INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

A STUDY ON THE FUNCTION OF INSECT FLOWER VISITORS IN MANGROVE POLLINATION

Vadthya Jyothi, Research Scholar, Department of Zoology, Monad University, Hapur, U.P.

Dr. Kapil Kumar, Associate Professor , Supervisor, Department of Zoology, Monad University, Hapur, U.P.

Abstract: Mangrove ecosystems are under grave risk while being a valuable ecological and economic resource. Several national and international programmes that include nurturing the seedlings in a nursery before transplanting them in deserted or abandoned locations have been created to restore mangroves. There are different levels of nursery-bred seedling survival in the field, however. Numerous research from throughout the world suggest that injecting seedlings with plant growth-promoting bacteria (PGPB) that has been isolated from the rhizosphere of mangrove plants may speed up their field development. Utilising such PGPB is a common approach in agriculture. PGPB, a species that is endemic to the mangroves of Navi Mumbai, a rapidly expanding coastal city that has seen considerable mangrove degradation, has, nevertheless, received very little academic attention. In order to examine its capacity to promote the development of Avicennia marina seedlings, the most prevalent mangrove species in the region, the work's objective was to isolate and analyse PGPB from Navi Mumbai mangroves.

1 Introduction

Mangroves are one of the most ecologically and economically significant ecosystems. They are the only woody halophytes found where land and sea converge (Alongi, 2002). Mangrove plants can survive salt, hence they may flourish in regions near the beach when the water is brackish and salty. Plants can adapt to the difficult environmental conditions in the coastal zone thanks to their robust root adaptations and salt filtration system. According to D.M. Alongi (2002), mangrove plants are shrubs or trees that grow well in locations with less wave energy and fine particle deposition. This enables these woody plants to have strong roots and spread out farther. The vast array of microhabitats in this ecosystem make it both sensitive and very productive (Mitra et al., 2015). Fig. 1 and Fig. 2. Mangrove trees have the power to protect the coastline and saturate the sea with nutrients. For a variety of organisms, the mangrove forest offers essential eating, nesting, and breeding grounds (Therattil and Olakkengil, 2011).This forest has a less complex architectural structure and fewer species than tropical rain forests (Alongi, 2002). Mangrove plants in the mangrove ecosystem are divided into three classes based on their morphological adaptation traits: Major elements (Strict or true mangrove); Minor elements; and Mangrove companions. Major and Minor mangroves are common in the mangrove environment. While mangrove-associated creatures may be found in both mangrove ecosystems and other habitats, such the landward zone often known as the back mangrove. True mangrove plants may be categorized based on their traits and physical adaptations.

True mangrove plants may have a woody structure, a salt excretory system, succulent leaves, viviparous germination, and several specialized root systems among their morpho-physiological traits. Only the mangrove environment has this specific kind of mangrove plant (Barik and Chowdhury, 2014; FAO, 2007). The Sundarban mangrove forest is the largest, most productive, and taxonomically diverse mangrove forest in the world (Mahadevia and Vikas, 2012). Bangladesh and India together share this forest, which has a unique mangrove environment. Approximately 40% of the whole Sundarban forest is in India, while the other 60% is in Bangladesh. The Sundarban Biosphere Reserve is situated on Indian land in the southern part of West Bengal.Which was established in 1829–1830, are the rivers that border the Indian Sundarban Delta on its eastern, western, southern, and northern sides, respectively (Biswas et al., 2016). In 1987, UNESCO inscribed this mangrove forest as a World Heritage Site.

