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Sociocultural Variables That Impact High School Students' Perceptions of Native Fauna: a Study on the Species Component of the Biodiversity Concept

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Abstract This study investigates the influence of school sector (private versus state schools) and student gender on knowledge of native fauna. Our main objectives were (a) to describe the knowledge of high school students from the province of Cordoba, Argentina with respect to native animal species, (b) to determine if any exotic species (introduced or domestic) are considered native, and (c) to analyze the effects of school sector and gender on the students' knowledge of the native fauna. In total, 321 students aged 15–18 from 14 urban schools (8 state and 6 private schools) were asked to write down ten animals native to Córdoba, Argentina, in a free-list questionnaire. Relative frequencies and Generalized Linear Mixed Models (GLMM) were used to analyze the categorized (animal names) and continuous answers (quantity of responses, number of native animals, etc.), with the 25 most frequently mentioned species showing a predominance of native ones, of which "Puma" (*Puma concolor*) and "Andean condor" (*Vultur gryphus*) were the most prominent. An overrepresentation of mammalian species compared to other classes of chordates was also found, with high school students mentioning native and domestic species higher on the free-list. Using GLMM, we found that school sector had a significant effect on the number of native animals mentioned at both national and local levels, and on domestic and mixed species. Finally, male students mentioned more species and more native animals than their female counterparts. These findings were interpreted and discussed in light of sociocultural and traditional ecological knowledge theories, from which several implications arose related to research and practice.

Keywords Biodiversity · Biological diversity · Traditional ecological knowledge · Fauna · State school · Argentina

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Introduction

The definition of biodiversity most widely used in politics and the media is the one given by the Convention on Biological Diversity (CBD), signed on 5 June 1992 in Rio de Janeiro (Brazil), in which it was described as consisting of all terrestrial and aquatic organisms (including animals, plants, and microbes) on all scales, i.e., from genetic diversity within populations to the diversity of species and the diversity of communities across landscapes (UNCED 1992). However, in the scientific field, more recent publications have broadened this concept of biodiversity to include species richness, composition, relative abundance, interactions, and spatial distribution of genotypes, species, communities, functional groups, and landscape units (Diaz et al. 2006).

Nowadays, a general consensus is that biodiversity sustains all life processes and directly contributes to human well-being by the following: (i) supporting the production of food, fuel, fibers, and genetic material; (ii) by providing educational, intellectual, and recreational opportunities, as well as aesthetic and spiritual enjoyment; and (iii) by reducing the risks posed by environmental changes (Mace et al. 2010). However, one of the most urgent global environmental problems of the recent decades is declining biodiversity (Secretariat of the Convention on Biological Diversity 2003), with the people who rely most directly on ecosystem goods and services, such as subsistence farmers, the rural poor, and traditional societies, facing the most serious and immediate risks from biodiversity loss (Díaz et al. 2006).

According to Kassas (2002), the CBD brought the issue of biodiversity to the attention of scientists, educators, policymakers, and the public worldwide. Furthermore, Agenda 21, adopted at the Conference of United Nations on Environment and Development (UNCED 1992), called for educational programs which are both locally relevant and culturally appropriate (article 36), since cultural differences in the perception of biodiversity and its loss are important factors that determine the success of programs aimed at awareness building (Fiebelkorn and Menzel 2013). The understanding and attitudes toward biodiversity components (such as animal species) influence people's opinions on which species should be bought as pets, sustainably managed, or might become extinct (Ballouard et al. 2012; Berg 2001; Evagorou et al. 2012; Grace and Ratcliffe 2002; Kilinc et al. 2013). More importantly, upbringing and life experiences might be crucial in determining awareness of the surrounding biodiversity.

In this context, the "composition attribute" of the biological diversity concept may comprise information about the type of a living organism (if it is a plant, an animal, a fungus, etc.), whether it belongs to a particular functional group (for instance, herbivores or carnivores, nitrogen-fixing plants, etc.), and the origin of the species (native, exotic, etc.). With regard to this, it has been suggested that animals are seen by people as being more important than plants, mainly because most are able to move about and communicate by sound, and thereby interact with humans (Lindemann-Matthies 2005; Prokop et al. 2007; Wandersee and Schussler 2001). An "animal blindness" phenomenon, as stated for plants by Wandersee and Schussler (2001), can be attributed to those less visible or considered to be "ugly" animals, such as bats, spiders, and snakes (Prokop and Tunnicliffe 2008, 2010; Prokop et al. 2009; Prokop et al. 2010. Moreover, the considered status of a species, i.e., whether it is native to a specific region or not, might influence everyday perceptions of biodiversity in relation to the species we come into direct contact with (Patrick and Tunnicliffe 2011). In fact, any exotic species that has been introduced to an ecosystem could be seen as native if it is frequently observed in the environment and reproduces rapidly in the wild. If so, the willingness to protect it might be even increased if it is a “charismatic” species, i.e., with a pleasant appearance and intelligent or human-like behavior. Hence, these attitudes and knowledge of biodiversity may influence current and future conservation efforts (Kilinc et al. 2013).

From a sociocultural point of view, the environmental understanding, practices, and beliefs that human communities possess constitute “traditional ecological knowledge” (TEK), which is not limited to any specific technical field (WIPO 2007). This knowledge, which is transmitted from one generation to another through observation and direct experience, tends to be socially embedded and contributes to cultural traditions, identities, beliefs, and worldviews (Pilgrim et al. 2008). Knowledge is often acquired through local management practices and may differ from conventional scientific knowledge, which has been the traditional “benchmark” for evaluating competence in science education (Reid et al. 2004). In this context, there is a growing number of studies on ecological knowledge that have surveyed localized differences in the knowledge levels of men and women, of old and young, of groups engaged or not in ecosystem management, of those from remote isolated villages or from more accessible and connected ones, and of those with different periods of time resident at one place (Hilgert and Gil 2006; Ladio and Lozada 2009; Toledo et al. 2010; Trillo et al. 2010; Reyes-García et al. 2005; Martínez and Luján 2011). In addition, on a large-scale level, it has been revealed that TEK declines in association with the economic growth of a country (Pilgrim et al. 2008). However, very little research has been undertaken on educational institutions in an urban context.

We question educational studies that traditionally have addressed the problem of biodiversity knowledge at the species level, by mainly focusing on the familiarity of children with organisms by asking pupils to name a specific number of animals, even in non-formal educational contexts, according to their preferences (Campos et al. 2012; Lindemann-Matthies 2005; Nates et al. 2010; Patrick and Tunnicliffe 2011). In such investigations, the identification of native species is a categorization process performed by the researcher rather than the student (Campos et al. 2012; Nates et al. 2010), and thus, may be an analytical artifact. In contrast, in the current study, a particular status of the species (local native animals) was specifically asked of a sample of high school students, thereby revealing the convergence of traditional and institutionalized knowledge about biodiversity. Moreover, to our knowledge, this is the first study in which the type of school, i.e., private or state, was examined as a sociocultural variable influencing knowledge of the local fauna.

The investigation we carried out asked the general question of whether traditional ecological knowledge is similar or differs among different segments of high school student populations in Argentina. For the current study, we chose to ask the following questions: (1) Which animals do students consider to be native and what are their taxonomic and origin characteristics? (2) Which animals do high school students list first in a free-list questionnaire? and (3) How do school sector (state versus private schools) and gender influence knowledge of native fauna?

The data collection for this study used free-listing in order to ascertain the knowledge of high school students concerning the species component of the biological diversity concept, by determining their ability to name animals native to the local geographical context. The base knowledge that arises from this investigation could be used in the future by teachers and policymakers to design lessons and campaigns concerning biodiversity protection and local fauna acknowledgement.

Theoretical Background

Traditional Ecological Knowledge

TEK is a concept that is used in the scientific community to refer to experience acquired over thousands of years of direct human contact with the environment (Berkes 1993). An example of TEK is the knowledge applied in the ethnobiological practices of people using plants and animals to treat human diseases and in traditional veterinary medicine (Martínez and Luján 2011; Martínez 2013; Toledo et al. 2010; Trillo et al. 2010). Ecological knowledge has substantial environmental, human, and economic value as it codes for and contributes to a wide range of ecosystem goods and services, including current and future pharmaceutical uses, agricultural diversity, and wild harvest opportunities for food, medicine, and fuel (Pilgrim et al. 2008). Local community groups can contribute to maintaining biodiversity and also provide ecosystem services in urban areas based on their ecological knowledge. For example, in Argentina, Toledo et al. (2010) found that forest loss was positively correlated with the loss of knowledge and use of medicinal native plants of the local people. These trends revealed that the knowledge and utilization of biodiversity by human communities is closely related to the habitat, where activities such as hunting, feeding domestic animals, and obtaining food and medicines may be impaired in a natural habitat fragmentation context.

In spite of TEK being acknowledged as having a fundamental importance in the management of local biodiversity, it has not been included in contemporary or modern education in the twenty-first century. Bowers (2001, cited in Reid et al. 2004) identified that the "centralized," "top-down," and "modernist" approaches to education found in the institutions, philosophies, and practices of formal, bureaucratized education are in conflict with systems of knowledge such as TEK-based approaches. Related to this, Reid et al. (2004) stated that those in positions of power and authority in education have not considered the custodians of such knowledge to be "traditional," appropriate, or authoritative, or that the knowledge itself is "rich," generalizable, or illuminative for teaching or learning.

In the science curricula, the debate on the status of TEK has been centered on a juxtaposition of two incompatible frameworks: "multiculturalism" and "universalism" (van Eijck and Roth 2007). This controversy is concerned with what should be included in curricular standards as "science" and "scientific knowledge," with some forms of knowledge in danger that are traditionally not denoted as such, including TEK. The roots of this debate can be traced to relativist notions of what counts as "truth" (or "reality") and, hence, to the conception of reality as being bound up with power structures in society, the so-called Foucault's regimes of truth (van Eijck and Roth 2007). Simply put, Reis and Ng-A-Fook (2010) pointed out that those on the "multiculturalist" side of the discussion profess that TEK is as valid (and valuable) as scientific knowledge. On the other hand, "universalists" prefer to see TEK as an inferior type of knowledge because it lacks the transcendent nature of real science, i.e., being very much bound to specific local contexts and situations. That is to say, they consider Western modern science (WMS) to be universal, meaning that it could be applied to all situations including those where TEK has been historically used (Reis and Ng-A-Fook 2010). In addition, van Eijck and Roth (2007) reject epistemological truth as a way of thinking about sciences in science education. Instead, they have adopted a "utilitarian perspective" of cultural historical activity theory (Leont'ev 1978) to demonstrate when traditional knowledge is considered to be science and when it is not (Reis and Ng-A-Fook 2010).

According to Alsop and Fawcett (2010), van Eijck and Roth's arguments seek to overcome the multicultural-universalism debate, and in search of a way of uniting these well-worn binary positions, they have looked to developing an epistemology that simultaneously entails both *culture* and *physical reality* by rejecting a position of *truth* and adopting "utilitarianism" as a measure of the validity of knowledge. This utilitarian perspective attempts to recalibrate science and TEK in the science education curriculum, which is one institution where *truth* is maintained (Mueller and Tippins 2010). This position also embodies the dynamic, heterogeneous, and plural nature of the products of human beings and knowledge (Alsop and Fawcett 2010). Therefore, in order to resolve the dispute between TEK and WMS, it is argued that one should simply consider the usefulness of each to particular situations without making their co-existence compulsory (Reis and Ng-A-Fook 2010). According to Mueller and Tippins (2010), van Eijck and Roth consider science not to be independent of the particular contexts in which it is practical, nor is it good for all people and at all times; rather, it is relativistic, being neither objective nor universal.

In order to survey TEK, a well-established ethnographic method that is used is "freelist," which simply entails listing things in a domain (e.g., types of living organisms, animals considered to be native, etc.) in whichever order they come to mind (Quinlan 2005). Freelisting involves three important assumptions: (a) when people freelist, they tend to list terms in order of familiarity; (b) individuals who know more about a subject list more terms than those who know less (for instance, gardeners may name many more ornamental plants than a regular office employee), and (c) terms that most respondents mention indicate locally prominent items, i.e., those relevant in the local context (Quinlan 2005). In the current study, we decided to use this ethnographic method to investigate the animal species that high school students from different sectors of Argentina consider to be native.

Sociocultural Theory

From a sociocultural perspective, learning takes place in social, cultural, and historical contexts, and is constructed in relation to prior ideas and experiences (Vygotsky 1978). Higher mental processes, such as those described by Piaget (1978), originate from social processes through internalization (Wertsch 1985), which involve interactions on the interpsychological (social) plane among individuals, followed by interactions on the intrapsychological (individual) plane. Internalization is not a direct copying of the understanding and practices from the social plane, but rather the formation of understanding and practices on the individual plane from activities on the social plane (Wertsch 1985), with this process being heavily mediated by discourse (Vygotsky 1981). The notion of the teacher assisting student performance through the "zone of proximal development" suggests that teachers can guide the discourse of the interpsychological plane to support students' knowledge construction. In fact, this constructivist perspective, or "constructivism," has been gaining acceptance among researchers and scholars in science education around the world (Staver 1998; Tobin and Tippins 1993).

