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Analysis of the prior knowledge of students about the ecological importance of vultures

Análise de conhecimentos prévios de alunos acerca da importância ecológica dos urubus

Análisis de los conocimientos previos de los alumnos sobre la importancia ecológica de los buitres

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Abstract
Despite vultures' vital role in nature, they are insufficiently addressed in Brazilian educational content, leading to misconceptions about these scavenging birds. With educators neglecting the topic, students rely on their families, social circles, and the media for information, perpetuating misunderstandings. To rectify this and enhance comprehension of vultures' ecological importance, this study examines student perceptions through prior knowledge (PK) analysis. The study involved high school graduates up to 2019 and first- and second-semester college Biology students in Pernambuco, Brazil. A questionnaire with context-rich, thought-provoking questions was employed to stimulate knowledge retrieval. Data was analyzed using Laurence Bardin's content analysis. Findings revealed students' limited knowledge about vulture species. When asked to explain color variations in vultures' heads, some students resorted to prior knowledge related to intraspecific dominance, sexual dimorphism, camouflage, and diet from other bird species. Some perceived vultures as environmental cleaners, while others associated them with carcass decomposition and disease transmission, along with negative aesthetic and hygienic attributes. It's imperative that students not only study textbook-highlighted species but also gain insights into local fauna and its environmental significance. This broader understanding can rectify misconceptions and promote the vital ecological role vultures play in maintaining the balance of ecosystems.
Keywords: Content analysis; Ethnobiology; Cathartidae; Biology teaching.

Resumo
Apesar do papel importante que urubus exercem na natureza, não são abordados com relevância nas orientações curriculares e conteúdos pedagógicos, ocasionando desconhecimento ou conhecimentos equivocados em relação a esses animais. Como não é um assunto abordado por professores, os conhecimentos que os estudantes têm advêm dos seus familiares, seu círculo social e de fontes de entretenimento. Para elaborar subsídios capazes de evitar equívocos sobre a função ecológica desses animais, o objetivo desta pesquisa foi investigar a percepção dos alunos acerca da importância ecológica dos urubus por meio de análise de conhecimentos prévios (CP). Foi utilizado um questionário com questões contextualizadas e provocativas, no intuito de incitar a retomada dos conhecimentos. Tivemos como público-alvo estudantes formados no ensino médio até 2019 e matriculados no 1º e 2º período do curso de Ciências Biológicas. O tratamento das informações obtidas foi realizado a partir da análise de conteúdo proposta por Laurence Bardin. Observamos que os estudantes apresentaram desconhecimento acerca das espécies de urubus apresentadas. Alguns deles recorreram aos conhecimentos prévios relacionados a outras aves. Quando questionados sobre a razão da variação da coloração da cabeça dos urubus, relacionaram com dominância intraespecífica, dimorfismo, camuflagem e alimentação. Alguns pontuaram que a função dos urubus é limpar a natureza; outros responderam que são decompositoras de carcaças e disseminam doenças. Também relacionaram os urubus aos aspectos negativos de estética e higiene. É importante que os alunos estudem espécies que estão nos livros didáticos, mas é válido que conheçam a fauna local, assim como a sua importância ambiental.
Palavras-chave: Análise de conteúdo; Etnobiologia; Cathartidae; Ensino de biologia.

Resumen
A pesar de la importancia de los buitres en la naturaleza, en Brasil, no reciben la debida atención en las directrices curriculares y contenidos pedagógicos. Esto resulta en una falta de conocimiento y en la propagación de ideas erróneas sobre estos animales. Dado que los educadores no incluyen a los buitres en sus enseñanzas, los estudiantes adquieren información sobre ellos principalmente de sus familias, amigos y los medios de entretenimiento. Con el objetivo de corregir estos malentendidos y mejorar la comprensión de la función ecológica de los buitres, se llevó a cabo una investigación centrada en la percepción de los estudiantes. Se utilizó un cuestionario diseñado para fomentar la reflexión y recuperar conocimientos previos. Los participantes fueron estudiantes de secundaria hasta 2019, y estudiantes de los primeros dos semestres de la carrera de Biología en Pernambuco, Brasil. Los resultados revelaron que los estudiantes tenían un conocimiento limitado sobre las especies de buitres. Al explicar la variación de color en la cabeza de los buitres, algunos recurrieron a conceptos como la dominancia intraespecífica, el dimorfismo sexual y el camuflaje. Otros asociaron a los buitres con la limpieza del medio ambiente, la descomposición de cadáveres y la transmisión de enfermedades, además de considerarlos estéticamente desfavorables. Es esencial que los estudiantes no solo se enfoquen en las especies mencionadas en los libros de texto, sino que también adquieran conocimientos sobre la fauna local y su importancia en el entorno ambiental.
Palabras clave: Análisis de contenido; Etnobiología; Cathartidae; Educacíon en biología.

