PLANTS AND ANIMALS IN BIOLOGY TEXTBOOKS FOR HIGH SCHOOLS (ISCED 3) IN SLOVAKIA

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Abstract

This study analyzed currently used gymnasium textbooks in the Slovak Republic from the perspective of the development of plant blindness, through a quantitative evaluation of mentions of plant and animal organisms. We analyzed 388 pages of two textbooks, identifying 635 organisms, of which 277 were animals (43.6%) and 300 were plants (47.2%). The Slovak genus name dominated in textbooks for both groups of organisms. On the other hand, scientific genus and species names were less frequent. Scientific names of animals (genus: 208, species: 190) were more common in textbooks than scientific names of plants (genus: 157, species: 141). The higher occurrence of scientific names for animals compared to plants in textbooks may provide better preparation for university studies related to zoology, whereas the lower emphasis on plant scientific names could make the transition to botany-focused subjects more challenging. A comparison of the number of non-vascular and vascular plants revealed a low number of mentions of non-vascular plants (24 organisms). In contrast, textbooks included a relatively high number of invertebrates (117 organisms) among animals. The low emphasis on organisms from the fungi kingdom (30 organisms) suggests the need for increased attention by textbook authors to this group of organisms. Similarly, textbooks included the names of only 28 unicellular organisms, of which 17 were bacteria. A weak emphasis on non-vascular plants, unicellular organisms, and fungi can negatively affect a comprehensive understanding of biodiversity, ecological relationships, and the perception of the importance of these organisms.

Keywords: *plant blindness*, *textbooks*, *scientific names*, *taxonomy*, *biodiversity*

1. INTRODUCTION

Botany is less attractive to students compared to other areas of biology, which has been confirmed in several studies. Students in Germany aged 15–17 showed the greatest interest in human anatomy and the least in botany (Holstermann & Bogenholz, 2007). For 16-year-old students from Finland, the area "*living organisms*", which includes plants and animals, is less attractive compared to human biology or genetics (Uitto, 2013). Also, the number of university graduates who would have a degree in botany is several times lower compared to other fields of biology, for example zoology or genetics (Stroud et al., 2022). The issue extends beyond merely lower student interest. It also involves limited knowledge compared to fields such as zoology. Students struggle even to recognize common plant species in their local environment. For example, in a study of 241 Swiss students (average age 12), participants accurately identified only 17.1% of plant species, compared to 41% of animal species. Even their teachers (13 participants) managed to identify just 51.7% of plant species and 61.2% of animal species correctly (Jaun-Holderegger et al., 2022). Recognizing and understanding living organisms is important not only for developing deeper scientific knowledge but also for fostering an appreciation and interest in nature. Supporting this, a study among Spanish students aged 12–17 showed a positive correlation between the ability to identify plants and their understanding of plants' roles within ecosystems (Pedrera, 2021). Germany study confirmed the relationship between knowledge and attitudes, specifically the level of animal species knowledge explained 17% of the variance in attitude toward the environment (Härtel et al., 2023). Plants undoubtedly play a crucial role in addressing numerous challenges related to global climate change, human health, and food security (Hiatt et al., 2021). Ignoring flora can directly hinder the achievement of majority of sustainable development goals (Coşkunserçe, 2024). An analysis

of 113 Paleolithic cave art sites across Europe, with 5,786 depictions, revealed that 0.07% of the paintings contained plants, while animal depictions (53.7%) were much more common (Walton et al., 2023). Another study provided evidence that students show a cognitive bias favoring animals when presented with an equal number of plant and animal images (14 each). Specifically, students recalled animal images more effectively than plant images (average recall of 6.5 animals versus 6 plants; Schussler & Ozlak, 2008). This tendency to overlook or undervalue plants in favor of animals is defined in the literature as plant blindness (Wandersee and Schussler, 1999) or Plant Awareness Disparity (PAD; Parsley, 2020).