Within this framework, concerning words, Vygotsky (1987) distinguishes between "sense" and "meaning," with the former being "the aggregate of all psychological facts that arise in our consciousness as a result of a particular word. Sense is a dynamic, fluid and complex formation which has several zones that vary in their stability […] In different contexts, a word's sense changes" (pp. 275–276). In turn, "meaning" offers the possibility of intersubjectivity (social construction), i.e., the sharing of the meanings of a word by two or more people, despite the variation in the senses they attribute to it. For instance, the understanding of the term "animal" may range from a naive perception of only mammals to a detailed scientific classification scheme for the animal kingdom (Wallace 2004). In the context of the current study, we acknowledge that people generate different meanings and senses for words such as "animal," "species," and "native," due to their prior experiences and existing concepts, and in interaction with academic knowledge acquired at school (Driver et al. 1994). According to Vygotsky (1991), the interaction between everyday and scientific concepts shapes the meanings that students construct, communicate, and represent (1991). During this construction activity, learners actively process information by either accommodating (i.e., adapting) their own cognitive structures or assimilating information in order to make it fit into the current worldview (Piaget 1978). Hodson (1999) points out that resulting beliefs and worldviews in everyday contexts may represent alternatives to scientific discourse, which sheds light in the current study on the animals students considered to be (a) species belonging to the homonymous kingdom, (b) native, and (c) native to Córdoba Province.

In science teaching, different perspectives have used their own terminologies to represent students' ideas about nature, such as "misconceptions," "alternative conceptions," "naive theories," "framework theories," "specific theories," "mental models," "facets," and "p-prims." We have utilized the term "conception" in the current study to describe students' naive mental structures that represent natural phenomena and processes, with these being part of a knowledge system. We suggest that the plurality of terms that widely refer to "conceptions" reflects the existence of a "representational pluralism" in science classrooms (Rodrigo 1994) as an emerging feature of different types of knowledge encounters (academic, scientific, and everyday way-of-thinking) (De Longhi 2000; Driver et al. 1994). However, as seen above for culturally transmitted everyday ecological knowledge (TEK), students' ideas about specific content have been frequently belittled in relation to the prioritized (higher)-status of natural sciences (WMS) (Mueller and Tippins 2010). Hence, certain conceptions have been considered as barriers (misconceptions) to the accommodation of scientific information, which gave rise to a "conceptual change" position (Posner et al. 1982).

After the recognition of the difficulties in the abandonment and subsuming procedure of students' ideas in the teaching process, the "conceptual profile" approach was first proposed as an alternative, which recognizes that people can exhibit different ways of seeing and interpreting the world due to their individual experiences. This model differs from conceptual change in suggesting that it is possible to use different ways of thinking in different domains, even within the scientific one, since there are epistemological and ontological differences between successive theories (Mortimer et al. 2012). Moreover, this position involves the recognition of the heterogeneity in people's meanings (Mortimer 1995). In fact, Mortimer et al. (2012) argued that "science itself is not a homogeneous form of knowing and speaking, and can provide multiple ways of seeing the world that can coexist in the same individual and provide a basis in different contexts" (p. 235). Although the conceptual profile approach has evolved to incorporate a sociocultural approach by drawing on ideas such as situated cognition and Vygotsky's influential concept of culturally located learning (Mortimer et al. 2012), the underlying assumption is a received view of canonical science (or correct conceptions—as opposed to misconceptions) and the ability to choose between competing conceptions based on accepted principles of practices within the epistemology of the scientific community.

Nonetheless, the notion of "plurality of representations" (Rodrigo 1994) is valid for integrating different epistemologies (everyday, scholar, and scientific) in science teaching, since it emphasizes the students' coping with the heterogeneous representations that may differ in terms of their adequacy to explain a set of facts according to specific scenarios (everyday or scientific) (Pozo and Rodrigo 2001). Consequently, "change" is considered to be a reconstructive process enabling several representations of the same domain to co-exist in the student's mind. The focus of teachers' concerns should therefore change, and instead of helping students to abandon common sense modes of thinking in favor of scientific ones, they should be helped to confront alternative models on more dialectical grounds. This alternative knowledge may differ not only in content but also in terms of the nature of the representation (Pozo and Rodrigo 2001). We think that this "representational pluralism" is related to the aforementioned van Eijck and Roth's utilitarian sense of TEK, since avoiding dogmatic teaching by addressing different points of view and contexts is crucial for environmental programs to succeed (Kassas 2002). Moreover, we believe that science teaching should also consider the students' plurality of conceptions of native fauna as part of their TEK about biodiversity (Reid et al. 2004).

In relation to the educational and social factors that influence the pupils' construction of meaning, school economic resources and family income should be taken into consideration, especially due to the complex social stratification (social heterogeneity) and the considerable difference in the distribution of institutional resources and practices (school heterogeneity) in Argentina (Cervini 2002). In a study conducted by Gamallo (2011), it was found that 80 % of the students attending state schools belonged to households in the two poorest quintiles of society whereas most pupils at private schools were from the most well-off sectors of society. In relation to the academic performance of students attending state or private schools, Cervini (1999) found that differences between school average yields at primary school were remarkably high, while at the secondary level, the variations in math and language performance were also significant (Cervini 2009).

Cervini (2002) also found that in Argentina, the opportunity to learn Math and Language was more strongly related to the educational institution students attend than to the province where they live. In relation to this, the Programme for International Student Assessment (PISA) findings for Argentina revealed that socio-economically advantaged schools, where most socio-economically advantaged students attend, usually have more educational resources and students tend to perform better (OECD 2010a). With respect to this, family economic level has been found to be significant for Math and Language-students' performance in primary schools, while the parents' level of education became significant for secondary education (Cervini 2009). In addition, students who come from an economically and culturally disadvantaged family progress less than their more advantaged peers, i.e., the gap in achievement between students of different socio-economic levels increases over time (Cervini 2006). Finally, according to PISA, the greater the socio-economic advantages of students in Argentina (and in other countries, such as Turkey, Uruguay, Hungary, and Italy), the greater the marginal increase observed in student performance (OECD 2010b).

Another sociocultural-related issue influencing differential knowledge construction is gender, which implies a set of social roles and relationships, personality traits, attitudes, behaviors, values, and relationships of power and influence that each society differentially attributes to each sex. In the context of the current investigation, we were interested in ascertaining whether male and female students have similar or different conceptions of animal biodiversity. In relation to this, Bourdieu (2000) stated that schools, similarly to households, are places of preparation, imposition, and reproduction of male domination principles over females. Educational institutions are not gender-neutral either and respond to and reproduce social patterns that perpetuate stereotypes considered to be "normal, objective and natural," based on sexual chromosomes that code for women (XX) and men (XY) (biological sexuality). In this context, it is “normal” for Bourdieu (2000) that male identity sends us to the “outside” public places, to “danger,” and to “outdoor” activities, while the female identity leads us to the “inner,” “private,” and “invisible” things. These actions are expressions of cultural gender roles that ascribe certain tasks and stereotypes to boys or girls (Fox Keller 2000). As a consequence, boys might be more aware of the local fauna and may interact more directly and more frequently with species than girls when fishing, hunting, playing, and being outside the house.

In the current study, school sector (state versus private schools) and gender of the students were tested as independent variables that influence a pupil’s ideas about the native fauna, with the former being an indicator of the socio-economical level of the assisting pupils. Although gender differences in students’ perceptions of biodiversity have been investigated extensively (see “Ecological Studies on Biological Diversity”), there is no conclusive evidence on the influence of socio-economic backgrounds on the knowledge of the native fauna at the end of the compulsory educational cycle.

Educational Studies on Biological Diversity

An increased interest in biodiversity education (BE) has been shown by educators and ecologists interested in creating a greater knowledge of biodiversity in different regions of the world (Barker and Elliott 2000; Campos et al. 2012; Grace and Ratcliffe 2002; Kassas 2002; Krombaβ and Harms 2008; Menzel and Bögeholz 2009; Nates et al. 2010; Songer et al. 2009; Van Weelie and Wals 2002). In addition, BE represents an excellent opportunity to link science and political issues because biodiversity embraces biological, spiritual, cultural, economic, aesthetic, and ethical points of view (Barker and Elliott 2000; Kassas 2002; Grace 2009). Therefore, a greater understanding of biodiversity is highly compatible with environmental education being a continuous learning process that enables participants to construct, critique, emancipate, and transform their world in an existential way (Van Weelie and Wals 2002).

In recent years, specific issues in biodiversity teaching and learning have been described. For example:

(a) ”Biodiversity” and “species diversity” are usually used as synonymous terms, thus narrowing the sense of the former, with its many components (genes, populations, functional groups, etc.) and attributes (composition, relative abundance, range, interactions, and spatial distribution) being ignored (Bermudez and De Longhi 2008; Bebbington 2005; Fiebelkorn and Menzel 2013; Kilinc et al. 2013; Lindemann-Matthies 2006);
(b) Pupils from developed countries consider that “the biodiversity” only takes place in the economically impoverished countries of Africa and Central America (Menzel and Bögeholz 2009);
(c) The existence of a “magical way of thinking” that presupposes the goodness and harmony of the elements of nature for the sake of being “natural” (Rohde 1996), and does not consider the negative effects generated by the introduction and rapid expansion of alien species;
(d) The recognition and appreciation of mainly animal species (and vegetables to a lesser extent) from nearby contexts, usually rich in exotic species (Ballouard et al. 2011; Bright and Stinchfield 2005; Campos et al. 2012; Nates et al. 2010);

(e) The emphasis on "friendly animals" such as large mammals (especially those with a pleasant appearance and intelligent or human-like behaviors) and "attractive plants" (with large, colorful, and fragrant flowers or edible fruit) (Ballouard et al. 2011; Campos et al. 2012; Lindemann-Matthies 2005; Nates et al. 2010; Snaddon et al. 2008);
(f) Familiarity with certain species increases with age and differs between boys and girls, since the former mostly recognize species from the field and surrounding communities, while the latter are mostly centered on ornamental and domestic species (Campos et al. 2012);
(g) The value of biodiversity conservation is often associated with sources of food and medicine (Menzel and Bögeholz 2009), without considering other ecosystem services that are useful to human beings and the ecosystem functioning;
(h) The fact that the mathematical concept of "proportion" may represent an "epistemological obstacle" (Bachelard 2002) to the understanding of relative abundance of the components of biodiversity (Bermudez and De Longhi 2008).

In relation to the "friendly animal centrism," Wagler and Wagler (2011) pointed out that research carried out over the last four decades has shown that there is a general trend among children to more frequently believe that the conceptual understanding of an animal refers to common well-known mammals (e.g., dolphin, giant panda, and koala bear) (Ballouard et al. 2011; Lindemann-Matthies 2005; Nates et al. 2010). Other groups of species with a high degree of familiarity and preference among students are domestic animals and those that have some kind of positive relationship with humans (Campos et al. 2012).

By contrast, "wild" animals are considered to be typically aggressive, able to attack and kill, and are therefore seen negatively (Jiménez 1998). Related to this, several studies have warned about the limited knowledge of almost all invertebrates and some "less charismatic" animals or those with a "bad reputation," such as snakes and bats, in both children and adults (Campos et al. 2012; Snaddon et al. 2008; Prokop and Tunnicliffe 2008; Prokop et al. 2009). In fact, Prokop et al. (2008) reported that although invertebrates perform many essential ecosystem services to humans, the general trend is to have a negative view of them. As a worldwide iconic example, arachnophobia is one of the most common animal aversions in Western society and has been attributed to biological, sociocultural, and personal factors since men are generally less afraid of spiders than women (Prokop et al. 2010). Regarding the conservation of reptiles, myths can generate either a positive or negative outlook, resulting in hatred due to an association with sin or evil (snakes) or love when considered as carriers of power and prosperity (Alves et al. 2012).

In the current paper, we investigated the number and identity of animals listed by high school students with respect to their belonging to a particular species, i.e., whether a given animal represents an identified species (for example, "Fox"), along with their taxonomical status (whether they are "charismatic mammals" or not, as in the case of arthropods, reptiles, etc.), and their origin (whether they are native to Argentina or not). Other studies that have focused on understanding the relationship between conceptual knowledge and attitudes found that a greater knowledge about insects that can be pests, or predators (such as wolves), or vectors of human diseases (such as mice) is associated with a negative attitude towards them (Prokop and Tunnicliffe 2010). Moreover, attitudes towards animals impact on people's preferences for conservation. For example, Jiménez (1998) found that students who have negative concepts of "wild" animals question the need to preserve them. In a similar study conducted by Ballouard et al. (2011), elementary students favored the protection of highly iconic exotic animals such as the giant panda or polar bear rather than others.

The objectives of the current study were (a) to describe the knowledge of high school students from the province of Cordoba, Argentina with respect to native animal species, (b) to determine exotic species (introduced or domestic) considered to be native, and (c) to analyze the influence of the school sector (state vs. private schools) and gender on students' knowledge of the native fauna.

