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Research Article

Enhancing Urban Biodiversity Awareness and Conservation Through Nature Walk-Based Pedagogy

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ABSTRACT

Nature walks can be an effective pedagogical tool for exploring and understanding the urban biodiversity. Through observation-based pedagogy, students can learn about the biodiversity that surrounds them. This is effective in inculcating an understanding of the ecosystem, the intricate relationships between the organisms in an ecosystem, and their adaptations and interactions, thereby increasing environmental awareness. Their critical thinking, teamwork, and communication skills also improve through group-based activities such as nature walks. The study evaluated the effectiveness of Nature-based pedagogy in improving students' understanding of urban biodiversity. Three themed nature walk sessions were conducted for undergraduate students (N=173) focusing on entomological diversity, lepidopteran diversity, and pond ecosystem ecology. Each session included a lecture-based module, followed by a quiz and then a nature walk-based module, followed by a quiz. Students also recorded field observations and microscopic analysis of collected samples. Mean quiz score significantly improved after nature walk based module sessions. Students exhibited enhanced ability to identify insect orders, life stages, ecological interactions and pond biodiversity. Qualitative feedback reflected high engagement, improved conceptual clarity and appreciation for urban biodiversity. Nature-walk based pedagogy substantially improves conceptual understanding, field identification skills and environmental awareness. Integrating structured nature walk-based modules in Zoology and Life Sciences curricula can enhance experiential, inquiry- based learning and promote conservation-oriented attitudes among undergraduate students.

Key words: Nature walk, Pedagogy, Entomological diversity, Collaborative learning, Curriculum.

INTRODUCTION

The scientific study involves stringent protocol-based discovery with the use of meticulous information, observation, and diligent experimentation to create a piece of verifiable information, which is in clear contrast to just memorisation of facts. While teaching science, lectures are used as pedagogical devices. Though lecture-based pedagogy is an important part of scientific discourse, it finds its origin in a time when access to scientific knowledge and information was severely limited and thus in today's time, lecture-based pedagogy fails to promote cognitive engagement (Schmidt et al., 2015). There is a huge misalignment between the way science is done and taught; scientists and science instructors all over the world have repeatedly pointed this out (Woodin et al., 2010). In the current era of science teaching, undergraduate science instructors focus on having more student-centric pedagogical approaches, shifting away from monologue-based learning. Reconfiguring the curriculum by moving the teaching spaces beyond the classroom leads to more immersive learning (Crouch & Mazur, 2001; Nilson, 2016.; Woodin et al., 2010).

An instructor often tends to over-emphasise theoretical discourse while teaching life science courses such as animal diversity, behaviour, anatomy, developmental biology, etc. Introducing Nature walks as a pedagogical tool to teach such courses will shift the ownership of learning through discovery and observation of the natural world to the students. Nature nurtures in a holistic manner improving mental health, sharpening cognition, and increasing learning engagement. Nature walks not only evoke students' love for nature but also allow them to recognize the natural values of the ecosystem. Integrating nature walks with the curriculum will lead to a more positive environmental attitude among students whereby students will be more emotionally connected to the natural world and will have a more immersive moral awareness of the environment around them. Nature not only stimulates all our senses but promotes inquiry-based learning thereby developing inquisitive minds. When students explore urban biodiversity, they may encounter species unfamiliar to them. This exploration enhances their understanding of species interactions and fosters deeper appreciation for the environment, encouraging conservation efforts. In fact, the

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term science derives from the Latin word "*Scientiae*" which means knowledge based on actual observation. Nature walks boost subsequent classroom engagement of the students, thereby improving learning engagement. Environmental moral education is significant in today's times when global environmental issues are of concern. Researchers have found that providing environmental moral education positively correlated to pro-environmental behavior in students (Begum et al., 2021).

METHODOLOGY

Three nature walk based sessions were conducted with undergraduate students of Zoology and Life Sciences. Each themed session was two hours long, comprising a 30-minute lecture, followed by a pre-nature walk quiz, a 60-minute guided nature walk, and a quiz and reflection segment. A total of 173 students participated across the three sessions. Session 1- entomological diversity (n=49), Session 2-lepidopteran diversity (n=53) and Session 3- pond ecosystem study (n=71). All students attended only one themed session, thus avoiding repeated-measure bias. Quiz questions contained 6-10 questions and evaluated taxonomic identification, ecological roles and biodiversity-related concepts (Figure 1). During all the nature walk sessions, students recorded field observations using photographs and videos and collected biological samples of insect eggs and pond water, which were later examined under the microscope to identify microinvertebrates and planktonic diversity. Additionally, the avian species cited along the trail were documented.

