El-Hayah

JURNAL BIOLOGI

Journal Homepage: http://ejournal.uin-malang.ac.id/index.php/bio/index

e-ISSN: 2460-7207, p-ISSN: 2086-0064

Original research article

Ecological Study of Lotus Plants (Nelumbo nucifera) in the Swamp Area of the Bengkulu University Campus Environment

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Email: bkaryadi@unib.ac.id

DOI: 10.18860/elha.v10i2.32587

Article Info

Article history:

Received 26 December 2024

Received in revised form 26 February 2025

Accepted 09 March 2025

Key Word:

Biodiversity

Ecological

Lotus (N. nucifera)

Swamp Area

Abstract

This study explores the ecological role of the Lotus plant (Nelumbo nucifera) in the swamp area of the University of Bengkulu campus, focusing on biotic and abiotic components before and after planting. As well as the interactions occurring within the ecosystem. Data were collected through direct observation in several plots from June 2024 to January 2025. Analysis was conducted in three stages: data reduction, display in tables and images, and verification for conclusions. Results showed improvements in abiotic factors after planting N. nucifera, such as temperature, TDS, pH, and dissolved oxygen (DO). The most significant abiotic factors were water pH, from 6.19 to 7.50, and DO from 2.5 mg/L to 3.9 mg/L. The presence of ***N. nucifera*** *also led to increased animal biodiversity, with species rising from 51 to 73, including decomposers, predators, pollinators, and pests. Symbiotic interactions like commensalism, parasitism, and mutualism were observed. N. nucifera displayed strong competitive ability, with consistent leaf growth and superior light absorption (844 Lux compared to 270 Lux in other plants). Abiotic factors, including temperature and light intensity, influenced flower blooming, with low morning temperatures supporting full blooming, while high temperatures caused flowers to close. This study highlights the potential of N. nucifera to enhance animal biodiversity and defines the various interactions that occur within the ecosystem, while emphasizing the need for further research to deepen understanding of the ecosystem's components and interactions.*

INTRODUCTION

Lotus (*Nelumbo nucifera*) is a plant that plays an important role in aquatic ecosystems, particularly as a natural water purifier or biofilter agent, thus enhancing the biodiversity of aquatic habitats (Yang et al., 2024). In efforts to preserve biodiversity within aquatic ecosystems, *N. nucifera* has become one of the leading species in scientific fields for its functions as a biofilter, metal accumulator, and phytoremediation agent (Fillah et al., 2023). As an aquatic plant, *N. nucifera* offers significant ecological benefits by mitigating pollutants within water ecosystems (Baroroh & Irawanto, 2016). The plant's broad leaves and extensive root system provide shelter and nutrients for a variety of aquatic life forms. Populations of *N. nucifera* can form microhabitats that support the nutritional needs and living spaces for aquatic fauna and insects (Astuti & Indriatmoko, 2018).

N. nucifera is widely distributed in temperate to tropical regions across several Asian countries such as India, China, Japan, and Southeast Asia. It thrives in shallow wetlands up to 2.5 meters deep, including lakes, lagoons, swamps, and river basins (Pal & Dey, 2013). This species can survive and develop in environments with varying or low water depth and nutrient levels, demonstrating its adaptability to diverse aquatic conditions, such as swamp ecosystems (Gowthami et al., 2021).

The campus environment of the University of Bengkulu (UNIB) features numerous ponds formed from swamp areas, one of which is the Science Pond. The Science Pond is a freshwater swamp ecosystem that serves as a habitat for various species of animals and plants. These components form a system that plays a vital role in the ecosystem.

The pond's drainage system is connected to laboratory waste and domestic waste from nearby campus canteens. Domestic waste refers to waste generated from residential, food service, and commercial activities. According to Said (2019), domestic activities can produce waste that negatively impacts water resources, including water quality degradation, which can disrupt and damage water ecosystems. This aligns with research by Devani et al. (2023) on the influence of laboratory and domestic waste in the environment of Universitas Negeri Padang (UNP), where dark brown water and foul odors were found in the water flow, indicating compromised water quality and health risks.