Methodology

Context

This study had a non-experimental design with a non-probabilistic sample and used an opportunity sample technique to recruit the schools. Education institutions were contacted through the Córdoba subsidiary of the Biological Sciences Teacher Association of Argentina (ADBIA), which is a nonprofit organization (Legal Entity 201/96), and through the contact list of the Master of Education in Experimental Sciences and Technology, a postgraduate career of the National University of Córdoba. Target teachers were defined as those working in the province of Córdoba and who (a) had taught classes over the last 3 years in the Argentinean mandatory system, specifically in the Natural-Science-oriented curriculum, (b) had previously taught the content of "biodiversity" the same year we contacted them, and (c) were not necessarily affiliated to ADBIA or taking courses in the above-mentioned Masters course. The curriculum of these classes included subjects such as Biology, Ecology, Environment and Society, Environmental Issues, etc., and involved the teaching of topics such as biodiversity, conservation, ecosystem, and environmental adaptations of the organisms to different environments (Education Ministry of Córdoba 2011).

When contacting the teachers by e-mail (by the end of May 2011), we provided general information about the topic of the investigation and asked them for (a) their school names, contact details, classes and subjects, time-tables, etc., and (b) for permission to contact their school principals if they were interested in collaborating with us. After a previously fixed 2-week period, 14 teachers had been identified who were willing to participate. Contact was made with their school principals personally (by the first author of this paper), and upon obtaining permission, we arranged a day with the teachers to give a written questionnaire to their students (see "Data Collection"). Data were collected from June to July 2011, at 14 urban schools (321 students aged between 15 and 18 years old) located in the province of Córdoba (Argentina), for eight classes from eight state schools and six classes from six private schools.

Two assumptions were made for the current study: that private and state school curricula did not differ and that teachers did not deviate from the typical curriculum items after we had contacted them to participate in the investigation. By keeping constant both the oriented curriculum to Natural Sciences and the relative time when students were taught about biodiversity (prior to data collection), we think that these assumptions were valid.

As the gender ratio of the schools in which data were collected was not provided by the principals, we decided to estimate the school gender ratio from the courses surveyed. In this way, for these courses, 57.9 % of the pupils were girls (57.6 and 58.2 % in private and in state schools, respectively) and 42.1 % were boys (42.4 and 41.8 % in private and in state schools, respectively). Finally, with respect to the geographic relationship of the schools in which the data were collected, four out of the eight state schools were located in the city of Córdoba, capital of the homonymous province, while the remaining four were situated in small towns in mountainous and agro productive regions. In the case of the private schools, four were located in the city of Córdoba and two were in small nearby towns.

Data Collection

A free-list written questionnaire was given to the students in a natural context (classroom), where they were asked to write down the names of ten animals native to Córdoba Province (Argentina) and to provide their own names in order to record their gender and to be able to contact them in case of future interest. All questionnaires were personally administered by the same researcher (the first author of this paper) in natural settings and under the supervision of the teacher. Students were given 25 min to complete the questionnaire.

Freelisted data allows the researcher to discover the "relative salience" of items across all respondents within a given domain, i.e., the statistic accounting for rank and frequency (Quinlan 2005). For example, in the domain of fauna terms, "Dog" is more salient if it appears more often and earlier in freelists than "Cat." According to Quinlan (2005), researchers can calculate the mean salience value for all listed items in order to reveal the intracultural salience of each term (e.g., how salient "Horse" is) and for the whole list of terms after a process of categorization (e.g., the frequency and rank of native animals). Although Quinlan (2005) states that individuals who "know" more about a subject list more terms than those who "know" less, a potential limitation of the current collection of data was that "recall" (list) could be considered to be the same as "understanding." With respect to this, when students list animals, we can only assume that they "know" them, but do not necessarily have a deep "understanding" of them in the terms stated by Wiske (1998), as this would imply being able to explain, give evidence and examples, generalize, and represent the topic in new ways.

Data Analysis

The taxa that students had written down were registered, and then the matching scientific and other vernacular names were identified. The given common names often matched more than one scientific name, with these names corresponding to (a) native, (b) exotic *sensu lato*, or (c) mixed origin (animal names corresponding to both native and exotic species at the national level—"Monkey," for instance). Secondly, five categories were created by splitting the exotic *s.l.* category into three subcategories: (a) exotic *sensu stricto* (exotic species excluding those introduced into Argentina, such as "Giant panda"), (b) domestic (pet and farmland animal species such as "Dog" and "Donkey," respectively), and (c) introduced species (animals that had an exotic origin to Argentina, but are now rapidly propagating, such as the "European hare").

For each species, the scientific names and taxonomical data (Phyllum, Class, Order, Family) were searched for in the "Species 2000 & ITIS Catalogue of Life" digital resource (Roskov et al. 2013), available at http://www.catalogueoflife.org/col/search/all. Vernacular names and their scientific matches were searched for on the internet (Wikipedia, Biodiversity Information System—available at http://www.sib.gov.ar/, at Avibase—the world bird database, available at http://avibase.bsc-eoc.org/avibase.jsp, among other sources), in books (Bonino 2012; Canevari and Vaccaro 2007; Heredia 2008; Kufner 2010; Laita and Aparicio 2005), and in technical papers (Cebollada Putz et al. 2012; Giraudo et al. 2006; Novillo and Ojeda 2008).

The order in which the species were mentioned by each student was also recorded. Then, the distribution of the 25 most mentioned species was investigated in order to fit model equations (logarithmic, exponential, quadratic, etc.) with SPSS (Statistical Package for Social Sciences®, version 17.0). The value of F, the general coefficient of determination (R^2), and the p values were calculated using the same statistical program.

We decided to establish ranks for the native category, and then treat the position in the free-list as a categorical variable so as to indicate the salience of the animals under this origin category (Quinlan 2005). Therefore, three categorical ranges were considered for the "native" category: (a) number of native species named in the list, i.e., up to ten species, (b) number of native species within the first five species named, and (c) number of native species within the first three species named. In contrast, the order in which individual species were free listed by the students was considered to be an ordinal variable. Hence, the position and number of mentions of species such as "Puma," "Dog," or "Hare" of the whole student sample was also registered. Although at an individual level the frequency number was always 1, since no repetitions were found within each student's list of animals (i.e., a student mentioning "Dog" twice in his/her free-list), at the class level this species approach indicated the percentage of the students mentioning a specific animal. As a result, the continuous variables (e.g., number of native animals) were proportion data (e.g., number of native animals named in relation to the total number of animals listed). Generalized Linear Mixed Models (GLMM) were used with a binomial error structure because the data had strictly bounded proportions, the variance was not constant, and the errors were non-normal (Bolker et al. 2008).

Analyses were carried out using Infostat® (http://www.infostat.com.ar, 2013 version), with essay number being the quantity of species requested (10) or the number of species named by each student in the case of individual species analysis. Models were fitted by a Laplace approximation, and a log-link function was applied using the lmer function of R's lme4 package for Infostat (R Development Core Team 2010; http://www.r-project.org/). The significance of fixed factors was tested using the Wald statistical test, and the Akaike Information Criterion (AIC) was used to assist in model selection (i.e., the more parsimonious and better the fit of the model, the lower the AIC value).

We also tested if the sociocultural variables "school sector" (private or state; categorical variable) and "gender" (male or female; categorical variable) influenced each response variable. For this purpose, we fitted generalized linear mixed models with each explanatory variable being the fixed factor, with the interaction between factors also being taken into consideration. The classes the students attended were considered to be random factors and the models were derived using backward selection, i.e., starting with a full model and at each step removing the most non-significant variable, which was considered to be that with the highest p value on the basis of the results of the Wald tests ($p<0.05$). This procedure was repeated until the model with the lowest AIC was obtained (Burnham and Anderson 2010). The post-hoc comparison test Least Significant Difference (LSD) was applied whenever $p<0.05$. In cases where the interaction of "school sector" and "gender" had an influence, a post-hoc comparison test was performed by extracting "classes" as the random factor (Campos et al. 2012).

Results

Familiarity with Species

Salient Species

Students were able to give 2925 responses, corresponding to 216 different categories of animal names. However, the "blank" was the most prominent (22.53 %) (Table 1), since the majority of the participants failed to complete the ten-species free-list. Table 1

Table 1 Absolute (*n*) and relative (%) frequencies, and nation and regional statuses of the 25 most-mentioned animal species by high school students in Cordoba, Argentina, attending state and private schools

Order	Spanish/English vernacular name	Scientific name	Class	Order	Family	*n*	Percent	National status	Local status
1	No answer	–	–	–	–	659	22.53	–	–
2	Puma/mountain lion, puma, cougar	*Puma concolor*	Mammalia	Carnivora	Felidae	164	5.57	Native	Native
3	Cóndor/Andean condor	*Vultur gryphus*	Aves	Ciconiiformes	Ciconiidae	108	3.69	Native	Native
4	Liebre/Hare	*Lepus capensis*	Mammalia	Lagomorpha	Leporidae	96	3.28	Introduced	Introduced
5	Gato montés/Geoffroy's cat	*Oncifelis geoffroyi*	Mammalia	Carnivora	Felidae	79	2.70	Native	Native
6	Vizcacha/plains vizcacha	*Lagortomus maximus*	Mammalia	Lagomorpha	Chinchillidae	74	2.53	Native	Native
7	Zorro/fox	*Dusicyon* spp.	Mammalia	Carnivora	Canidae	69	2.36	Native	Native
8	Quirquincho/hairy armadillo	*Chaetophractus villosus*	Mammalia	Xenarthra	Dasypodidae	65	2.22	Native	Native
9	Cuis/Southern mountain cavy	*Microcavia australis*	Mammalia	Rodentia	Caviidae	58	1.98	Native	Native
10	Vaca/cattle	*Bos primigenius*	Mammalia	Artiodactyla	Bovidae	54	1.85	Domestic	Domestic
11	Yarará/crossed pit viper	*Bothropoides* spp.	Reptilia	Serpentes	Viperidae	52	1.78	Native	Native
12	Pato/duck	*Cirina* spp., *Netta* spp., etc.	Aves	Anseriformes	Anatidae	47	1.61	Mixed	Mixed
13	Caballo/horse	*Equus caballus*	Mammalia	Perissodactyla	Equidae	42	1.44	Domestic	Domestic
14	Perro/dog	*Canis lupus familiaris*	Mammalia	Carnivora	Canidae	42	1.44	Domestic	Domestic
15	Burro/asinus	*Equus asinus*	Mammalia	Perissodactyla	Equidae	41	1.40	Domestic	Domestic
16	Garza/great white egret	*Ardea alba*	Aves	Ciconiiformes	Ardeidae	38	1.30	Native	Native
17	Paloma/pigeon, dove	*Patagioenas picazuro*, *Columba livia*, *Zenaida auriculata*, etc.	Aves	Columbiformes	Columbidae	37	1.26	Mixed	Mixed
18	Gato/cat	*Felis silvestris catus*	Mammalia	Carnivora	Felidae	35	1.20	Domestic	Domestic
19	Iguana/common iguana	*Iguana iguana*	Reptilia	Squamata	Iguanidae	33	1.13	Native	Exotic
20	Tero/Chilean lapwing	*Vanellus chilensis*	Aves	Ciconiiformes	Charadriidae	32	1.09	Native	Native
21	Guanaco/guanaco	*Lama guanicoe*	Mammalia	Artiodactyla	Camelidae	29	0.99	Native	Exotic
22	Ñandú/American rhea	*Rhea americana*	Aves	Rheiformes	Rheidae	27	0.92	Native	Native
23	Conejo/common rabbit	*Oryctolagus cuniculus*	Mammalia	Lagomorpha	Caviidae	26	0.89	Exotic	Exotic
24	Perdiz, inambú/nothura, spotted tinamou	*Nothura* spp., *Nothoprocta* spp., *Rhynochotus* spp.	Aves	Tinamiformes	Tinamidae	25	0.85	Native	Native
25	Gallina/domestic fowl, feral chicken	*Gallus gallus*	Aves	Galliformes	Phasianidae	24	0.82	Domestic	Domestic

also shows that the five most frequently mentioned species (salient) were "Puma" (native), "Andean condor" (native), "Hare" (exotic, introduced), "Geoffroy's cat" (native), and "Plains vizcacha" (native). Other native species that were less frequently mentioned were "Fox" (*Dusicyon* spp.), "Hairy armadillo" (*Chaetophractus villosus*), and "Cavy" (*Microcavia australis*). In spite of this, many domestic species were considered to be native by the students, such as "Cattle" (*Bos primigenius*), "Horse" (*Equus caballus*), "Dog" (*Canis lupus familiaris*), "Asinus" (*Equus asinus*), "Cat" (*Felis silvestris catus*), and "Domestic fowl" (*Gallus gallus*).

Species Taxonomy

Regarding the phylogenetic status of the named species, the majority were Chordates (98.23 %, Table 2), i.e., deuterostome animals possessing a notochord, a hollow dorsal nerve cord, pharyngeal slits, an endostyle, and a post-anal tail for at least some period of their life cycles. Among Chordates, mammals were the most prominent, representing 53.88 % of the species mentioned. Out of the remaining 35 phyla that actually comprise the Animalia kingdom (Roskov et al. 2013), the only two named by the students were arthropods and mollusk specimens.

