

Primary Students' Perceptions of Animals: Insights for Primary Science Education

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ABSTRACT

A scientifically grounded grasp of the living world is bound up with students' prior conceptions, which can shape how new scientific knowledge is acquired and interpreted. This study examined primary-school students' perceptions of animals as a component of their prior conceptions and sought to identify patterns of thinking that may contribute to misconceptions relevant to early science teaching. The sample comprised 189 students from the first to the fourth grade. Data were gathered by questionnaire and analyzed using descriptive statistics, correlational analysis, t-tests, analysis of variance, and qualitative content analysis of students' justifications. A strong association emerged between the appeal of animals' appearance and the intensity of fear toward them, showing that students' evaluations are shaped not merely by biological characteristics but by esthetic, affective, and experiential factors. The identified misconceptions involve the overgeneralization of traits, fictional representations, and the neglect of ecological function, particularly for less appealing animals such as the spider, snake, bat, and earthworm. Boys reported less fear of animals than girls, whereas no differences emerged by grade. The results point to a need for reshaping students' representations by redirecting them from the appearance criterion to a grasp of the ecological function of animals.

KEY WORDS: Animal perception, fear of animals, prior conceptions, misconceptions, early science education

INTRODUCTION

Early science education aims to develop children's grasp of the living world, of biological diversity, and of the interrelationships among organisms within ecosystems, in which observation, inquiry, and firsthand experience hold an important place (Tomažič et al., 2020). The formation of such a grasp is bound up with students' prior conceptions – the conceptual representations, experiences, and affective factors that influence how students interpret new scientific knowledge. Emotional reactions, esthetic judgments, and socioculturally shaped beliefs about animals can encourage or hinder the development of scientifically grounded conceptions (Juliadilla et al., 2025). Within the theory of conceptual change, prior conceptions are existing representations that students draw on when interpreting new content; they can support learning, but when not aligned with scientific explanations they can obstruct conceptual change and persist alongside scientifically acceptable ones (Posner et al., 1982; Vosniadou, 1994). Unlike many conceptual misconceptions in science, conceptions of animals are strongly infused with affective components – fear, disgust, interest, and attachment – that shape the experience of particular species and the readiness to work with living organisms (Prokop and Fančovičová, 2017; Tomažič et al., 2020). Examining the perception of animals is a diagnostic starting point for teaching that takes account of students' existing conceptions and supports a scientifically grounded grasp of biodiversity. Even so, the conceptual and affective

starting points of primary-school students remain insufficiently researched from the perspective of early science methodology, since research to date has focused mainly on older students or adults and has rarely considered their role in shaping scientific conceptions and planning instruction (Borgi and Cirulli, 2015; Neldner and Wilks, 2022). Starting from this gap, the present paper considers the perception of animals within the theory of prior conceptions, aiming to recognize patterns of student thinking that may support or constrain a grasp of biodiversity, with attention to misconceptions linked to that perception and the possibilities for reshaping them pedagogically.

THEORETICAL BACKGROUND

Prior Conceptions and Conceptual Change in Learning about the Living World

The theory of conceptual change assumes that learning science involves re-examining and restructuring existing conceptions in light of new experience and scientific explanations (Olaogun and Hunsu, 2025). Change becomes possible when a student recognizes an existing explanation as inadequate and a new one as intelligible, plausible, and applicable (Posner et al., 1982). It is gradual, since prior conceptions are often tied to intuitive, experientially shaped ways of interpreting the world, and unfounded conceptions can develop into stable misconceptions resistant to change (Vosniadou, 1994). In learning about the living world, these conceptions are frequently linked to an affective dimension: Interest, curiosity, fear, and aversion can

direct attention and encourage or limit interaction with living organisms (Prokop and Fančovičová, 2017; Tomažič et al., 2020). Examining students' perception of animals can serve a diagnostic function, since effective, constructivist-oriented instruction presupposes knowledge of the structure, intensity, and variability of students' starting points.

Two terms used with different meanings need to be distinguished. A misconception is an individual belief inconsistent with a scientific explanation. An alternative conception is a broader, more neutral term for a coherent, experientially grounded student conception with its own internal logic (Wandersee et al., 1994). In keeping with this distinction, the “appearance criterion” is interpreted here as an overarching alternative conception – an organizing principle by which students evaluate animals – whereas the overgeneralization of traits, representations shaped by fiction, and the neglect of ecological function are treated as derived misconceptions that follow from it. Misconception is reserved for concrete erroneous claims, and alternative conception for the superordinate interpretive framework.

Research to date shows that children often prefer vertebrates and familiar, domestic, and aesthetically appealing species, whereas invertebrates and other less popular species are more rarely evaluated positively and are less well known (Kellert, 1993; Prokop et al., 2008; Borgi and Cirulli, 2015). Since these groups make up an important part of biodiversity and carry significant ecological functions, such patterns can limit the development of a comprehensive grasp of the living world. Systematic science education with active and experiential learning can improve knowledge of species, a grasp of their role, and a more positive stance toward their conservation (Corbacho-Cuello et al., 2024; Gavrilakis et al., 2024; Granato et al., 2025). Negative or oversimplified perceptions accordingly represent an important methodological challenge, but equally a starting point for prompting conceptual and affective change.

