rufus</i>	87.7**	97.3**
Bem-te-vi – <i>Pitangus sulphuratus</i>	83.6**	87.8**
Capybara – <i>Hydrochoerus hydrocaeris</i>	80.0**	87.8**
Wildcat – <i>Felis tigrine</i>	76.4**	87.8**
Caturrita – <i>Myiopsitta monachus</i>	76.4**	86.5**
Bugio – <i>Alouatta fusca</i>	70.0**	93.2**
Woodpecker – <i>Colaptes campestris</i>	70.0**	70.3**
Lobo-guará – <i>Chrysocyon brachyurus</i>	64.6**	73.0**
Prawn – <i>Didelphis albiventris</i>	63.6**	68.9**
Cardeal – <i>Paroaria coronate</i>	62.7**	68.9**
Canário-da-terra – <i>Sicalis flaveola</i>	61.8*	77.0**
Sabiá-laranjeira – <i>Turdus rufiventris</i>	57.3	62.2*
Anteater – <i>Myrmecophaga tridactyla</i>	45.5	64.9**
Veado-mateiro – <i>Mazama americana</i>	40.0*	48.6
Onça – <i>Panthera onca</i>	32.7**	35.1**
Puma – <i>Puma concolor</i>	23.6**	95.5**
Emma – <i>Rhea americana</i>	20.0**	20.3**
Urubu rei – <i>Sarcoramphus papa</i>	15.5**	24.3**
<b>Exotic mammals</b>		
Kangaroo – <i>Macropus rufogriseus</i>	86.4**	94.6**
Zebra – <i>Equus quagga boehmi</i>	84.6**	93.2**
Giraffe – <i>Giraffa camelopardalis</i>	80.9**	91.9**
Lion – <i>Panthera leo</i>	80.9**	90.5**
Tiger – <i>Panthera tigris</i>	80.0**	90.5**
Hippopotamus – <i>Hippopotamus amphibius</i>	65.5**	87.8**
Chimpanzee – <i>Pan troglodytes</i>	56.4	52.7
Macaco-aranha – <i>Ateles chamek</i>	55.5	59.5
Panda – <i>Ailuropoda melanoleuca</i>	64.6**	97.3**
<b>Exotic birds</b>		
Agapornis – <i>Agapornis personatus</i>	81.8**	86.5**
Peacock – <i>Pavo cristatus</i>	75.5**	78.4**
Ostrich – <i>Struthio camelus</i>	60.0	89.2**
Canary – <i>Serinus canarius</i>	47.3	68.9**
Calopsita – <i>Nymphicus hollandicus</i>	34.6**	52.7
Pomba doméstica – <i>Columba livia</i>	31.8**	31.1**
Parakeet – <i>Melopsittacus undulatus</i>	29.1**	33.8**
Sparrow – <i>Passer domesticus</i>	14.6**	18.9**

\*( $p < 0.05$ ) \*\* ( $p < 0.01$ ) Significant difference from 50% via binomial test.

Source: prepared by the authors.

## Exotic domestic animals and exotic mammals and birds

Students were unsuccessful in categorising *Bos taurus* and *Gallus gallus domesticus* as 'exotic', although answers for the North American *Meleagris gallopavo* (59.1 and 75.7%) and the Asian *Bubalus bubalis* (70.9 and 73%) reached higher values. In South America, the domestication of cattle, pigs, and poultry dates from the beginning of colonisation, so that those species have become relevant in cultural life and economic development (ROSA *et al.*, 2017).

Correct answers were high for some species, especially those found in the zoo near the schools in the city of Sapucaia do Sul, such as *Panthera leo*, *Pan troglodytes*, *Giraffa camelopardalis*, *Hippopotamus amphibius*, *Panthera tigris*, and *Equus quagga boehmi*, which were correctly categorised as 'exotic' by more than 80% of students, except for the hippopotamus in MI. The proximity of the schools to a public zoo enhanced species knowledge and likely strengthened associations of those animals with their exotic origins. *Ailuropoda melanoleuca* and *Macropus rufogriseus*, which are associated with specific regions/countries (China and Australia), also showed correct answer rates above 64%.