RESULTS

The first nature walk session (study of Entomological diversity) included 49 participants. The average score improved from 3.44 (out of 6) to 4.69 (out of 6) in pre and post-nature walk quizzes respectively (Figure 1). A one-way repeated measures ANOVA revealed a significant effect of the nature walk intervention on student quiz performance. Post–nature walk quiz scores (mean = 4.69) were significantly higher than pre–nature walk scores (mean = 3.45) ($F(1,48) = 47.30$, $p < 0.001$). The common insects that were noticed during nature walks were lepidopterans (butterflies and moths),Odonates (dragonflies and damselflies) found in wetland areas, Orthoptera (hemipteran bugs, grasshoppers), Hymenoptera (ants, wasps, and honey bees) (Figure 4). Wasp and termite mound was also observed (Table 2).

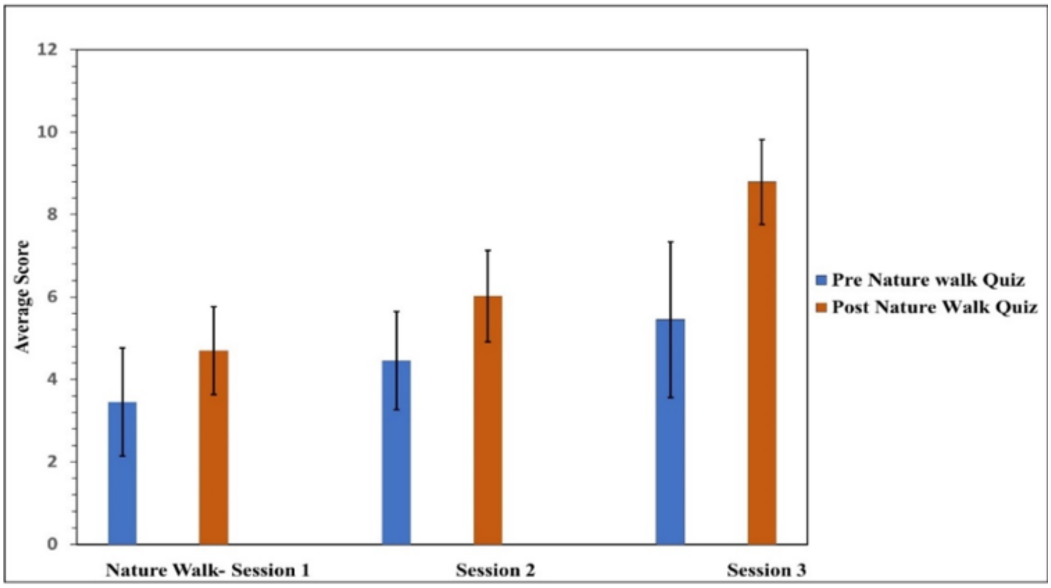
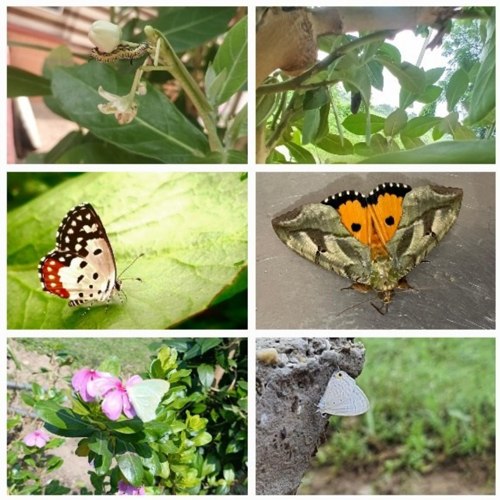


Figure 1. Mean pre- and post-nature walk quiz scores across three independently conducted sessions involving different student cohorts. Error bars represent ± SD. In each session, post-intervention scores were significantly higher than pre-intervention scores (repeated measures ANOVA, $p < 0.001$). Maximum possible scores were 10 for Sessions 1 and 3 and 8 for Session 2

Table 1. Summary of learning gains and changes in score variability following the nature walk intervention across three independently conducted sessions.