Students' Representations: Emotions, Stereotypes, and Sociocultural Influence

One way in which unscientific representations form is stereotyped generalization – ascribing the characteristics of particular species to a whole group (Stewart and Raihani, 2023). Such generalization need not be entirely inaccurate, since it can arise from the real features of some species, yet it becomes a misconception when a property is unjustifiably ascribed to all members of a group (all spiders venomous, all snakes dangerous). In early science education, it is important, then, to distinguish scientifically grounded caution toward genuinely dangerous species from a stereotyped overgeneralization of danger, which can entrench aversion and obstruct a grasp of ecological role. Affective reactions partly have an evolutionary basis; fear of species that may bite, sting, or pose a threat serves a protective function (Seligman, 2016). Disgust plays an important part as well, and may be more strongly linked

to avoidance than fear itself (Woody et al., 2005). Although adaptive, these reactions become a problem when joined to inaccurate beliefs or generalized to whole groups, since they then lead to the avoidance of contact and restrict opportunities to learn about the animals' real characteristics and ecological role.

Students' representations are shaped as well by sociocultural factors. Children take on patterns of evaluating animals by observing adults' reactions (Muris et al., 2010), whereas fairy tales, fables, and media portrayals often ascribe qualities that cannot be carried over to real species (Kubiatko, 2012) and can contribute to misconceptions – ascribing intentions, feelings, or dangers that do not match an animal's actual biology (Prokop et al., 2009). Since representations form through the interplay of cognitive, experiential, and sociocultural factors, they are an important starting point for instruction aimed at re-examining them and developing scientifically grounded conceptions.

Instructional Procedures for Reshaping Starting Points

Research in science education methodology shows that the affective and conceptual components of prior conceptions change most effectively through experiential learning. Direct contact with animals, observation, and hands-on work reduce fear and aversion, develop more positive attitudes, increase interest in and knowledge of species, and reduce the avoidance of less familiar organisms (Randler et al., 2012; Almeida et al., 2017; Prokop and Fančovičová, 2017). Accurate information on its own is not, then, sufficient for conceptual change; it needs firsthand experience and active participation. Born (2018) distinguishes three related aspects of learning about animals: Education about animals, education for animals, and education with animals (firsthand encounter, observation, and investigation) – of particular importance for species toward which students express fear, aversion, or stereotyped beliefs.

Previous Research on Students' Beliefs and Perceptions of Animals

Students' beliefs about particular animals result from a complex interplay of individual, sociocultural, and biological factors – sex, age, area of residence, cultural context, level of education, and experience with pets (Su and Martens, 2018). Students who keep pets as a rule express more positive attitudes and better knowledge of species (Prokop and Tunnicliffe, 2010). Alongside the noted bias toward vertebrates and toward aesthetically appealing and familiar species (Prokop et al., 2008; Borgi and Cirulli, 2015), girls more often report reactions linked to fear of animals (Borgi and Cirulli, 2015). Developmental research shows that children ascribe to animals a high moral status that declines with age (Neldner and Wilks, 2022), whereas esthetic appeal increases the readiness to protect them (Gunnthorsdottir, 2001). A decline in firsthand experiences with nature limits opportunities to learn about the real characteristics and ecological roles of species (Soga and Gaston, 2016; Schuttler et al., 2019); children's grasp of the animal world may then rest more on indirect experience and

cultural portrayals, yielding better knowledge of exotic than of local species (Ballouard et al., 2011; Larson et al., 2018). Children's perception of animals, then, is not determined by biological knowledge alone but shaped through the interplay of experience, emotional reactions, familiarity, and sociocultural influences, and the present paper treats it as a source of insight into students' conceptions of the living world and a basis for instruction promoting a scientifically grounded grasp of biodiversity.

RESEARCH METHODOLOGY

Aim and Research Questions

This study examined the perception of animals among primary-school students as a component of their prior conceptions about the living world, through an analysis of the appeal of appearance, the intensity of fear toward them, and the justifications on which students base their ratings. It sought to establish the association between the appeal of appearance and the intensity of fear, to identify patterns of student representations that point to possible misconceptions, and to consider their significance for planning instruction in early science education.

The following research questions arise from the stated aim:

- RQ1. How do primary-school students rate the appeal of particular animals' appearance and the intensity of fear toward them, and by what justifications do they support these ratings?
- RQ2. Is there an association between the rated appeal of animals' appearance and the intensity of fear toward them, and do perceptions differ with respect to students' sex and grade?
- RQ3. Which patterns of student representations of animals can be identified on the basis of the justifications for their ratings, and to what extent do these patterns point to features of misconceptions?

Participants

The study involved 189 primary-school students from the first to the fourth grade, aged 6–10 years. A convenience sample was drawn from 10 primary schools in the Republic of Croatia, covering urban and rural settings. The sample was almost balanced by sex (52.4% girls, 47.6% boys) and by grade: First-, third-, and fourth-grade students each made up 24.9% of the sample, and second-grade students 25.4%.

Research Instrument

A questionnaire was constructed to examine students' perception of animals as a component of their prior conceptions about the living world, drawing on previous research into children's perceptions of and attitudes to animals (Kellert, 1993; Prokop and Tunnicliffe, 2010; Kubiato, 2012), the esthetic rating of animals, the intensity of fear (Tomažič et al., 2020), and the link between emotional reactions and students' conceptions (Prokop and Fančovičová, 2017). The questionnaire had three parts. The first covered demographic

characteristics (sex and grade); the second examined two aspects of perception, the appeal of appearance and the intensity of fear. Ten animals were selected that previous research associates with different patterns of emotional reactions and attitudes (Kellert, 1993; Prokop and Tunnicliffe, 2010; Kubiato, 2012), on three criteria. The first concerned the expected range of affective reactions, and so included animals most often linked to positive attitudes and high appeal (dog, cat, rabbit, horse, and butterfly) along with those more often rated negatively or eliciting unease and fear (snake, spider, bat, earthworm, and bee) (Kellert, 1993; Prokop et al., 2008). The second was the inclusion of both vertebrates and invertebrates, since research points to differences in children's perception of these groups. The third concerned different ecological roles important for biodiversity; the species accordingly represent different functional groups – pollinators (bee), decomposers and soil-forming organisms (earthworm), predators (spider, snake), and domestic animals with which students more often have firsthand experience. All the selected animals were expected to be recognizable to students from everyday life or from the Nature and Society curriculum, so the ratings were age-appropriate. For each animal, students rated on a five-point Likert scale the appeal of its appearance (1 = I do not like it at all; 5 = I like it very much) and the intensity of their own fear (1 = I am very afraid; 5 = I am not afraid at all), and then justified each answer, yielding the qualitative data used to identify possible misconceptions. Higher scores on the fear scale therefore indicate lower intensity of fear.

