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Research Article

Using entomological collections to enhance elementary school learning

Jan Walter [1*], Jiří Kout [1]

[1] Department of Biology, Geosciences and Environmental Education, Faculty of Education, University of West Bohemia, Plzeň, CZECH REPUBLIC
***Corresponding Author:** jwalter@cbg.zcu.cz

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ABSTRACT

Insects are the most successful group of living organisms on the earth. They are a regular part of the school curriculum and, in light of ongoing insect extinction, should become one of the crucial topics in education. For proper understanding, it is necessary to support learning activities with a focus on species identification. We compared two demonstrative methods of teaching insect species at the lower secondary stage in elementary schools. Demonstrations using entomological collections and images were evaluated to determine which method is more effective for knowledge acquisition. Statistical analyses showed significant differences between the two observed learning methods. Pupils who used biological collections achieved better results compared to those who learned using images only.

Keywords: insects, insect collection, teaching, pupils, biology, science education

INTRODUCTION

Biological education is an indispensable part of the school curriculum (Gaston & Spicer, 2004). It aims to enhance basic knowledge about ecological processes, species, their identification, biology, and life history (Eugenio-Gozalbo & Cubero-Ortega, 2022; Lindemann-Matthies, 2006). Insects represent the most successful group of living organisms on the earth, potentially accounting for over 90% of all living animal life forms (Chapman, 2009; Ruppert & Barnes, 1994). At the same time, insects are undergoing a global mass extinction (Cardoso et al., 2020).

Biodiversity loss is one of the most urgent global problems facing humankind, and studies focusing on biodiversity have rapidly declined (Taszakowski & Depa, 2022). This decline is linked to an expertise crisis, as the pool of taxonomic experts in Europe has been shrinking for decades (Hochkirch et al., 2022). Faunistic studies are currently sidelined and undervalued by high-impact journals, despite being fundamental to most scientific and biodiversity research (König & Schmitt, 2023). Therefore, it is crucial to revive taxonomic research and ensure the education of the next generation of taxonomists (Löbl et al., 2023).

The relationship between insects and humans is undisputed, and as an educational subject, they naturally arouse curiosity due to their omnipresence (Iliff, 1981; Thompson, 1999). Therefore, they are an integral part of the educational curriculum. The importance of insects lies in their crucial ecological roles, such as pollination, decomposition, and serving as a food source for other animals and even for humans (Govorushko, 2019). They are the basis of trophic pyramids in most ecosystems on earth (Schoenly et al., 1991). Many species are also known as pests and carriers of significant pathogens (Ruppert & Barnes, 1994).

Insects are useful models for teaching general biological principles (Fischang, 1976) due to the fact that their forms, functions, physiology, biology are diverse and relatively well recognized (Bergman, 1947). The relationship with insects is formed at an early age in preschool children through games, children's TV programs, and coloring or picture books with insect-related themes (Lu & Jeng, 2012). Later, during elementary school education, it is repeatedly recommended to use biological literature to acquire knowledge and to reinforce the importance and appreciation of insect biodiversity (Lu & Jeng, 2012; Shipley & Bixler, 2017). Pupils should gain knowledge not only about the impact of insect species on humans but also about species identification.

The direct contact with the object has showed as an important learning method, according to the saying "Once seen alone is better than a hundred times heard". Such contact creates emotional experiences and strengthens the relationship with the object of knowledge (Cimer, 2007). Moreover, personal experiences lead to lasting knowledge and provide a high level of learning enjoyment (Sieg & Dreesmann, 2024), while emotional encounters with real-world phenomena may also support pupils' creative thinking (Patrick, 2010; Yassir & Abeer, 2014).

Direct contact with insect species can take place during field trips, which positively influence pupils' knowledge (Chocholoušková & Műllerová, 2020), or through the use of entomological collections as a didactic tool (Santos & Souto, 2011). It has been confirmed that studying insects using entomological collections is well accepted by students, increases their interest in insects, and supports their motivation for further work with biological materials (Silva & Vieira, 2021).

We compare two demonstrative methods of teaching insect species at the elementary schools. Specifically, we have investigated which method; teaching by with entomological collections or using images of insects; is more effective for acquiring knowledge about insects in several elementary schools in the Czech Republic. We analyze the results of a final test in which pupils were asked to recognize selected insect species. We hypothesize that pupils who learn using entomological collections will achieve better results in species identification than those who use images as learning tools.

METHODS

Test Design, Instruments, and Statistical Analysis

We analyzed five national textbooks with emphasis on following mentioned insect species. Analysis of textbooks showed the most frequent insect´ orders and species, respectively. The most frequent orders were beetle (Coleoptera), butterflies and moths (Lepidoptera), bees and wasps (Hymenoptera), mayflies (Ephemeroptera), crickets (Orthoptera), dragonflies (Odonata), flies (Diptera), lacewings (Neuroptera), and true bugs (Hemiptera).