Such pollution can significantly disrupt the biodiversity of the Science Pond ecosystem. Therefore, optimizing the use of the Science Pond as a learning resource requires minimizing chemical pollution through the planting of *N. nucifera*. The plant's phytoremediation capabilities are expected to reduce pollution in the pond (Thongtha et al., 2014). This study provides insight into the adaptive potential of *N. nucifera* in swamp ecosystems, its role in increasing animal biodiversity, defining abiotic and biotic components, and describing interactions occurring within the Science Pond. The research also aims to support the preservation of the pond ecosystem as a learning resource for students at UNIB.

The main results obtained were the most significant abiotic factor in the form of DO from 2.4 mg/L to 3.9 mg/L. Abiotic components increased from 51 to 73 animal species. The interactions obtained were symbiosis and competition, 3 types of symbiosis were obtained in the form of commensalism, parasitism and mutualism. While the competition obtained 2 types in the form of growth rate competition with the highest growth rate results with 567 leaves in the water plot and light intensity competition won by broad-leaved plants. The flowering process is influenced by light intensity and temperature with perfect flower flowering at 07.30-10.30 WIB.

1. MATERIALS AND METHODS

Time and Location

The research was conducted from August 2024 to January 2025 at the Science Pond of the University of Bengkulu. Species identification, interaction analysis, competition observation, and monitoring were carried out at the Integrated Science Hut (POSTER) of the University of Bengkulu. The Science Pond is located within the learning laboratory area of the Faculty of Teacher Training and Education (FKIP) at UNIB. It covers an area of 40 × 11 meters, with a swamp-like terrain featuring water depths ranging from 20 cm to 150 cm.

Tools and Materials

Field observation tools included a mini emergency lamp, a 30×30 cm wooden board, thermometer, lux meter, DO meter, TDS meter, pH meter, soil pH meter, soil meter, camera, 200× zoom macro lens, and a smartphone. Supporting tools included a hoe, area boundary ropes, and bamboo sticks for marking plots. Materials used in this study consisted of rodent glue traps and water samples.

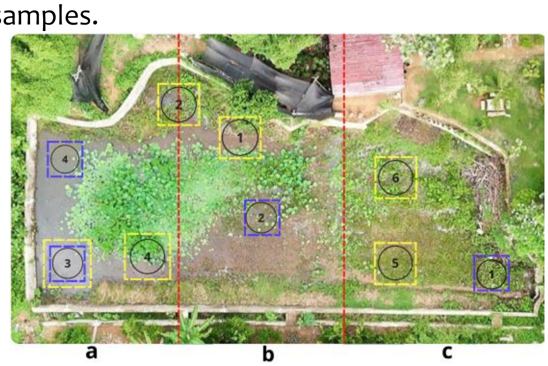

Figure 1. Research location (a) Water area, (b) Muddy area, (c) Land area.

Plot size 1x1 m

Plot size 3x3 m

The first stage of implementation involved dividing the Science Pond area into three distinct zones: (1) *Aquatic Area* – a region with the highest water volume **(Figure 1a)**. (2) *Muddy Area* – a zone with the deepest mud and the softest soil structure **(Figure 1b)**. (3) *Dry Land Area* – a region with minimal water and a hard soil structure **(Figure 1c)**. The three areas were divided into four plots with a size of 1x1 m to measure the abiotic and biotic environmental components. While six plots with a size of 3x3 m to determine the interaction of the abiotic and biotic environment. In each area, N. nucifera seedlings were planted, in August planting was carried out with a total of 80 seedlings. Observations of abiotic and biotic components, environmental interactions and the ability of N. nucifera growth competition interactions were gradually observed in June 2024 (before-planting) and January 2025 (after-planting).

Observations of the biotic and abiotic conditions in the pond area were conducted in two periods: before planting (*before-planting*) and after planting (*after-planting*) of *N. nucifera*. These observations included animal species inventory, identification of environmental interactions, symbiosis, competition, interactions affecting flower blooming, and physical conditions of the pond, such as temperature, light intensity, pH, TDS, and DO. All observations were conducted in each plot across the three areas (aquatic, muddy, and dry land). Data collection on abiotic factors and inventory of animal species were carried out by observation for 3 days before planting (June 2024) and after planting (January 2025), data collection on symbiosis was carried out during August-December 2024, and environmental interactions were carried out for 7 weeks from October 2024-January 2025.