Session	Mean Gain (marks)	% Learning Gain	Reduction in Variability
Session 1	+1.24	12.45%	18.6% ↓
Session 2	+1.57	19.58%	7.0% ↓
Session 3	+3.34	33.4%	~46% ↓

Table 2. Depicts terrestrial ecosystem of insects mainly focusing on Lepidoptera and pond ecosystem along with an ecological pyramid.

	Organisms Shown/Observed	Theoretical learning	Nature Walk learning
	Images of Various insects	Terrestrial ecosystem (Insecta)	
1.	 Different images show a caterpillar, pupa, butterfly, moth (with antennae), and butterfly feeding on a flower.	Read about Lepidoptera. Studied their different features like wings, antennae, mouthparts, resting position, egg, larvae (caterpillar), etc. through diagrams and figures.	Identified key details of lepidopterans in real vision like Scales- Wings have scales. Antenna- Club-shaped or fibrous. Observed mouth parts (siphoning type) and insect feeding pattern. Figured out the difference between the sitting position of the butterfly and the moth. Life stages like caterpillar, pupa, and adult observed in nature.
2.	 The images above show a honeybee feeding on a flower, a wasp nest, an termite mound and various other insects including a dragonfly.	Read about many other insect orders including Odonata, Hymenoptera, Diptera, Isoptera etc. Studied different types of antennae, mouthparts, feeding mechanisms, eyes, and various life stages of different arthropods. Mimicry in arthropods was studied.	Honeybees- Have both forewings and hindwings. Hoverfly- Possess halteres instead of hindwings. The feeding and nesting behaviour of different insects was observed. Mechanism of flight of different insects was observed. Similar looking organisms were easily differentiated through the study of their behaviour and life stages.

Pond ecosystem

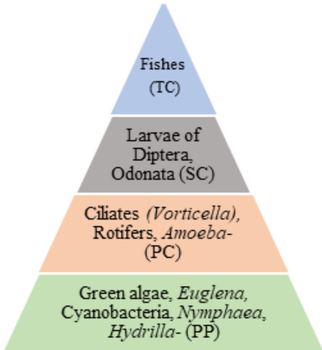
3.

The images show microscopic organisms- Vorticella, Amoeba, Euplotes, Euglena and a rotifer.

Learned about biotic (Producers, consumers, decomposers) and abiotic (Temperature, pH, Turbidity, Water, gases like oxygen and carbon dioxide) factors in pond ecosystem along with the different zones in a pond (benthic zone, littoral zone, and limnetic zone).

Calculated the dissolved oxygen, turbidity (using Secchi disc), pH of the pond.

Observed an aquatic food chain with primary producers (PP), primary consumers (PC), secondary consumers (SC), and Tertiary consumers (TC).



An ecological pyramid showing different levels of the food chain observed in the pond

The second nature walk session (Study of lepidopteran diversity) included 53 participants. The average score in the pre-nature walk quiz was 4.4 (out of 8) which improved to 6 (out of 8) in the post-nature walk quiz (Figure 1). For Session 2, a one-way repeated measures ANOVA revealed a significant effect of the nature walk intervention on student performance. Post–nature walk quiz scores (mean = 6.02) were significantly higher than pre–nature walk scores (mean = 4.45) ($F(1,52) = 50.06$, $p < 0.001$) (Table 1). The common lepidopterans spotted were- Mottled emigrant (*Catopsilia pyranthe*), plains cupid (*Chilades pandava*), Blue pansy (*Junonia orithya*), Danaid Eggfly (*Hypolimnas missipus*), Common Mormon (*Papilio polytes*), Cucumber moth (*Diaphania indica*), Fruit piercing moth (*Eudocima*), Green drab moth (*Ophiusa tirhaca*). Students also spotted the caterpillar and pupa of the African monarch butterfly (Table 2). The difference between the sitting position of a butterfly and a moth was also noted very clearly. Butterflies keep their wing vertically above the body. Whereas moths display their wings (Figure 3) (Table 2).

