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Aquatic Plant – Insect Interactions: A Study of Water Lily – Epollinator Systems

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Abstract: Aquatic plants contribute significantly to the structure, function, and service delivery of aquatic ecosystems and fulfill a variety of ecological tasks. Numerous aquatic plant species are used or may be used for a variety of tasks, including water purification, soil improvement, building materials, fuel, and feed. Finding methods to regulate such flora by harvesting and using it is desirable because some of these plants can also be an annoyance to water transportation, fisheries, or water supply systems. There are about 100 species of water lilies in the Nymphaeales order, and they all develop into aquatic plants. In addition to being commercial crops, the majority of them have long been revered as cultural icons, particularly in Buddhism and Hinduism. In evolutionary biology, the water lily order plays crucial roles as an early angiosperm branch. The Nymphaeaceae are rhizomatous, aquatic, annual or perennial herbs. The family is further distinguished by the presence of latex, which typically has prominent, stellate-branched sclereids protruding into the air canals, and the dispersed vascular bundles in the stems. Simple hairs typically produce mucilage. This study proposes the water lily – epollinator systems.

Keywords: Aquatic Plants; Water Lily; Nymphaeaceae.

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I. Introduction

The genus Nymphae, which include both hardy and delicate aquatic plants, is a member of the family Nymphaeaceae. This genus is found all over the world. Many cultivars have been developed, and many species are cultivated for their aesthetic features. Some taxa are imported species in non-native regions, while others are weeds. Water lilies are the popular name for plants in this genus in the United Kingdom. The genus name, which comes from the Greek nymphaia and the Latin nymphaea, which mean "water lily," was inspired by the nymphs of Greek and Latin mythology. It provides useful shade, which prevents algae from spreading in lakes and ponds, in addition to being aesthetically pleasing. Cultivars and hybrids make up a large portion of the typical water lilies used in water gardening. Breeders have attempted to create interspecific hybridizations in cultivars to achieve desired features of interest. Interspecific hybridizations have been attempted in the past to produce a blue-hardy water lily hybrid, but the majority of these attempts have failed. After more than a century of hybridization, the current generation of hybridizers continues to work toward producing a resilient blue-flowered water lily. Breeding barriers are related to hybridization efficiency and can occur at various points during the pollination, fertilization, and embryogenesis processes. One prevalent problem in cross-breeding that has a negative impact on the effectiveness of plant breeding and the yield of seeds or fruit is a pre-fertilization barrier. The primary components of this barrier are the stoppage of pollen tube growth and ovule penetration, as well as the failure of pollen grains to germinate on the stigma. Although the behavior of the pollen tube growth in the style was not observed, pre-fertilization barriers were also found in the interspecific hybridization of tropical water lilies, which was caused by pollen tube behavior on stigma. The flowers of the majority of species close in the evening, with the exception of night-blooming lilies like Nymphaea jamesoniana, which do the opposite. Since the stigma is no longer sensitive and the stamen or male organs are developed and distributing pollen onto visiting insects, there are no longer any dangerous water hazards after the first day. After the stigma is fertilized and the pollen is released, the flower is dragged underwater on a spring-like stalk. The seeds are closer to the substrate, more shielded from predators, and kept moist until they are distributed since they grow underwater shown in Figure 1.