1. Introduction

A common issue in current science education debates is the need to include the student in the teaching process (Brum, 2013). One of the ways to insert the student in the school environment ensuring his active participation is through the analysis of prior knowledge (PK), considered the product of several individual situations and which may be information and knowledge acquired through the family environment, groups of friends or sources of entertainment such as reading, television, cinema and the internet, and which of course can be obtained progressively in the school environment (Vitorasso, 2010). Prior knowledge is important because it provides the structure needed to absorb new knowledge. On the other hand, even though PK is often addressed in the classroom, it is not articulated, in other words, it is not worked upon (Sobral, 2006). However, this type of knowledge should serve as a starting point for the development of a better teaching and learning process. Based on an analysis of prior knowledge, it is possible to understand student perception of current environmental issues.

In recent decades, there has been an increase in appreciation of environmental conservation in several spheres, including the educational one (Murat, 2005). According to Paraskevopoulos *et al*. (1998), in environmental education it is possible to assume that a) if people are aware of the reasons and ways to protect the environment, they will strive to preserve it; b) the school should assume shared responsibility in educating about environmental conservation and preservation; and c) environmental education should be a part of the school curriculum. That said, it is necessary to raise awareness about the importance of environmental conservation, especially in schools, since students who are well-informed about environmental problems are more likely to be adults more concerned with the environment and who will be able to disseminate the knowledge acquired in school in their communities (Medeiros *et al*., 2011). It is thus necessary to understand students' perception of environmental issues, so that this information can be used as a framework for mapping out the knowledge they already have.

Environmental perception can be defined as the way individuals perceive and interact with the environment through their senses, eliciting different reactions depending on their culture, concepts, and values (Fernandes *et al*., 2004.; Melazo, 2005). Environmental issues are increasingly present in contemporary daily life, and thus environmental education can act to reshape previously formed concepts by generating possibilities for new knowledge, methodologies, and skills from the perspective of an interdisciplinary education (Jacobi, 2003). In this sense, environmental education becomes an important tool to raise awareness about the importance of conserving species and the environment.

Wilson (2002) points out that there are two ways in which people can connect to the environment: biophilia and biophobia. Biophilia is the tendency to positively bond with living beings, while biophobia is characterized by adverse

reactions that may be related to aversion, discomfort, or fear. To avoid biophobic reactions towards some animals it is necessary to deconstruct previous mistaken concepts about species culturally considered repugnant by a large part of society, such as frogs, rodents, and scavengers.

In the entertainment industry, vultures are commonly portrayed in a negative light. Examples are Buzz Buzzard, a character from the Woody Woodpecker cartoons depicted as a rogue and scammer who loves to deceive others, and the vultures from the Disney movie *Mowgli* who, despite not being portrayed as "evil", are characterized as "goofy, dumb, stupid" animals (Virani, 2012).

Vultures used to be positively perceived in different cultures. In ancient Egypt, the vulture was a symbol of knowledge and Queen Cleopatra used a vulture-shaped headdress. The Egyptian vulture was sacred to the ancient pharaohs and was immortalized in the hieroglyphic alphabet as the letter A. Persians considered vultures symbols of royalty because of their size and how elegantly they soared on air columns (Kushwaha, 2016). However, popular perception has changed over the years.

These days, vultures are treated indifferently and often even repulsively. Their morphological and behavioral characteristics can induce some aversion in the population. Even Charles Darwin, during his journey on the Beagle, while observing the turkey vulture (*Cathartes aura*) described vultures as disgusting birds that wallow in putridity (Houston, 2001). In spite of being considered repugnant by many people, these creatures are the most efficient scavengers in the animal kingdom, as they play an important cleaning role by eliminating decomposing organic matter and, thanks to their gastric juices, neutralize toxins and carrion bacteria, preventing the spread of diseases and potential risks of infection (Sick, 2001).

Currently, several factors contribute to the decrease in the number of these birds, such as indirect poisoning, airplane engine ingestion, and electrocution by power lines (Allan, 1989; Janss, 2000; Serrano *et al*., 2005). The decline of the vulture population can potentially cause several environmental and public health problems. India has faced serious health problems caused by the spread of diseases due to the increase in the number of facultative scavengers such as wild dogs and rodents (Pain *et al*., 2003; Ogada *et al*., 2012). Along with the decrease in vulture populations, the number of wild dogs in that country has increased dramatically, since they are one of the biggest carcass consumers in urban regions, in addition to being the main reservoirs of diseases like rabies (Markandya *et al*., 2008). Dogs and rodents are potential disease transmitters because they are not able to neutralize the pathogens present in the carcasses they feed on, since their gastric juices are not as acidic as those of vultures (Ogada *et al*., 2012).