Traditionally, zoos are characterised by exotic species, and their conditions of captivity have been questioned by some people in recent decades. Dohn (2013) demonstrated the positive possibilities of zoos when they are planned and executed with the intention of education. According to Rose *et al.* (2019), zoos are potential locations to develop, implement, and complete scientific research, providing special conditions to test interesting hypotheses. In the last decade, certain species have received great academic interest, while other taxa have received no increasing focus.

Among the exotic birds mistakenly classified as 'native', *Passer domesticus* obtained the lowest percentage of correct answers (14.6% and 18.9%), likely because it has long inhabited the region, generating an association between 'native' and 'common'. However, it is exotic to Brazil, in spite of being found in almost all countries (LIMA *et al.*, 2012). The exotic *Melopsittacus undulatus* and *Nymphicus hollandicus* showed low percentages of correct responses, close to 30%, except for HI students for the last (52.7%), probably because these birds are domesticated and bred in captivity. *Agapornis personatus* (more than 80% correct) and *Pavo cristatus* (more than 75%) are also marketed as domestic species, but their conspicuous colours were considered by students as 'uncommon' and consequently associated with exotic species.

European colonisation generated a pronounced introduction of species to supply food, for sports, and other reasons (ROSA *et al.*, 2017). Considering the examples of alien species' deleterious environmental impact on the structure or dynamics of ecosystems, management responses should be prioritised according to the risks faced by each species (BLACKBURN *et al.*, 2014).

## Native mammals and birds

Correct answers for birds commonly observed near urban centres, such as *Vanellus chilensis*, *Pitangus sulphuratus*, and *Furnarius rufus* (AZPIROZ, 2012), were above 80%, demonstrating that familiarity and proximity to a species are associated with the concept of 'native'. *Vanellus chilensis* is a bird native to pampa, commonly found in urban environments, and that is appears in local folk music. *Furnarius rufus* inhabits



trees, and in urban areas. *Pitangus sulphuratus* and *Myiopsitta monachus* are frequent in the urban centres of Brazilian cities. *Colaptes campestris* and *Turdus rufiventris* live in forests, the countryside, and urban spaces, and *Sicalis flaveola* in open wooded areas and parks. *Paroaria coronata* is recognised for the red plumage on its head and is a victim of illegal smuggling trade (AZPIROZ, 2012).

The *Sarcoramphus papa* was described as 'non-native', with correct answers below 25%, indicating an association between 'exotic' and 'different/strange' due to the bird's colourful appearance and beak, which are unlike those of birds commonly encountered in southern Brazil's urban spaces. *Rhea americana* is on the endangered list (AZPIROZ, 2012) and with correct answer rates close to 20% in MI and HI.

Both *Myrmecophaga tridactyla* and *Mazama americana*, which are critically endangered (SILVA, 1994), were recognised as 'native' by less than 50% of students, except the first in HI (64.9%). Thus, educational practices focusing on these aspects should be strengthened to enhance student and teacher awareness about at-risk species. *Panthera onca* is also critically endangered but were recognised by few students as 'native', indicating an association between 'large cat' and 'exotic'. *Felis tigrina* had a correct answer value above 75%. One of the most common primates in Rio Grande do Sul and a typical character in the state's folklore, *Alouatta fusca* showed correct answer percentages above 70%. The endangered *Chrysocyon brachyurus*, the largest canid in South America (KASPER; MAZIM, 2014), was also recognised as 'native' by more than 64% of students. *Didelphis albiventris* is common in urban centres (correct answers above 60%), and *Hydrochoerus hydrochaeris* (correct answers above 80%) has a wide distribution and high population density (IOB; STOLZ, 2014; SILVA, 1994). In general, the results revealed student misconceptions about native animals and a lack of knowledge on local fauna, which not only has an impact on cultural production but also contributed to environmental deterioration, since people are not engaged in conservation efforts. **Table 5** shows the percentages of students who identified the origin of plants accurately.