Species Origin

Figure 1a shows that the majority of the students named native species (65.21 %). However, concerning whether the mentioned exotic *s.l.* species were domestic, introduced, or simply exotic species from other regions of the world (such as lion, zebra and elephant), i.e., "exotic *s.s.*", Fig. 1b shows that the exotic animals were mainly domestic species and also indicates that approximately 7 % of the exotic animals named had been introduced to Argentina.

Individual Species Naming Order

When taking into account the order in which the species were mentioned in the free-listing questionnaire, "Puma" (*Puma concolor*) and "Condor" (*Vultur gryphus*) fitted an exponential and logarithmic function, respectively (Fig. 2a, b). For the introduced species "European hare" (*Lepus capensis*) (Fig. 2c), the distribution was exponential, but the coefficient of determination (R^2) was lower than that of "Condor" or "Puma" due to data dispersion. For domestic pet species such as "Dog" (Fig. 3a, b) and "Cat," only a significant logarithmic distribution was found for the former. Finally, regarding livestock domestic species, "Horse" and "Cow" did not reveal significant fits to quadratic distributions (Fig. 3c, d), indicating that they were mentioned in any order in the free-list.

Influence of Sociocultural Variables on Students' Knowledge of Native Fauna

Table 3 shows that school sector and gender of the students were significant factors influencing the majority of the students' responses. Male pupils mentioned more overall species than their girl peers (GLMM: χ^2=21.14; p<0.001), with the latter consistently giving more blank answers (GLMM: χ^2=19.53; p<0.001). According to Quinlan (2005) for free-lists studies, individuals who know the most (in our case, boys) tend

Table 2 Relative frequency (%) of the Classes and Phyla of the animals named by high school students attending state and private schools in Cordoba, Argentina. The ITIS number of species for each Class and the number of Argentinean animal species (endangered between parentheses) are given as a reference to the overrepresentation of some Classes

Phylum	Class	Percent	ITIS (2013)	Argentina[a] (endangered)[b]
Chordata	–	98.23	65,932	–
	Mammalia	53.88	4843	375 (39)
	Aves	30.59	9924	993 (48)
	Reptilia	7.55	9789	12 (6)
	Actinopterygii	5.11	31,182	72 (37)
	Amphibia	0.84	6439	157 (30)
Arthropoda	–	1.73	914,856	–
	Insecta	1.65	794,830	(13, "other invertebrates"
	Arachnida	0.25	63,614	–
	Branchiopoda	0.04	1363	–
	Malacostraca	0.04	28,175	–
Mollusca	–	0.04	41,655	–
	Gastropoda	0.04	30,245	(0, "molluscs")

[a] www.countdown2010.net/files/Argentina%20y%20Biodiversidad.pdf

[b] http://goo.gl/p3nnAa Table 5—number of threatened species in each major group of organisms in each country (critically endangered, endangered, and vulnerable categories only)

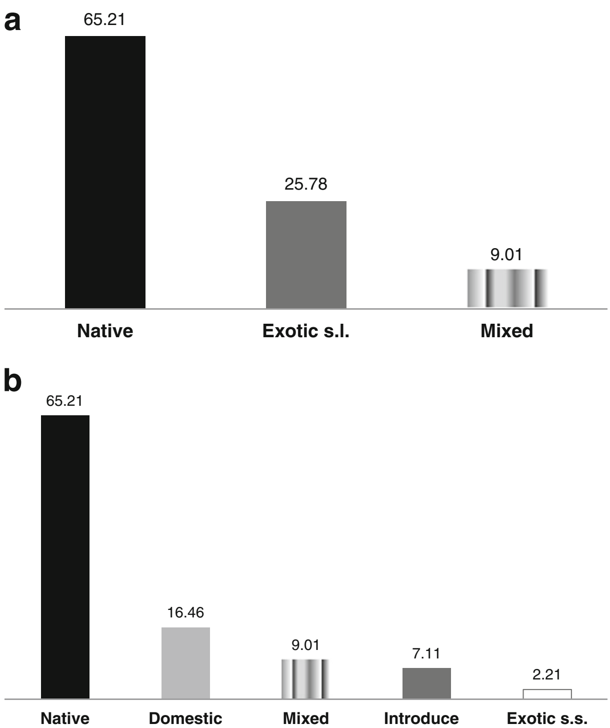

Fig. 1 Relative frequency (%, *numbers over bars*) of the species status categories of the animals named by high school students attending state and private schools in Córdoba, Argentina. **a** Three categories: native, exotic *sensu lato*, and mixed **b** The "exotic *s.l.*" category has been split into domestic, introduced, and "exotic *sensu stricto*" species

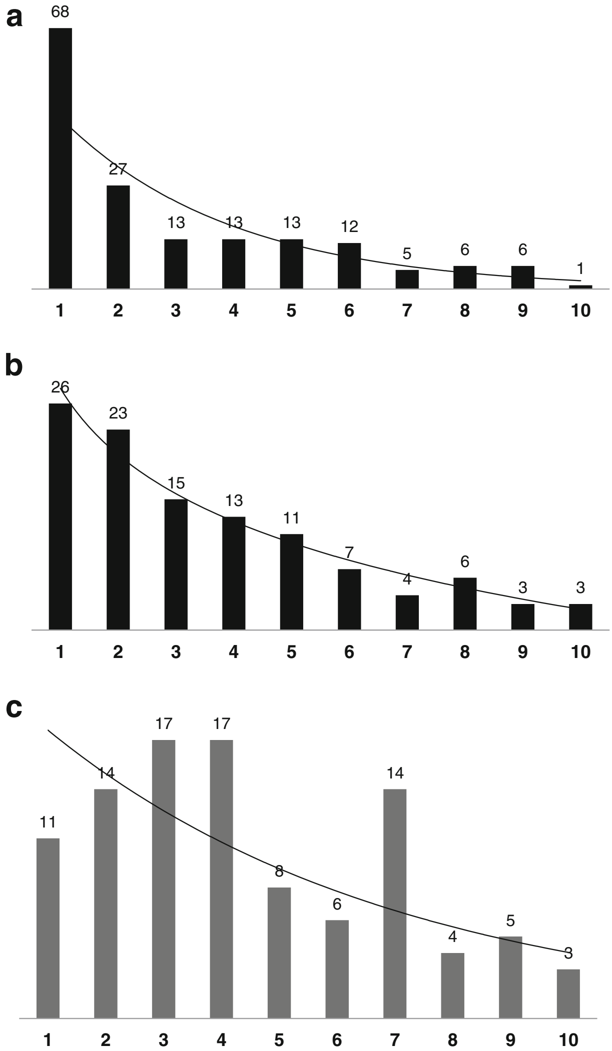

Fig. 2 Absolute frequency (*numbers over bars*) and best equation distribution model of some species as a function of the order of being named in the questionnaire (from 1st to 10th place). *Solid line* represents the adjusted line to the distribution. **a** Native: "Puma" (*P. concolor*), exponential distribution (F=38.421, R^2=0.828, p=0.000). **b** Native: "Andean condor" (*V. gryphus*), logarithmic distribution (F=218.541, R^2=0.965, p=0.000). **c** Introduced: "European hare" (*L. capensis*), exponential distribution (F=12.869, R^2=0.617, p=0.007)

to mention more terms than those who know less (girls). Gender difference was also evident as male students named more animals that were native than female students did (GLMM: χ^2=12.61; p<0.001).

In relation to the school sector, this variable was consistently significant for the first three (GLMM: χ^2=6.57; p=0.010), first five (GLMM: χ^2=7.90; p=0.003), and for the whole list of animals mentioned (GLMM: χ^2=6.66; p=0.010), with private schools having the highest percentage of native species mentioned (at a national level) (Table 3). In contrast, the number of species native to Córdoba named was higher in state schools (GLMM first-five mentioned: χ^2=5.09; p=0.024; GLMM first-three mentioned χ^2=7.06; p=0.008), but was still lower for girls (GLMM all mentions: χ^2=23.64; p<0.001; GLMM first-five mentioned: χ^2=18.59; p<0.001; GLMM first-

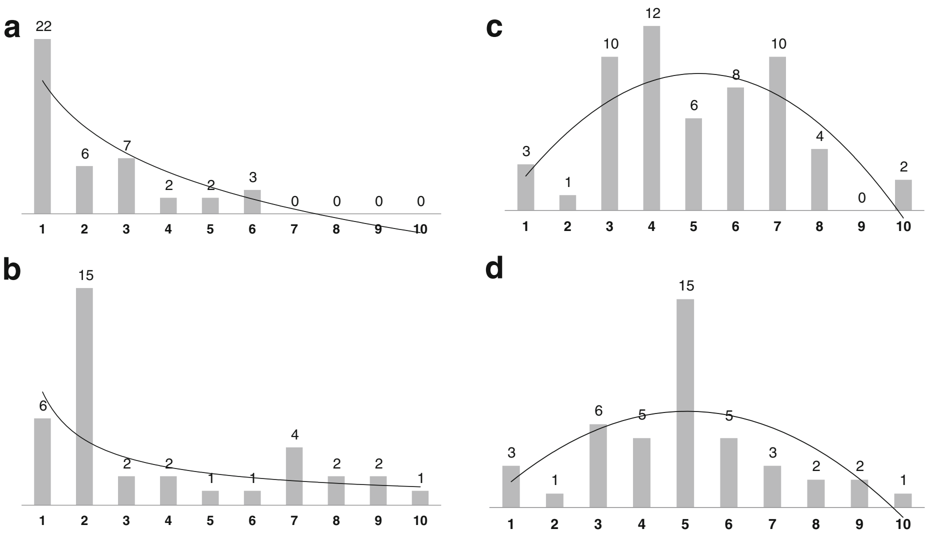

Fig. 3 Absolute frequency (*numbers over bars*) and best equation distribution model of some species as a function of the order of being named in the questionnaire (from 1st to 10th place). *Solid line* represents the adjusted line to the distribution. **a** Pet: "Dog" (*C. lupus familiaris*), logarithmic distribution (F=35.662, R^2= 0.817, p=0.000). **b** Pet: "Cat" (*F. silvestris catus*), potential distribution (F=4.151, R^2=0.372, p=0.081). **c** Livestock: "Cow" (*B. primigenius*), quadratic distribution (F=4.420, R^2=0.558, p=0.057). **d** Livestock: "Horse" (*E. caballus*), quadratic distribution (F=2.091, R^2=0.374, p=0.194)

three mentioned χ^2=6.80; p=0.009). Regarding the domestic species, state school students named more pets (dog, cat, etc.) and farm animals (horse, chicken, etc.) (GLMM: χ^2=30.85; p<0.001) than private school students.

In contrast with the findings for native and domestic species, the number of exotic *s.s.* and introduced species was independent of the school sector (GLMM exotic: χ^2=1.68, p=0.196; GLMM introduced: χ^2=1.15, p=0.284) and gender of the students (GLMM exotic: χ^2=1.10, p=0.295; GLMM introduced: χ^2=3.47, p=0.068). Finally, mixed species naming was influenced by the interaction of both school sector and gender of the students (GLMM: χ^2=3.92; p=0.048), with females attending private schools significantly being the group that mentioned these species the least.

The effect of school sector and gender of the students was also tested for the 25 most-mentioned individual animals (Table 4), and it was found that "Puma" (*P. concolor*) and "Andean condor" (*V. gryphus*) were mainly mentioned by private school students, while "Fox" (*Dusicyon* spp.), "Duck" (*Cirina* spp., etc.), "Dog" (*C. lupus familiaris*), "Asinus" (*E. asinus*), "Pigeon" (*Patagioenas picazuro*, etc.), and "Cat" (*F. silvestris catus*) were primarily mentioned by state school students.