Most species of Old World vultures and condors are threatened due to rampant persecution and indirect poisoning (Ogada, 2012; Birdlife, 2021). According to the latest edition of the Instituto Chico Mendes Red Book (2018), among the vulture species that occur in Brazil only *Sarcoramphus papa* is near threatened and considered a difficult species to see (Sick, 1997). If there is an uncontrolled decrease of vultures in Brazil, the country may face several public health problems since, according to some studies, in areas devoid of vultures a carcass can take three to four times longer to decompose (Menq, 2016). Given what has been said, the importance of vultures is not restricted to the ecological aspect, as they can also influence various areas of society such as public health and the economy, which directs academic focus to the need for ways of sensitizing the population to the relevance of vulture conservation.

According to Martins (2010), knowledge is provisional, independent, and interdisciplinary, that is, it is open to new connections that may be established later and, furthermore, there exists a collaborative knowledge network which allows people to apprehend reality and help their mutual development. Thus, an educational process which takes into consideration the integration of students' individual knowledge enables the deconstruction or reconstruction of social knowledge that influences their individual practices.

The aim of this study was to identify the previous knowledge of college students majoring in Biology regarding the ecological importance of vultures and to analyze it to develop subsidies for elucidating the issue. To that end, an online questionnaire was applied via Google Forms to permit content analysis and a mapping of the students' previous knowledge of the subject, with a view to later raise not only student awareness, but school and family communities' as well.

Prior knowledge and its significance for the teaching and learning process

Prior knowledge can be the product of several individual situations and can be obtained in the family environment, friend groups, and sources of entertainment like reading, television, movies and the internet, in addition to being progressively acquired in the school environment (Vitorasso, 2010). As previously stated, it is knowledge that students have acquired throughout their lives and is intimately related to the individual, and it may or may not be scientifically correct, or be organized (Ramos, 2010). According to Driver *et al*. (1994, p.1), "[...] it is important in science education to appreciate that scientific knowledge is both symbolic in nature and also socially negotiated", i.e., it should be borne in mind that the objects of science are not the phenomena of nature, but the constructions developed by the scientific community to interpret them (Driver *et al.* 1994).

Prior knowledge needs to be converted into action and expressed in spoken, written or symbolic language. Underestimating students' personal experiences and treating them as unfounded without understanding them would be a mistake on the part of teachers, for education and the assimilation of knowledge take place through the student's personal experience (Moreira, 2011; Pivatto, 2014).

Pozo presents three origins for prior knowledge: sensory (spontaneous conceptions), cultural (induced conceptions), and school-related (analogical conceptions). Sensory knowledge is based on information obtained from interactions with the natural world; cultural knowledge relates to a set of beliefs shared by the social group to which the student belongs; and school knowledge is related to comparison of the distinct knowledge domains (Pozo, 1998). All discoveries derive from an interaction between explicit and tacit prior knowledge and thereby make up personal knowledge (Polanyi, 1967). Explicit and tacit prior knowledge may be summarized as:

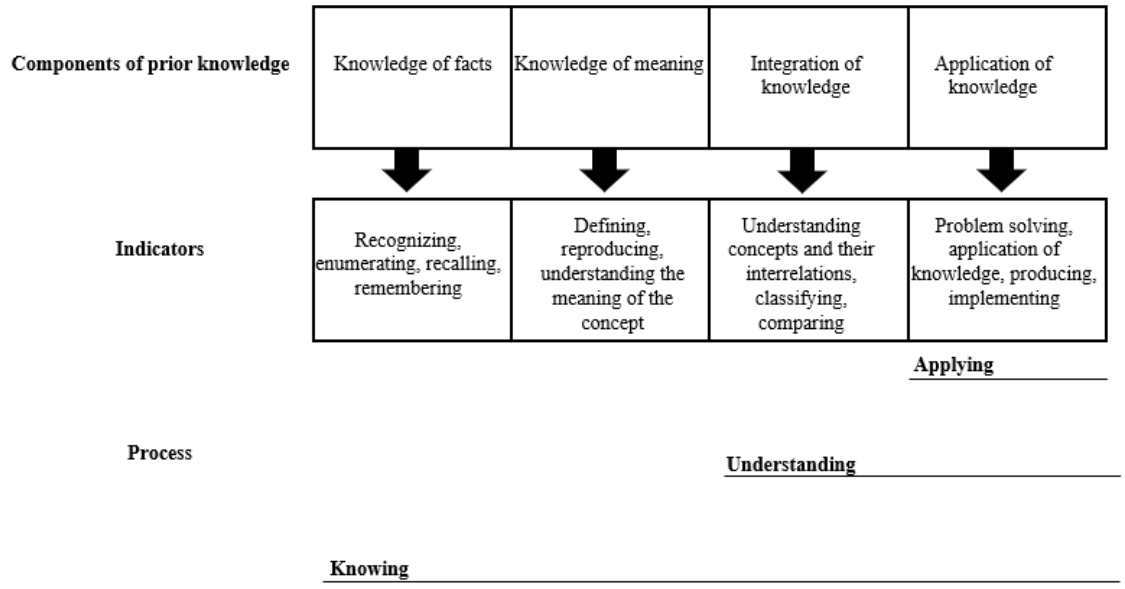
> Human beings create explicit prior knowledge by engaging with objects, that is, through personal involvement and commitment, or what Polanyi calls "inhabiting". To know something is to create its image or pattern through the tacit integration of details. (...) Therefore, scientific objectivity is not the only source of knowledge. Much of our prior knowledge is the fruit of our voluntary effort to deal with the world. (Nonaka & Takeuchi, 1997, p. 65).