Procedure and Data Analysis

The study was a cross-sectional study using a mixed-methods approach that combined a quantitative analysis of students' ratings with a qualitative analysis of their justifications. Data were gathered by paper-and-pencil during regular classes, in keeping with the ethical principles of research with children. The head teachers of the participating schools consented, and parents/guardians were informed of the aim, content, and procedure and gave written consent for their children's participation. Participation was voluntary, following a developmentally appropriate explanation of the purpose and the students' oral assent; students could withdraw at any time without consequences. The study was carried out anonymously, results were analyzed at the group level, and it was approved by the Ethics Committee of the Faculty of Teacher Education, University of Zagreb.

Statistical processing was performed in the Statistical Package for the Social Sciences (version 23.0; IBM Corp., Armonk, NY, USA). Normality was checked with the Shapiro–Wilk test. Some variables, in particular the ratings of polarizing species, departed from normality (for example, the earthworm: $W = 0.94$; $p < 0.01$), so the key analyses were further supported by non-parametric procedures (Spearman's ρ alongside Pearson's r ; the Mann–Whitney U alongside the t -test), which yielded comparable results. Given the sample size ($n = 189$), parametric tests were retained as primary, being robust to moderate departures from normality. Internal reliability was

estimated with Cronbach's α . Alongside descriptive indicators, one-sample t-tests were conducted against the theoretical scale midpoint ($M = 3$), together with independent-samples t-tests and a two-way analysis of variance (sex $\times$ grade level), in which grade was collapsed into two levels (grades 1–2 and grades 3–4). The dependent variables in both analyses were composite scores averaged across all 10 animals. The association between appeal-of-appearance ratings and fear scores was analyzed with Pearson's correlation coefficient at the species level. Effect sizes were computed (Cohen's d and partial η^2), 95% confidence intervals [CIs] using Fisher's z-transformation, and a Holm correction for multiple comparisons.

Students' open-ended responses were analyzed by qualitative content analysis to identify recurring patterns in their justifications and representations that may point to particular misconceptions. The categories analyzed related to appearance, emotional reactions, perceived danger, personal experience, usefulness, ecological role, and stereotyped and fictional portrayals.

In this study, students' prior conceptions about animals are not treated as directly measurable variables but as latent interpretive frameworks reconstructed from patterns in students' ratings and their justifications. The Likert-scale ratings of the appeal of appearance and the intensity of fear are not a measure of the conception itself but indicators of the manner of evaluation. The mean rating of a given animal shows the outcome of applying a particular criterion but does not, on its own, reveal which criterion the student used. The criterion itself (for example, the appearance criterion) is reconstructed only by linking the quantitative patterns with the qualitative analysis of justifications.

RESULTS

The internal consistency of the scales was examined with Cronbach's α . Both scales showed satisfactory reliability: $\alpha = 0.79$ for the appeal-of-appearance scale and $\alpha = 0.85$ for the fear scale, confirming an adequate level of internal consistency.

Students' Appeal-of-Appearance Ratings for Particular Animals

Figure 1 shows pronounced differences in the appeal-of-appearance ratings for particular animals. The highest appeal was assigned to the dog, rabbit, butterfly, horse, and cat, and the lowest ratings to the earthworm, snake, spider, bat, and bee, so appeal-of-appearance ratings are not distributed evenly across the animals studied. For each animal, a one-sample t-test was conducted against the theoretical scale midpoint ($\mu = 3$), together with descriptive indicators, 95% CIs, Cohen's d , and a Holm correction for multiple testing (Table 1).

Five animals (dog, rabbit, horse, butterfly, and cat) were rated significantly above the midpoint, with very large effects ($d = 1.51$ – 2.83 ; all p Holm < 0.001). The bee was likewise above the midpoint, but with a small effect ($d = 0.27$). The earthworm was the only animal rated significantly below the

midpoint, with a moderate effect ($d = -0.45$). The bat does not differ significantly from the midpoint (p Holm = 0.562), whereas the snake and spider, in spite of means below 3, do not reach significance after correction (p Holm = 0.127) – connected with the greater variability of responses for these two species (Standard deviation [SD] ≈ 1.5), whose lower means reflect pronounced individual differences rather than a uniform pattern. The ratings differ in uniformity as well: The largest gap between adjacent means was between the cat ($M = 4.48$) and the bee ($M = 3.37$), separating the more highly rated animals (narrow CIs in the upper scale, high agreement) from the more lowly rated (the bat, snake, and spider; wider intervals, greater dispersion).

The relationship between the mean appeal-of-appearance rating and the variability of students' responses was analyzed at the level of individual animals ($n = 10$; Figure 2). A strong negative association was found ($r = -0.95$; $p < 0.001$): Animals rated as more appealing had more uniform ratings, whereas animals with lower ratings of appeal showed greater dispersion. The restriction of the scale range must be taken into account, since ratings near its upper bound naturally allow less variability. The pattern was confirmed with the rank correlation coefficient, which does not assume a linear relationship (Spearman's $\rho = -0.90$; $p < 0.001$).