**Table 5** – Percentage of correct answers regarding plants from MI and HI students

Exotic plants	MI (%)	HI (%)
Cipreste italiano – <i>Cupressus sempervirens</i>	66.4**	86.5**
Cinamomo – <i>Melia azedarach</i>	60.0	43.2
Jacarandá-mimoso – <i>Jacaranda mimosiifolia</i>	52.7	28.4**
Perna-de-moça – <i>Brachychiton populneus</i>	51.8	47.3
Falsa-seringueira – <i>Ficus elastica</i>	50.9	25.7**
Casuarina – <i>Casuarina equisetifolia</i>	48.2	39.2
Extremosa – <i>Lagerstroemia indica</i>	47.3	75.7**
Ligustro – <i>Ligustrum lucidum</i>	46.4	32.4**
Pata-de-vaca – <i>Bauhinia variegata</i>	42.7	50.0
Figueirinha-roxa – <i>Euphorbia cotinifolia</i>	40.0*	43.2
Pinus – <i>Pinus elliotii</i>	34.6**	31.1**
Eucalyptus – <i>Eucalyptus grandis</i>	30.9**	25.7**
Native plants		
Figueira – <i>Ficus cestrifolia</i>	93.6**	95.9**
Pitangueira – <i>Eugenia uniflora</i>	85.5**	91.9**
Pau-Ferro – <i>Caesalpinia ferrea</i>	70.9**	67.6**
Guajuvira – <i>Cordia americana</i>	79.1**	48.6
Araçá – <i>Psidium cattleianum</i>	70.9**	64.9**
Canela – <i>Nectandra lanceolata</i>	74.6**	62.2*

Butiá – <i>Butia odorata</i>	73.6**	85.1**
Jaboticaba – <i>Plinia trunciflora</i>	69.7**	73.0**
Araucária – <i>Araucaria angustifolia</i>	69.1**	82.4**
Timbaúva – <i>Enterolobium contortisiliquum</i>	58.2	78.4**
Aroeira – <i>Schinus terebinthifolius</i>	55.5	64.9**
Paineira – <i>Ceiba speciosa</i>	48.2	48.6
Goiaba-serrana – <i>Acca sellowiana</i>	46.4	59.5
Chá-de-bugre – <i>Casearia sylvestris</i>	46.4	37.8*
Guabiroba – <i>Campomanesia xanthocarpa</i>	44.6	51.4
Banana-do-mato – <i>Bromelia antiacantha</i>	42.7	44.6
Ipê-amarelo – <i>Handroanthus albus</i>	39.1*	50.0
Ingá-ferradura – <i>Inga sessilis</i>	27.3**	43.2
Cedar – <i>Cedrela fissilis</i>	27.3**	32.4**
Uvaia – <i>Eugenia pyriformis</i>	21.8**	14.9**
<b>Exotic plants with edible fruits</b>		
Ameixa-do-Japão – <i>Eriobotrya japonica</i>	67.3**	82.4**
Pear tree – <i>Pyrus communis</i>	37.3**	33.8**
Starfruit tree – <i>Averrhoa carambola</i>	32.7**	40.5
Peach tree – <i>Prunus persica</i>	31.8**	31.1**
Persimmon tree – <i>Diospyros kaki</i>	28.2**	25.7**
Mulberry – <i>Morus nigra</i>	21.8**	29.7**
Lemon – <i>Citrus limon</i>	18.2**	16.2**
Mango – <i>Mangifera indica</i>	17.4**	28.4**

\*( $p < 0,05$ ) \*\* ( $p < 0,01$ ) Significant difference from 50% via binomial test.

Source: prepared by the authors.