Discussion

The purpose of this study was to investigate whether traditional ecological knowledge varied in the different segments of high school student populations in Argentina, by specifically determining the knowledge of native fauna through a free-list written

Table 3 Effect of school sector (St, state; Pri, private) and gender of the students (M, male; F, female) on the proportion of animal species named by high school students in Cordoba, Argentina. Generalized Linear Mixed Models (GLMM) included school sector and gender of the students as fixed factors, and grade as the random factor. Non-significant effects were not included. Akaike's Information Criterion (AIC) values and significance for the overall models; value, standard error (S.E.), and significance ($p<0.05$; Wald test) for effect coefficients are shown

Category	Whole model		Factors					
Number of…	AIC	*p*	Effect	Mean±SD	Coefficient	S.E.	*T* value	*p*
Answers	1395	***	Gender (M>F)	0.80±0.04>0.73±0.05	0.41	0.11	3.55	***
Missing answers	1404	***	Gender (F>M)	0.26±0.05>0.20±0.04	−0.37	0.08	−4.39	***
Native spp.[a]	1080	***	Sector (Pri>St)+Gender (M>F)	0.49±0.01>0.45±0.01 0.50±0.01>0.44±0.01	−0.25 0.16	0.09 0.10	−2.74 1.58	** *
Native spp. (first 3 mentions)[a]	596	***	Sector (Pri>St)	0.69±0.04>0.60±0.04	−0.49	0.19	−2.57	**
Native spp. (first 5 mentions)[a]	434	**	Sector (Pri>St)	0.32±0.01>0.27±0.01	−0.31	0.11	−2.94	**
Exotic *s.s.* spp.[a]	205	ns	–	–	–	–	–	–
Mixed spp.[a]	305	*	Sector × gender (F St=M St=M Pri>F Pri)	0.08±0.01=0.07±0.01= 0.06±0.01>0.04±0.01	−0.65	0.30	−2.17	*
Domestic spp.[a]	912	***	Sector (St>Pri)	0.14±0.03>0.07±0.02	0.74	0.13	5.49	***
Introduced spp.[a]	322	ns	–	–	–	–	–	–
Native spp.[b]	1132	***	Gender (M>F)	0.72±0.04>0.64±0.05	0.33	0.11	3.08	**
Native spp. (first 3 mentions)[b]	361	***	Sector (St>Pri) Gender (M>F)	0.91±0.02>0.84±0.03 0.90±0.02>0.85±0.02	0.59 0.52	0.21 0.20	2.74 2.55	** *
Native spp. (first 5 mentions)[b]	590	***	Sector (St>Pri) Gender (M>F)	0.87±0.02>0.82±0.03 0.88±0.02>0.80±0.03	0.35 0.60	0.15 0.14	2.37 4.22	* ***

St state, *Pri* private, *M* male, *F* female, *s.s. sensu stricto*, *ns* not significant

*Significant at 0.05 probability level; **significant at 0.01 probability level; ***significant at 0.001 probability level

[a] Nation level

[b] Local level

Table 4 Significant effects of school sector and gender of the students on the proportion of the 25 most named animals by high school students in Cordoba, Argentina. Generalized Linear Mixed Models (GLMM) included school sector and gender of the students as fixed factors, and grade as the random factor. Akaike's Information Criterion (AIC) values and significance for the overall models; value, standard error (S.E.), and significance ($p<0.05$; Wald test) for effect coefficients are shown

Species	Scientific name	Whole model		Factors					
English vernacular name		AIC	*p*	Effect	Mean±SD	Coefficient	SD	*T* value	*p*
Puma	*Puma concolor*	243	***	Sector (Pri>St)	0.09±0.01>0.05±0.01	−0.41	0.21	−1.91	*
Condor	*Vultur gryphus*	252	***	Sector × gender (Pri F>Pri M=St M>St F)	0.08±0.01>0.05±0.01=0.05±0.01 > 0.02±0.01	1.24	0.41	3.00	**
Fox	*Dusicyon* spp.	215	***	Sector (Pri>St)	0.05±0.01>0.02±3.7E−3	−0.91	0.33	−2.79	**
Duck	*Cirina* spp., etc.	156	***	Sector (St>Pri)	0.03±5E−3>3.8E−3±2.1E−3	1.72	0.54	3.20	***
Dog	*Canis lupus familiaris*	155	***	Sector (St>Pri)	0.03±4.4E−3>0.01±2.5E−3	2.08	0.74	2.80	***
Asinus	*Equus asinus*	172	***	Sector (St>Pri)	0.02±3.4E−3>4.9E−3±2.0E−3	0.94	0.44	2.12	*
Pigeon	*Patagioenas picazuro*, etc.	153	***	Sector (St>Pri)	0.02±4.2E−3>0.01±2.5E−3	1.92	0.75	2.57	**
Cat	*Felis silvestris catus*	147	**	Sector (St>Pri)	0.02±4.0E−3>0.01±2.5E−3	1.98	0.75	2.65	**
Rabbit	*Oryctolagus cuniculus*	132	*	Sector × gender (St F>= Pri M=Pri F>= St M)	0.02±4.0E−3>=0.01±0.01= 0.01±3.9E−3>= 3.5E−3±2.5E−3	−2.03	0.97	−2.09	*

St state, *Pri* private, *M* male, *F* female

*Significant at 0.05 probability level; **significant at 0.01 probability level; ***significant at 0.001 probability level questionnaire applied to students attending state or private institutions. In this context, biodiversity knowledge, expressed as the ability to name native animals, might provide an indication of a person's connectivity to the local environment and reveal their traditional ecological knowledge (Pilgrim et al. 2008), as well reflecting the influence of science teaching in compulsory education. We assume that students may have learnt and remembered the names of the species they found attractive or easy to memorize or had direct experience with (Lindemann-Matthies 2005; Patrick and Tunnicliffe 2011), or had been specifically taught these species (Nates et al. 2012; Randler 2008).

Familiarity with Species

Biological, Ecological, and Cultural Relevance of Salient Species

First of all, it is worth noting that the majority of the participants failed to complete the ten-species free-list and that the "blank answer" was the most prominent, which might indicate a low or only moderate knowledge of the fauna. However, the mean number of responses of the current study was higher than Lindemann-Matthies (2005) findings for a Swiss sample of students. Also, it is important to acknowledge that the recorded number of responses and categories of animal names was higher than the 165 plants given by the same sample of students in another study (Bermudez, unpublished data). These findings reveal a similar trend of animal species richness as that found by Schwarz et al. (2012) when investigating the knowledge of Brazilian children about biodiversity in the Mata Atlântica biome, which might indicate an "animal centrism" in the students' biodiversity knowledge. In addition, such centrism has been previously described in elementary science textbooks in relation to the disparities present between plant and animal content coverage and photographs. With respect to this, Link-Pérez et al. (2010) found that animal photographs far outnumbered those of plants, were labeled more specifically, and showed more examples of the diversity of animal groups compared to the plant groups. Moreover, Rodríguez et al. (2014) described that the treatment of animal content was more extensive and was introduced in a more conspicuous way than that of plants.

Regarding the salient animals in the current study, "Puma" (*P. concolor*), "Andean condor" (*V. gryphus*), "Hare" (*L. europaeus*), "Geoffroy's cat" (*Oncifelis geoffroyi*), and "Plains vizcacha" (*Lagostomus maximus*) were named the most frequently by high school students, which are all considered to be native with the exception of "Hare" and thus might indicate a good knowledge of native fauna. Our findings differed from those reported by Campos et al. (2012), who found that only two out of the ten most frequently named animals could be considered native. Moreover, Campos et al. (2012) found that children mentioned many iconic species such as "Lion" (*Panthera leo*), "Tiger" (*Panthera tigris*), and "Elephant" (*Elephas maximus* and *Loxodonta africana*), whereas in the current study, these species were absent. One possible explanation of these differences might be the character of the question posed in the questionnaire and the influence of formal education, since in the present study we specifically asked high school students for "native" species. In relation to "Hare," it seems to have lost its association with an exotic animal in the ecological knowledge of the students, since a native ecosystem equivalent (the "Mara" or "Patagonian hare") received just 19 mentions (against 96 mentions of "Hare").

Next, we considered the biological and ecological characters of the five most frequently named species and their sociocultural relevance to the Argentine context through their social representations, history, and conservation status. The most salient of these species ("Puma") is a feline that can reach large dimensions and have cryptic, nocturnal and solitary habits, and tolerates a wide range of climates and habitats due to its ecological plasticity (Perovic and Pereira 2006). Its prey are often reared by humans (goats and sheep, etc.), so it is frequently considered to be bloodthirsty (Berg 2001). Consequently, the relationship between the human and the "Puma" presents multiple and repeated stories of conflict and misunderstandings (Sillero-Zubiri 2000), and pumas are now threatened primarily by loss and destruction of their habitat and through the indiscriminate hunting of their natural prey. It is currently on the CITES II list, although it is considered to be of "least concern" to IUCN (2013).

The "Andean condor" is the world's largest flying bird. It is considered to be a "flagship species," thus explaining the great importance attached to the protection of its habitat and the conservation of the biodiversity. People also associate the "Condor" with the generation of environmental services and ecosystem conservation actions (Pérez-Zapata et al. 2010). In fact, the Condor's image appears as an element of cultural integration and as a symbol of American identity, with it appearing in indigenous rock art, ceramics, textiles, and as part of the literary, poetic, and musical expression (Aguirre 2003). In Argentina, this species has also been depicted in many cartoons and caricatures as a humanized figure linked with children, for example in "The Adventures of Penacho and Cataplún" and in "Condorito" cartoons (Montealegre 2007). In the province of Córdoba, the National Park "Quebrada del Condorito" was set up in 1996 in order to protect the origins of an important watershed, vital for the area, and for the conservation of the breeding habitat of the Andean condor. However, as its population is decreasing, it is currently categorized as being "near threatened" (IUCN 2013).

According to Long (2003), America and Europe are clear examples of invasions by exotic mammals. As a paradigmatic example in Argentina, the "European hare" spread so rapidly across the country in some provinces that it was declared to be a pest by the early twentieth century (Jaksic et al. 2002). This produced a separation from native herbivores such as the "Patagonian hare" (*Dolichotis patagonum*), while favoring the expansion of local predators (foxes and pumas) (Bonino et al. 1997; Novillo and Ojeda 2008). Moreover, the proliferation of the "European hare" has had a negative impact on pasture, agriculture, and native forest regeneration.

"Geoffroy's cat," the fifth most-mentioned species, is a small felid of a size similar to a domestic cat, which inhabits a wide variety of habitats, including areas under livestock management and crops (Castillo et al. 2008). This felid is an animal hunted by the local people, to use its skin, for meat consumption, and to prevent predation on poultry (Vilela et al. 2009; Soler et al. 2004). It is a key species in the ecosystem, since it is at the top of the food chain and mainly consumes rodents, hares, and lizards. Although it is believed that the bobcat is a species with a high adaptability to different habitats (Castillo et al. 2008), it is under pressure from the expansion of agricultural limits and new roads. It is worth noting that *O. geoffroyi* is near to being threatened according to IUCN (2013) and appears in Appendix I of CITES (Convention on International Trade of Endangered Species of Wild Fauna and Flora) (NEP-WCMC 2013).

In sixth place of the most frequently named animals were "Vizcachas," which are large herbivorous rodents, native to the grasslands and semi-arid scrub of Argentina. They live in social groups and share a communal burrow system called a "vizcachera" (Branch et al. 1999). Ecologically and behaviorally, "Vizcachas" have profound effects on the grasslands and semi-arid scrub of Argentina, with intense grazing around the "vizcacheras" affecting plant communities and producing a species replacement and increased bare ground in the area of greatest activity (Arias et al. 2003). However, it is a key species for determining the vertical distribution of nutrients in the soil profile (Villarreal et al. 2008) and it is an essential component of the "Puma" diet (Pessino et al. 2001). "Vizcachas" have already disappeared from much of their original range and they continue to be subjected to eradication programs as they are considered to be competitors of domestic livestock (Branch et al. 1999). In the social sphere, "Vizcacha" (or "old vizcacha") appears as a main character in the epic poem "Martín Fierro," written by José Hernández and published in 1872, portraying the rural spaces of Argentina—especially the pampas—and which is acknowledged as the pinnacle of Argentinean "gauchesque" poetry. Martín Fierro is a "gaucho" to whom social injustice makes him an outlaw. In the book, "Vizcacha" is a cunning and mischievous old man who has a negative view of life and advises Fierro to distrust and to be selfish.

All of the aforementioned cultural and biological species characteristics may have influenced the ecological knowledge of the students about the native fauna. However, future research needs to be performed in order to interpret and describe the representations that the students have of the listed animals by obtaining this information directly from the students (actor's perspective).

Taxonomic Classification of the Named Species

The taxonomic classification of the named species revealed that the majority of the named animals were Chordates, which is in agreement with Patrick and Tunnicliffe's (2011) findings for American and English samples of primary students. Here, the underestimation of much richer phyla, e.g., Arthropoda—which actually have a number of species around 14-fold greater than that of Chordates—was analogous to the overrepresentation of mammalian species against other classes of Chordates. Similar results were found by Snaddon et al. (2008) when investigating children's perceptions of rainforest biodiversity by asking primary-age children to draw their ideal rainforest, where it was found that mammals, birds, and reptiles were over-represented against others (especially insects and annelids), with respect to their contribution to total biomass and species richness.

These findings may be explained by the fact that "charismatic animals," almost exclusively represented by mammals and birds, receive disproportionally more attention than other taxonomic groups (Balmford et al. 2002; Nates et al. 2010; Lindemann-Matthies 2005), with this bias possibly resulting in the general support shown by people for the protection of aesthetic, large, or human-like species (Ballouard et al. 2011, 2012; Patrick and Tunnicliffe 2011). Campos et al. (2012) and Schwarz et al. (2012) noted that less popular organisms, including almost all invertebrates and many vertebrates, remain relatively unknown for most adults and children. Prokop et al. (2008) explained that even though invertebrates perform many essential and beneficial ecological services for humans and live in the same places, the general trend is to view them negatively. This may also be the case for chordates with a "bad reputation," such as snakes, which were also underestimated by students both in the current and in previous studies (Prokop et al. 2009). Taking all the above observations into consideration, it may be hypothesized that all crucial ecosystem services provided by insects (pollination, decomposition, biological control, de Bello et al. 2010) are underestimated by the students or, at least, that there is little knowledge of the native species performing these ecosystem functions.