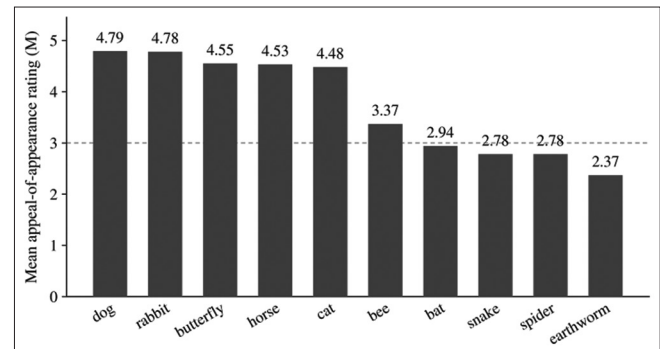


Figure 1: Mean appeal-of-appearance rating by species ($n = 189$)

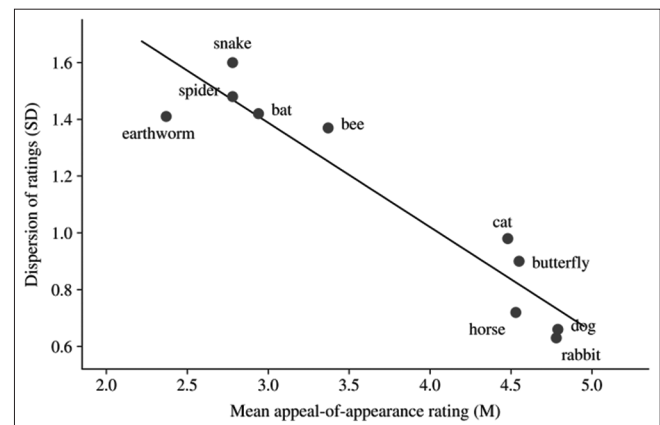


Figure 2: Relationship between the mean appeal-of-appearance rating (M) and the dispersion of ratings (standard deviation) at the level of individual animals

Students' Fear Scores for Particular Animals

Figure 3 shows pronounced differences in the fear scores for particular animals (lower values indicate higher intensity of fear). The snake attains the lowest mean value, pointing to the most pronounced fear, followed by the spider, bee, and bat. The earthworm, horse, cat, dog, rabbit, and butterfly are associated with lower intensity of fear.

For each animal, a one-sample t-test was conducted against the theoretical scale midpoint ($\mu = 3$), together with descriptive indicators, 95% CIs, Cohen's d , and a Holm correction for multiple testing (Table 2).

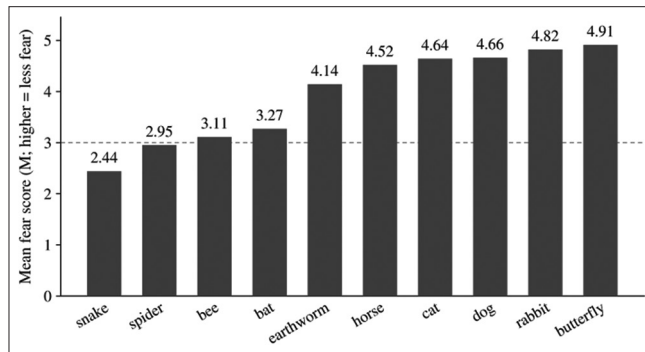


Figure 3: Mean fear score by species ($n=189$; higher values indicate lower intensity of fear)

Only the snake was rated significantly below the midpoint, pointing to the most pronounced fear among the animals analyzed, with a small-to-moderate effect ($d = -0.36$). The mean fear scores for the spider and bee do not differ significantly from the midpoint ($p_{\text{Holm}} = 0.664$ and 0.583), whereas the bat shows a small but significant departure above it ($p_{\text{Holm}} = 0.047$; $d = 0.18$), that is, toward lower fear. The remaining six animals – earthworm, horse, cat, dog, rabbit, and butterfly – were rated significantly above the midpoint, indicating lower fear, with large to very large effects ($d = 0.84$ – 3.54). As with appearance, the greater variability of responses for the spider and bee ($SD \approx 1.5$) reflects pronounced individual differences, keeping their means near the neutral region of the scale. The ratings differ in uniformity as well: The largest gap between adjacent means was between the bat ($M = 3.27$) and the earthworm ($M = 4.14$), setting apart animals toward which students express low fear, with narrow CIs and uniform responses, and the snake, spider, bee, and bat, with wider intervals and greater dispersion reflecting more varied fear scores.

The relationship between the mean fear score and the variability of responses was analyzed at the level of individual animals ($n = 10$; Figure 4). A very strong negative association was found ($r = -0.92$; 95% CI $[-0.98, -0.70]$; $p < 0.001$; $r^2 = 0.85$): Animals toward which students express lower fear

Table 1: Descriptive statistics and one-sample t-tests of the appeal-of-appearance ratings against the scale midpoint ($\mu=3$)

Species	M	Standard deviation	Standard error	95% Confidence interval	t (188)	p-value	p (Holm)	Cohen d
Dog	4.79	0.66	0.048	(4.70, 4.88)	37.29	<0.001	<0.001	2.71
Rabbit	4.78	0.63	0.046	(4.69, 4.87)	38.84	<0.001	<0.001	2.83
Butterfly	4.55	0.90	0.065	(4.42, 4.68)	23.68	<0.001	<0.001	1.72
Horse	4.53	0.72	0.052	(4.43, 4.63)	29.21	<0.001	<0.001	2.13
Cat	4.48	0.98	0.071	(4.34, 4.62)	20.76	<0.001	<0.001	1.51
Bee	3.37	1.37	0.100	(3.17, 3.57)	3.71	<0.001	0.001	0.27
Bat	2.94	1.42	0.103	(2.74, 3.14)	-0.58	0.562	0.562	-0.04
Snake	2.78	1.60	0.116	(2.55, 3.01)	-1.89	0.060	0.127	-0.14
Spider	2.78	1.48	0.108	(2.57, 2.99)	-2.04	0.042	0.127	-0.15
Earthworm	2.37	1.41	0.103	(2.17, 2.57)	-6.14	<0.001	<0.001	-0.45