In the final test, beetle, butterflies, bees and wasps were represented by three species of each order, whereas other order were represented just one species of these orders, namely: beetles: *Coccinella septempunctata*, *Lucanus cervus*; *Nicrophorus vespillo*; butterflies: *Aglais io*, *Papilio machaon*; *Pieris brassicae*; bees and wasps: *Bombus terrestris*, *Vespa crabro*, *Vespula vulgaris*; mayflies: *Ephoron virgo*, crickets: *Gryllus campestris*; dragonflies: *Libellula depressa*; flies: *Musca domestica*; lacewings: *Chrysoperla carnea*; true bugs: *Pyrrhocoris apterus*. In total, we selected 15 species for the final test according to their frequency in the textbooks.

A total of 186 pupils from five classes participated in the testing. All were sixth-grade students attending lower secondary level of elementary schools in the Czech school system. 93 pupils learned exclusively the insect species using a biological collection consists of dry insect specimens, and other 93 pupils learned the species using images of given insect species only. We selected the given images of insects based on photographs of live insect species, so that the key characteristics of the given taxon were clearly visible. The insect topic was taught for one month. Biology teachers responsible for the respective classes conducted the teaching and final test. During this period, pupils learned not only the species included in the final test, but also other species which are included as incorrect answers in the final test (Table 1).

Table 1. Results of tests comparing pupils who learned about insects using entomological collections and those who used images only

Q	Species	N		BRU
		C	I	
1	*Chrysomela populi*	3	1	I
	Coccinella septempunctata	**79**	**87**	
	Pyrrhocoris apterus	4	1	
	Coccinella bipunctata	7	4	
2	*Gonepteryx rhamni*	3	7	C
	Parnassius apollo	6	6	
	Papilio machaon	2	3	
	Pieris brassicae	**82**	**77**	
3	***Vespa crabro***	**78**	**67**	C
	Vespula vulgaris	7	15	
	Syrphus ribesii	6	10	
	Bombus terrestris	2	1	
4	*Gryllus campestris*	5	3	C
	Dytiscus marginalis	2	9	
	Nicrophorus vespillo	**79**	**73**	
	Melolontha melolontha	7	8	
5	***Emphemera vulgaris***	**83**	**76**	C
	Chrysoperla carnea	5	10	
	Apanteles glomeratus	3	5	
	Episyrphus balteatus	2	2	
6	*Aglais urticae*	5	4	C
	Vanessa atalanta	2	5	
	Maniola jurtina	2	10	
	Aglais io	**84**	**74**	
7	*Apis mellifera*	3	12	C
	Bombus terrestris	6	5	
	Vespula vulgaris	**83**	**72**	
	Syrphus ribesii	1	4	
8	***Lucanus cervus***	**85**	**85**	S
	Melolontha melolontha	1	5	
	Oryctes nasicornis	5	3	
	Calosoma inquisitor	1	0	
9	*Vanessa atalanta*	0	9	C
	Papilio machaon	**85**	**78**	
	Maniola jurtina	7	5	
	Saturnia pavonia	1	1	
10	*Syrphus ribesii*	0	0	C
	Vaspula vulgaris	0	0	
	Bombus terrestris	**92**	**90**	
	Vespa crabro	1	3	
11	*Melolontha melolontha*	5	11	C
	Dytiscus marginalis	3	12	
	Nicrophorus vespillo	3	8	
	Gryllus campestris	**82**	**62**	
12	*Coenagrion puella*	4	16	C
	Libellula depressa	**84**	**60**	
	Calopteryx virgo	7	13	
	Anax imperator	0	4	
13	***Musca domestica***	**82**	**87**	I
	Lucilia caesar	2	1	
	Sarcophaga carnaria	5	5	
	Stomoxys calcitrans	0	0	
14	*Emphemera vulgaris*	10	17	C
	Apanteles glomeratus	1	7	
	Chrysoperla carnea	**81**	**68**	
	Episyrphus balteatus	1	1	
15	*Leptinotarsa decemlineata*	0	1	C
	Coccinella septempunctata	1	4	
	Graphosoma lineatum	2	4	
	Pyrrhocoris apterus	**90**	**84**	

Note. The correct answers are in bold. Q: Question; N: Number of answers; C: Collection; I: Images; S: Same; & BRU: Better results using

Afterwards, the pupils passed the exam consisting of the 15 species which the pupils had to identify. The exam respected methods of learning; pupils that learned the insect species using entomological collection identified the dry insect specimens and pupils using images identified photographs of given species. Pupils tagged one answer (A, B, C, or D) that they consider as correct.