Origin Classification of the Named Species

Since the majority of the students named native species (65.2 %), our findings revealed a good general knowledge about the native animal species in Argentina, which is analogous to the awareness of the Brazilian (Mata Atlântica) fauna that Schwarz et al. (2012) found in primary students from the Joinville Region. However, our results are in disagreement with those of Campos et al. (2012), who asked Argentinean children to list the names of ten animals without specifying that they had to be native. In that study, as well as in that of Nates et al. (2010), the majority of the mentioned species were mainly domestic (dog, cat, horse) and exotic *s.s.* species (lion, tiger, elephant). In addition, our findings differ from those of Lindemann-Matthies (2005), who found that only 24.9 % of the animals mentioned by children were wild species native to Switzerland. In that investigation, the proportion of domestic and exotic species was also higher than in the current study. Finally, in spite of the number of introduced species named by the students being relatively low (7 %), the fact that they are propagating spontaneously in Argentina might be contributing ideas to the students' concepts of native species.

Individual Species Naming Order

When associating the order in which the species were mentioned in the free-listing questionnaire as being an indication of species salience (Quinlan 2005), our findings showed that native and domestic animals (pets) were the most familiar to the sample of high school students in Argentina. In addition, we found that the more times one particular native animal was named by students (frequency), the sooner they mentioned it in the free-list (position). For instance, the *P. concolor*'s and *V. gryphus*' exponential and logarithmic fittings revealed a strong trend for these to be named in the upper places of the list (species salience), with the same pattern being found for *L. capensis*, thereby enforcing the idea that the hare's salience might have been a consequence of students thinking it had a native origin due to its abundance in Córdoba's ecosystems. For domestic livestock species, non-significant quadratic distributions indicated that they were mentioned randomly in the free-list.

Influence of Sociocultural Variables on Students' Knowledge of Native Fauna

Our study revealed that school sector and gender of the students were significant factors influencing the majority of the students' responses. Since male pupils mentioned more species than their girl peers, then, in agreement with Quinlan (2005), they were the individuals who demonstrated the most knowledge within the sample. Nevertheless, the percentages of native species mentioned in both cases represented a solid knowledge of the Argentinean fauna.

In the province of Córdoba, ethnobotanical studies on the knowledge of the uses of plants have revealed gender differences, since it was found that women knew more medicinal plants than men because they are often responsible for the maintenance of family health (Toledo et al. 2010). These differences were not only quantitative but also related to the marked interest, attitudes, and emotions shown by women when talking about medicinal plants. In contrast, Martínez and Luján (2011) found that in Córdoba, veterinary ethnobotanical knowledge was mainly restricted to male cattle breeders, who were more often in direct contact with livestock animals (horses, cows, and chickens). According to Muiño (2012), both the house and the peridomestic space are places dominated by women in many regions of Argentina. Men, however, have a greater influence in relation to the activities of the mountain areas, such as herding, hunting, and gathering.

Regarding the origin of the animals listed, the finding that male students named more native species than girls is in agreement with Campos et al. (2012) and Lindemann-Matthies' (2005) findings, but differs from studies of Schwarz et al. (2012) and Nates et al. (2010), where no gender differences were reported or where boys favored exotic animals. Our results might be explained by a differential contact of boys with nature in the local context or by educational and generational issues, either related to the respondents or to their family members, or be due to their experiences and use of animal species. In a similar study, Lindemann-Matthies (2005) found that girls prefer to have pets while boys have a stronger interest in wild animals compared to "traditional" domestic pets (dog, cat, etc.). In fact, in similar studies performed in Argentina, Campos et al. (2012) and Nates et al. (2010) found that girls are more likely to perceive and like species in the vicinity of their home (e.g., dogs and roses) due to a more defined aesthetic and anthropomorphic orientation. Consequently, it has been stated that boys tend to have more personal experiences with animals from the field (Prokop et al. 2008) and that girls have greater emotional affection for large, attractive, and primarily domestic pet animals (Kellert 1985). Our findings could also be explained by the "masculine" stereotype being associated with "the outside" and that of "feminine" being related to "private" and "domestic" places (Bourdieu 2000).

Another finding of the current study was that school sector (an indicator of the socio-economic background of the students) was a significant variable influencing knowledge of fauna, with native animals at a national level being more salient in the case of private school students (in frequency of being mentioned and position in the free-list—first three and first five terms listed). These results may be explained by two non-mutually exclusive reasons: (a) that private schools studied were more effective than state schools in promoting the appreciation of the Argentinean fauna, or (b) that children attending private schools possessed a more profound ecological background, due to their lifestyles and experiences (Campos et al. 2012). As previously stated, since the majority of the most economically affluent sectors of society attend private schools (Gamallo 2011), it is feasible to suppose that these families can afford textbooks—whose publishing houses are principally established outside Córdoba Province (Bermudez, personal communication)—to obtain an indirect contact with nature. On the other hand, state school pupils might be kept in touch with plants and animals in their proximate contexts. In favor of this latter hypothesis, state school students mentioned more pets and farm animals than private school students. However, future research should address among other issues the sources of students' knowledge of fauna (as Campos et al. 2012), their lifestyles, family experiences with nature, and the school textbooks that are used to teach biodiversity in the context of Córdoba. Furthermore, it should be investigated if different socio-economic groups in Argentina hold the same or differing views about gender, and, if so, whether this influences the interaction with nature and the knowledge of biodiversity.

The effect of school sector of the students on individual species revealed that private school students mainly mentioned natives ("Puma", "Andean condor", etc.), while domestic animals were primarily named by state school pupils. These findings confirm that private school students are more familiar with native species (at a national level), while those of state schools are more knowledgeable about domestic animals (pets and farm animals).

In relation to the exotic *s.s.* and introduced species being named regardless of the school sector or sex of the students, our findings differ from those of Lindemann-Matthies (2005), who showed a more significant tendency of boys to mention exotic species than girls. In fact, the listed exotic *s.s.* and introduced animals in the current study might indicate a common and strong influence of the traditional ecological knowledge that does not originate from school.

Educational Implications and Perspectives

The findings of the current study have implications for (a) scientists engaged in public outreach, (b) environmental education researchers, (c) those studying gender differences, (d) those investigating the role between TEK and formal schooling, and (e) teachers.

Concerning scientists, the recognition and consensus in the scientific community on the negative impact of biological invasions on biodiversity (Mack et al. 2000) should induce those interested in the popularization of science to design campaigns specifically oriented to the recognition of native species in the proximate contexts and in the field, in order to be able to differentiate native from exotic and invasive species, and to empower citizens to favor reproduction of native plant species in their gardens and urban parks (since they are the home and food of the local fauna). In addition, taking into account that about 43 % of the Earth's land surface has been converted into anthropogenic habitats (Barnosky et al. 2012), and that in Argentina the expansion of the agricultural frontiers has been driven by soybean cultivation (Aizen et al. 2009), ecologists and environmental organizations should develop strategies oriented at reconfiguring and enhancing the knowledge of the native fauna, e.g., publishing specific content about local animals for different ecosystems. To this end, biodiversity education is essential in order to achieve successful conservation campaigns (Fiebelkorn and Menzel 2013). Furthermore, it is necessary to try to introduce people to the diversity of local organisms, including "less attractive" and "inconspicuous" species, especially those not belonging to the mammal class of chordates. Finally, conservation dissemination needs to emphasize the consequences of species introductions and habitat degradation for local biodiversity.

With respect to environmental education researchers, a further challenge would be the inclusion of the socio-economic variables of the studied sample, not only in order to be able to apply ecological knowledge more appropriately when discussing socio-scientific issues (Grace and Ratcliffe 2002; Grace 2009) but also to analyze the economic and societal factors (Cervini 2002, 2009) that influence our ways of interacting with nature. In relation to this, Bourdieu (1984) considers that the aesthetic choices of a person are based on "class fractions," which actively distance one social class from the other by defining aesthetic concepts such as "taste." Consequently, our predispositions to certain kinds of food, music, and art (and species, from our point of view) are taught and instilled in children. Then, self-ascription to a certain class fraction is achieved by impelling the child's internalization of preferences for objects (such as animals) and behaviors that are suitable for a member of such a social class (Bourdieu 1984). Therefore, environmental researchers should consider surveying the socio-economic backgrounds of the students, for which "school sector" may constitute a good indicator—at least in Argentina and other countries with high educative heterogeneities due to disparate socio-economic advantages. Teachers should use the findings of the current study to take into account the prior knowledge that students bring to the classroom by considering the sector of the school they are working for, for example, an Argentinean teacher in a Biology class in an urban state school should spend more time and put a greater emphasis on the teaching of the native fauna than at a private school. Conversely, the focus on domestic fauna should be deepened if teaching in a private educative institution, since students attending private schools know fewer pet and farmland animals than their state school peers.

A further concern is the belief of high school students that some invasive and exotic species are native, as these conceptions and personal observations are often unacted upon in formal science education (Patrick and Tunnicliffe 2011). In the current study, pets and farm animals were recognized as native species, in the context of a fuzzy notion of a concept (Re et al. 2011) generated by a set of perceptions that also integrates native species at a national level, such as "Cachalot" or "Sperm whale" (*Pseudoseisura lophotes*), "Llama" (*Lama glama*), and "Giant anteater" (*Myrmecophaga tridactyla*). This concept serves to emphasize the importance of the construction of plural and collective ideas generated from the presence and distribution of the fauna in the local context (home and school yards, squares, parks, etc.). Therefore, a future widening of the known native animal species would represent a step against the "mammal" and "loveable animal" centrism that students seem to possess towards more notorious and human-like species (Lindemann-Matthies 2005; Patrick and Tunnicliffe 2011; Prokop and Tunnicliffe 2008; Prokop et al. 2009, 2010). With regard to this, it has been suggested that education in school should encompasses a greater appreciation of species other than "charismatic ones" (Snaddon et al. 2008), and that educational efforts might best focus on the affective realm in order to raise emotional concern and sympathy for a broad range of species (Lindemann-Matthies 2005).

In this framework, we consider that it is important for schools and environmental organizations to improve student knowledge about native and adventitious species, particularly biological invaders, by using natural settings as sources of information (Feisinger et al. 1997). Recognition and the ability to name at least the most common organisms will greatly enhance a teacher's ability to deliver biology fieldwork, which needs to be encouraged as an integral part of biology (Bebbington 2005). This fieldwork needs to recognize the importance of students honing their skills related to the identification of animals and their origin status, thus leading to their questioning why and how certain organisms live and interact (biological and ecological characters), and gaining knowledge about the sociocultural representations of the species at local and regional contexts, such as their presence in myths, stories, comics, etc.

Regarding those interested in gender studies, for more than three decades there has been a certain awareness of gender differences with regard to interest in science careers, perceptions of scientists, and science-related experiences (Jones et al. 2000), but it was only more recently that biodiversity education studies relating gender characteristics have appeared (Lindemann-Matthies 2005; Prokop and Tunnicliffe 2010). From the current study, several implications arise. We recommend that gender should systematically be taken into consideration in the appreciation and familiarity of students with animals in environmental and science education research. Concerning practice, the current research sheds light on the differences in familiarity of boys and girls with native species, even in the last 3 years of the compulsory educational cycle (15–18 years old). Therefore, teachers have the responsibility to present biological diversity as being equally appropriate for girls and boys, and to encourage girls to learn about more species and more native animals (at national and local levels). Moreover, biology teachers should incentivize both boys and girls not only to be aware of more animals but also to be able to discriminate the native from the exotic ones (introduced, domestic, and foreign species) at both national and regional levels. Indeed, evidence from current and other previous studies shows that we cannot continue to avoid these issues. As stated by Jones et al. (2000), for science education to maintain the *status quo* without transforming the culture is to condemn girls to know fewer animals and with a higher proportion of exotic species than boys. In relation to this, Bourdieu (2000) stated that schools, similarly to households, are places of preparation, imposition, and reproduction of male domination principles over females. Even when liberated from religious influences, schools may continue to transmit a patriarchal representation (based on the homology between the male/female and the adult/child relationship) of their own hierarchical structures, disciplines ("soft" *versus* "hard") and school labeling (Bourdieu 2000).

We strongly suggest that educators must not assume that biodiversity knowledge is gender-neutral; rather, a better understanding of the strongly interwoven socio-economic and gender factors influencing ecological knowledge needs to be stressed. This can only be achieved if more space is given to real-world examples and if sufficient time is provided to be able to disentangle and understand the complex interrelations among gender and their interaction with nature. At a practical level, teachers ought to spend more time and put special emphasis on the teaching of the fauna in general and the native representatives, in particular in the case of girls. Conversely, more hours should be dedicated and focused on domestic fauna if teaching in a private educative institution, since students attending state schools know more pet and farmland animals than their private school peers.

Finally, the findings of the present study revealed for teachers and for those investigating the role between TEK and formal schooling, a heterogeneous concept of "native animal," which includes mainly native and domestic species as well as introduced and exotic ones. Although modern western science would label these conceptions of "native" as erroneous, acknowledging the "principle for cultural diversity" (Mueller and Tippins 2010) would provide space for the heterogeneity of representations (Rodrigo 1994). From our results, we suggest that the students' native concept is pluralistic and that it is based on the academic and everyday way of thinking about animals (mainly mammals) reproducing in the local context, whether they are growing up in their original habitat or not. In this context, we make the case for considering dialectical relationships between science and TEK in order to ensure cultural diversity in science education, emphasizing the need to dissolve the dualisms that may emerge when science is elevated in status in comparison with other types of knowledge (Mueller and Tippins 2010). Simply put, when teaching biodiversity "components" (such as species) and their "attributes" (such as origin, taxonomy, and the belonging to a particular functional group), teachers should consider bringing to the class everyday experiences that co-exist with academic knowledge in relation to the native fauna, which may be absent in the prescribed curriculum and may differ in terms of their adequacy to explain according to specific scenarios (everyday or scientific) (Pozo and Rodrigo 2001). A practical solution would be to show and legitimate the co-existence between TEK and formal science and to include both sources of knowledge according to their "relevance" within a particular context.