Table 2: Descriptive statistics and one-sample t-tests of the fear scores against the scale midpoint ($\mu=3$). Higher values indicate lower intensity of fear

Species	M	Standard deviation	Standard error	95% Confidence interval	t (188)	p-value	p (Holm)	Cohen d
Snake	2.44	1.56	0.113	(2.22, 2.66)	-4.94	<0.001	<0.001	-0.36
Spider	2.95	1.58	0.115	(2.72, 3.18)	-0.44	0.664	0.664	-0.03
Bee	3.11	1.43	0.104	(2.90, 3.32)	1.06	0.292	0.583	0.08
Bat	3.27	1.52	0.111	(3.05, 3.49)	2.44	0.016	0.047	0.18
Earthworm	4.14	1.36	0.099	(3.94, 4.34)	11.52	<0.001	<0.001	0.84
Horse	4.52	0.94	0.068	(4.39, 4.65)	22.23	<0.001	<0.001	1.62
Cat	4.64	0.92	0.067	(4.51, 4.77)	24.51	<0.001	<0.001	1.78
Dog	4.66	0.86	0.063	(4.54, 4.78)	26.54	<0.001	<0.001	1.93
Rabbit	4.82	0.64	0.047	(4.73, 4.91)	39.10	<0.001	<0.001	2.84
Butterfly	4.91	0.54	0.039	(4.83, 4.99)	48.63	<0.001	<0.001	3.54

show greater uniformity of responses, whereas animals linked to higher fear show greater variability. Ratings near the upper bound of the scale allow less variability of response. A similar pattern was confirmed by the rank coefficient (Spearman's $\rho = -0.98$; $p < 0.001$), pointing to a stable association between the level of fear scores and the degree of agreement among students.

Relationship between the Appeal-of-Appearance Ratings and the Fear Scores

Comparison of the two scales at the level of individual animals ($n = 10$) revealed a strong association between the mean appeal-of-appearance rating and the fear score ($r = 0.80$; $p = 0.005$). Since a higher fear score indicates lower intensity of fear, animals rated more positively on appearance are for the most part linked to less pronounced fear. Particular animals depart from this pattern. The earthworm departs from it since, in spite of a lower appeal-of-appearance rating ($M = 2.37$), it is linked to low intensity of fear ($M = 4.14$). The snake and bee depart in the other direction, since they are linked to more pronounced fear relative to their appeal-of-appearance ratings. Such departures show that the appeal-of-appearance ratings and the fear scores, though associated, are different dimensions of students' perception of animals and may be shaped by different factors.

Differences with Respect to Sex and Grade

A two-way analysis of variance examined differences in the appeal-of-appearance ratings and the fear scores by students' sex and grade, and their interaction. For the appeal of appearance, no significant effects of sex or grade were found, nor any interaction (Table 3).

By contrast, for the fear score, a significant main effect of sex was found ($F(1, 185) = 20.71$; $p < 0.001$; $\eta_p^2 = 0.10$), whereas the effect of grade and the sex $\times$ grade interaction were not significant (Table 4). The effect size shows that sex is linked to moderate differences in the fear scores.

Boys report less fear of animals ($M = 4.09$) than girls ($M = 3.78$), where a higher value denotes less fear. The animals were divided, by appeal-of-appearance ratings, into two groups: More appealing (dog, rabbit, butterfly, horse, and cat) and less appealing (snake, spider, bee, bat, and earthworm). T-tests then examined boy-girl differences in the appeal-of-appearance ratings and fear scores for these groups (Table 5). Girls gave higher appeal-of-appearance ratings for the more appealing animals ($M = 4.68$) than boys ($M = 4.56$), whereas boys gave higher appeal-of-appearance ratings for the less appealing animals ($M = 2.91$) than girls ($M = 2.57$). The most pronounced difference was in fear of less appealing animals, where boys report less fear ($M = 3.46$) than girls ($M = 2.86$), with a medium-to-large effect ($d = 0.76$; 95% CI [0.46, 1.06]). Differences in appeal for the more appealing ($d = -0.34$; 95% CI [-0.63, -0.05]) and less appealing ($d = 0.45$; 95% CI [0.16, 0.74]) animals point to small-to-moderate effects, whereas the difference in fear of more appealing animals was not significant ($d = -0.03$; 95% CI [-0.32, 0.26]).

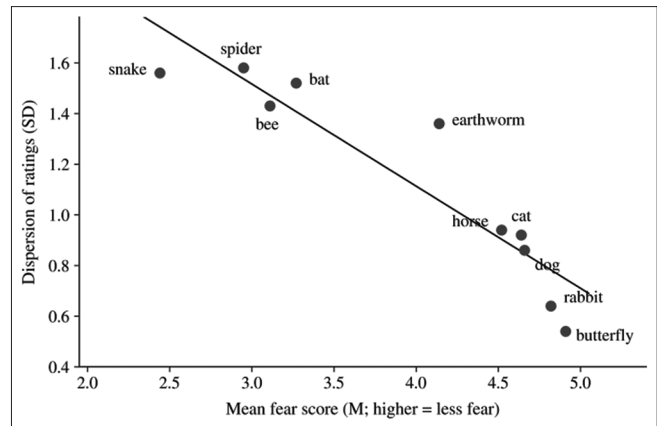


Figure 4: Relationship between the mean fear score for particular animals (M) and the dispersion of students' ratings (standard deviation). Higher values indicate lower intensity of fear