Animal species were observed during both before- and after-planting periods using color traps, sediment collection, and documentation. Color traps were designed to attract insects that are drawn to flower colors. Sediment collection was conducted to capture animals living in the sediment and at the bottom of the water surface. **Color traps** were created using 30 × 30 cm colored paper, covered with transparent plastic and rodent glue. **Sediment sampling** was done using a scoop net with a diameter of 1 mm, length of 25 cm, and width of 40 cm. **Animal**

documentation was conducted using a Nikon camera and a smartphone camera.

Measurements of abiotic components, such as air temperature, humidity, soil pH, light intensity, TDS, DO, and water pH., were carried out both before and after planting. Measurements were carried out in the morning at 08:00 WIB, noon at 12:00 WIB and evening at 16:00 WIB. Data collection related to environmental interactions was divided into three main aspects: Animal symbiosis with *N. nucifera*, Plant competition involving *N. nucifera*, and Environmental factor interactions with the flower blooming process.

Data Analysis

The data were analyzed descriptively by illustrating the conditions of the research subjects or objects based on abiotic and biotic components obtained through exploratory surveys and direct field observations. The data analysis followed these steps: 1) Inventory and identification of animal and plant species. 2) Analysis of the pond's physical conditions, with data presented in the form of images, tables, short descriptions, and flowcharts. 3) Verification and validation of observational data using several sources and references (Rahman et al., 2018).

2. RESULTS and DISCUSSION

Abiotic Factors Before and After Planting

The results of the abiotic factor measurements "before-planting and after-planting" (Table 1) are in the form of the results of measurements of environmental components such as air temperature, air humidity, soil pH, light intensity, TDS, DO, and water pH. The biotic factors "before-planting and after-planting" (Table 2) are in the form of research results of animal species found totaling 20 orders and 55 families from 73 animal species.

Biotic Interactions

Two types of biotic interactions were observed: symbiosis and competition (Table 3). Three types of symbiosis were documented—commensalism, parasitism, and mutualism. In terms of competition, two forms were noted: competition in growth rate and competition for light intensity. Table 4 shows that *N. nucifera* had the highest leaf growth in one plot, with a final count of 567 leaves (Figure 2). In light competition (Table 5), the open area received the highest intensity, with a difference of 574 Lux compared to the shaded area. Abiotic interactions influencing flower blooming were primarily temperature and light intensity (Figure 3).

The findings are summarized as follows

Table 1. Measurement Average of abiotic factors before and after planting *Nelumbo nucifera*

Observation		Abiotic Factors						
		Air temperature (°C)	Air humidity (%)	pH soil	Light intensity (Lux)	TDS (ppm)	DO (mgL)	Water pH
Before	Morning	35.7	55.6	6.3	139	151	3.1	6.28
	Noon	37.7	55.6	6.4	432	139	2.4	6.16
	Afternoon	32.8	69	6	144	151	1.9	6.14
Average		35.4	60.1	6.2	238	147	2.5	6.19
After	Morning	38.5	60.6	6.4	825	121	4.1	7.47
	Noon	42.5	40	6.1	882	113	3.7	7.43
	Afternoon	34.5	74.3	6.6	797	112	3.9	7.61

Average	38.5	58.3	6.4	835	115	3.9	7.5

Table 2. Animal diversity found in the research area

No	Order	Species Before	Species After	General Role
1	Hymenoptera	4	3	Pollinator, Predator
2	Diptera	5	7	Pollinator, Predator, Decomposer, Pest
3	Araneae	6	7	Predator
4	Orthoptera	2	7	Predator, Pest
5	Coleoptera	6	7	Predator, Decomposer, Pest
6	Hemiptera	7	8	Predator, Pest
7	Blattodea	2	1	Decomposer
8	Lepidoptera	3	8	Pollinator, Pest
9	Odonata	5	6	Predator
10	Anura	1	3	Predator
11	Mantodea	1	4	Predator
12	Thysanoptera	1	1	Pest
13	Cyprinodontiformes	1	1	Decomposer
14	Mesogastropoda	3	4	Decomposer, Pest
15	Decapoda	1	1	Decomposer
16	Perciformes	1	1	Predator
17	Arhynchobdellida	1	1	Predator
18	Squamata	0	1	Predator
19	Anabantiformes	0	1	Predator
20	Megadrilacea	1	1	Decomposer