ISSN: 2057-5688

The mangrove ecosystem is one of the most important ecosystems in terms of global ecology and biodiversity, and it is the only forest in the tropics and subtropics that is situated where land meets the sea (Alongi, 2002). Less than 1% of the planet's surface is covered with mangrove habitats, which are mostly located between the Tropics of Capricorn and Cancer. In terms of the size and variety of their mangrove systems, South and Southeast Asia is home to the greatest (Singh et al., 2012). In 2000, the first thorough assessment of all mangrove forests in the world indicated that they covered an area of 137,760 km2, dispersed throughout 118 territories and countries. Only 0.7% of the tropical forests in the globe are covered by mangroves, according to research. The two continents with the highest mangrove coverage are Asia (42%) and Africa (20%), followed by North and Central America (15%), Oceania (12%), and South America (11%). Only fifteen countries are home to about 75% of the world's mangroves. Indonesia is the highest-ranked of the 15 countries, according to Giri et al. (2010). Australia, Brazil, Mexico, Nigeria, Malaysia, Myanmar, Papua New Guinea, Bangladesh, Cuba, India, Guinea Bissau, Mozambique, Madagascar, and the Philippines are the next-highest-ranked countries.

About 3.1 per cent of globe's mangroves can be found in India. India is the home of the fourth largest mangrove area around the globe. The total area of the Indian coastline comprises 4,661.56 km2. The mangrove ecosystem in India is divided into three main areas which are the islands and the west coast that faces with the Arabian Sea, and the east coast that faces to the Bay of Bengal. Around 60 percent of the eastern region in the Bay of Bengal, 27 percent of the west region in the Arabian Sea, and 13 percent of the andaman Nicobar and Andaman islands are covered by mangroves. Mangrove-filled regions can be seen within regions like Indian state comprising West Bengal, Andhra Pradesh, Orissa, Andaman and Nicobar Islands, Kerala, Tamil Nadu, Goa, Gujarat as well as Maharashtra as well as other states. Of the states mentioned, West Bengal has the largest percentage of mangroves then followed by Gujarat

(Singh and co. (2012) Remadevi et. al. (2008)).

2 Literature Survey

A unique ecological environment to host a range of bacterial communities is created by mangroves. These bacteria are vital for the functioning of these habitats, and they occupy many niches. 2001 (Kathiresan and Bingham).In along with a myriad of unknown diazotrophic bacteria, sulfate-reducing bacterial as well as purple photosynthetic organisms, blue-green bacteria and heterotrophs with facultative or anaerobic characteristics have been discovered within mangrove sediments. Microorganisms that are nitrogen fixers and non-nitrogen fixing diatoms, cyanobacteria blue-green microalgae, green microalgae and fungus have completely colonized the surface of pneumatophore in mangroves. mangroves.The numerous microbial and animal species that alter and reuse nutrients within the ecosystem of mangroves are vital for the well-being of mangroves (Holguin and colleagues. 2001). Bacteria play an essential part in transporting nutrients within mangrove ecosystems as they could comprise approximately 91% of the of the mangrove's microbial biomass. (2000) Vazquez et al.Mangrove ecosystems are rich with organic matter. But they're usually deficient in nutrients, specifically nitrogen and the phosphorus. Mangroves thrive despite this (deMelo and de Azevedo 2011,). The strong interactions between microbes, nutrients and plants that serve as a way to conserve and recycle nutrients within the mangrove ecosystem can explain this conundrum. In subtropical and tropical mangrove ecosystems, a very prolific and diverse microbial population constantly converts the nutrients from the decaying mangrove leaf to sources of nitrogen or phosphorus as well as other plant-based nutrients. The exudates from the roots of plants act as food sources to the bacterium to turn into (Holguinet and. 2001).

Mangroves are an important ecological and economic resource because they serve as important nidification and breeding grounds for a variety of animals, including Birds, fish, crustaceans and reptiles. and mammals. They are also the renewable wood source and an accumulation area for pollution, sediment as well as carbon, nutrients and birds as well as a buffer from coastal erosion and tsunami damages. However, they are highly endangered ecosystems that have been vanishing at the rate of between 1 and 2 percent per year throughout their entire range. Mangrove decline has been mostly attributed to habitat devastation brought on by human encroachment (Joseph et al., 2018).