Inadequate learning through misinformation may block the acquisition of relevant information (Kelly & Glaspole, 2006). One way to work with new information is to use prior knowledge as a tool to assess the gaps and misconceptions in student knowledge and thus provide the necessary support to potentialize the learning process (Martens; Hermans, 2000; Shariff *et al*., 2007). For prior knowledge to be accessed and worked upon more effectively, it is necessary to understand what type of PK the focus is (Hailikari *et al*., 2008).

That said, there are two kinds of prior knowledge: declarative and procedural (Biggs, 2003). Hailikari et al. (2008) developed a model to explain prior knowledge (Figure 1). Declarative knowledge is considered the most basic, but not the less important; it is public knowledge, which is subject to evidence that makes it verifiable, replicable, and logically consistent, and can be found in books and on the internet (Biggs, 2003). According to Hailikari *et al.* (2008), this type of knowledge consists of facts that students can remember or reproduce. Students having only declarative knowledge can answer basic questions that do not entail integration or application of knowledge (Dochy, 1992).

On the other hand, procedural knowledge is characterized by the ability to integrate the knowledge obtained, understand the relationships between concepts and, further, to be able to solve problems by applying previous knowledge (Hailikari *et al*., 2008).

Figure 1 - Types of prior knowledge.



Source: Adapted from Hailikari *et al.* (2008, p. 3).

Some studies indicate that declarative knowledge by itself does not contribute as effectively to the student's personal and social development. On the other hand, students who can integrate knowledge from the beginning of school life have a greater chance of succeeding. These findings demonstrate the importance of recognizing and working upon prior knowledge at the start of the teaching and learning process, so that it is not necessary to ask “what” they know, but “how much” they know (Biggs, 2003; Hailikari *et al*., 2008).

Regardless of its origin, prior knowledge should be used by the teacher as a premise to develop the students’ process of conceptual change, to help them think in terms different from daily thinking, having scientific knowledge as a basis (Pivatto, 2014).

Bird-related content in the curriculum

For Saviani (2002), the study curriculum is the selection, sequencing and dosage of cultural contents to be developed in teaching and learning situations. This curriculum can be subdivided into formal, actual, and hidden (Libâneo, 2007). The formal curriculum is the one established and validated by educational organizations and expressed in the curriculum guidelines, such as the National Curriculum Parameters (PCN+) and can be stated explicitly in the objectives and competences of the fields of study. The actual curriculum is the one applied in the classroom by the teacher, who uses as a basis the pedagogical program, the competences listed in the PCN+, and the lesson plan derived thereof. The hidden curriculum, on the other hand, represents the external influences that can positively or negatively affect the teaching and learning process (Libâneo, 2007; Silva *et al*., 2013). According to Silva (2003, p. 78), “[...] the hidden curriculum consists of all aspects of the school environment which, without being part of the formal and explicit curriculum, implicitly contribute to relevant social learning".

Despite the aid given by the formal curriculum in guiding the contents taught in class, the teaching of Natural Sciences needs to be (re)constructed, depending on the needs and changes of society (Arend, 2017). On the other hand, research on teaching and learning, focused on the way the student learns, is not included in the curriculum proposals and seems to be ignored by some teachers, something which becomes a problem in the school environment (Vander, 2004).

"Birds" does not figure as an explicit content in the formal curriculum, in terms of the contents included in the National Common Curriculum Base (BNCC) and in the National Curriculum Parameters. On the other hand, it is possible to establish a link between certain competences and the content in question. The BNCC, in skill EM13CNT205 of specific competence 2, states that it is necessary to:

> Discuss the importance of preserving and conserving biodiversity, taking into account qualitative and quantitative parameters, and evaluating the effects of human activity and of environmental policies to ensure the planet's sustainability (Brasil, 2018).

According to the National Curriculum Parameters, competence-based teaching constitutes a challenge to organize knowledge in a contextualized way, that is, learning situations that are part of the student's daily life and provide subsidies for them to act in different contexts and even in unusual situations (Brasil, 2006).