The third nature walk session (Study of the pond ecosystem) included 71 participants. After the nature walk session, the average score in the quiz improved from 5.4 to 8.7 (out of 10) (Figure 1). For Session 3, a one-way repeated measures ANOVA revealed a significant effect of the nature walk intervention on student performance. Post–nature walk quiz scores (mean = 8.79) were significantly higher than pre–nature walk scores (mean = 5.45) ($F(1,70) = 146.55$, $p < 0.001$) (Table 1). In this session, the students examined the depth of the garden pond, and its turbidity through the Secchi disc method and collected samples of water from the pond (Total depth of the pond- 0.86meters). Students could identify the amphibian larval stages (tadpoles), Fish species (*Gambusia*), Gastropods (Pond snails), and Odonates (Dragonflies, damselflies). On microscopic analysis, huge diversity was observed of protozoans such as *Euglenoids*, *Amoeba, Paramecium,* and other ciliates, Rotifers (*Floscularia* and *Lecane*), Gastrotrichs, Nematodes, Annelids like *Chaetogaster*. The plant species included *Nymphaea* and *Hydrilla* (Figure 2). An aquatic food chain was established in the pond naturally which was figured out by students. *Euglena,* blue-green algae, and plants like *Nymphaea* and *Hydrilla* acted as primary producers. Ciliates, rotifers etc. were primary consumers. Larvae of mosquitoes and Odonates functioned as secondary consumers. Fish like *Gambusia* served as tertiary consumers (Table 2). The session also provided an opportunity to explore the diverse avian population. Species evenness and richness of different species of birds were noted. Additionally, several natural behavioural activities exhibited by various species were also observed. Across three independently conducted sessions involving different student cohorts, the nature walk intervention was consistently associated with measurable learning gains. The magnitude of improvement varied between sessions, with percentage gains of 12.45% in Session 1, 19.58% in Session 2, and 33.4% in Session 3. In all sessions, post-intervention scores showed reduced variability relative to pre-intervention scores, with the most pronounced reduction observed in Session 3. Together, these results indicate that the nature walk–based approach was effective across cohorts and suggest that iterative refinement of the activity may have enhanced both the extent and consistency of student learning (Table 1).