Total: 51 species before planting, 73 species after planting

Table 3. Animal interactions with *Nelumbo nucifera*

Species	Observed Interaction	Type of Symbiosis
Asian Toad (*Duttaphrynus melanostictus*)	Lays eggs, seeks shelter	Commensalism
Snakehead Fish (*Channa striata*)	Builds nest	
Garden Spider (*Argiope appensa*) & Jawed Spider (*Tetragnatha extensa*)	Nesting	
Dragonfly Nymph (*Orthetrum sabina*)	Uses leaves for metamorphosis	
Paddy Grasshopper (*Oxya intricata*)	Nests, feeds, eats leaves	
Golden Apple Snail (*Pomacea canaliculata*)	Lays eggs on leaf stalk, feeds on stalk and leaves	Parasitism
Fall Armyworm (*Spodoptera frugiperda*)	Consumes leaves during metamorphosis	
Hoverfly (*Helophilus trivittatus*)	Pollinator	Mutualism
Honeybee (*Apis mellifera*)	Pollinator	

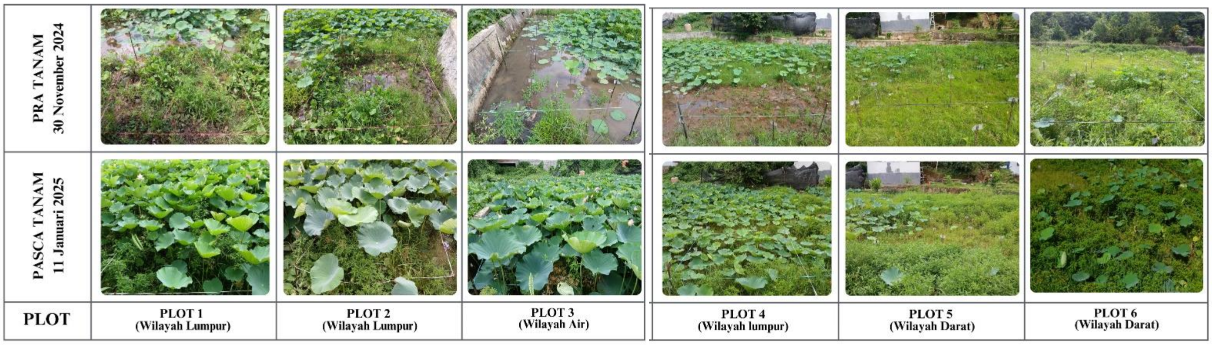

Figure 2. Competitive behavior of *Nelumbo nucifera*

Table 4. Weekly leaf growth rate.

Plot	**(leaf) week to**						
	1	2	3	4	5	6	7
1	3	5	17	27	47	72	112
2	1	5	7	17	39	53	76
3	10	27	48	109	164	231	567
4	3	15	25	57	61	82	105
5	3	3	5	5	5	7	9
6	13	15	18	25	31	38	45

Table 5. Differences in light intensity between *N. nucifera* and other plants.

Area	**Intensitas Cahaya (Lux)**			
	Morning	**Noon**	**Afternoon**	**Average**
Open	621	993	920	844
Shaded	95	361	354	270
Light Difference	526	632	566	574