True mangroves as well as mangrove allies are two of the main groups in which mangroves are classified. Mangroves that are true typically reside within the mangrove ecosystem and don't extend into the terrestrial community. Mangroves are distinguished through (i) specific morphological features (aerial roots or vipary), (ii) physiological processes for salt removal or salt excretion, as well as (iii) the taxonomic distinction from their terrestrial counterparts. Mangrove companions is a term used to describe the non-arborescent, herbaceous and sub-woody and climber species that have been found to flourish close to the mangrove's tidal boundary areas. A majority of species that belong to the category of "mangrove associates" were naturally or unintentionally scattered from the beach forest or upland zones and therefore aren't truly inhabitants of the mangrove forest. Therefore, they do not fulfill the definition of mangroves in the sense defined by Tomlinson (1986). They can only be found as transitional plants and don't inhabit mangrove habitats in totality. Mangroves that are genuine are believed to be real halophytes and mangrove associates are glycophytes that have a particular degree in salt tolerance.

The several plant groups that make up mangroves are suited to the tropical intertidal habitat. There are around 84 mangrove plant species worldwide, which are divided into 24 genera and 16 families. Table 2.1 lists the 16 genera and 11 families in which there are 70 species of real mangroves, and Table 2.2 lists the 8 taxa and 5 families in which there are 14 species of mangrove allies. True mangrove families comprise Avicenniaceae, Bombacaceae, Combretaceae, Maliaceae, Myrtaceae, Myrsinaceae, Pellicieraceae, Plumbaginaceae, Rhizophoraceae, Rubiaceae, and Sonneratiaceae and semi-mangrove families

ISSN: 2057-5688

include Acanthaceae, Euphorbiaceae, Lythraceae, Palmae and Sterculiaceae (Wu and others. (2008)).

Mangroves that cover 66 square kilometers on the Mumbai coast is comprised of a number of authentic mangrove species. They can be divided into five genera and families. Avicennia marina, as well as Sonneratia Apetala belong to the ten species significantly more common than the other species of mangrove. Avicennia Marina is the most dominant mangrove throughout the Mumbai coastline, accounting for 50 percent of the Important Value Index, 78 percent of trees as well as 71% of base area, as well as 75.63 percent of the adult density (Kantharajan and co. 2018, 2018). Avicennia marina, Avicenniao fficinalis and the Bruguiera cylindrica, Sonneratia apetala, Ceriops tagal, Excoecaria agallocha, Acanthus ilicifolius, and Aegiceras corniculatum are eight of the mangrove species found in Thane Creek. Avicennia marina, which has an Importance Value Index of 157.29 and is most resilient to biotic and abiotic challenges, predominates the vegetation in general (Shindikar et al., 2009).

3 Methodology

In order to choose the best locations for investigations on the phenology and reproductive biology of Heritiera fomes and Cerbera odollam, extensive field trips were conducted in several mangrove forests across India in 2008 (Kerala, Karnataka, Maharashtra, Goa, Tamil Nadu, Odisha, and West Bengal) (Figure 1 A). In India, Heritiera fomes populations were mostly found in the Sunderbans (West Bengal) and Mahanadi delta (Odisha). Dangmal and Kalibhanjadia in Bhitarkanka National Park (Figure 1 D, F) and Kharnashi outside the park were chosen for observation and experiments on Heritiera fomes because to their accessibility and safe surroundings. Three years in a row, Dangmal (BKNP) was the site of a phenology research. In 2009 and 2011, research on the reproductive biology of Heritiera fomes was done in Dangmal. 2010 saw no special authorization granted, therefore observations and experiments were conducted.

The Indian east and west coastlines are thinly covered with Cerbera odollam.