Table 3: Results of the two-way analysis of variance for the dependent variable "appeal of appearance"

Source of variance	F (1, 185)	p-value	η_p^2
Sex	2.89	0.09	0.015
Grade	1.44	0.23	0.008
Sex $\times$ Grade	2.13	0.15	0.011

Table 4: Results of the two-way analysis of variance for the dependent variable "fear score"

Source of variance	F (1, 185)	p-value	η_p^2
Sex	20.71	<0.001	0.101
Grade	0.99	0.32	0.005
Sex $\times$ Grade	1.88	0.17	0.010

After a Holm correction, the differences in the appeal-of-appearance ratings and fear scores for the less appealing animals remained significant, whereas the difference in the appeal-of-appearance ratings for the more appealing animals no longer reached significance. The absence of a significant main effect of sex on the overall appeal-of-appearance rating can be connected with the opposite direction of the two groups: Girls rated higher the animals that overall attained higher ratings, boys the animals that attained lower ratings; the overall result should be viewed together with the individual-group analyses. The differences between boys and girls are not apparent in the general appeal-of-appearance rating but chiefly in fear of animals linked to greater variability. No differences by grade were found, whereas sex differences were confirmed in fear, in particular toward the less appealing animals. This group includes the earthworm, which, in spite of lower appeal-of-appearance ratings, is not linked to higher fear – a less favorable appeal-of-appearance rating does not necessarily imply more pronounced fear; students apply different criteria when rating particular animals.

An analysis of differences among students of different grades revealed no significant differences (Table 6); the patterns of

students' ratings were similar across all grades of primary education covered.

Qualitative Analysis of the Justifications for Students' Ratings

To gain a deeper insight into the reasons for students' ratings, the open-ended responses justifying the appeal-of-appearance ratings and fear scores for each of the 10 animals were analyzed by qualitative content analysis with quantification of categories, using a combined (deductive-inductive) approach. The initial set of categories was derived deductively, from the theoretical framework of prior conceptions and previous research into attitudes to animals (a priori categories: Appearance, emotional reaction, perceived danger, familiarity, usefulness, and ecological role). During coding, the scheme was supplemented inductively with new categories arising from the responses (for example, fictional and stereotypical beliefs). The unit of analysis was the individual student's justification of the rating of a given animal. Since a response could contain several reasons, multiple coding was applied, and the same response could be assigned to more than one

category. Responses that did not express a substantive reason (e.g., "I don't know," unclear, or blank responses) were not coded into any category.

Coding was carried out independently by two researchers. Each first analyzed 20% of randomly selected responses to develop and align the scheme. Eleven codes were initially identified and, after review and the merging of related categories, reduced to seven final categories. Inter-coder reliability on the double-coded responses was very good (Krippendorff's $\alpha = 0.82$), and remaining disagreements were resolved by discussion to consensus. The rest of the material was coded by a single coder according to the agreed scheme. The final system is presented in Table 7 and linked to relevant theoretical approaches to the evaluation and perception of animals.

After coding, the frequency of each category of justification was computed for each animal (Table 8). The criteria by which students justify their ratings differ across animals. For the dog, cat, rabbit, and horse, justifications linked to familiarity, personal experience, and appearance appear more often, whereas danger/harmlessness is rarely stated. For the snake and

Table 5: Results of the t-test for the appeal-of-appearance ratings and fear scores for more and less appealing animals with respect to sex. Higher fear scores indicate lower intensity of fear

Contrast	M boys	M girls	t	p-value	d	95% Confidence interval
Appeal of appearance – more appealing animals	4.56	4.68	-2.32	0.02	-0.34	(-0.63, -0.05)
Appeal of appearance – less appealing animals	2.91	2.57	3.06	0.002	0.45	(0.16, 0.74)
Fear score – more appealing animals	4.70	4.71	-0.18	0.86	-0.03	(-0.32, 0.26)
Fear score – less appealing animals	3.46	2.86	5.22	<0.001	0.76	(0.46, 1.06)

Table 6: Results of the t-test for the appeal-of-appearance ratings and fear scores for more and less appealing animals with respect to grade. Higher fear scores indicate lower intensity of fear

Contrast	M grades 1 and 2	M grades 3 and 4	t	p-value
Appeal of appearance – more appealing animals	4.61	4.64	-0.63	0.53
Appeal of appearance – less appealing animals	2.69	2.77	-0.66	0.51
Fear score – more appealing animals	4.70	4.71	-0.18	0.86
Fear score – less appealing animals	3.12	3.17	-0.38	0.71

Table 7: Categories for coding the open-ended responses, with a link to the theoretical framework

Category	Operational criterion	Example responses	Link to theoretical framework
Appearance and morphological features	The rating is based on external appearance or physical features.	"It's ugly;" "It's cute;" "It's slimy"	Aesthetic orientation
Emotional reaction	The rating stems from the student's feelings.	"I'm afraid of it;" "I love it;" "It disgusts me."	Humanistic/Negativistic
Perceived danger	The rating is based on the presumed dangerousness of the species.	"It's venomous;" "It bites;" and "It stings."	Negativistic
Familiarity and personal experience	The rating stems from personal experience or closeness.	"I have a dog;" "It's a pet."	Humanistic
Anthropocentric usefulness	Value is judged by benefit/harm to humans.	"It guards the house;" "It gives honey."	Utilitarian
Ecological role	The student states the role of the species in nature.	"Bees pollinate flowers;" "Earthworms loosen the soil."	Ecologicistic/Naturalistic
Fictional or stereotypical beliefs	The rating rests on biologically unfounded beliefs (fairy tales, media, and folklore).	"The food of bats is blood;" "They get tangled in your hair."	Mythical dimension (Prokop et al., 2009)

spider, justifications more often involve perceived danger, in particular a bite or venom. For the bat, biologically unfounded beliefs appear as well – including the generalized belief that blood is the food of bats and the belief that bats get tangled in one's hair – pointing to representations linked to fictional portrayals. The bee shows differing patterns: Some students stress the possibility of a sting, whereas others recognize its role in pollination. The earthworm is most often described through appearance, whereas its ecological role is rarely stated.