It is worth emphasizing that both science and TEK are now considered to be an integral part of our social development (Reiss and Ng-A-Fook). With respect to this, Mueller and Tippins (2010) have pointed out that all TEK should be considered as being a contrasting, divergent, and complementary expression of activity systems of science that can help to clarify our worldviews. Hence, the contribution of TEK to environmental education should be primarily to focus attention on its role in improving environmental, conservation, and sustainable development strategies (Reid et al. 2004). In addition, researchers working on TEK and biology teachers should ask the students to interact with their family members, by interviewing their parents and other relatives about their favorite organisms, or to bring to the school some specimens from their backyard. Finally, students should be encouraged to share their experiences with pets, farmland animals, and native animals in the wild in personal and family activities such as recreational journeys, the rearing of animals at home, and fishing in local rivers. Future studies that take into account curriculum issues, environmental and socio-economic contexts, as well as students' attitudes to species conservation should now be undertaken.

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References

Aguirre, S. (2003). *Mitos de Chile. Diccionario de seres, magia y encantos*. Santiago de Chile: Sudamericana/ Random House Mondadori.

Aizen, M. A., Garibaldo, L. A., & Dondo, M. (2009). Expansión de la soja y diversidad de la agricultura argentina. *Ecologia Austral, 19*(1), 45–54.

Alsop, S., & Fawcett, L. (2010). After this nothing happened. *Cultural Studies of Science Education, 5*(4), 1027–1045.

Alves, R. R. N., Vieira, K. S., Santana, G. G., Vieira, W. L. S., Almeida, W. O., Souto, W. M. S., Montenegro, P. F., & Pezzuti, J. C. B. (2012). A review on human attitudes towards reptiles in Brazil. *Environmental Monitoring and Assessment, 184*(11), 6877–6901.

Arias, S. M., Madanes, N., & Quintana, R. D. (2003). Estructura y composición de la vegetación en vizcacheras activas e inactivas en el delta del Paraná. *Mastozoología Neotropical / Journal of Neotropical Mammalogy, 10*(1), 9–20.

Bachelard, G. (2002). *The formation of the scientific mind*. Manchester: Clinamen Press.

Ballouard, J. M., Brischoux, F., & Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS ONE, 6*(8), e23152. doi:10.1371/journal.pone.0023152.

Ballouard, J. M., Provost, G., Barre, D., & Bonnet, X. (2012). Influence of a field trip on the attitude of schoolchildren toward unpopular organisms: an experience with snakes. *Journal of Herpetology, 46*(3), 423–428.

Balmford, A., Clegg, G., Coulsen, T., & Taylor, J. (2002). Why conservationists heed Pokémon. *Science, 295*(5564), 2367.

Barker, S., & Elliott, P. (2000). Planning a skills-based resource for biodiversity education. *Journal of Biological Education, 34*(3), 123–127.

Barnosky, A. D., Hadly, E. A., Bascompte, J., Berlow, E. L., Brown, J. H., Fortelius, M., Getz, W. M., Harte, J., Hastings, A., Marquet, P. A., Martinez, N. D., Mooers, A., Roopnarine, P., Vermeij, G., Williams, J. W., Gillespie, R., Kitzes, J., Marshall, C., Matzke, N., Mindell, D. P., Revilla, E., & Smith, A. B. (2012). Approaching a state shift in Earth's biosphere. *Nature, 486*(7401), 52–58.

Bebbington, A. (2005). The ability of A-level students to name plants. *Journal of Biological Education, 39*(2), 62–67.

Berg, K. (2001). Historical attitudes and images and the implications on carnivore survival. *Endangered Species Update, 18*(4), 186–189.

Berkes, F. (1993). Traditional ecological knowledge in perspective. In J. T. Inglis (Ed.), *Traditional ecological knowledge: concepts and cases* (pp. 1–9). Ottawa: International Development Research Centre.

Bermudez, G. M. A., & De Longhi, A. L. (2008). La Educación Ambiental y la Ecología como ciencia. Una discusión necesaria para la enseñanza. *Revista Electrónica de Enseñanza de las Ciencias, 7*(2), 275–297.

Bolker, B., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J. S. S. (2008). Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology and Evolution, 24*(3), 127–135.

Bonino, E. E. (Ed.). (2012). *La Conservación de la Fauna en Córdoba*. Córdoba: Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba.

Bonino, N., Sbriller, M., Manacorda, M. M., & Larosa, F. (1997). Food partitioning between the Mara (*Dolichotis patagonum*) and the introduced Hare (*Lepus europaeus*) in the Monte Desert, Argentina. *Studies on Neotropical Fauna and Environment, 32*(3), 129–134.

Bourdieu, P. (1984). *Distinction: a social critique of the judgement of taste*. Cambridge: Cambridge University Press.
Bourdieu, P. (2000). *La dominación masculina*. Barcelona: Anagrama.
Branch, L. C., Hierro, J. L., & Villarreal, D. (1999). Patterns of plant species diversity following local extinction of the plains vizcacha in semi-arid scrub. *Journal of Arid Environments, 41*, 173–182.
Bright, A., & Stinchfield, H. (2005). *Assessment of public knowledge, values and attitudes toward biodiversity and sustainable forestry. Final report to the national commission on science for sustainable forestry*. Fort Collins: Colorado State University.
Burnham, K. P., & Anderson, D. R. (2010). *Model selection and multimodel inference. A practical information—theoretic approach*. New York: Springer.
Campos, C. M., Greco, S., Ciarlante, J. J., Balangione, M., Bender, J. B., Nates, J., & Lindermann-Matthies, P. (2012). Students' familiarity and initial contact with species in the Monte desert (Medonza, Argentina). *Journal of Arid Environments, 82*, 98–105.
Canevari, M., & Vaccaro, O. (2007). *Guía de mamíferos de América del Sur*. Buenos Aires: Editorial L.O.L.A.
Castillo, D., Luengos Vidal, E., Lucherini, M., & Casanave, E. (2008). First report on the Geoffroyi cat in a highly modificated rural area of the Argentine Pampas. *Cat News, 49*, 27–28.
Cebollada Putz, C., Basso, M., Ruiz De Los Llanos, E., & Kufner, M. (2012). The chacoan fauna of Córdoba (Argentina) affected by the agricultural transformation of the habitat. *Ecologia Aplicada, 11*(2), 77–87.
Cervini, R. (1999). *Calidad y equidad en la educación básica de Argentina. Factores Asociados al Logro Escolar, No 5*. Buenos Aires: Ministerio de Cultura y Educación de la Nación.
Cervini, R. (2002). Desigualdades socioculturales en el aprendizaje de matemática y lengua de la educación secundaria en Argentina: un modelo de tres niveles. *RELIEVE, 8*(2), 126–148.
Cervini, R. (2006). Progreso de aprendizaje en la educación secundaria básica de Argentina: un análisis multinivel de valor agregado. *REICE: Revista Electrónica Iberoamericana sobre Calidad, Eficacia y Cambio en Educación, 4*(3), 54–83.
Cervini, R. (2009). Comparando la inequidad en los logros escolares de la educación primaria y secundaria de Argentina: un estudio multinivel comparativo. *REICE, 7*(1), 5–21.
de Bello, F., Lavorel, S., Díaz, S., Harrington, R., Cornelissen, J. H., Bardgett, R. D., et al. (2010). Towards an assessment of multiple ecosystem processes and services via functional traits. *Biodiversity and Conservation, 19*(10), 2873–2893.
De Longhi, A. L. (2000). La construcción del conocimiento: un problema de Didáctica de las Ciencias y de los profesores de ciencias. *Revista de Educación en Biología, 3*(1), 13–21.
Díaz, S., Fargione, J., Chapin, F. S., III, & Tilman, D. (2006). Biodiversity loss threatens human well-being. *PLoS Biology, 4*, 1300–1305. doi:10.1371/journal.pbio.0040277.
Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5–12.
Education Ministry of Córdoba. (2011). *Diseño curricular de Educación Secundaria. Orientación Ciencias Naturales (Secondary Education Curriculum Design. Orientation Natural Sciences). Volume 4*. Córdoba: Education Secretary.
Evagorou, M., Jimenez-Aleixandre, M. P., & Osborne, J. (2012). 'Should we kill the grey squirrels?'A study exploring students' justifications and decision-making. *International Journal of Science Education, 34*(3), 401–428.
Feisinger, P., Margutti, L., & Oviedo, R. D. (1997). School yards and nature trails: ecology education outside the university. *Trends in Ecology and Evolution, 12*, 115–120.
Fiebelkorn, F., & Menzel, S. (2013). Student teachers' understanding of the terminology, distribution, and loss of biodiversity: perspectives from a biodiversity hotspot and an industrialized country. *Research in Science Education, 43*(4), 1593–1615.
Fox Keller, E. (2000). *Lenguaje y vida. Metáforas de la biología en el siglo XX*. Buenos Aires: Manantial.
Gamallo, G. (2011). Mercantilización del bienestar. Hogares pobres y escuelas privadas. *Revista de Instituciones, Ideas y Mercados, 55*, 189–233.
Giraudo, L., Kufner, M., Torres, R., Tamburini, D., Briguera, V., & Gavier, G. (2006). Avifauna del bosque chaqueño oriental de la Provincia de Córdoba, Argentina. *Ecología Aplicada, 5*(1–2), 127–136.
Grace, M. (2009). Developing high quality decision-making discussions about biological conservation in a normal classroom setting. *International Journal of Science Education, 31*(4), 551–570.
Grace, M. M., & Ratcliffe, M. (2002). The science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24*(11), 1157–1169.
Heredia, J. (2008). *Anfibios del Centro de Argentina/Amphibians of Central Argentina*. Buenos Aires: Editorial L.O.L.A.
Hilgert, N. I., & Gil, G. E. (2006). Medicinal plants of the Argentine Yungas plants of the Las Yungas biosphere reserve, Northwest of Argentina, used in health care. *Biodiversity and Conservation, 15*(8), 2565–2594.

Hodson, D. (1999). Critical multiculturalism in science and technology education. In M. Stephen (Ed.), *Critical multiculturalism: rethinking multicultural and antiracist education* (pp. 216–244). London: Routledge Falmer.
IUCN (International Union for the Conservation of Nature). (2013). IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>.
Jaksic, F. M., Iriarte, J. A., Jimenez, J. E., & Martinez, D. R. (2002). Invaders without frontiers: cross-border invasions of exotic mammals. *Biological Invasions, 4*(1–2), 157–173.
Jiménez, M. (1998). Concepciones sobre algunas especies animales: ejemplificaciones del razonamiento por categorías. Dificultades de aprendizaje asociadas. *Enseñanza de las Ciencias, 16*(1), 147–157.
Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. *Science Education, 84*(2), 180–192.
Kassas, M. (2002). Environmental education: biodiversity. *The Environmentalist, 22*, 345–351.
Kellert, S. R. (1985). Attitudes toward animals: age-related development among children. *The Journal of Environmental Education, 16*, 29–39.
Kilinc, A., Yeşiltaş, N. K., Kartal, T., Demiral, Ü., & Eroğlu, B. (2013). School students' conceptions about biodiversity loss: definitions, reasons, results and solutions. *Research in Science Education, 43*(6), 2277–2307.
Krombaβ, A., & Harms, U. (2008). Acquiring knowledge about biodiversity in a museum—are worksheets effective? *Journal of Biological Education, 42*(4), 157–163.
Kufner, M. B. (Ed.). (2010). *Reserva natural del Vaquerías. Plan maestro de manejo*. Córdoba: Universidad Nacional de Córdoba.
Ladio, A. H., & Lozada, M. (2009). Human ecology, ethnobotany and traditional practices in rural populations inhabiting the Monte region: resilience and ecological knowledge. *Journal of Arid Environments, 73*(2), 222–227.
Laita, H., & Aparicio, G. (2005). *Cien peces argentinos*. Buenos Aires: Albatros.
Leont'ev, A. N. (1978). *Activity, consciousness, and personality.* Englewood Cliffs: Prentice-Hall.
Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: how children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education, 27*(6), 655–677.
Lindemann-Matthies, P. (2006). Investigating nature on the way to school: responses to an educational programme by teachers and their pupils. *International Journal of Science Education, 28*(8), 895–910.
Link-Pérez, M. A., Dollo, V. H., Weber, K. M., & Schussler, E. E. (2010). What's in a name: differential labelling of plant and animal photographs in two nationally syndicated elementary science textbook series. *International Journal of Science Education, 32*(9), 1227–1242.
Long, J. L. (2003). *Introduced mammals of the world: their history, distribution and influence*. Collingwood: CSIRO Publishing.
Mace, G. M., Cramer, W., Díaz, S., Faith, D. P., Larigauderie, A., Le Prestre, P., Palmer, M., Perrings, G., Scholes, R. J., Walpole, M., Walther, B. A., Watson, J. E. M., & Mooney, H. A. (2010). Biodiversity targets after 2010. *Current Opinion in Environmental Sustainability, 2*(1), 3–8.
Mack, R. N., Simberloff, D., Lonsdale, W. M., Evans, H., Clout, M., & Bazzaz, F. A. (2000). Biotic invasions: causes, epidemiology, global consequences, and control. *Ecology Applications, 10*, 689–710.
Martínez, G. J. (2013). Use of fauna in the traditional medicine of native Toba (qom) from the Argentine Gran Chaco region: an ethnozoological and conservationist approach. *Ethnobiology and Conservation, 2*, 2.
Martínez, G. J., & Luján, M. C. (2011). Medicinal plants used for traditional veterinary in the Sierras de Córdoba (Argentina): an ethnobotanical comparison with human medicinal uses. *Journal of Ethnobiology and Ethnomedicine, 7*(1), 23.
Menzel, S., & Bögeholz, S. (2009). The loss of biodiversity as a challenge for sustainable development: how do pupils in Chile and Germany perceive dilemmas? *Research in Science Education, 39*, 429–447.
Montealegre, J. (2007). Identidad y representaciones en un mundo globalizado El Cóndor: familiaridad cultural e identidades diversas. *Polis, 18*, 2–13.
Mortimer, E. F. (1995). Conceptual change or conceptual profile change? *Science & Education, 4*, 267–285.
Mortimer, E. F., Scott, P., & El-Hani, C. N. (2012). The heterogeneity of discourse in science classrooms: the conceptual profile approach. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 231–246). Dordrecht: Springer.
Mueller, M. P., & Tippins, D. J. (2010). van Eijck and Roth's utilitarian science education: why the recalibration of science and traditional ecological knowledge invokes multiple perspectives to protect science education from being exclusive. *Cultural Studies of Science Education, 5*(4), 993–1007.