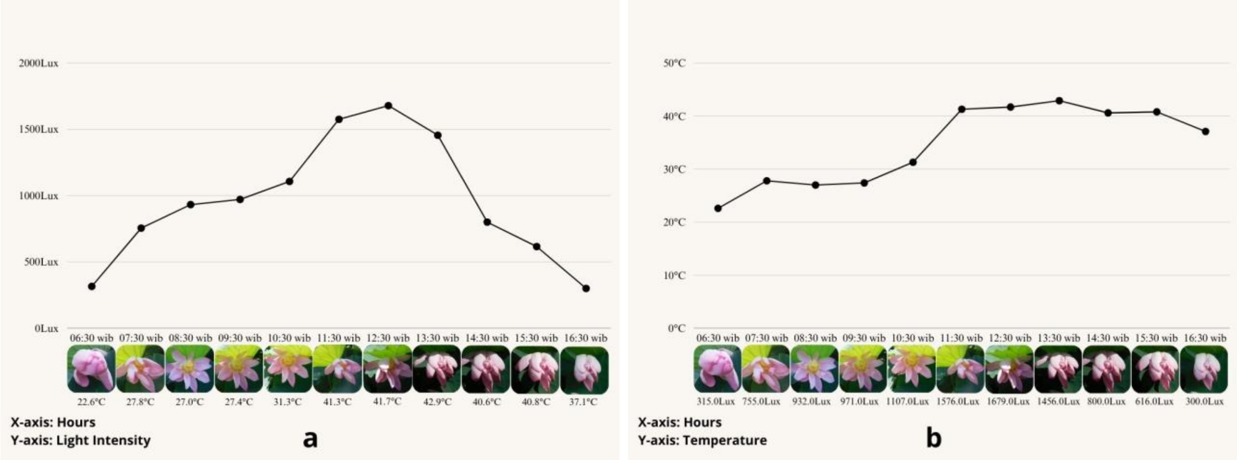

Figure 3. a. Light Intensity b. Temperature Graphs

3. DISCUSSION

This indicates that the dragonfly population at Based on an ecological study of Nelumbo nucifera at the Bengkulu University campus using an exploratory (survey) method, two main categories were identified: environmental components and environmental interactions.

Environmental Components.

Environmental components refer to the elements that form and influence an ecosystem. These components are categorized into biotic and abiotic elements. **Biotic components** include all living organisms (both macro and micro) that interact with each other. **Abiotic components** refer to non-living elements, such as physical and chemical factors and environmental processes (Mutakin, 2018).

Abiotic Components

Based on the results shown in Table 1, data on abiotic factors were collected both before and after planting. The study revealed significant differences in abiotic conditions in the research area. Prior to planting, average humidity was 60.1%, light intensity 238 Lux, air temperature 35.4°C, soil pH 6.2, TDS 0.147 ppm, and water pH 6.19. After *N. nucifera* was introduced, the values changed to humidity 58.3%, air temperature 38.5°C, soil pH 6.4, light intensity 835 Lux, TDS 0.115 ppm, and water pH 7.50. These shifts indicate a more optimal environment for supporting diverse flora and fauna.

According to Warsito (2023), abiotic environmental factors such as light intensity, dissolved oxygen (DO), water pH, and temperature are crucial for plant growth. The ideal DO range for aquatic species is between 4–5 mg/L (good) and 6-8 mg/L (optimal), while the ideal pH is between 6.5 and 8.0. Arerapapa et al. (2022) also stated that environmental conditions greatly affect the life of organisms. Water that is too acidic or alkaline can disrupt digestion and respiration, and low DO can lead to mass mortality.

This study recorded a significan timprovement in DO levels from. 2. 5 mg/L to 3.9 mg/L. The increase in DO to 3.9 mg/L indicates an improvement in water quality. This increase is likely due to photosynthesis activity and removal of contaminants by N. nucifera plants which can remove organic contaminants, increase microbial activity by providing sufficient oxygen (0.2-2.1 mL/min), which contributes to improving water quality (Abd Rasid, et al., 2019). Water pH also increased from 6.19 to 7.50, indicating a more favorable condition. Changes towards neutral indicate conditions are becoming balanced, light pH is more supportive of biodiversity because many aquatic organisms live optimally in the pH range of 6.5-8.5. This increase shows the ability of N. nucifera to restore the chemical quality of water, this increase is likely due to the ability to absorb heavy metals and other compounds. This is evidenced by the results of the biotic component study, namely the diversity of species found after planting was higher than before planting N. nucifera.