Beyond the frequency of individual categories, their co-occurrence within the same justification was analyzed, since multiple coding was applied. The linking of categories – for example, appearance and perceived danger (“It’s ugly and venomous.”) or danger and fictional beliefs for the bat – shows that students’ ratings often do not rest on a single isolated feature but involve several connected elements of perception. From the distribution and co-occurrence of categories, recurring patterns of representation were identified, along with those pointing to possible misconceptions relevant to early science education (Table 9).

To link the qualitative and quantitative findings, an integrative display connects, for each animal, the mean

appeal-of-appearance ratings and fear scores with the most frequent patterns of justification (Table 10). This allows a comparison of the animals for which students more often state biological and ecological features with those for which ratings are more often linked to appearance, perceived danger, or representations shaped by experience and cultural portrayals.

The findings show that students’ ratings of animals follow patterns connecting the quantitative appeal-of-appearance ratings and fear scores with the qualitative justifications. The role of appearance and familiarity stands out: The ratings of some animals rest more often on visible features, prior experiences, or perceived danger than on a grasp of their ecological role. Alongside this, unjustified generalization of traits, representations shaped by fictional portrayals, and anthropocentric evaluation appear as well. Such patterns constitute prior conceptions that, if not re-examined during teaching, can obstruct the development of a comprehensive grasp of the animal world and of biodiversity.

DISCUSSION

In this study, the perception of animals is treated as a component of the prior conceptions with which students enter science

Table 8: Frequency of the categories of justification by animal species (%)

Animal	Appearance	Emotions	Danger	Familiarity	Usefulness	Eco role	Fiction
Dog	34	22	2	38	15	3	0
Cat	36	20	3	34	10	2	0
Horse	29	16	2	21	18	6	0
Rabbit	41	18	1	27	8	2	0
Butterfly	27	15	1	8	4	32	0
Snake	11	14	74	2	3	1	6
Spider	18	21	69	1	1	2	0
Bee	8	9	51	3	12	31	0
Bat	12	15	27	1	2	3	40
Earthworm	42	18	6	1	2	2	0

Table 9: Patterns of prior conceptions and misconceptions identified through the analysis of the open-ended responses

Dominant pattern	Operational criterion and typical responses	Most pronounced for species	Interpretation
Appearance criterion	Appearance is the main measure of worth, danger, or acceptability. “It’s ugly;” “It’s pretty;” “It looks dangerous.”	Earthworm, spider, snake, bat (negative); rabbit, cat, dog (positive)	Perceptual features override biological and ecological comprehension.
Overgeneralization of danger	A dangerous trait is ascribed to a whole group or species. “All snakes are venomous;” “All spiders bite.”	Snake, spider	Danger is generalized without distinguishing dangerous from harmless species.
Misconceptions from fiction	Beliefs taken from fairy tales, films, cartoons, or folklore. “Blood is the food of bats;” “They get tangled in your hair.”	Bat	Fictional portrayals are transferred to real animals.
Anthropocentric evaluation	The value of the species is judged by its usefulness to humans. “It guards the house;” “It gives honey.”	Horse, dog, bee	The value of the species is reduced to its benefit for humans.
Neglect of ecological role	The role of the species in nature is absent from the justification. “The earthworm is useless;” “The bee only stings.”	Earthworm, spider, snake (and partly bee)	The ecological function of the species is not included in the evaluation.
Familiarity as a safety criterion	Positive rating since the species is familiar or domestic. “I have a dog;” “It’s soft;” and “It’s a pet.”	Dog, cat, rabbit, and horse	Familiarity and emotional closeness shape a positive evaluation.

Table 10: Integrative display: Appeal-of-appearance ratings, fear scores and the dominant patterns of justification by species. For the fear scores, higher values indicate lower intensity of fear

Species	M appearance	M fear score	Dominant justification pattern	Integrated conclusion
Dog	4.79	4.66	Familiarity, appearance	Positive rating driven by closeness and appealing appearance.
Rabbit	4.78	4.82	Appearance, familiarity	Rating driven by appearance and familiarity.
Butterfly	4.55	4.91	Ecological role, appearance	Aesthetic appeal with spontaneous recognition of pollination.
Horse	4.53	4.52	Familiarity, usefulness	A familiar and useful domestic animal.
Cat	4.48	4.64	Appearance, familiarity	A pet, consistently rated positively.
Bee	3.37	3.11	Danger, ecological role	A transitional, polarized case (sting vs. pollination).
Bat	2.94	3.27	Fiction, danger	Rating driven by fictional misconceptions.
Snake	2.78	2.44	Danger	Fear driven by perceived danger and overgeneralization.
Spider	2.78	2.95	Danger, appearance	Danger together with aversion based on appearance.
Earthworm	2.37	4.14	Appearance	Aversion based on appearance without fear — a dissociation of appearance and fear.

instruction, not solely as an expression of personal preferences. Students often form their ratings from immediately available features – external appearance, familiarity, and perceived danger – whereas biological features and ecological role appear more rarely. When appearance becomes the dominant criterion for drawing conclusions about an animal's features or role, this can lead to misconceptions and limit the development of a scientifically grounded grasp of the living world. Familiar and/or highly appealing species (dog, rabbit, butterfly, horse, and cat) students rate strongly and uniformly positively, describing them as pretty, soft, and dear, whereas aversion to the earthworm, snake, spider, bee, and bat is justified by a preformed judgment about the whole group (it bites, it's venomous, and it's slimy). The appearance criterion branches into domain-specific misconceptions: Overgeneralization of a trait (all snakes or spiders are venomous and dangerous), a misconception taken from fiction and the media (the generalized belief that blood is the food of bats), and blindness to ecological function (the earthworm useless, the bee reduced to its sting). These findings are in keeping with research on children's representations of animals (Kubiatko, 2012; Prokop et al., 2009).