## Exotic plants

It is concerning that *Pinus elliotii* and *Eucalyptus grandis* presented percentages of correct answers close to 30% with no increase in HI. It is possible that the abundance and familiarity of these trees lead students to associate 'known' with 'native', even though these are potential invasive species (ABREU; DURIGAN, 2011; BACKES; IRGANG, 2009; MUSENGUI; ARCHIBALD, 2017). This trend was also evident for common species in the afforestation of urban areas such as *Euphorbia cotinifolia*, *Ligustrum lucidum*, *Casuarina equisetifolia*, and *Bauhinia variegata*, which were correctly marked as 'exotic' by only a small percentage of students (30-50% for MI and HI) due to the association between 'native' and 'easy to find'. *Lagerstroemia indica*, commonly observed in the urban environment, was correctly identified as exotic only in HI (75.7%).

*Melia azedarach* (60% and 43.2%) and *Jacaranda mimosiifolia* (52.7% and 28.4%) presented lower correct percentages, unlike *Cupressus sempervirens* (above 66%), since its popular name ('Italian cypress') indicates an exotic origin. The proliferation of exotic plants is associated with adverse effects for many animal species that have ecological relationships with them, depending on factors such as the extent of the invasion and the taxonomic group affected. These aspects are relevant to understanding the issue in question and can be addressed in relation to the ecological relationships existing among species within each ecosystem or biome (BACKES; IRGANG, 2009; CLUSELLA-TRULLAS; GARCIA, 2017). Students can be taught about the possible damage caused by the introduction of invasive species, as demonstrated by studies related to the management of flora to conserve native forests (PETRI; ARAGAKI; GOMES, 2018), and teachers should be aware of this when developing educational practices.

## Native plants

In the group of native plants, species commonly observed in urban residential neighbourhoods were marked correctly by high percentages of students, including the *Ficus cestrifolia* (above 90%), whose conspicuousness makes it well-known. Native plants with edible fruits commonly seen in students' daily life (KÖHLER; CORRÊA; BRACK, 2013; LORENZI; LACERDA; BACHER, 2015) were also correctly identified, including *Eugenia uniflora* (>85%), *Psidium cattleianum* (>64%), *Butia odorata* (>73%) and *Plinia trunciflora* (>69%).

Other trees commonly found in urban spaces had correct answer values equal to or above 62%, such as *Nectandra lanceolata* and *Caesalpinia ferrea* – frequently found in urban afforestation (BACKES; IRGANG, 2009). *Cordia americana*, with a popular name that denominates a well-known neighbourhood in the city (Guajuviras), scored 79.1% in the nearby MI, compared to 48.6% in the HI in another municipality. Meanwhile, *Schinus terebinthifolius*, commonly associated with allergies, was correctly recognised by a high percentage of HI students (64.9%). However, the fruit *Eugenia pyriformis* was not recognised by most students during the research activities (21.8 and 14.9%), despite its edible nature.

A group of trees found less frequently in Brazil's urban spaces demonstrated correct results near or below 50%, including *Ceiba speciosa*, *Casearia sylvestris*, *Campomanesia xanthocarpa*. Low levels of correct answers were also found, with rare exceptions, for *Inga sessilis* (native to the Atlantic Forest), *Acca sellowiana* (cultivated in subtropical countries such as New Zealand and Australia), and *Bromelia antiacantha* (native to almost all of Brazil's fields) (BACKES; IRGANG, 2009; KÖHLER; CORRÊA; BRACK, 2013; LORENZI; LACERDA; BACHER, 2015).