Biotic Components

The study of animal biodiversity in the Bengkulu University science pond revealed a total of 84 animal species, consisting of 20 orders and 55 families. This information is presented in Table 2. The insect orders found include Hymenoptera, Diptera, Coleoptera, Hemiptera, Lepidoptera, Blattodea, Odonata, Mantodea, Thysanoptera, and Orthoptera. While the non-insect orders include Araneae, Anura, Cyprinodontiformes, Anabantiformes, Decapoda, Mesogastropoda, Arhynchobdellida, Megadrilacea and Squamata. The Hymepoptera order consists of the Vespidae, Braconidae, and Formicidae families. The Diptera order consists of Dolichopodidae, Tephritidae, Syrphidae, Calliphoridae, Muscidae, and Culcidae. The Coleoptera order consists of the Tenebrionidae, Coccinellidae, Scarabaeidae, Elateridae, Hydrophilidae, Chrysomelidae, and Dytiscidae families. The Hemiptera order consists of the Reduviidae, Pentatomidae, Alydidae, Delphacidae, Cicadellidae and Flatidae families. The Lepidoptera order consists of the Pieridae, Nymphalidae, Hesperiidae, Noctuidae, Sphingidae, Lycaenidae and Papilionidae families. The Blattodea order consists of the Ectobiidae and Termitidae families. The Odonata order consists of the Coenagrionidae and Libellulidae families. The Mantodea order consists of the Gonypetidae, Hymenopodidae, Mantidae and Liturgusdae families. The Thysanoptera order consists of the Thripidae. The Orthoptera order consists of the Grylidae, Tettigoniidae and Acrididae families. The Araneae order consists of the Lycosidae, Tetragnathidae, Salticidae, Dictynidae, Araneidae, Oxyopidae and Thomisidae families. The Anura order consists of the Ranidae and Bufonidae families. The Cyprinodontiformes order consists of the Aplocheiilus family. The Anabantiformes order consists of the Channidae and Osphronemida families. The Decapoda order consists of the Palaemonidae family. The Arhynchobdellida order consists of the Hirudinidae family. The Megadrilacea order consists of the Acanthodrilida family. The Squamata order consists of the Veranidae family. The Orthoptera (grasshoppers) and Lepidoptera (butterflies and moths) orders are the most commonly found orders at the research location, this is due to several factors such as N. nucifera being the main food source and creating an ecosystem that supports survival.

According to the data, four general ecological roles were identified among the species in the study area: predator, pollinator, decomposer, and pest. Putriyani et al. (2024) stated that insects play vital roles as pollinators, predators, and decomposers, but they may also act as harmful pests. However, to determine the specific roles of each species in relation to *N. nucifera*, further in-depth research is needed. The biodiversity in this study area represents a well-preserved environmental community, as it consists of many species across different taxa. This supports the statement by Hanifa et al. (2022) that a community is considered to have high biodiversity if it is composed of a wide variety of species.

Prior to planting, a total of 51 animal species were found across 18 orders and 42 families. These included 19 families acting as predators, 11 as decomposers, 10 as pests, and 4 as pollinators. After planting, 73 species from 20 orders and 51 families were identified: 13 families as decomposers, 27 as predators, 13 as pests, and 4 as pollinators. The highest number of species belonged to the predator group, while pollinators were the least represented. This research shows an increase in animal diversity after planting *N. nucifera*, from 51 to 73 species. This suggests that the presence of *N. nucifera* contributes positively to species richness and overall biodiversity in the area.

The existence, abundance and diversity of animals are influenced by the conditions of physical and chemical parameters and environmental conditions (Hasbi, et al., 2025). In line with Normasari (2012) stated that factors such as food availability, habitat, season, and environmental quality affect species diversity. After planting *N. nucifera*, the area provided better access to food, habitat, and environmental quality. Animal presence is also influenced by light responses, which affect their activity during different times of day—morning, noon, afternoon, or night. These behaviors include visiting flowers, laying eggs, or feeding on plant parts, as observed in bees, snails, and caterpillars (Anggraini et al., 2016).

Environmental Interactions

Environmental interactions refer to the reciprocal relationships between one organism and another. Environmental interactions are categorized into two types: biotic interactions and abiotic interactions. Both biotic and abiotic components interact with each other and can influence the lives of organisms within the ecosystem. Biotic and abiotic components are essential in maintaining ecological balance. These factors play a crucial role in determining the sustainability of life for organisms within the ecosystem (Ayorbaba et al., 2021).

Biotic Interactions

Biotic interactions between organisms are diverse and can include predation, competition, and cooperation (symbiosis). This study identified two types of biotic interactions: symbiosis and competition. Competition occurs among organisms that require the same resources. When two species coexist in an environment and interact without competition or predation, symbiotic interactions are formed.

Symbiosis

The increased biodiversity creates conditions where interactions take place. The types of interactions found in the study area were interspecific interactions, which occur between organisms of different species. Based on the analysis, the results of this study documented three types of symbiosis: commensalism, parasitism, and mutualism. Each type of symbiosis has distinct criteria. According to Elfidasari (2007), mutualism refers to a relationship between two species in which both benefits, while commensalism involves a relationship where one species benefits and the other is neither helped nor harmed. Lastly, parasitism refers to a relationship where one organism benefits at the expense of the other.