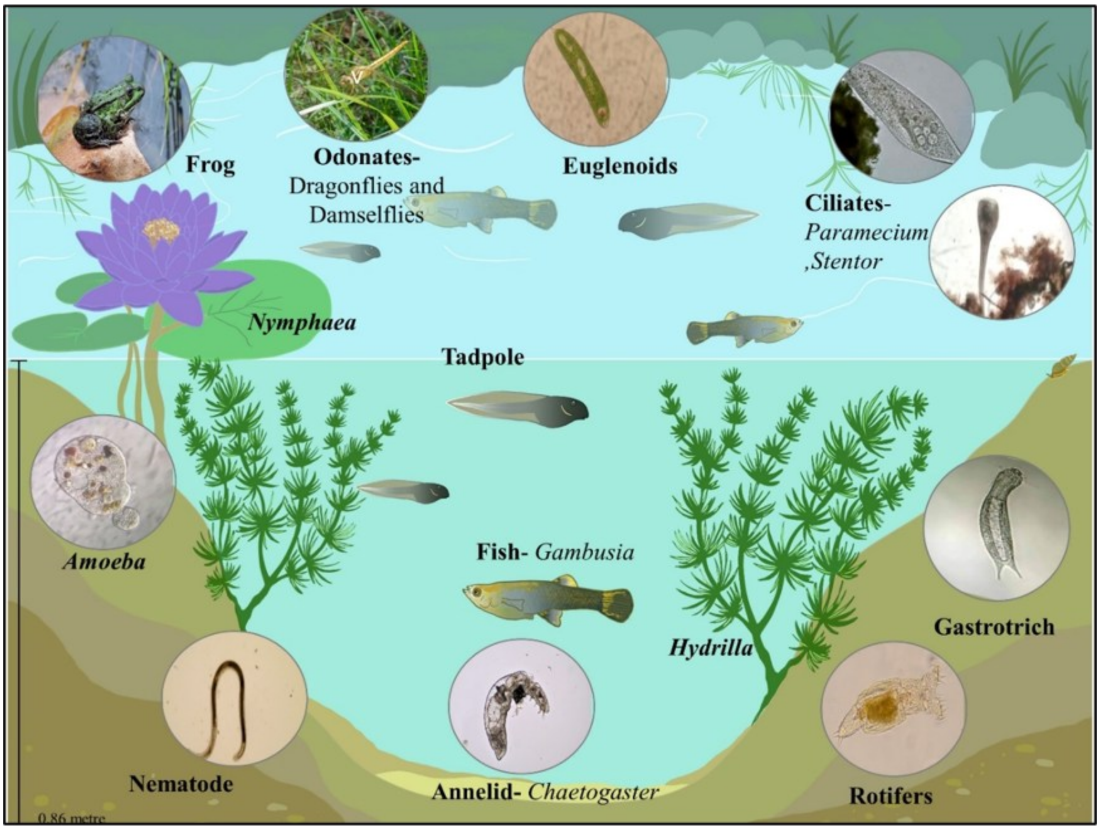


Figure 2. Pond ecosystem – The garden pond on campus includes plant species like *Nymphaea, Hydrilla,* etc., frogs, toads, odonates are often found near the pond, and inside the pond- tadpoles, Fish-*Gambusia* are present. Microscopic species found were Ciliates, *Amoeba*, Gastrotrichs, Rotifers, and Euglenoids

DISCUSSION

1. Study of Pond Ecosystem

In an urban landscape, the aquatic diversity remains largely undisturbed even though many anthropogenic stressors might be present like heavy metals, invasive species, and mismanagement with the removal of riparian vegetation. Compared to rivers and lakes, ponds have traditionally been known to support insignificant biodiversity since they are small lentic water bodies (Figure 2). Individual garden ponds in urban areas may have relatively fewer species but they show enormous diversity in terms of abiotic and biotic conditions. A garden pond is of small size and set within an impervious matrix. It is stocked with fish and does not dry out as it is manually filled from time to time (Hassall, 2014). Urban wetlands help in maintaining a great micro and macroinvertebrate diversity. These invertebrates help in our understanding of the various forces that influence the loss of diversity in urban areas (Jones & Leather, 2012; Vehkaoja et al., 2020). Knowledge gaps exist with respect to the understanding of pond ecology but active research collaborations in understanding pond ecosystems can help build better urban pond capes and increase urban species richness and diversity (Hill et al., 2021). When encountering urban/garden ponds during nature walks, the macro and micro invertebrate diversity associated with them can be studied (Figure 4). This will help in understanding these urban wetlands better.

2. Understanding the entomological diversity

The patterns of diversity of an urban landscape can be explored with the study of insects, as they are abundant and display a variety of life histories (Diamond et al., 2023). Additionally, the short life cycle, huge diversity, and easy collection and identification make the insect diversity easy to monitor though there is a lack of standardized methods (Montgomery et al., 2021).

Students of life science learn to differentiate between different orders of insects in their curricula but correct identification and differentiation requires practice and hands-on training. The use of the Insect taxonomy key becomes important here, but unlike the classroom study of the taxonomic key, being in nature, exploring and finding insects, and identifying them helps them learn better entomological skills. The observations in nature also include different life stages of these insects, through this, they can understand and differentiate insects based on the presence and absence of wings, the types of wings they possess, their hemi or holometabolous life cycles, and how at times in certain insects the usual two pairs of wings may modify to become balancing structures such as halteres (order- Diptera). The lepidopteran insects (butterflies and moths) attract the most attention from an observer due to their scaly and brightly coloured wings, siphoning proboscis for feeding, and a life cycle that undergoes a huge transformation from egg, larva, pupa to adult, every stage significantly different from the other (Table 2). An observer can note the difference between a moth and a butterfly through their resting position and type of antenna. The moths are also usually less brightly coloured and nocturnal (Figure 3). These observations naturally catch attention when lepidopterans are encountered during these walks.