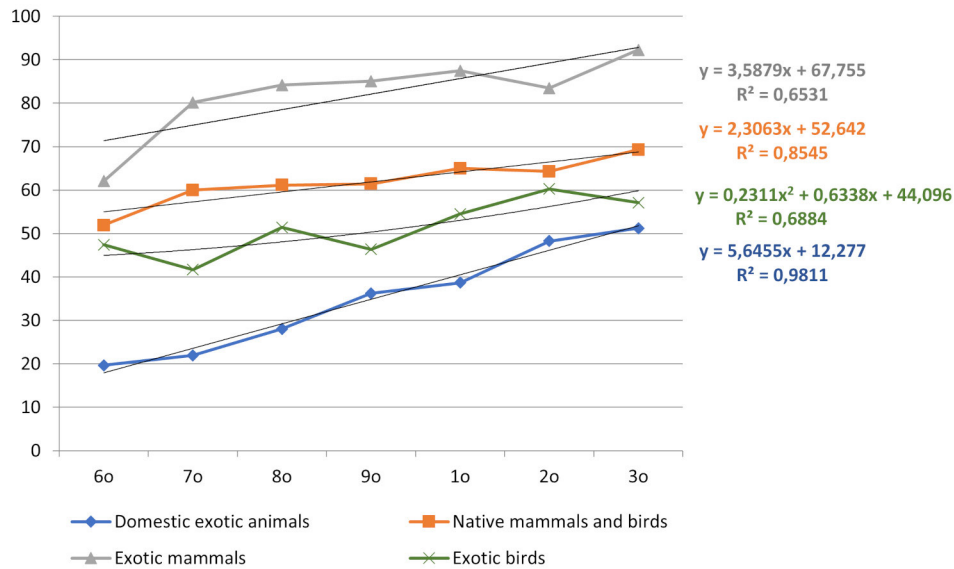
## Exotic plants with edible fruits

Correct answer values were low for *Pyrus communis*, *Prunus persica*, *Morus nigra*, *Citrus limon*, and *Mangifera indica*, which were erroneously classified as 'native' (between 16-40% correct answers), with a clear association between the 'frequent presence of the fruits in local establishments' and 'native', except for *Eriobotrya japonica*, the name of which indicates an exotic origin (67.3 and 82.4%). *Prunus persica* is from China, *Pyrus communis* is from Europe, and *Citrus limon* is from Asia (KÖHLER; CORRÊA; BRACK, 2013; LORENZI; LACERDA; BACHER, 2015). The reduced awareness of the alien origin of some species and the possible deleterious effect and invasive potential on local ecosystems are relevant (DAVIS *et al.*, 2011). In terms of the educational process, this theme is profoundly inherent to knowledge about the ecological relations of biotic elements and is a crucial subject for middle and high school students (CLUSELLA-TRULLAS; GARCIA, 2017; RIO GRANDE DO SUL, 2005; STERN; POWELL; HILL, 2014).

There was a marked increase (**figure 1**) in correct identification over the school years for exotic domestic animals, producing a linear model ( $y = 5.6455x + 12.277$ ) with a very high coefficient of determination ( $R^2 = 0.98$ ), clearly indicating that students in higher grades had greater knowledge on the matter; however, the average of correct answers was still very low (20% to 50%). For native mammals and birds, a linear model ( $y = 2.3063x + 52.642$ ) was obtained with a high potential to explain the phenomenon, with  $R^2 = 0.85$  indicating that knowledge of the origin of these animals increased

markedly as students progressed at school. Further studies are necessary to understand more accurately the causes for this phenomenon; however, such an increase is likely a consequence of teaching in many disciplines and even non-formal education, with the educational process as a contributing factor to students' capacity to 'know the world'.