That students' misconceptions are not uniform is shown by the different relationships between appearance, fear, and justifications. More negative ratings of the earthworm are linked chiefly to its appearance and to weaker recognition of its ecological role, whereas for the snake and bat representations linked to danger or fictional portrayals appear more often. Students' prior conceptions, then, have different sources and call for procedures adapted to their cause and structure. In keeping with the theory of conceptual change (Posner et al., 1982; Vosniadou, 1994; Potvin and Cyr, 2017), teaching should begin by diagnosing how students explain a particular animal. For the overgeneralization of a trait – that all snakes or spiders are dangerous – the emphasis should be on cognitive conflict and re-examining the generalization by comparing representatives of the same group and investigating the real features of organisms. For representations shaped by fiction, effective procedures involve analyzing stories and media content, comparing fictional and real behavior, and working

with authentic sources so that students distinguish an animal's symbolic role in culture from its real biology. For animals such as the earthworm, where a lower rating stems chiefly from appearance rather than fear, the key is a shift from a perceptual to a functional criterion, prompted by investigative activities – observing earthworms in the soil, building simple ecosystem models, or tracking the decomposition of organic matter – so that students see that the importance of an organism stems not from its appearance but from its role in maintaining the ecosystem.

The appeal-of-appearance ratings of particular animals are to a large extent linked to the intensity of fear, and animals rated lower on appearance are more often accompanied by justifications linked to perceived danger. Students' perception of animals so involves not merely the recognition of features but affective reactions and preformed beliefs. This is in keeping with research linking fear and aversion with the rating of danger and appearance (Borgi and Cirulli, 2015; Prokop and Fančovičová, 2017) and with findings of a greater inclination toward vertebrates relative to particular invertebrate groups (Prokop et al., 2008). It underscores the importance of developing biodiversity literacy directed as well at less familiar or less positively perceived organisms whose ecological role is often insufficiently recognized.

Sex differences further confirm the importance of the affective components of students' representations. The differences found are linked chiefly to fear rather than to the general appeal of appearance, in keeping with research showing more pronounced fear of particular animals among girls (Røskoft et al., 2003) and connected with differences in the readiness to take risks (Tomažič, 2011). Of particular methodological importance is the relationship between the average level of ratings and their variability, which points to the diversity of prior experiences, emotional reactions, and representations that students bring into the educational system. The areas of greatest variability are important sites for teaching: They show where students lack shared starting points and where different patterns of comprehension, including possible misconceptions, may arise. Effective early science education, for this reason,

calls for the diagnostic recognition of students' different representations and their gradual linking with a scientifically grounded grasp of biodiversity.

Certain limitations must be taken into account. The sample is a convenience sample limited to ten schools, which limits generalizability. Furthermore, the number of animals rated is likewise limited by the participants' age and concentration, and among the youngest by reading skill.

Several methodological recommendations follow: (a) Teaching should begin with the diagnostic recognition of students' prior conceptions; (b) instructional procedures should be adapted to the identified misconceptions; and (c) firsthand observation and investigation of living organisms should be included. These principles can be presented as a four-phase conceptual-change cycle: Diagnosis, differentiation, restructuring, and consolidation. Diagnosis identifies students' existing representations; differentiation selects an approach suited to a pattern of comprehension; restructuring links existing representations with scientifically grounded explanations; and consolidation applies the new comprehension in a broader context of the relationship with the living world. The model rests on the theory of conceptual change (Posner et al., 1982; Vosniadou, 1994), and the contribution of this paper is the linking of the identified patterns of students' perception of animals with possible procedures for reshaping them. Further research is needed to test the proposed approach in practice.

CONCLUSION

The study shows that primary-school students apply different criteria in rating animals, criteria that for the most part do not stem from the biological features and ecological role of the organisms. The appeal-of-appearance ratings, the fear scores, and the justifications point to prior conceptions, in which the visible features of animals, prior experiences, and indirectly shaped representations play an important role. However, the animals rated lower on appearance did not form a single group: For the snake and spider, lower ratings were linked to fear and to generalizations about danger; for the bat, to representations shaped by fiction; whereas for the earthworm a rating based on appearance predominated, with rare recognition of its ecological role. Such patterns show that misconceptions have different starting points and call for different instructional approaches. The contribution of this paper lies in considering the perception of animals as a diagnostic indicator of the prior conceptions relevant to early science education. The areas of greatest methodological importance are not solely those in which students express more negative ratings but those in which there is greater diversity of representations and a possibility of reshaping them. Instructional approaches should, then, broaden the initial criteria for rating animals – from appearance, familiarity, or perceived danger to a grasp of the biological features and ecological role of organisms. Future research should include further validation of the instrument and

the testing of instructional interventions directed at conceptual change and a more comprehensive grasp of the animal world.

ETHICS STATEMENT

The study was approved by the Ethics Committee of the Faculty of Teacher Education, University of Zagreb (Approval No. Klasa: 643-03/23-02/21; Urbroj: 251-378-17-23-2; June 08, 2023). Written informed consent was obtained from the parents or legal guardians of all participating children, and the children provided oral assent before participation. Participation was voluntary and anonymous, and participants could withdraw at any time without consequences.

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