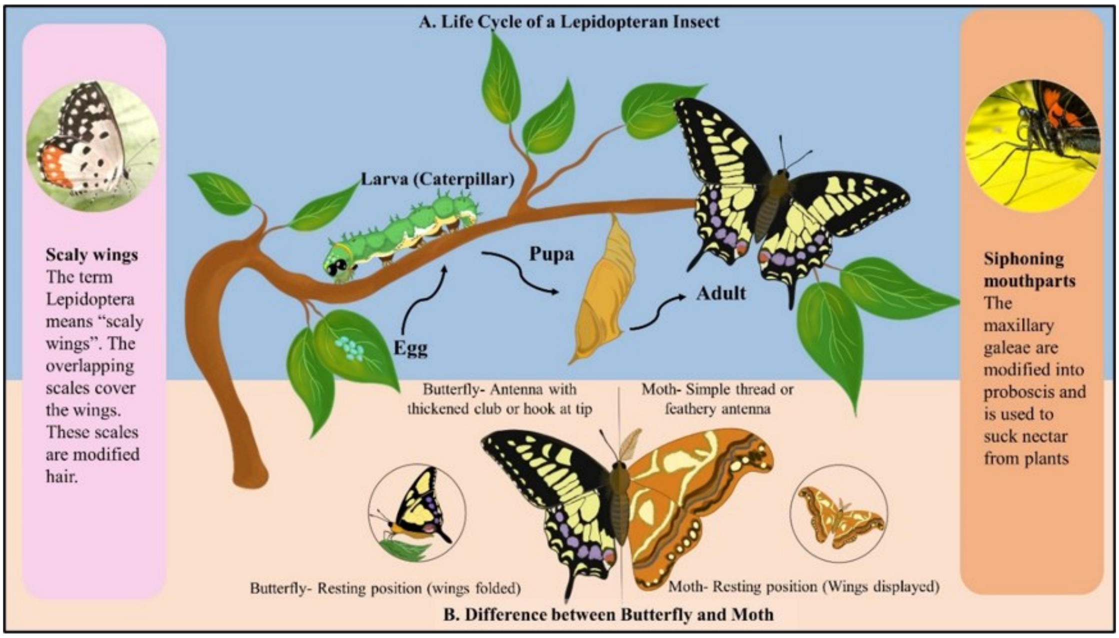


Figure 3 A. Life cycle of Lepidopteran Insect B. Difference between moth and butterfly. Left Panel- Lepidoptera- *lepid*- 'scale' + *pteron* 'wing'- Scaly winged insects, Right panel- Siphoning mouthparts

Figure 4 Diversity of Arthropods captured during nature walk sessions (Lepidopterans- Moths and butterflies and other arthropods (wasps, honey bees, flies, grasshoppers, bugs, millipedes, spiders, etc.)

3. Differentiating the different arthropods

Urbanization causes arthropod pest diversity to increase as there is a lack of predators for these pest species. At the same time, urban habitats are comparatively warmer and support the growth of these pests, due to this there is the likelihood that these arthropods will proliferate in number and cause pest outbreaks (Dale et al., 2016; Lagucki et al., 2017). Local habitats, seasonality, and degree of urbanization, all influence the arthropod diversity in urban areas (Adams et al., 2020).

Arthropods are the most abundant group of animals and they play a key role in the ecosystem. They act as pollinators, help in recycling nutrients and soil formation, etc. (Schapheer et al., 2021). For a layman, all arthropods are termed bugs. The diversity of arthropods found in cities includes mostly insects but also arachnids, crustaceans (such as Isopods), centipedes, millipedes, etc. Woodlice is a common isopod crustacean found in damp and humid urban environments which they invaded from aquatic environments. Many insects, millipedes have a similar appearance to woodlice (Figure 5). The Nature Walk session helped the students differentiate the insects from other arthropods (such as arachnids and crustaceans). The basic morphological differences between arthropods can be noticed during nature walks, like the number of legs. Woodlice are crustaceans, thus they possess multiple legs, but other similar-looking insects can be differentiated as they have 3 pairs of legs, while arachnids have 4 pairs of legs.