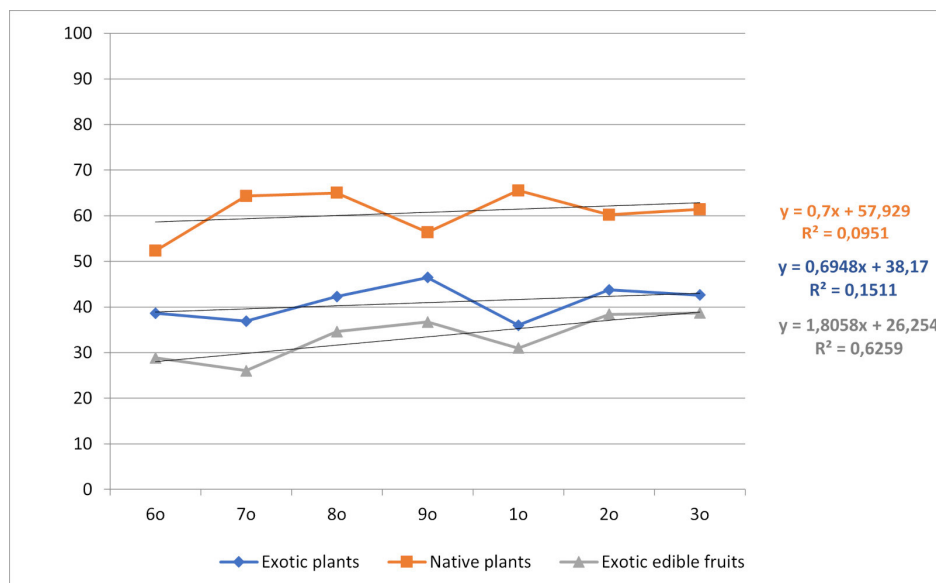
**Figure 1** – Regression analysis of percentages of correct answers for animals



For exotic plants, students gave very low percentages of correct answers. The average was below 50% in all school years, demonstrating lack of knowledge on the origins of exotic plants, with indexes below 40% for plants with commonly edible fruits in the state – *i.e.*, proximity to students' daily life experiences linked 'I know them' with 'they are native'.

The model obtained did not indicate an increase in correct answers for exotic plants over the years of schooling ( $y = 0.6948x + 38.17$ ), with  $R^2 = 15.1\%$  (**figure 2**). Similarly, there was no growth in the percentages of correct answers for native plants ( $y = 0.7x + 57.929$  and  $R^2 = 9.5\%$ ); however, except for year 6 of MI, the percentage of correct answers was nearly 60%. Correct answers for exotic plants that are culturally known for their edible fruits showed considerable growth from year 6 of MI to year 3 of HI ( $y = 1.8058x + 26.254$  and  $R^2 = 62.6\%$ ), likely because teaching enhances knowledge on these subjects, even in disciplines other than natural sciences. A similar tendency occurred for animals, mainly those domestically bred in local farms. Percentages of correct answers given in each year for the exotic plants group provided a model with an  $R^2$  pronouncedly higher than for other plants, which indicates a similar effect to that obtained with domestic exotic animal.

In general, correct answers for animals increased more over the school years than those for plants. Botanists have reported lack of interest in their science and in plants in general and have attempted to explain why the public is unaware of the importance of plants to their own wellbeing (FLANNERY, 2012). Affective experiences such as observations and guided explorations have shown to enhance students' attention to plants; thus, educational practices should be applied to minimise the effects of 'plant blindness' (students' inability to observe plants in the environment) and 'zoocentric focus' in education and urban culture (NYBERG; SANDERS, 2014).

**Figure 2** – Regression analysis of percentages of correct answers for plants

Source: prepared by the authors.

### Urban and rural areas

When comparing the percentages of correct answers from students who had lived in rural areas (RA) with others who had not (UA), the only discrepancies observed referred to domestic exotic animals (RA = 65.9%, UA = 49.2%). In the other groups, a pronounced similarity was observed for native animals (RA = 68.4%, UA = 65.4%), exotic mammals (RA = 87.4%, UA = 87.2%), exotic birds (RA = 57.9%, UA = 57.3%), exotic plants (RA = 44.4%, UA = 40.2%), native plants (RA = 60%, UA = 59.4%), and exotic fruit trees (RA = 38.6%, UA = 35.5%). In fact, activities related to unknown species, as well as known but uncommon species, can strengthen knowledge of and proximity to animals and plants (LINDEMANN-MATTHIES, 2005). Further studies comparing rural schools with urban schools could clarify and corroborate these results.