Plant Awareness Disparity (PAD) arises from several factors, but our research specifically addresses the educational environment. In the United Kingdom, primary school curricula focus primarily on teaching students to recognize common wild and garden plants, with minimal attention given to plant ecology. At the secondary education level, curricula emphasize bioenergetics, reproduction, and plant anatomy, while ecological aspects and species identification receive comparatively little attention (Stroud et al., 2022). An analysis of two peer-reviewed educational journals aimed for science teachers (*Science and Children* and *Science Scope*) revealed that articles predominantly covered animal-related topics (45% and 33%, respectively), whereas plant-related (15% and 9%) and fungi-related topics (1% for each journal) were significantly less common (Patrick and Matteson, 2017). Textbooks also exhibit this imbalance, favoring animals over plants. For instance, Link-Pérez et al. (2010) analyzed 1,288 photographs in 11 primary education textbooks. Photographs of animals were more common in the textbooks than of plants (59.6% vs. 25.6%). Furthermore, animals were often identified by specific names (e.g., rhinoceros, skink; 82%) compared to plants (57%). Schüssler et al. (2010) reported that animal-related topics tended to focus on adaptations, while plant-related topics mostly concerned structural aspects. Additionally, textbooks provided more animal examples than plant examples (239 and 422 versus 119 and 174). A review of four American university-level general biology textbooks revealed a considerable disparity in illustrations, with animals represented by 80–150 images compared to 20–50 images of plants (Brownlee et al., 2021). On the contrary, Turkish textbooks used plant-related vocabulary more frequently (62.5%) than animal-related vocabulary (37.5%). Illustrations also favored plants (49.8% vs. 35.3%), but the term animal appeared more frequently than plant (54.1% vs. 45.9%). General animal categories (e.g., fish, insects) were also represented more frequently than plant groups (e.g., grasses, trees; Ahi et al., 2018). In summary, although the emphasis on botanical education varies across countries, a global decline in botanical education is evident (Stroud et al., 2022). Jose et al. (2019) found that botanists' motivations for choosing their field comes from their childhood through agricultural activities, nature walks, or influential teachers. Teachers thus play a key role in developing students' interest in botany, which requires a high level of expertise and genuine interest in the subject from the teachers. A recent survey conducted in Slovakia highlights this issue, revealing that nearly half of teachers self-critically admitted deficiencies in their knowledge of plant biology beyond the curriculum (Kováčik and Vydra, 2023).

Based on the characteristics discussed above, it appears that declining standards of botanical education represent a widespread issue. One factor potentially contributing to the development of plant blindness, or Plant Awareness Disparity (PAD), may be the textbooks themselves. Consequently, our study focuses on analyzing the mentions of plant and animal organisms in biology textbooks currently used in Slovak secondary schools (gymnasiums).

2. MATERIALS AND METHODS

This analysis identified and quantified the mentions of plant and animal organisms in biology textbooks currently used in Slovak secondary schools (gymnasiums). Gymnasium education (ISCED 3A) prepares students for university studies in various academic fields. Two textbooks from a single textbook series intended for gymnasium students were selected for analysis. The first textbook predominantly covers chapters related to ecological communities (e.g., alpine ecosystems) and introduces various representatives of these communities. The second textbook focuses primarily on anatomy, morphology, and physiology of different organism groups, and also includes a chapter focused on genetics. These textbooks are intended for first- and second-year gymnasium students.

The analysis involved a review of 388 pages of two textbooks to create a comprehensive list of all references to organisms. Initially, all organisms listed in the textbooks were compiled into a summary data table. Duplicate mentions were subsequently removed so that each organism appeared only once, resulting in a total of 635 unique organism names.

The compiled list was then categorized into three distinct groups: plants, animals, and other organisms. Each organism's name was further analyzed to determine whether it was mentioned using a Slovak common or scientific (Latin) genus/species names. In other words, if the text mentioned the organism Humboldt penguin (in Slovak), the coding determined only the Slovak genus and species name. All 635 organism names underwent this classification process. The resulting data was used to evaluate the mentions of plant and animal organisms and to generate graphs illustrating these findings. The graphs were created using GraphPad Prism version 10.1.1 for Windows (GraphPad Software, Boston, Massachusetts, USA).