PCN+ presents six structuring themes of biology: interaction between living beings; life quality of human populations; identity of living beings; diversity of life; transmission of life; ethics and genetic manipulation; and origin and evolution of life (Brasil, 2006). The first thematic unit of the first structuring theme is called "the interdependence of life", and two of its objectives allow the inclusion of the theme "birds" in the classroom, even if indirectly:

> - Recognize that living beings in an ecosystem, whether it be a lake, a forest, a field or a simple garden, maintain multiple relationships with other beings, which can be indifferent coexistence or mutual help with some and conflict with others, to the point of harming others or themselves.
> - Evaluate the significance of interactions among individuals to the set of species involved and to the functioning of the system (Brasil, 2006).

From the above discussion on BNCC and PCN+, it can be gathered that there is no content or competence specifically dealing with birds in high school, but that it is possible to include the theme in the competences and structuring themes mentioned and to work with them in the classroom.

Representatives of family Cathartidae in Brazil

New World vultures are grouped in family Cathartidae (Sick, 2001). There are seven species in all, of which five are commonly found in Brazil: the turkey vulture (*Cathartes aura*), lesser yellow-headed vulture (*Cathartes burrovianus*), greater yellow-headed vulture (*Cathartes melambrotus*), black vulture (*Coragyps atratus*) and king vulture (*Sarcoramphus papa*). Of the five, only *C. melambrotus* does not occur in the state of Pernambuco (Farias *et al.*, 2008).

The morphology of these animals is quite characteristic and allows easy identification (Campbell, 2015). A striking feature is the featherless head and neck, essential to facilitate post-feeding hygiene, as it prevents the accumulation of food remains and, consequently, of microorganisms. These birds have a thick feather collar in the basal portion of the neck that prevents food debris from spreading to the body plumage (Sick, 2001; Campbell, 2015). Nostril morphology was one of the characteristics Fisher (1955) used to distinguish Old World from New World vultures: the former have septate nostrils, while the latter have perforate nostrils."

Like the species of family Ciconiidae, to thermoregulate Cathartids spread their wings and defecate on their own legs, a behavior called urohidrosis. Some studies indicate that the bare neck also plays an important role in thermoregulation (Sick, 2001).

The species of this group display dominance hierarchy when they gather (Kruuk, 1967; Houston, 1975). Upon arriving at a carcass, the king vulture is the first to feed, ripping the carcass open and making it easier for others to feed (Campbell, 2015). The hierarchy is established according to the size, strength, and hunger of the birds (Sick, 2001).

These animals are considered the most efficient scavengers in the animal kingdom, as they provide a cleaning service that prevents the transmission of disease to other scavengers. Vultures do not spread disease due to the extremely acidic pH of their stomachs, which equals 1.0; this allows the neutralization of any microbiological threats (Sick, 2001). They are called obligatory scavengers, as their diet consists primarily of carrion. Their body morphology does not allow them to be efficient predators; an example is the disposition of the toes, which cannot hold the prey, and which explains their behavior of stepping on carcasses. There are some exceptions in the literature, such as reports of *C. atratus* possibly fishing (Keppeler *et al.*, 2020) and of *C. burrovianus* preying on snakes of genera *Bothrops* and *Xenodon* (Almeida *et al.*, 2010; Severo-Neto *et al.*, 2014).

Studies by Sazima (2007) indicate that *C. atratus* is a species with high behavioral plasticity and high exploratory capacity for finding food resources, even looting beachgoers' plastic bags.

Vultures and urban environment

The black vulture is a bird that occurs widely and commonly associates with humans (Sick, 2001). Typically, members of this species are found in cities and open fields and rarely occur in dense forests. Vulture association with humans stems from the large food supply generated by humans, such as large amounts of organic matter improperly dumped in garbage dumps, slaughterhouses, and constant food disposal areas such as ports and markets. In addition, vultures cluster close to highways and roads to feed on fresh road kills (Souza, 2001; Novoselova, 2016). These birds also use buildings in urban areas as resting and breeding sites (Leal, 2016).

As the process of urbanization is increasingly widespread, the presence of black vultures in cities is increasing and, accordingly, they are seen less in forests (Spina, 2019). The ecological imbalance caused by human occupation of environments previously available to that species can cause several problems, such as increased risk of collision between birds and aircraft during take-off, approach and landing (Severo-Neto *et al.*, 2006). Due to the increase in air traffic and to *C. atratus'* size and habit of gliding, these collisions have become more frequent in Brazil (Novoselova, 2016). According to Carrete *et al*. (2009), given its positive response to human-induced transformations of the environment the black vulture is an example of a winning species.

2. Methodology

To analyze prior knowledge (PK), a semi-structured questionnaire with two thought-provoking questions (Appendix A) involving problem situations that can be met in everyday life was sent to college Biology students in the state of Pernambuco, Brazil. According to Gil (1999, p. 128), the questionnaire is "the investigation technique composed of a more or less high number of written questions presented to people, to find out their opinions, beliefs, feelings, interests, expectations, lived experiences etc". Thus, the questionnaire proved an effective way to retrieve students' knowledge by means of questions that foster the resurgence of previous knowledge.