The species' numbers were very small in the Bhitarkanika National Park. Therefore, Halyangadi (near Mangalore), Karnataka, was chosen as the research location for Cerbera odollam based on the abundance of trees and ease of access. C. odollam is randomly scattered across Halyangadi, which is located on the bank of the Nandini River, close to the Pavanje Bridge, on the riverbank, close to the seacoast, and in neighboring low land regions. In order to gather samples of flowers and fruits and to examine the phenology and reproductive biology of both mangrove tree species, extensive fieldwork (317 days) was done at Dangmal (BKNP), Kharnashi (KHNS), Kalibhanjadia (KALI), Halyangadi (HAL), and Kumbhalangi (KBL) (Figure 1 C, E).

Process

Mangrove trees called Heritiera fomes are evergreen. The trunks of the trees had deep grooves and were 30 to 50 cm in diameter at breast height (DBH). The wood and bark had longitudinal fractures and were a greyish brown color. The stem was tough, reddish brown, rough, and resilient to insect attack. Branches had distinct leaf scars, were dichotomous, deliquescent, and formed whorls at the top. A mature tree had well-developed buttress roots and pneumatophores that resembled pegs. The species' roots only extend just below the soil's surface and do not delve deeply into it.

Simple, dorsiventral, alternating leaves with two stipules were found at each node. These had a sharp tip and were petiolate, whole, and coaracious. The color of the leaf's ventral and dorsal surfaces varied; the ventral surface was dark green, while the dorsal surface had a silvery tint. In order to identify the species during the vegetative phase, the color of the leaf was employed as a key distinguishing source. Three locations in Bhiterkanika were examined for variations in leaf area. Bhiterkanika has the most leaf area, followed by Kalibhanjadia and Kharnashi.

ANATOMY OF VEGETATIVE PARTS

The growing seed has a noticeable root system from the start. The pneumatophores had a thick bark covering that was lenticulated. The phellogen originated from the epidermis (Figure 5F). Light microscopy or scanning electron microscopy were used to study the stem, root, and leaves in order to understand the anatomical and surface characteristics that aid in the species' survival in its natural habitat. The presence of peltate trichomes, which give the stem of a six-month-old plant a rough texture, was seen in the transverse slice of the stem. The juvenile stem in T.S. showed biseriate rays and a widespread porous state. Large intercellular gaps separated the parenchymatous cells, which were organized lopsidedly in the cortex. In the cortical area, several of the cells had thick cytoplasm. This area has a lot of cells that looked like resin ducts. In the transverse slice, cells of tannin and mucin were also seen. The cortex and pith of the root were visible. Sclerenchyma and phloem fibers covered prominent phloem. Mild yearly rings were seen in secondary xylem.

Table 3.1. Heritiera fomes: Average size of buttress root and diameter at breast height at three different study sites

Study site	Buttress root (N=20)	Diameter at breast height (DBH) (N=20)
Dangmal	95.88±25.72	49.85±23.03
Kalibhanjadia	62.96±30.35	43.44±10.91
Kharnashi	37.69±21.02	29.35±9.96

4 .Discussion

The connection between plants and animals in the pollination system only depends on how the plants reproduce. In terms of plant-animal interaction, plants that are more prone to cross pollination are significantly more interactive than those that are self-pollinating (Stephenson, 1981; Pandit & Choudhury, 2001). The current research shows that all four mangroves had a little tendency for cross-pollination, as shown by the fact that all the mangroves under investigation had greater reproductive success rates for cross-pollination systems than for self-pollination systems.

Because the maturity of the stigma and anther happens virtually at the same time and because of their location being almost at the same level, the floral morphology of AC favors the self pollination process. The current evidence also suggests that, among all the mangroves that have been studied, the AC plant had the lowest self- and cross-pollination reproductive success rates.The self-pollination method had the best reproductive success for AC, whereas the cross-pollination system

ISSN: 2057-5688

had the lowest. In contrast, AR has a weak protandrous character and is self-compatible (Solomon Raju & Karyamsetty, 2018). Even though AR can adjust to self compatibility, it had the greatest cross-pollination reproductive success of all the plants in our investigation.