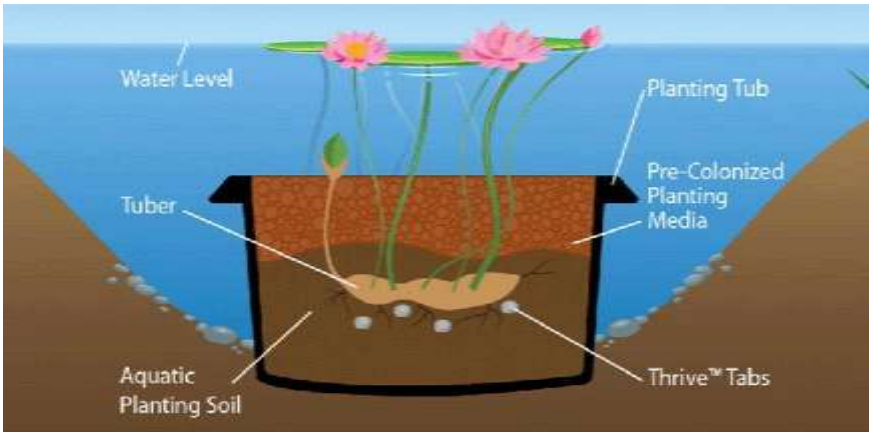


Figure 1: Planting of Water Lily

II. Literature Review

The stigmatic (female) phase of water lily flowers occurs before the pollen-releasing (male) phase, making them protogynous. This strategy reduces self-pollination and increases cross-pollination (Zhang et al., 2021). When the flower opens in the female phase, generally in the morning, the stigma is visible, but the pollen-producing stamens stay closed. The bloom exudes a strong fragrance, produces heat (thermogenesis), and secretes nectar or other sweet liquids to attract pollinators, usually beetles or flies. Insects carry pollen from other flowers inside the bloom and deposit it onto the sticky stigmas. The bloom closes in the evening, trapping insects within for the night (Tom, 2015). During the male phase, the bloom reopens. The stamens exude pollen, which covers both visiting and incarcerated insects. Insects carry pollen to another bloom when the flower is in its receptive female phase. After pollination, the bloom yields seeds, submerges, and shuts down forever (Fahida, 2012). This two-step process raises the possibility of cross-pollination while preventing self-fertilization. One special organ of plants is pollen. It frequently develops a particular morphology following prolonged evolution, notably in relation to characteristics like size, shape, aperture type, and exine ornamentation.

Because pollen's morphological traits are very stable and simple to see, pollen can offer proof of the systematic classification, origin, and evolution of species—a crucial foundation for investigating the evolution of different species and variants. A significant portion of the phylogenetic analysis of angiosperms and seed plants is the pollen of primitive angiosperms, and many scholars think that the pollen properties of water lilies have a significant impact on the evolutionary history of other plants. However, the reproductive biology, physiology, biochemistry, and functional activity of plants in the genus Nymphaea have been the primary subjects of recent research (Gibson & Gagliano, 2017). The Nymphaea family, which includes the perennial decorative water flower Nymphaea L., is found in temperate, tropical, and subtropical climates. Tropical water lilies and cold-resistant water lilies are the two categories into which the roughly 46 species found globally fall (Xiong et al., 2023). One of the most valuable species of tropical water lily is N. hybrid, which has lovely colors, lovely postures, and nice blossom scents. In the 1970s, after the introduction of the American fragrant water lily as a breeding material, Chinese horticultural workers carried out crossbreeding for many years and cultivated a number of red, yellow, pink, purple, and other varieties, which were identified as N. hybrid by the Nanjing Institute of Comprehensive Utilization of Wild Plants. Currently, Guangzhou, Fujian, Hainan, Zhejiang, Sichuan, Jiangsu, and certain northern regions of China are the primary locations for the cultivation of N. hybrid. In addition to being a great plant for beautifying and purifying water, N. hybrids may be used as premium aquatic cut flowers that many people like for their pleasant scents. Thus, a wealth of aromatic aquatic plants can be found in N. hybrid germplasms. Furthermore, because of the abundance of nutrients and bioactive compounds in its blossoms, a great deal of research has been done on its wide range of potential uses in food, medicine, cosmetics, and other fields.

III. Aquatic Ecosystems and Life

Of all the natural resources, water is without a doubt the most valuable and necessary. It is nature's priceless gift to humanity and the millions of other living things on the planet; it is the elixir of life. One of the most significant and prevalent elements in the ecosystem, water is essential to life as we know it. Water is the birthplace of life and the source of its nourishment. Water is an essential component of all plant and animal tissues, and without it, life cannot exist, not even for brief periods of time. In the past, civilizations grew built around bodies of water that were used not just for human sustenance but also for transportation and agriculture. It took longer for the significance of water quality to be recognized. Even though water is the greatest medium on Earth, its potability and purity for life support have been seriously threatened since the industrial revolution began and additional biological contamination sources were introduced. Despite making up only 0.3 percent of the planet's water and 0.8% of its land area, freshwater environments are hotspots for biodiversity, home to 2.4% of all known species. Concern over the preservation and restoration of healthy river ecosystems is growing globally as a result of the considerable ecological degradation and biodiversity loss in riverine systems brought on by river exploitation. Aquatic Plants Roots shown in Figure 2.