2.1 Questionnaire

1. Luís was traveling with his parents to visit his grandparents who live in the countryside. Since he was a child, he has always enjoyed observing the landscapes through the car window. On one stretch of the road, Luís saw the carcass of an animal that had probably just been run over and noticed several birds around it, and They had some interesting characteristics: predominantly black plumage, and the color of their heads set them apart, while most had black heads, some had yellow heads, and others had red heads. What birds are these? Why did the color of their heads vary? What were they doing?

2. In India, farmers used to administer a medication called Diclofenac to their animals. However, instead of having a positive effect, it was poisoning and eventually killing these animals. Some days later, studies indicated that the medicine was causing renal failure in the animals, leading to their death and even after death, their carcasses still poisoned. This region has always had a high number of vultures, something that has always caused discomfort and rejection in the population. But a few months after the incident, residents noticed a drastic decrease in the number of these vultures, as they no longer saw the birds flying all over the city. On the other hand, residents noticed an increase in the number of scavengers such as wild dogs in open dumps and garbage cans in the city, which led to the spread of diseases such as rabies, since these animals are considered potential reservoirs of pathogens. If you consider what just has been said, why did the population are uncomfortable with the presence of vultures? Why did the number of these birds decrease? How did the increase in the number of other scavengers occur? Why are wild dogs considered threats to human health?

The questions were sent to the institutional e-mail of students enrolled in the first and second semesters of college Biology. One of the criteria for inclusion in the study was the students having finished high school in 2019, in addition to having access to a device such as a notebook, computer or cell phone with which to take the questionnaire.

2.2 Data analysis

This study has a qualitative exploratory character, which allows flexibility, that is, it enables researchers to use imagination and creativity so they can explore new approaches during the research (Godoy, 1999). To reinforce the qualitative nature of the work, the analysis of the data herein obtained is based on the methodological principle of content analysis by Bardin (2011).

Content analysis (CA) can be defined as a set of constantly improved methodological tools that can be applied to various types of discourse (Bardin, 2011). This data analysis technique, popularized by Laurence Bardin in 1977 in the book *L'analyse de contenu*, is a methodology widely used in social sciences research, normally associated with well-defined objectives geared to reveal what is hidden in the text by decoding its message. For Bardin (2011, p.31), content analysis is not just a tool, but a “range of instruments; or, more vigorously, a single instrument, but marked by a great disparity of forms and adaptable to a very vast field of application: communications”.

The CA method, according to Bardin, consists of treating the information according to a specific script that follows a few phases, starting with a) pre-analysis, characterized as the organization phase, where the initial ideas are systematized so that they lead to a precise outline for the development of the later stages, in addition to being responsible for formulating hypotheses, choosing documents and preparing indicators that inform the final interpretation; b) exploration of the material, in which specific techniques are applied according to the previously defined objective; and c) processing results and interpretations.

The first step further has several sub-steps, described by Bardin (2011):

i) Floating reading;

ii) Choice of documents;

a. Exhaustiveness rule;

b. Homogeneity rule;

c. Relevance rule;

iii) Formulation of hypotheses and objectives;

iv) Referencing of the indices and elaboration of indicators;

v) Preparation of the material.

The second phase, or the material exploration phase, consists of "coding, decomposition or enumeration operations, according to the previously formulated rules" (Bardin, 2011, p. 131).

At this stage, the information needs to be coded, by means of defining the recording units, which are "the coded units of meaning" (Bardin, 2011, p. 134), so that these units can later be categorized. In this study, the recording units were coded through thematic analysis, whereby the answers' cores of meaning were used to test the study's initial hypothesis. Categorizing was performed through grouping by assimilation of recording units.

The third step is the processing and the interpretation of the results obtained. In this step the raw results were refined in order to be meaningful and valid.

In addition, results were interpreted by inference. Based on the answers, it was possible to advance interpretations regarding the research objectives, besides allowing unexpected discoveries about students' answers.

3. Results and Discussion

From the questionnaire, 19 answers were obtained from first and second semester college Biology students. The answers were analyzed according to the content analysis methodology proposed by Bardin (2011).

From the categorizing of recording units, three main categories were defined and subdivided into subcategories (Table 1).

In the first category, we examined student recognition of vulture species, through the association between the bird and its diet. The fact that the black vulture is a bird with black plumage may cause it to be confused with other species, such as the smooth-billed ani (*Crotophaga ani*), even if plumage color is all they have in common.

Table 1 - Category "classification" and subcategories "identification" and "variety of species".