The two Avicennia species that were being researched, AM and AO plants, demonstrated a wider range of reproductive success via cross pollination than through self pollination. Although these plants were described as being substantially protandrous and supporting self-pollination, Solomon Raju et al. (2012) found that both plants have a considerable need on floral visits. According to Primack et al. (1981), it is likely that the protandry that assisted in the insect pollination promotes the outcrossing of mangroves. According to Clarke and Myerscough (1991), the protandrous feature of AM exhibits a larger range of pollen ovule ratio, mass blooming, anthesis timing, and flower visitor incidence, all of which are most likely to aid in pollen transmission inside the plant.

Although the current study documents the effectiveness of cross-pollination in the reproduction of AM, this plant also permitted self-pollination. Although the fruit set or reproductive success of the AM plant is not solely dependent on the pollinator, Coupland et al. (2006) and Clarke (1992) showed that the involvement of insect pollinators is effective for the pollination of this plant.

According to Triest et al. (2017), the protandrous character of AO may lead to a greater range of outcrossing, which promotes genetic variety more probable. Although this plant's reproductive system is supported by self-pollination, stigma behavior is more prone to favor cross-pollination reproduction (Solomon Raju et al., 2012). The current investigation showed that whereas AO encouraged self-pollination, cross-pollination was more successful. As a result, all plants sustain both self-pollination and cross-pollination, but only cross-pollination is successful in terms of reproduction. The outcome shown that both AC and AR effectively encouraged both the cross-pollination process and self-pollination. While the cross-pollination method was validated

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

as being more probable than the self-pollination method for both Avicennia plants.

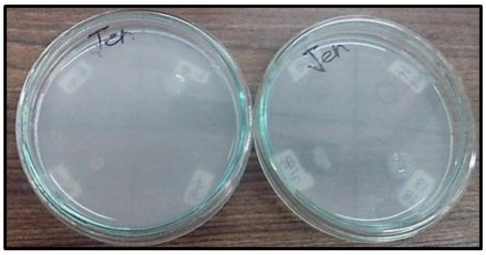

Fig. 4.1: Growth of isolates on Jensen's nitrogen free medium

Worldwide, mangroves and other maritime plants have been reported to engage in diazotrophic activity, albeit the species involved differ from location to site. The rhizosphere, tree bark, dead and decaying leaves, pneumatophores (aerial roots), cyanobacterial mats covering the surface of sediments, and the sediments themselves all showed high rates of nitrogen fixation. Black mangroves were discovered to have cyanobacteria, diatoms, green microalgae, bacteria, and fungus inhabiting the surface of the pneumatophores (aerial roots).

In soil, phosphorus may be found in both organic and inorganic forms. Organic sources of phosphorus are abundant in organic materials produced from dead and decomposing plant detritus. However, only the free form of phosphorus that is present in the soil is used by plants. Plant roots or soil microbes may make soil phosphates accessible. As a result, phosphate-dissolving soil organisms contribute to the correction of crop plants' phosphorus shortage (Subbarao, 1995). Due to the high concentration of cations in interstitial water, phosphates often precipitate in marine sediments, rendering phosphorus mostly inaccessible to plants. Mangrove plants would benefit greatly from phosphate-solubilizing bacteria (PSB), which are possible providers of soluble forms of phosphorus.

On Pikovaskaya's agar plates with 3% NaCl, 21 isolates had zones of clearance, indicating that they have the ability to solubilize inorganic phosphates.

ISSN: 2057-5688

Fig. 4.2: Phosphate solubilisation on Pikovaskaya's agar containing 3% Na

5 Conclusion

The most productive mix of cultures for promoting mangrove development was then determined by testing the chosen isolates in different combinations. In order to get rid of the bacteria and nutrients that are naturally present in mangrove soil, hydroponic conditions were applied. The seedlings' growth was compared to that of control plants grown in uninoculated cocopeat after they were planted in cocopeat that had been culture-enriched. The development of the mangrove seedlings was accelerated by all test culture combinations, with the exception of the triple culture (N5+N13+N14).