Muiño, W. (2012). Los “puestos” del oeste pampeano. La relación de los campesinos criollos con las plantas a través de los huertos y jardines. In P. Arenas (Ed.), *Etnobotánica en zonas áridas y semiáridas del Cono Sur de Sudamérica* (pp. 225–250). CONICET: Buenos Aires.

Nates, J., Campos, C., & Lindermann-Matthies, P. (2010). Students' perception of plant and animal species: a case study from rural Argentina. *Applied Environmental Education and Communication, 9*(2), 131–141.

Nates, J., Campos, C., & Matthies, P. L. (2012). The impact of a short conservation education workshop on Argentinean students' knowledge about and attitudes towards species. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(4), 257–267.

NEP-WCMC. (2013). UNEP-WCMC Species Database: CITES-listed species on the world wide web: http://www.unep-wcmc-apps.org/isdb/CITES/Taxonomy/country_list.cfm/isdb/CITES/Taxonomy/country_list.cfm?col=1&country=AR.

Novillo, A., & Ojeda, R. A. (2008). The exotic mammals of Argentina. *Biological Invasions, 10*(8), 1333–1344.

OECD. (2010). PISA 2009 Results: what makes a school successful?—resources, policies and practices (Volume IV). http://dx.doi.org/10.1787/9789264091559-en.

OECD. (2010). PISA 2009 results: overcoming social background—equity in learning opportunities and outcomes (Volume II). http://dx.doi.org/10.1787/9789264091504-en.

Patrick, P., & Tunnicliffe, S. D. (2011). What plants and animals do early childhood and primary students' name? Where do they see them? *Journal of Science Education and Technology, 20*(5), 630–642.

Pérez-Zapata, J. M., Molano-Monsalve, C., Flórez-Ochoa, J. D., Rendón-Vásquez, A., & Flórez, G. M. (2010). Diseño de material educativo para la enseñanza de la conservacion del Cóndor de los Andes (Vultur gryphus). *Revista Luna Azul, 30*, 197–203.

Perovic, P., & Pereira, J. A. (2006). Familia Felidae (G. Fischer, 1817). In R. M. Bárquez, M. Díaz, & R. A. Ojeda (Eds.), *Mamíferos de Argentina. Sistemática y Distribución* (pp. 93–100). Tucumán: Sarem.

Pessino, M. E. M., Sarasola, J. H., Wander, C., & Besoky, N. (2001). Long-term response of puma (*Puma concolor*) to a population decline of the plains vizcacha (*Lagostomus maximus*) in the Monte desert, Argentina. *Ecología Austral, 11*, 61–67.

Piaget, J. (1978). *Success and understanding*. Cambridge: Harvard University Press.

Pilgrim, S. H., Cullen, L. C., Smith, D. J., & Pretty, J. S. (2008). Ecological knowledge is lost in wealthier communities and countries. *Environmental Science & Technology, 42*(4), 1001–1009.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gerzog, W. A. (1982). Accommodation of a scientific conception. Toward a theory of conceptual change. *Science and Education, 66*(2), 211–227.

Pozo, J. I., & Rodrigo, M. J. (2001). From content change to representational change in conceptual knowledge. *Infancia y Aprendizaje, 24*(4), 407–423.

Prokop, P., & Tunnicliffe, S. D. (2008). “Disgusting” animals: primary school children's attitudes and myths of bats and spiders. *Eurasia Journal of Mathematics, Science and Technology Education, 4*(2), 87–97.

Prokop, P., & Tunnicliffe, S. D. (2010). Effects of having pets at home on children's attitudes toward popular and unpopular animals. *Anthrozoos: A Multidisciplinary Journal of The Interactions of People and Animals, 23*(1), 21–35.

Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2007). Is Biology boring? Student attitudes toward Biology. *Journal of Biological Education, 42*(1), 36–39.

Prokop, P., Prokop, M., & Tunnicliffe, S. (2008). Effects of keeping animals as pets on children's concepts of vertebrates and invertebrates. *International Journal of Science Education, 30*(4), 431–449.

Prokop, P., Ozel, M., & Uşak, M. (2009). Cross-cultural comparison of student attitudes toward snakes. *Society and Animals, 17*(3), 224–240.

Prokop, P., Tolarovičová, A., Camerik, A. M., & Peterková, V. (2010). High school students' attitudes towards spiders: a cross-cultural comparison. *International Journal of Science Education, 32*(12), 1665–1688.

Quinlan, M. (2005). Considerations for collecting freelists in the field: examples from ethnobotany. *Field Methods, 17*(3), 219–234.

Randler, C. (2008). Teaching species identification—a prerequisite for learning biodiversity and understanding ecology. *Eurasia Journal of Mathematics, Science and Technology Education, 4*(3), 223–231.

Re, G. E., Eynard, C., Martiarena, M., Menna, J. M., Hick, E., & Gil, M. (2011). *Los árboles de la ciudad universitaria diagnóstico de estado y riesgo aparente*. Córdoba: Universidad Nacional de Córdoba.

Reid, R., Teamey, K., & Dillon, J. (2004). Valuing and utilizing traditional ecological knowledge: tensions in the context of education and the environment. *Environmental Education Research, 10*(2), 237–254.

Reis, G., & Ng-A-Fook, N. (2010). TEK talk: so what? Language and the decolonization of narrative gatekeepers of science education curriculum. *Cultural Studies of Science Education, 5*(4), 1009–1026.

Reyes-García, V., Vadez, V., Huanca, T., Leonard, W., & Wilkie, D. (2005). Knowledge and consumption of wild plants: a comparative study in two Tsimane' villages in the Bolivian Amazon. *Ethnobotany Research and Applications, 3*, 201–207.

Rodrigo, M. J. (1994). El hombre de la calle. El científico y el alumno: ¿un solo constructivismo o tres? *Investigación en la Escuela, 23*, 7–15.

Rodríguez, F. D. P. M., de las Heras, M. A., Pérez, R. R. F., & de León, P. C. (2014). El conocimiento escolar sobre los animales y las plantas en primaria: Un análisis del contenido específico en los libros de texto. *Revista Electrónica de Enseñanza de las Ciencias, 13*(1), 97–114.

Rohde, G. M. (1996). *Epistemología ambiental: uma abordagem filosófica científica sobre la efetuacao humana alopoiética*. Porto Alegre: EDIPUCRS.

Roskov, Y., Kunze, T., Paglinawan, L., Abucay, L., Orrell, T., Nicolson, D., Culham, A., Bailly, N., Kirk, P., Bourgoin, T., Baillargeon, G., Decock, W., De Wever, A. & Didžiulis V. (2013). Species 2000 & ITIS Catalogue of Life, 10th December 2013. Digital resource at www.catalogueoflife.org/col. Species 2000: Naturalis, Leiden, the Netherlands.

Schwarz, M. L., André, P., & Sevegnani, L. (2012). Children's representations of the biological richness of the Mata Atlântica biome. *Ciência & Educação (Bauru), 18*(1), 155–172.

Secretariat of the Convention on Biological Diversity (2003). *Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto protocol. Montreal*, SCBD, 154p. (CBD Technical Series no. 10).

Sillero-Zubiri, C. (2000). Resolución de conflictos entre los grandes carnívoros y el hombre. *Mastozoología Neotropical, 7*(2), 69–72.

Snaddon, J. L., Turner, E. C., & Foster, W. A. (2008). Children's perceptions of rainforest biodiversity: which animals have the lion's share of environmental awareness? *PLoS ONE, 3*(7), e2579. doi:10.1371/journal.pone.0002579.

Soler, L., Carenton, J. M., Cáceres, C., Pérez, P., Fleita, A., Taboada, A., Miller, G., Gonzalez, R. (2004). La conservación de los carnívoros silvestres del Nordeste Argentino a través de la participación de los pobladores locales. *MEMORIAS: Manejo de Fauna silvestre en Amazonia y Latinoamérica*, 634–643.

Songer, N. B., Kelcey, B., & Gotwals, A. W. (2009). How and when does complex reasoning occur? Empirically driven development of a learning progression focused on complex reasoning about biodiversity. *Journal of Research in Science Teaching, 46*(6), 610–631.

Staver, J. R. (1998). Constructivism: sound theory for explicating the practice of science and science teaching. *Journal of Research in Science Teaching, 35*(5), 501–520.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 3–21). Washington, DC: AAAS Press.

Toledo, B. A., Trillo, C., & Grilli, M. (2010). Uso de plantas medicinales en relación al estado de conservación del bosque en Córdoba, Argentina. *Ecología Austral, 20*(3), 235–246.

Trillo, C., Toledo, B. A., Galetto, L., & Colantonio, S. (2010). Persistence of the use of medicinal plants in rural communities of the Western Arid Chaco (Córdoba, Argentina). *The Open Complementary Medicine Journal, 2*, 80–89.

UNCED (United Nations Conference on Environment and Development). (1992). *Convention on Biological Diversity (CBD)* (p. 30). Rio de Janeiro: United Nations Conference on Environment and Development.

van Eijck, M., & Roth, W. M. (2007). Keeping the local local: recalibrating the status of science and traditional ecological knowledge (TEK) in education. *Science Education, 91*(6), 926–947.

Van Weelie, D., & Wals, A. (2002). Making biodiversity meaningful by environmental education. *International Journal of Science Education, 24*(11), 1143–1156.

Vilela, A., Bolkovic, M., Carmanchahi, P., Cony, M., de Lamo, D., & Wassner, D. (2009). Past, present and potential uses of native flora and wildlife of the Monte desert. *Journal of Arid Environments, 73*(2), 238–243.

Villarreal, D., Clark, K. L., Branch, L. C., Hierro, J. L., & Machicote, M. (2008). Alteration of ecosystem structure by a burrowing herbivore, the plains vizcacha (*Lagostomus maximus*). *Journal of Mammalogy, 89*(3), 700–711.

Vygotsky, L. (1978). *Mind in society*. London: Harvard University Press.

Vygotsky, L. S. (1981). The genesis of higher mental functions. In J. V. Wertsch (Ed.), *The concept of activity in soviet psychology* (pp. 144–188). New York: Sharpe, Inc.

Vygotsky, L. S. (1987). Thinking and speech. In R. W. Rieber & A. S. Carton (Eds.), *The collected works of L.S. Vygotsky* (pp. 39–285). New York: Plenum Press.

Vygotsky, L. S. (1991). *Thought and language*. Cambridge: The MIT Press.

Wagler, R., & Wagler, A. (2011). Arthropods: attitude and incorporation in preservice elementary teachers. *International Journal of Environmental and Science Education, 6*(3), 229–250.

Wallace, C. S. (2004). Framing new research in science literacy and language use: authenticity, multiple discourses, and the "Third Space". *Science Education, 88*(6), 901–914.
Wandersee, J. H., & Schussler, E. E. (2001). Toward a theory of plant blindness. *Plant Science Bulletin, 4*, 2–9.
Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge: Harvard University Press.
Wiske, M. S. (1998). *Teaching for understanding. Linking research with practice*. San Francisco: Jossey Bass.
World Intellectual Property Organization (WIPO). (2007). Intergovernmental committee on intellectual property and genetic resources, traditional knowledge and folklore, the protection of traditional knowledge: revised objectives and principles, WIPO/GRTKF/IC/12/5(c) of 6 December 2007.