The number of correct answers was analyzed using the non-parametric paired samples Wilcoxon test in software R studio (R Core Team, 2025). We compared the number of correct answers of pupils tested using dry insect specimens and the pupils tested using images of species. The statistical significance was defined at $p < 0.05$. For the graphic presentation of the Wilcoxon test, we used a boxplot visualization.

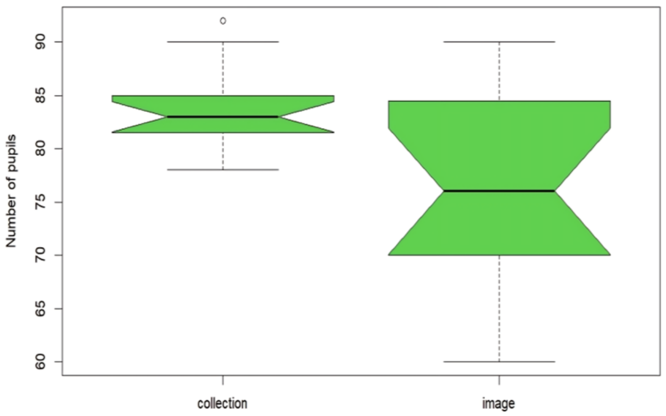

Figure 1. Box plot illustrating the differences in pupil learning outcomes between the use of entomological collections and insect images. The x-axis represents the number of pupils who answered correctly. (R Core-Team, 2025)

RESULTS

The comparison has been made between two groups of pupils, teaching by two different methods in insect identifying, from the primary schools in the Czech Republic. We found a significant difference ($V = 96$, $p = 0.0069$) in the number of correct answers between pupils who learned insect species using collection (min/max = 78/92, median = 83, standard deviation = 3.852) and those who used images (min/max = 60/90, median = 76, standard deviation = 9.312). The box plot visualization (**Figure 1**) indicates that the number of correct answers among pupils using collections is more consistent. In contrast, pupils who learned from images achieved lower results on average and showed greater variability. In general, pupils who used collections achieved the highest number of correct answers in 12 questions. Pupils who learned using images performed better in 2 questions, and the number of correct answers was the same in 1 question.

DISCUSSION AND CONCLUSION

The teaching process is dynamic, and new technologies continuously reshape education, including the teaching of biology (Mellado et al., 2010). In biology education, various teaching methods offer a wide range of possibilities, differing in effectiveness, student motivation, preparation time, and the depth of knowledge gained. Comparing teaching methods has long been a common practice in biology education (e.g., Abrahams & Millar, 2008; Colyer, 1960).

Biology teaching grounded in practical experience and direct engagement fosters deeper understanding and more lasting knowledge, a principle already emphasized in Piaget's (1953) theory. Pupils acquired long-lasting knowledge and enjoyed the learning using practical activities with outdoor bumblebee-keeping, and it has been repeatedly confirmed that hands-on activities are considered particularly suitable for long-term knowledge acquisition (Sieg & Dreesmann, 2022).

Direct contact with the subject matter enhances the memorization of specific objects and terms. For example, most pupils demonstrated significant improvement following field trips and became familiar with a broader range of terminology (Chocholoušková & Műllerová, 2020). Pupils who gain knowledge of biology from their own experiences will, among other things, give them a positive relationship with nature, including insects (Ernst et al., 2012). Moreover, practical teaching methods are generally more enjoyable for students. However, not everyone gives a positive opinion at practical teaching (Hodson, 1990; Osborne, 1993). Hence, it is important mention that suitable types of teaching or learning depend on the topic.

Our results support the use of practical activities in schools as a more effective method for improving species identification skills. Pupils who worked with an entomological collection achieved higher scores compared to those who learned using images (**Figure 1**). We can expect that similar results will be achieved in other groups of organisms and hence we recommend practical teaching in species recognition.

In line with other research in biology education (e.g., Rodriguez Soto & Hernandez Barbosa, 2015; Suyanto et al., 2022), our small-scale experiment comparing entomological collections and images supports the idea that direct contact with the object of study is a more effective approach for knowledge acquisition.

It is also essential that teachers possess a solid understanding of biodiversity in order to effectively convey this knowledge to their pupils (Skarstein & Skarstein, 2020). Therefore, the ability to identify local species should be considered a key skill in undergraduate teacher training. It is crucial that knowledge about local species is important as a motivation aspect to the next generations to protect biodiversity (Melis et al., 2021). Unfortunately, there is a noticeable decline in students' knowledge levels (OECD, 2023), which necessitates the exploration of more effective learning methodologies.

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