### Biomes

When students were presented the names of the Brazilian biomes so that they should indicate their presence within the state, the results indicated Pampa (MI = 54.5, HI = 93.2%), Atlantic Forest (21.8, 27.0%), Cerrado (49.1, 37.8%), Caatinga (18.0, 6.8%), Pantanal (30.0, 6.8%), and Amazon (34.5, 4.1%), although only the first and the second are correct. HI students had better knowledge about the Amazon, Caatinga, and Pantanal (< 7%) than MI students (18 to 34.5%) because these three biomes are not present in Rio Grande do Sul. It is worrying that only half of MI students included the Pampa, and the very low percentages obtained for the Atlantic Forest (21.8 and 27%) are also concerning. The Pampa occupies almost two-thirds of Rio Grande do Sul, with its own fauna, flora, and tremendous biodiversity comprising herbaceous vegetation ranging from grasses to sparse trees. The Atlantic Forest has a high biodiversity value of plants and animals, although the impact of human occupation and this biome's destruction have been accentuated in the last three decades, resulting in severe changes due to habitat fragmentation (CORDEIRO; HASENACK, 2009; RIBEIRO *et al.*, 2009).

When asked, 'Can agriculture disfigure biomes?', only 35% of MI students answered 'yes' compared to 73% in HI. The main reasons for the negative answers in MI were 'because it has plants', 'the biome is preserved even with agriculture', and 'agriculture has nothing to do with biomes'. Students who answered 'yes' mentioned agriculture's relationship with 'deforestation', 'pollution', 'loss of fauna', and the 'use of toxic products', while in HI, students' justifications for their answers included 'agriculture helps biodiversity', 'done correctly, with limits, it does not change [things]' and 'what is planted is compatible'. Agriculture is a relevant production sector for the economy and development of many cities in Rio Grande do Sul, although industrialisation, intensification of land use, and erroneous use of pesticides have severely impacted local biodiversity (RIO GRANDE DO SUL, 2005).

### **Educational practices**

When questioned about what attracted the most attention, answers predominantly mentioned the theme of 'exotic and native plants and animals' (41.9 and 27.0%), which, when integrated with the qualitative data, indicated the importance of images to arouse student interest. To obtain subsidies for the development of pedagogical practices related to the issues examined in this study, students were asked to indicate appropriate methods for such activities. The highest rates of agreement were observed for 'fieldwork' (81.8% and 94.5%) and 'laboratories' (80 and 83.8%). 'Teachers' explanations' and 'lectures' were mentioned by only 60.9% (MI) and 59.5% (HI), indicating the primacy of practical activities.

Educational practices involving animals and plants are enhanced with concrete activities, hence hands-on fieldwork and laboratory activities can help students improve their learning. In this sense, teachers should be aware that they do not need significant financial resources to be efficient. School gardens, photographs, and even drawings are useful in furthering student's knowledge on the natural environment and the ecological relations between species, particularly in countries with significant biodiversity (BARKER; SLINGSBY; TILLING, 2002; STERN; POWELL; HILL, 2014).

### **Fieldwork**

The second phase of the research involved fieldwork with another student group. Data were collected through a questionnaire that included statements obtained from the categories constructed in the first phase, which represented a sequential exploratory design comprising one part of mixed method research (CRESWELL; CLARK, 2011). During the visit, students enjoyed the fieldwork and exhibited some surprise at the species and the possibility of seeing them so closely. For native species, results of the multiple-choice questions regarding definitions were 'originating from some region' = 55.3%, 'common or easy to find' = 23.7%, and 'found in forests' = 21.0%. For exotic species, results were 'rare or hard to find' = 55.3%, 'unusual appearance' = 23.7%, 'wild' = 13.1%, and 'introduced in an area where it did not originally exist' = 7.9%.

These results corroborated the data anticipated and provided an extensive association between 'native/native to a region' and 'easy to find' and between 'exotic' and 'hard to find' and 'unusual appearance'. Thereafter, students analysed a list of popular and scientific names of species that could be found in zoos. Answer percentages

ranging between 80 and 90% were found for the exotic *Panthera tigris*, *Pavo cristatus*, *Panthera leo*, *Pan troglodytes*, and *Hippopotamus amphibius* and the natives *Ara ararauna*, *Ramphastos dicolorus*, *Hydrochoerus hydrocaeris*, and *Panthera onca*. With percentages from 60 to 80% were the exotic *Giraffa camelopardalis*, *Equus quagga boehmi*, *Struthio camelus*, and *Loxodonta africana* and the natives *Alouatta fusca*, and *Myiopsitta monachus*. Lower than these values were the natives *Vanellus chilensis*, *Rhea americana*, *Mazama americana*, *Chrysocyon brachyurus*, and *Felis tigrine*; same for the exotic *Macropus rufogriseus* and *Ailuropoda melanoleuca*.