Based on the observations, five species were identified as engaging in commensalism, where one organism benefits without harming the other. In these interactions, one organism is not disturbed by the presence of the other. In terms of parasitism, two species were found to exhibit this interaction. The plant *N. nucifera* is harmed by the snails and caterpillars, which damage parts of the plant such as photosynthetic areas and consume the stems, ultimately leading to the plant's death. In mutualism, both species involved benefit, enhancing their ability to survive and thrive. For example, pollinator species and the *N. nucifera* flowers form a mutualistic relationship. Pollinators (such as butterflies and bees) collect nectar for food, benefiting from this interaction. In return, the flowers benefit because the pollinators help with fertilization. As the pollinators move from one flower to another, pollen sticks to them and is transferred to the stigma of other flowers, resulting in pollination (Normasari, 2014).

Competition Growth Rate

There are 7 plant species in the study area, including lotus (*Nelumbo nucifera*), water hyacinth (*Eichhornia crassipes*), water primrose (*Ludwigia hyssopifolia*), water convolvulus (*Limnocharis flava*), bulrush (*Rhynchospora corymbosa*), creeping vinca (*Mikania cordata*), and rice grass (*Leersia hexandra*). The species are categorized into three groups: broad-leaved, narrow-leaved, and sedge plants. The broad-leaved plants dominate and grow better than others, as shown in Figure 2, which illustrates the competition between *N. nucifera* and other plants for space, water, nutrients, and light. According to Wirda & Abdul Azis (2014), the most contested resources in competition are water and light. Competition affects plant growth.

However, in this case, the presence of other plants has not inhibited the growth of *N. nucifera* because of its fast growth rate and ability to absorb light intensity, allowing it to outcompete other plants. This is in line with Purba et al. (2023), who state that competition shifts when one organism is displaced by another with superior biological traits, such as higher reproductive capacity, larger and stronger bodies, and other better biological characteristics. Currently, the science pond is 80% dominated by *N. nucifera*, as shown in Figure 4.

Figure 4. Research site after-planting of Lotus (*Nelumbo nucifera*)

The study results on competition showed that the growth rate of *N. nucifera* was faster than other plants because the lotus has the ability to absorb nutrients and water through its roots. The morphology of the lotus roots is dense and long, allowing it to expand nutrient absorption in an area (Fillah-A, et al., 2023). This occurs in three areas: aquatic, muddy, and terrestrial areas. Based on Figure 2, the growth rate during the first week (November 30, 2024) shows the initial leaf growth of *N. nucifera*, while in the seventh week (January 11, 2025), *N. nucifera* had already dominated almost every plot, with the highest number of leaves, as shown in Table 4. This table presents the changes that occurred in each plot area. However, some plots did not show any significant growth rate changes. The slowest growth rate was in plots 5 and 6, the terrestrial areas, with only 3 new leaves in the first week and 9 new leaves in the seventh week. Meanwhile, the plot with the most significant growth rate was plot 3 in the aquatic area, which saw a rise from 10 leaves in the first week to 567 leaves in the seventh week. This is because plots 5 and 6 are terrestrial areas that do not have enough water to meet the needs of *N. nucifera*, while plot 3 in the aquatic area has sufficient water supply. In addition to the rapid leaf growth, the competitive ability of lotus plants is also evident in their competition for light intensity with other plants.

Competition for Light Intensity

N. nucifera has very large leaves that allow it to absorb high light intensity and block other plants from receiving light. Based on observations in Table 5, the study compared two areas: open areas (unshaded by *N. nucifera*) and shaded areas (covered by *N. nucifera*). In the morning, the average light intensity in the open area was 621 Lux, while in the shaded area, it was 95 Lux. During midday, the open area had an average light intensity of 993 Lux, while the shaded area had 361 Lux. In the afternoon, the open area recorded 920 Lux, while the shaded area received 354 Lux. The difference in light intensity blocked by *N. nucifera* between the open and shaded areas was 526 Lux in the morning, 632 Lux at noon, and 566 Lux in the afternoon, with an average daily difference of 574 Lux, which represents the amount of light intensity blocked by *N. nucifera* from other plants. The research on *N. nucifera* shows that the light intensity in shaded areas is significantly reduced because the plant with broad leaves absorbs most of the light. According to Yustiningsih (2019), leaf anatomy and morphology are key adaptive mechanisms for plants to optimally absorb light.