Figure 2: Aquatic Plants Roots

IV. Water Lily Pollinator Systems Affected by Insects

Typically floating or elevated above the water's surface, water lily flowers are solitary, bisexual, radial, and have girdling vascular bundles in their receptacle. They also have a lengthy pedicel. Some species are protogynous and mainly cross-pollinated, but self-fertilization is feasible because the male and female phases overlap on the second day of flowering and because it is self-compatible. Although this is only one of these plants' many reproductive techniques, the female and male sections of the flower are often active at separate times to aid in cross-pollination (Uribe, 2021). Types of Water Lily shown in Figure 3.

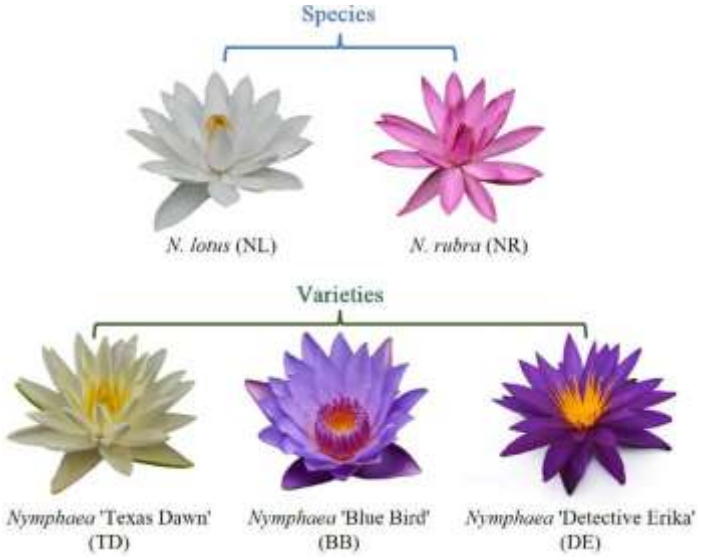


Figure 3: Types of Water Lily

Insects are used in the unique pollination process of water lilies to move pollen from one blossom to another: The stigmatic surface of the flower is receptive and cup-shaped on the first day of opening. The stigmatic cup contains a delicious, sticky substance that attracts insects, who then fall and discharge their pollen (Murail et al., 2024). The pollen dissolves and fertilizes the flower. Pollination by insects versus wind: While insects pollinate water lilies, wind pollinates plants like water hyacinths. Insects Plants pollinated by insects typically have larger, sticky, and spiky pollen grains in addition to bright, fragrant blooms. Wind: Wind-pollinated plants usually have light-colored flowers that don't smell good, and their pollen grains are lighter and smaller.

The beetle is one type of bug that pollinates water lilies. Fossil evidence indicate that flies and beetles were among the first insects to pollinate flowering plants around 150 million years ago. Beetles are the most diverse collection of organisms on the planet. In fact, around one in four of all known species of bacteria, fungus, plants, or animals are beetles. As one might expect from such a diverse group, beetles have a wide range of colors, forms, and ecological roles (Zhou et al., 2022). In the late Jurassic period, about 150 million years ago, beetles and flies were probably the first insects to pollinate blossoming plants, based on fossil evidence. Beetles continue to pollinate a wide variety of flowers, such as magnolias and water lilies. The study of aquatic plant-insect interactions, particularly in water lily (Nymphaeaceae) pollination systems, highlights the complex and unique linkages between plants and their pollinators in watery environments. Water lilies have evolved unique characteristics, including huge, spectacular flowers, thermogenesis, and synchronized flowering activities, to attract specific pollinators, including beetles, flies, and bees. These changes maximize pollination success while overcoming the challenges of their aquatic environment.

V. Conclusion

Water lily pollination systems provide a unique and interesting model for studying aquatic plant-insect interactions. The mutualistic relationship that water lilies have with their primary pollinators, particularly beetles, highlights their sophisticated adaptations, which include floral thermogenesis, vibrant colors, fragrance creation, and protogynous flowering. Due of the significant differences in pollination dynamics between aquatic and terrestrial systems, these modifications ensure successful reproduction and efficient pollen transmission. Research on water lily pollinator systems highlights the ecological importance of these interactions in maintaining aquatic biodiversity, while also contributing to our understanding of plant-pollinator co-evolution and evolutionary biology. However, human-caused pressures like habitat loss, water contamination, and climate change pose a major threat to these delicate systems. Protecting the plants and their pollinators through conservation efforts and additional research is essential to the sustainability of aquatic ecosystems.

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