Dohn (2013) showed students' increasing interest during a zoo field trip as a consequence of active involvement in hands-on activities, novelty, surprise, knowledge acquisition, and social involvement. These educational practices not only enhanced affective enrolment but also stimulated students' learning motivation.

Even though the visited zoo housed only native species, students identified a high number of exotic species on the list of names that they probably recognised from another zoo near their cities in Sapucaia do Sul. Fieldwork proved germane to the observation of the species *in loco*, corroborating previous results on the proficiency of this strategy to address the issue. Such practices could also help strengthen the proximity to and knowledge of plants for students and urban culture in general (NYBERG; SANDERS, 2014). Fieldwork in places where living animals and plants can be found helps students enjoy classes in a content-dominated curriculum, appreciate natural history, and connect theory and observations (BARKER; SLINGSBY; TILLING, 2002). This educational practice allows a detailed approach to the ecological relations among species through the on-site observation of animals and plants in their habitat. Studies on the effects of introduced species on native fauna have demonstrated the damage caused at different taxonomic levels and highlighted the need for both students and teachers to better understand the effects of these processes on biodiversity (CLUSELLA-TRULLAS; GARCIA, 2017; DECHOUM *et al.*, 2018). Furthermore, in a study with students aged between 8 to 16, Lindemann-Matthies (2005) demonstrated that activities with different plants and animals enhance proximity to and attractiveness of unknown species. Before undertaking educational activities, they first considered just decorative or garden species, pets and exotic animals. Post-test questionnaires showed that the more wild plant and animal presence children observed during the programme, the higher the increase in their appreciation of these species.

### Final remarks

The results of the present study show that, although students knew many of the species presented, they experienced difficulties recognising some as 'native' or 'exotic'. There were associations between native and 'known' and between 'exotic' and 'unknown' or 'rare', as well as a tendency to consider commonly seen exotic trees with edible fruits as 'native'. Likewise, domesticated exotic animal species (the cow and the rooster) were considered 'native', as were pine and eucalyptus, as a consequence of being commonly observed in the cities where the students live.

For all school years considered in this study, rates of correct answers about the origins of exotic mammals were higher than those about native mammals, native birds, exotic birds, and domestic exotic animals; however, regression analysis showed an increase in learning over the school years. Furthermore, the differences found among

students who frequently visited rural areas occurred only in relation to domestic animals raised on farms.

Concerning the level of difficulty, HI students more accurately grasped the complicated concepts of 'native' and 'exotic' compared with MI students, but the outcomes were the opposite for biodiversity. Biomes were similar in terms of difficulties found in MI and HI, suggesting a negative correlation between school grades and the difficulty ascribed.

It should be noted that the knowledge analysed is associated with regional valorisation and the promotion of environmental awareness, contextualising the process with the issue of anthropic impact. As such, the realisation of educational practices with conceptual aspects and parallels with biodiversity can effectively contribute to the teaching of science and biology, especially reckoning regional peculiarities. With activities in this realm, it is possible to build knowledge regarding the importance of native species and the potential invasive risks of the introduction of exotic species. Thus, given the vast availability of information on Brazilian biodiversity, there is a need to combine scientific advances and results related to biomes, obtained by researchers from different fields, with the experiences accrued during teachers' professional activities to improve educational processes in our schools. Given the small sample of the present study, future research, specifically with students from rural areas, could further clarify the subject with the aim of improving knowledge on perceptions about local biodiversity and exotic species.

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