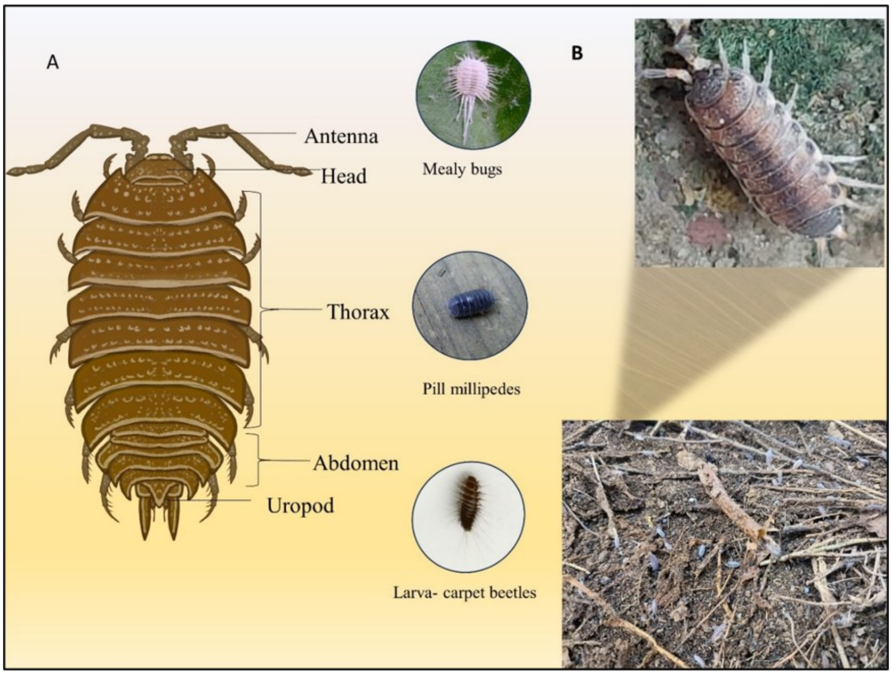


Figure 5. Wood Louse – Isopod crustacean can resemble insects such as mealy bugs, larval forms of certain beetles and pill millipedes