3. RESULTS

3.1. Organisms in textbooks

A detailed analysis of 635 identified organism names revealed relatively balanced mentions of plant and animal species in high school biology textbooks. In total, 277 animal and 300 plant names were found (Table 1). Expressed as percentages, 43.6% of the total organisms were animals, while 47.2% were plants (n = 635, representing 100%). The remaining organisms (58 or 9.2%) were species of unicellular organisms and fungi not belonging to the animal or plant kingdom (Table 1). These results probably indicate an intentional effort by textbook authors to maintain an equivalent representation of plant and animal organisms' names in currently used biology textbooks. A detailed analysis of plant mentions revealed that textbooks contain fewer names of non-vascular plants. The number of mentions of invertebrates and vertebrates is relatively balanced (Table 1). Based on these data, we recommend that textbook authors include a greater number of non-vascular plants in biology textbooks.

Table 1. Overview table showing the number of main groups of organisms listed in Slovak high school textbooks (Slovak names)

group of organisms	sub-group	number of organisms
unicellular organisms	plants (algae and related taxons)	1
	animals (e.g. *Paramecium*)	10
	bacteria	17
plants	non-vascular (e.g. mosses)	24
	vascular (ferns and flowering)	276
animals	invertebrate (e.g. beetles)	117
	vertebrate (from fish to mammals)	160
fungi	macro-/micro-fungi and lichens	30

3.2. Slovak and scientific names

The study analyzed both Slovak and Latin (scientific) names of organisms mentioned in biology textbooks. Regarding the Slovak names, textbooks contained slightly more mentions of plant genus names and, conversely, more animal species names (Figure 1). These results suggest that despite a slightly higher overall occurrence of plant organisms in biology textbooks, plant species names are mentioned less frequently (Figure 1). Expressed as a percentage, only 64.0% of plants contained Slovak names at the species level, but up to 76.5% of animals were named at the species level. These findings indicate that biology textbooks apply binomial nomenclature less consistently to plants than to animals.

The analysis of scientific names also indicates a lesser emphasis on binomial nomenclature for plants compared to animals. Although plants are mentioned slightly more overall, textbooks more frequently include scientific genus and species names for animals (Figure 2). Familiarity with scientific organism names can enhance students' comprehension of professional terminology and improve their ability to work with scientific texts. Limited knowledge of plant species names and their scientific designations may pose greater challenges for students in mastering botanical subjects compared to zoological ones.

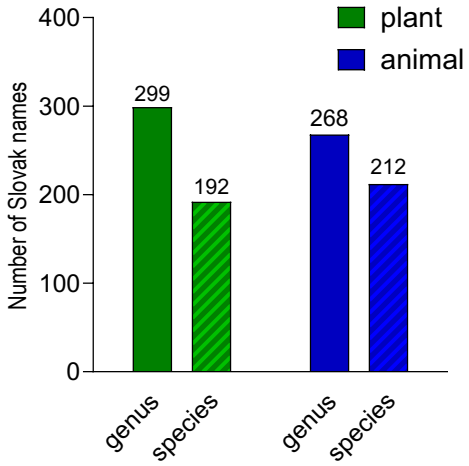

Figure 1. Number of Slovak genus (solid columns) and species (hatched columns) names of plants (green columns) and animals (blue columns) mentioned in biology textbooks.

4. DISCUSSION

This study identified a relatively balanced representation of plant (300) and animal (277) organisms in Slovak high school (gymnasium) biology textbooks. These results reflect the textbook authors' efforts to maintain a balanced presentation of biodiversity. This is a positive outcome, considering that familiarity with biodiversity can form students' perceptions of the importance of organisms and influence their attitudes toward the environment. Supporting this idea, the ability of Spanish students to identify plant species positively correlated with their understanding of plants' roles within ecosystems (Pedrera, 2021). A German study confirmed the relationship between knowledge and attitudes (Härtel et al., 2023). Our findings indicate positive results in the Slovak context, as we observed a relatively balanced occurrence of plant and animal organisms' names, which contrasts with findings from other countries. In American primary-school textbooks, animal-themed photographs accounted for 59.6%, while only 25.6% depicted plants. Moreover, caption analysis showed that specific organism names were included in 82% of animal photographs, but in only 57% of plant photographs (Link-Pérez et al., 2010).