The values of almost all the evaluated physical and chemical growth parameters increased in the combination culture N13+N14. It demonstrated a striking 200% rise in the weight of the shoot as well as the plant's protein content. Thus, we may draw the conclusion that it was the most productive combination of the tested cultures and should be further researched in order to be turned into a productive inoculant. The pure culture N14 had a great impact on the plant's physical development as well, increasing the values of all the measured physical parameters. It enhanced the plant's protein content by more than 125% and the weight of the shoots by 200%. Thus, we may draw the conclusion that N14 can be an effective inoculant for the plant's growth promotion.

6 Reference

1. Lee, S. Y. et al. Ecological role and services of tropical mangrove ecosystems: a reassessment. Global Ecol. Biogeogr. 23, 726–743 (2014).

2. Giri, C. Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecol. Biogeogr. 20, 154–159 (2011).

ISSN: 2057-5688

3. Alongi, D. M. Te Impact of Climate Change on Mangrove Forests. Curr. Clim. Change Rep. 1, 30–39 (2015).

4. FAO (Food and Agriculture Organization of the United Nations) In Te world's mangroves 1980–2005. FAOForestry Paper 153.(Forest Resources Division, FAO, Rome, 2007).

5. Igulu, M. M. et al. Mangrove Habitat Use by Juvenile Reef Fish: Meta-Analysis Reveals that Tidal Regime Matters More than Biogeographic Region. PLoS ONE 9(12), e114715 (2014).

6. Alongi, D. M. Carbon Cycling and Storage in Mangrove Forests. Annu. Rev. Mar. Sci. 6, 195–219 (2014).

7. Alongi, D. M. Carbon sequestration in mangrove forests. Carbon Manag. 3, 313–22 (2012).

8. Alongi, D. M. Present state and future of the world's mangrove forests. Environ. Conserv. 29, 331–49 (2002).

9. Saenger, P. In Mangrove ecology, siviculture and conservation. (Kluwer Academic Publishers, Dordrecht, 2003).

10. Alongi, D. M. Mangrove Forests: Resilience, protection from tsunamis, and responses to global climate change. Estuar. Coast. Shelf S. 76, 1–13 (2008).

11. Spalding, M., Kainuma, M. & Collins, L. In World Atlas of Mangroves. A collaborative project of ITTO, ISME, FAO, UNEP-WCMC, UNESCO-MAB and UNU-INWEH. (Earthscan, London, 2010).

12. Polidoro, B. A. et al. Te loss of species: mangrove extinction risk and geographic areas of global concern. PLoS ONE 5, e10095 (2010).

13. McLeod, E. & Salm, R. V. In Managing Mangroves for Resilience to Climate Change. (IUCN, Gland, Switzerland, 2006).

14. Gilman, E., Ellison, J., Duke, N. & Field, C. Treats to mangroves from climate change and adaptation options: a review. Aquat. Bot.89, 237–250 (2008).

15. Van Lavieren, H. et al. In Securing the future of mangroves. A Policy Brief. UNU-INWEH, UNESCO MAB with ISME, ITTO, FAO, UNEP WCMC and TNC. (UNU-INWEH, Canada, 2012).

16. Ellison, J. C. & Zouh, I. Vulnerability to Climate Change of Mangroves: Assessment from Cameroon. Cent. Afr. Biol. 1, 617–638 (2012).

17. Loreau, M. Linking biodiversity and ecosystems: towards a unifying ecological theory. Proc. Trans. R. Soc. B 365, 49–60 (2010).

ISSN: 2057-5688

18. Cardinale, B. J. et al. Efects of biodiversity on the functioning of trophic groups and ecosystems. Nature 443, 989–992 (2006).

19. Worm, B. et al. Impacts of biodiversity loss on ocean ecosystem services. Science 314, 787–790 (2006).