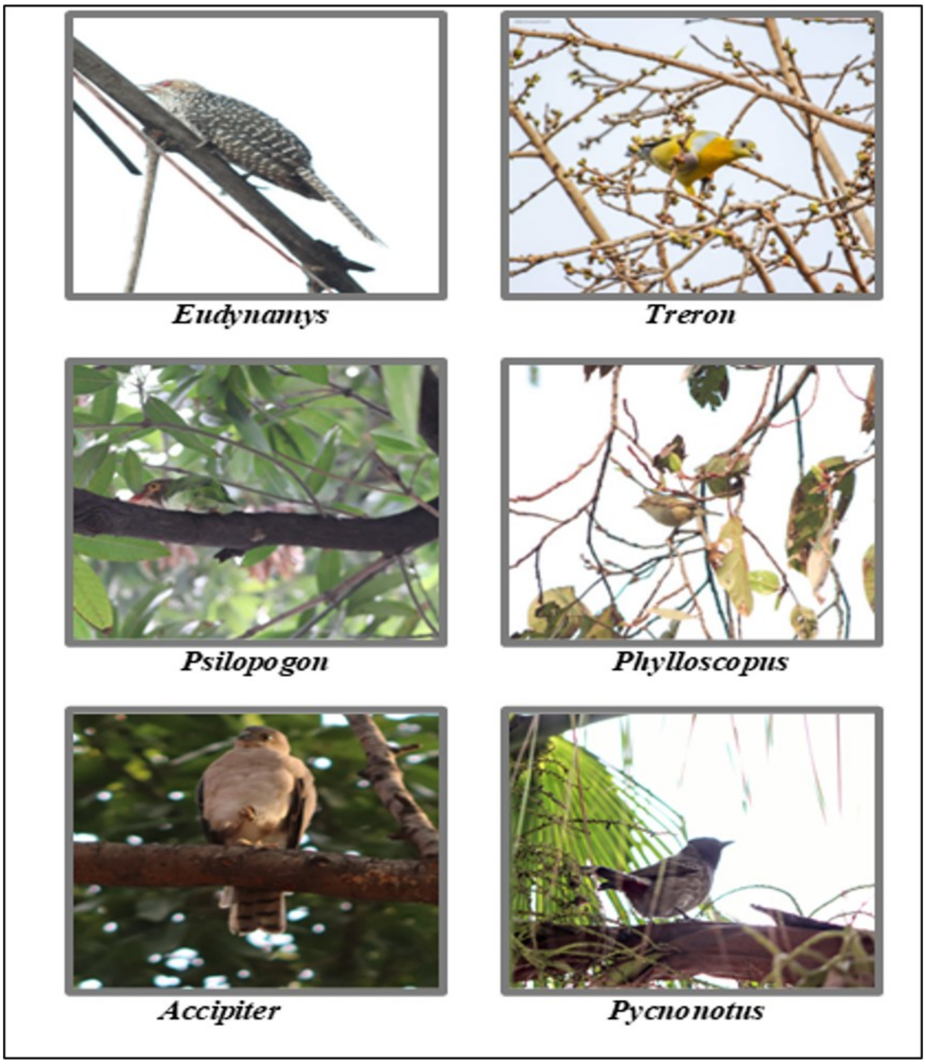


Figure 6. Various species of birds including *Eudynamys* (Koel), *Treron* (Yellow footed green pigeon), Psilopogon (Brown-headed barbet), Phylloscopus (Hume's warbler), Accipiter (Shikra) and Pycnonotus (Red-vented bulbul) found during nature walk**.**

4. Avian Diversity

In urban areas, the overall species richness of birds has declined. On the other hand, a few species, including scavengers and insectivores, thrive well in these areas (Chamberlain et al., 2018). Although urbanisation has led to a significant decline in bird diversity, small green spaces like gardens and parks have shown high species richness and abundance (Prihandi & Nurvianto, 2022).

During the nature walk session, various bird species were observed. Common species with high species evenness, such as Rock pigeons, Jungle Babblers, Rose-ringed Parrots, and Common Myna, were easily spotted. Whereas, species with lower evenness including the Yellow-footed green pigeon, Koel, Shikra etc., were discovered with more careful observation (Figure 6). The abundance of food sources, less competition, and access to water through ponds and other sources provide a conducive environment for these birds to thrive. These bird species exhibit different behaviours like producing distinct calls to attract mates, building nests, issuing alarm calls and parental care. Nature walk activity helps student to understand all these unique phenomena of nature and allows them to interact with diversity in their surroundings.

5. Collaborative Activity

Collaborative learning is an ingenious way of solving a problem by working together in a group. Nature walks are collaborative learning experiences that involve sharing observations and discussions. Collaborative learning helps in the development of social communicative skills, develops a cooperative learning environment, reduces anxiety, and improves engagement and critical thinking. By working in a group students arrive at a common consensus through cooperation. There is a need to shift the focus toward cooperative learning as compared to competition and collaborative activities such as learning through nature walks can significantly improve that (Han & Ellis, 2021; Laal & Ghodsi, 2012).

6. Mental health benefits

The therapeutic benefits of being in natural spaces are well-known (Grassini, 2022). Many researchers have found that spending time in nature is important for the mental and physical well-being of individuals. During the COVID-19 pandemic, which led to national lockdowns all over the world, people had to deal with social isolation, loss of loved ones, unemployment, etc. and this severely impacted their mental wellbeing. To overcome from this the individuals who regularly spent more days outdoors in greener spaces showed a decrease in symptoms of anxiety and depression (Stock et al., 2022; White et al., 2019). Nature walks help increase the memory span of not only healthy adult individuals but also individuals with major depressive disorder (Berman et al., 2012). In the 1980s, the Ministry of Agriculture, Forestry, and Fisheries of Japan came up with an ecotherapy concept called '*Shinrin-yoku*' also known as 'Forest Bathing'. The concept simply focuses on walking in a natural environment and consciously connecting with it through all five senses (vision, smell, hearing, touch, and taste). This practice has been shown to improve immunity by increasing the activity of Natural Killer cells and granulysin, perforin, and granzyme A/B expressing cells (Li, 2010). Volatile allelochemical compounds from plants called phytoncides play a role in enhancing the immune activity of NK cells (Li et al., 2008). Nature walks thus are beneficial in not only the mental but also the physical well-being of individuals. Depression and anxiety in college students are increasing due to several reasons like excessive use of gadgets, insomnia, poor nutritional habits, etc. (Ramón-Arbués et al., 2020). This may have long-term detrimental effects on their mental health, impacting their future career goals.

CONCLUSION

The integration of nature walks with the curriculum will help them navigate through these issues easily. Further, Nature walks invoke curiosity and inquisitiveness in the students, and thus they are an effective participant-centric inquiry-based pedagogical tool that should become part of the biological science curriculum.

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