Category	Subcategory	Recording unit	Context unit
Classification	Identification	Species	S1: "*They were vultures"* S2: "*The birds were vultures"* S3: "*The birds observed are vultures"* S4: "*Vultures."* S6: "*The birds are vultures"* S7: "*They were vultures."* S8: "*Vulture."* S9: "*Vultures."* S10: "*VULTURES."* S11: "*Vultures."* S12: "*Vultures."* S13: "*They were vultures."* S14: "*The birds were vultures."* S15: "*These birds are vultures."* S16: "*Vultures."* S17: "*They are vultures."* S18: "*Probably vultures."* "S19: *These birds are vultures."*

Classification	Variety of species	Dominance	E06: "[...] *different head color to be able to differentiate the dominant bird."*
		Sexual dimorphism	E07: "The *colors of the heads I'm not sure about, but I think it's the difference of sexes."* E09: "*Maybe because they are different species or the sexes are different."*
		Camouflage	E05: "[...] *this can result either because of the place where they live, or in the case of many animals that acquire camouflage and other resources over time in response to the ecosystem, to adapt."*
		Diet	E05: "[...] *another reason could be the food, where we have as an example the flamingos that feed on crustaceans that make them turn pink."*

Source: Authors.

All students were able to recognize the bird by its scavenging habits, except for S5, who did not specifically address the species the question referred to. In fact, vultures do not feed exclusively on carcasses, since in some situations they can feed on fish and on newborn or incapacitated animals, as well as on fruits and vegetables (Souto, 2008; Barbara, 2015).

In category "classification", subcategory "variety of species", we analyzed the answers as to the reason for the color variation in vulture heads, to find whether students are aware of the variety of species in family Cathartidae. Commonly, people only know the black vulture, as it is a more common species in urban areas (Houston, 1994). In the question, the species commonly found were presented: turkey vulture, lesser yellow-headed vulture, greater yellow-headed vulture and black vulture. Student 6 proposed that the difference in head color is related to dominance, that is, depending on the head color the individual assumes the role of leader of the group. When representatives of family Cathartidae are gathered in a "banquet", the king vulture feeds first and exerts a certain dominance, which benefits the other vultures, as it rips the carcass open and facilitates the feeding of the others (Sick, 2001).

Students 7 and 9 related head color variety to sexual dimorphism, which is the distinction of the two sexes of a species by means of secondary sexual characteristics, where males and females can differ in size, shape, and qualitative traits, such as color, odor, or vocalization (Ralls & Mesnick, 2009; Silva, 2012). It is a common feature in the animal kingdom, so this perception may be related to the fact that several bird species present a sex-related distinction of characteristics; an example is the birds of paradise, where males are flashier and females have more "neutral" coloration. In Cathartids, no evident sexual dimorphism exists.

Student 5 pointed out that the difference in head color "*can result either because of the place where they live, or in the case of many animals that acquire camouflage and other resources over time in response to the ecosystem, to adapt"*. It is known that some species of birds use their plumage to camouflage themselves in trees, e.g. the common potoo (*Nyctibius griseus)*, but that is not the case of the black vulture. Using previous knowledge about other birds to explain unfamiliar issues was common, as in the case of S5, who related head color to feeding habits, thus associating it with flamingos, which acquire a pink color due to their diet. Some students, like S7 and S9, recognized that the reason for different head coloration is that these vultures belong to different species and genera.

It is worth noting that, more than once, students mentioned the king vulture in their answers, such as S1 ("*the head color varied because these are king vultures*") and S3 ("*the king vulture, for example, has a different plumage from the others*") though, as mentioned before, it is not a species commonly seen in daily life. According to Sick (2001), it is a rare bird in Brazil since, like other large raptors, it is hunted as a trophy. As it is difficult to see, we believe that it was recognized because of its white plumage, which sets it apart from the other species. In addition, the king vulture is displayed in zoos and exalted by the media for its majesty and grandeur. But the same entertainment media that praises this species ignores the

existence of the other Cathartid species.

The category “ecology”, as shown in Table 2, encompasses the parts of the answers pertaining to the ecological role of vultures.

Table 2 - Category “ecology” and subcategory “function”.

Category	Subcategory	Recording unit	Context unit
Ecology	Function	Sanitize	S4: “*They are partly responsible for cleaning up the environment/space.”* S4*: “Knowing that the vultures have the function of cleaning up the space.”* S5: “[...] *by eating the corpses they help to prevent epidemics and diseases.”* S12: *“They were cleaning up nature.”* S12: “[...] *because they are animals that clean up nature, by feeding on these decomposing organisms.”*
		Decompose	S8: “*it was decomposing the animal.”*
		Spread plagues	S8: “*Because vultures spread plagues.”* S15: “[...] *they inspire a certain fear in people, because they spread diseases.”*

Source: Authors.