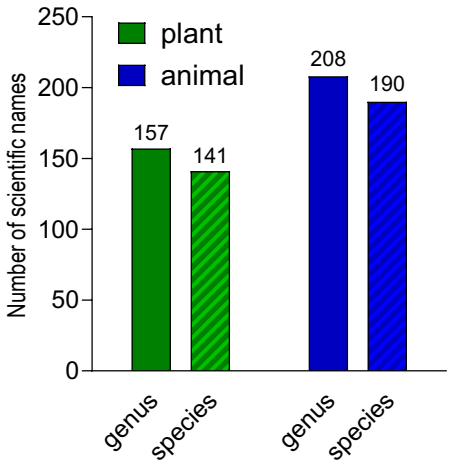

Figure 2. Number of scientific genus (solid columns) and species (hatched columns) names of plants (green columns) and animals (blue columns) mentioned in biology textbooks.

Another study comparing two textbook series showed that animal-related topics focused primarily on adaptations, whereas plant-related topics emphasized structural features. Examples of animals were also more frequently provided compared to plants (239 and 422 versus 119 and 174, respectively; Schussler et al., 2010). Similarly, analysis of four American university-level general biology textbooks revealed a considerably higher number of animal images (80–150) compared to plant images (20–50; Brownlee et al., 2021). In line, Turkish textbooks contained more plant-related words than animal-related words (62.5% vs. 37.5%) and images of plants (49.8%) than animals (35.3%). On the contrary, references to animal groups (e.g., fish, insects) exceeded plant groups (e.g., grasses, trees; Ahi et al., 2018).

However, balanced mention of plant and animal species in textbooks is only one of the prerequisites for developing knowledge about organisms found in our surroundings. Teachers also play a critical role. In this context, Lindemann-Matthies et al. (2017) found that schools are the second most important source of species-related knowledge, following family in first place. The same study suggests that student-centered instruction is regarded as the most effective method for developing the ability to identify and name organisms. Direct, hands-on experiences are equally important. Kaasinen (2019) demonstrated that familiar species often have distinct identification features, and individuals typically have personal memories and multisensory experiences associated with them. For example, children may have picked and tasted berries, had a spruce Christmas tree, have been burnt by common nettle, or collected dandelions to make flower chains.

An essential prerequisite for developing species identification skills is a knowledgeable teacher with strong identification abilities. However, several studies have shown that teachers themselves often possess limited knowledge regarding plant and animal species. For instance, a Swiss study revealed that teachers could correctly identify only 51.7% of plant species and 61.2% of animal species (Jaun-Holderegger et al., 2022). A similar study conducted in Germany indicated that teacher-training students identified only 23% of plant species and 44% of animal species (Lindemann-Matthies et al., 2017). Based on our results, we conclude that Slovak biology textbooks contain a relatively balanced number of plant and animal species and thus do not significantly contribute to the phenomenon known as plant blindness or Plant Awareness Disparity (PAD). However, globally, a decreasing emphasis on botanical education has led to a notable decline in botanical knowledge and awareness, resulting in long-term consequences for plant conservation and ecological understanding (Stroud et al., 2022).

Our study found significant differences in the use of species-level names between plants and animals, indicating a stronger emphasis on binomial nomenclature for animals. In this context, results from a German study highlight that many participants identify organisms primarily at the generic level rather than at the species level. For example, approximately 80% of participants recognized the genus name of *Betula*, but fewer than 5% knew the species name *pendula*. Similar results were observed for other plants

(*Matricaria chamomilla*, *Cirsium arvense*, *Tilia platyphyllos*, *Lamium purpureum*, *Ranunculus repens* and *Geranium pratense*) and animal species (*Larus ridibundus*, *Salmo trutta*, *Hirundo rustica* or *Cepaea nemoralis*; Lindemann-Matthies et al. 2017). We also believe that differences in the number of scientific names for plants and animals could negatively affect students' ability to master specialized botanical terminology.

5. CONCLUSIONS

The results of our study confirmed that high school biology textbooks in Slovakia are characterized by a relatively balanced number of plant (300) and animal (277) organisms. Despite this balance, we noted a certain disproportion in the use of scientific names, with plants being mentioned with less emphasis on scientific nomenclature compared to animals. This disproportion may negatively affect students' ability to acquire professional terminology, navigate taxonomic systems and work with professional texts.

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