According to Imakulata (2023), a stable ecosystem is marked by high biodiversity. The data obtained from the study indicate an increase in various animal species whose presence plays an important role in maintaining the stability of the ecosystem through their ecological interactions. The improvement of abiotic factors suggests that the science pond ecosystem at Bengkulu University is favorable for the survival of both flora and fauna. Observations regarding the diversity of animals and the interactions that occur may also be supported by the attractive reproductive organs of *N. nucifera*, in the form of the lotus flower. This is evidenced by an increase in pollinator insect species after the presence of the *N. nucifera* flowers. Therefore, it is crucial to study and understand the flowering of *N. nucifera*.

Abiotic Interactions

Abiotic interactions refer to the relationships between organisms and the non-living components of their environment. Abiotic interactions include physical factors such as temperature, water, soil, and light intensity. In this study, two abiotic factors temperature and light intensity were found to have an observable effect.

Temperature And Light Intensity Factors

The blooming phase of *N. nucifera* lasts for four days, from the beginning of blooming until it wilts, with the peak blooming occurring on the third day. Figure 3 presents a graph and photos of the lotus flower in various stages: bud, initial bloom, full bloom, and closing, recorded from 06:30 WIB to 16:30 WIB. The Figure 3 (a) shows the fluctuations in light intensity during the blooming of the lotus flower (*Nelumbo nucifera*). It was found that light intensity of 315 Lux to 1107 Lux was required for the flower to fully bloom in the morning. Meanwhile, during the afternoon and evening, with light intensities between 1576 Lux and 300 Lux, the flower begins to close.

In Figure 3 (b), the temperature is shown to affect the blooming process of *N. nucifera*. At lower temperatures ranging from 22.6°C to 31.3°C, the lotus flower blooms, while at higher temperatures (37.1°C to 42.9°C), the flower begins to close. This is because higher air humidity at high temperatures can inhibit the blooming of the flower and prevent excessive evaporation. Based on the findings, it is suggested that both light intensity and temperature affect the blooming process of the flower, from blooming to wilting. This aligns with the statement by Annisa et al. (2017), who stated that abundant sunlight can trigger blooming, while high temperatures can inhibit blooming.

4. Conclusion

This study shows that *N. nucifera* plays an important role in improving environmental quality, particularly in improving water quality by increasing oxygen levels. Observations of abiotic factors before and after planting reveal that the environment has become more supportive of various flora and fauna species. Species diversity increased from 51 to 73 species, with a total of 84 species found, where animals acting as predators dominated, and pollinator species were found to be the least abundant. Additionally, the study found three types of symbiosis: commensalism, parasitism, and mutualism. *N. nucifera* also demonstrates highly competitive ability, particularly in its growth rate, which reached 567 leaves within seven weeks. Furthermore, the lotus has broad leaves that absorb light intensity and block other plants from receiving light. The blooming process of *N. nucifera* is influenced by light intensity and temperature, with full bloom occurring on the third day.

This is in line with the conditions of the river current in Telaga Aqua, which flows so that it has good oxygen circulation for the growth of dragonfly larvae (nymphs), which will have an impact on the even distribution of dragonflies. The presence of dragonflies in Telaga Aqua can also be used as a bioindicator of water quality, which is supported by the diversity of riparian vegetation in Telaga Aqua. A healthy river ecosystem is an important component for dragonfly habitat so that the dragonfly life cycle is well maintained.

5. Suggestions

Based on the research conducted, the author offers the following suggestions:

1. It is recommended to conduct further research on the interaction between *N. nucifera* and other animals in the ecosystem.
2. It is suggested to explore the economic potential of *N. nucifera* as an aquatic vegetable or for medicinal use.
3. Further in-depth research is encouraged regarding the specific role of animal species in relation to *N. nucifera*.

6. ACKNOWLEDGEMENTS

The author would like to express gratitude to LPPM UNIB for funding the research through the research umbrella "Conservation Strategy of Potential Local Plants in the UNIB Campus Conservation Area as Learning Resources" with number: 2935/UN30.15/PT/2024. Thanks are also extended to all individuals who contributed to this research

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