In category “ecology”, subcategory “function”, three students (S4, S5, and S12) pointed out that vultures are important environmental cleaners. These results agree with those of Mdhlano *et al*. (2018) since, in their research, 70-80% of respondents living in communities adjacent to a national park frequented by vultures answered that these birds play an important biological role in nature. They also corroborate the work of Whelan *et al*. (2008), who indicated that vultures play a sanitizing role in nature, by acting as “nature's garbage destroyers”, keeping the environment healthy and clean.

Vultures are highly specialized to quickly handle large carcasses and play a key role in the flow of energy and of nutrients, in addition to reducing the spread of pathogens by other scavengers (Parmenter; Macmahon, 2009; Wenny *et al.*, 2011). But according to S8 and S15 in their answers "*Because vultures spread plagues*" and "[...] *they inspire a certain fear in people, because they spread diseases”*, vultures act in disease propagation. Many people think that as vultures are often amidst carrion and in garbage dumps they are full of potential pathogens that can cause disease. In truth, their morphology provides mechanisms, such as bare heads and necks and a barrier of feathers in the basal portion of their necks, that prevent food debris from spreading over their bodies (Houston, 1994). In the same answer, S8 referred to the vulture's scavenging habit as a “decomposition” of the dead animal. Although the diet of scavengers and decomposers consists of dead animals, vultures are not capable of chemically destroying tissues; that is the role of bacteria, fungi, and enzymes, whose action results in the transformation of carcasses into gases, liquids, and salts (Saraiva, 2011).

The last category, perception, encompasses the answers students gave about features related to vultures’ hygiene and aesthetics that characterize how they view these birds (Table 3).

Table 1 Category “perception” and subcategory “social representation”.

Category	Subcategory	Recording unit	Context unit
Perception	Social representation	Hygiene	S2: “*Because an animal that eats rotten meat is disgusting.”* S7: *“Another point is the bad smell they give off.”* S10: *“[..] associated with an image of disgusting scavenging animals.”* S16: “[...] *the bad smell maybe bothered residents.”*
		Aesthetics	S3: “*Vultures are animals that inspire a certain prejudice in the layman, due to their color, diet and beauty.”*

Source: Authors.

Jodelet (2001, p. 22) points out that social representation "[...] is a form of knowledge, socially elaborated and shared, with a practical objective, and which contributes to the construction of a reality common to a social group". Thus, using some answers given by the students, the category "perception" and the subcategory "social representation" were defined to discuss some answers that referred to vultures using aesthetic and hygiene parameters.

Student 2 answered that people are repulsed by this animal because *"an animal that eats rotten meat is disgusting."* On the other hand, S7 and S16 related repulsion to the bad smell these animals exhale. The carcasses that vultures feed on endow them with a characteristic smell, which cannot be felt over long distances, but only upon closer contact. Studies show that when these animals feed on fresh meat they do not give off a bad smell (Campbell, 2015).

Other animals are bombarded with negative criticism related to their morphological traits and their habits. The results in this category agree with studies by Rissate *et al.* (2019), who investigated student perception of frogs and who obtained similar answers, always associating these animals to negative features. Other animals such as bats are also targets of biophobia. A study carried out with high school students revealed that most students highlighted their negative traits, besides underscoring their appearance with sentences like "Bats are horrible" (Silva e*t al.*, 2018).

In conclusion, it is necessary to realize that all living beings have ecological importance and their role to play in nature, that aesthetic characteristics should not be considered in isolation, and that each animal does play a role in maintaining the balance of nature and therefore deserves to be respected (Conceição & Pigatto, 2020).

4. Conclusion

The prior knowledge that the students demonstrated in this study is intermediate when compared to the results obtained by Mdhlano *et al*. (2018), since practically all their respondents answered that vultures play an important sanitizing role in nature.

From the answers obtained in the questionnaire, it could be seen that students were able to recognize vultures by relating the birds to their scavenging habits. Despite the existence of more than one species of vulture, few students were able to associate head color to the different species, resorting to their prior knowledge of biology to associate this color variation to camouflage, diet, sexual dimorphism and dominance, traits that can be found in other bird species.

The present study found no unanimity in the answers about the role that vultures play in nature. Some students related their scavenging habits to the spreading of plagues and to decomposition of carcasses, which underscores the need to disseminate the important role these animals play in sanitizing the environment as opposed to propagating diseases. In addition, students resorted to aesthetic and hygiene aspects to characterize these animals according to their appearance and the bad smell they give off, always highlighting negative characteristics.

Students' prior knowledge of vultures is more related to other bird species and to more common behaviors in the animal kingdom, and a lack of knowledge about a bird that can be observed almost daily was noticeable. That said, it is important that the theme "Vultures" be added to the formal curriculum or even worked with in the actual curriculum, so that students acquire knowledge of the fauna of their locality, as well as of other species that cause repulsion in a large part of the population, such as frogs, rodents and bats. Learning about the species presented in textbooks is important, but even more important is to recognize local biodiversity, that is, those species that can be observed daily, and to learn about them to find out how to preserve them.

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