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RESEARCH ARTICLE

# An investigation on soil-plant-AMF relationships in lateral transitional zones of a Riverine Island

**Mariyom Dai and Oyi Dai Nimasow***

Department of Botany, Rajiv Gandhi University, Rono Hills, Doimukh 791 112, Arunachal Pradesh, India

*Corresponding Author e-mail: oyidai.nimasow@rgu.ac.in
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## Abstract

Riverine floodplains, characterized by heterogeneous physico-chemical soil characteristics represent a challenging environment for plants to grow. In these areas, lateral zonation is shaped by flooding events. Plants growing in riverine floodplains can benefit from their association with Arbuscular Mycorrhizal Fungi (AMF), as these fungi help in alleviating the stresses associated with such environments. The present study investigated the vegetation, soil characteristics and mycorrhizal associations in three different lateral transitional zones viz. Emergent zone (EZ), Ecotone zone (ECZ), and Core zone (CZ) within Daying Ering Wildlife Sanctuary, a riverine island of one of the big rivers in Arunachal Pradesh. Sampling was done by belt transect method and vegetation cover, soil properties, AMF diversity, infective propagules in soil, spore density population, and host root infection were assessed in these zones. Physico-chemical properties of soil except moisture content, varied significantly across the zones. Soil nutrients and moisture were highest in the CZ while pH and bulk density was more in the EZ. Root infection by AMF, the number of infective propagules in soil, and the AMF spore population were highest in the CZ. The ECZ exhibited the highest values for both the Simpson and Shannon Diversity indices. The study highlights the complex interactions between soil properties, plant community composition, and mycorrhizal associations in different lateral transitional zones of the river island.

Keywords: Riparian ecosystem, Daying Ering Wildlife Sanctuary, mycorrhizal fungi

## 1. Introduction

River islands exhibit an aquatic-terrestrial transition zone with unique biotic, biophysical, and landscape characteristics (Naiman and Decamps, 1997; Wiens, 2002). They represent a riparian ecosystem with distinct vegetation patterns, displaying discrete lateral transitional zones as one moves from wetland to upland areas (Sieben and Reinecke, 2008). The lateral zonation of riparian vegetation is shaped by flooding events. Vegetation on riverbanks and zones inundated annually differs from that in zones inundated interannually (Sieben and Reinecke, 2008). The wet river bank is occupied by a pioneering plant community, mostly while the dry bank has tall grasses and shrubs (riparian scrub), followed by the upland forest that lies above the flooding zone (Dixon and Johnson, 1999). Two distinct zones based on terrestrial plant community characteristics can be identified in river islands such as (i) Emergent Zone (EZ): land area between the base flow and bank full levels of the river, dominated by scrubs and grasses, and (ii) Core Zone (CZ): land at highest elevation heavily vegetated by trees, weeds, and grasses. An Ecotone zone (ECZ) between the core area and the emergent zone, well-demarcated with high species richness.

The symbiotic association between higher plants and AMF is crucial for plant growth and survival, enhancing nutrient acquisition and tolerance to biotic and abiotic stresses. Riverine floodplains, characterized by their heterogeneous physico-chemical soil characteristics, represent a challenging environment for plants to grow. Recent studies have shown that plants growing in riverine floodplains can benefit from their association with mycorrhizal fungi. The fungi may help to reduce the stresses associated with such environments. Harner et al. (2010) found that mycorrhizal colonization was positively correlated with plant growth and survival in riverine floodplain environments.

Daying Ering Wildlife Sanctuary (DE-WLS), a mid-channel river island spanning approximately 1,638.4 ha within the Siang River, represents a vital floodplain habitat. As a protected area, it harbors diverse flora and fauna across its expanse, including many smaller islands and dense forests. An interesting feature of this sanctuary is its distinct plant distribution pattern across discrete lateral transitional zones representing scrub vegetation, grassland with sparsely growing shorter trees, and forested areas at the highest elevation. These heterogeneous habitat patches exist in close proximity and exhibit variations in resource availability. The mosaic of habitats along freely flowing rivers presents a distinctive landscape to investigate the abundance and composition of mycorrhizal fungi and their association with plant communities growing in various lateral zones. Therefore, for the present study, we selected DE-WLS to investigate the vegetation present in different lateral transitional zones, and the soil-plant-AMF relationships.

## 2. Materials and methods

*2.1. Study area and vegetation type*


**Figure 1.** Map of the study area (DE-WLS), East Siang, AP.

The Daying Ering Wildlife Sanctuary (27°57'34"N 95°25'22"E; 100-150m amsl), formerly known as Lali Wildlife Sanctuary since its establishment in 1976, was renamed in 1986. It is a large island of

1,638.4 ha area surrounded by the river Siang, and serves as a habitat for numerous endangered animal and plant species with various other life forms. The climate is humid tropical monsoon with temperature ranging between 12 to 22°C in December-January and 24 to 33°C in July-August. The average annual rainfall (2018-2019) in the Pasighat area, where the sanctuary is located, is 2276 mm, with the highest precipitation recorded in July (670 mm). According to the Lower Siang Hydroelectric Project report of 2013, about 75% of the sanctuary comprises alluvial wet savanna grassland, while 15% is comprised of alluvial plain semi-evergreen forest, and the remaining 10% is submerged under watercourses.

*2.2. Study site*

The present study focused on the Borguli region (28°01′11″N 95°26′00″E; 149 m amsl) within the Daying Ering Wildlife Sanctuary (DE-WLS). The study site delineates three distinct zones, gradually transitioning from the riverbed to the core forest. The Emergent Zone (EZ) characterizes the riverbed region, primarily featuring grasses, herbs, and a few shrub species. It experiences periodic flooding during monsoon, fostering plant growth mainly in the winter season. The Ecotone Zone (ECZ) represents an intermediary area predominantly populated by *Alpinia nigra*, *Leea asiatica* and *Saccharum* sp. etc. This zone marks the transition between the riverbed and the dense forest, showcasing a unique blend of vegetation. The Core Zone (CZ) encompasses the forested region, constituting the core habitat of DE-WLS.

*2.3. Determination of vegetation cover at the selected site*

Vegetation cover was determined by Line intercept method (Canfield, 1941). Three plots each of 100 m × 100 m size were randomly selected in each zone and three 100 m long line transects were laid. 10 sampling points positioned at 10 m interval were selected along the transect. Tree density was calculated using the Nearest Individual Method, a distance-based technique (Cottam and Curtis, 1956), which is essentially a variant of the line intercept method. At each sampling point, the nearest tree was identified, and the distance to this nearest tree from the line transect was measured. Tree density was calculated using the formula:

Tree density = 1/Mean Area = 1/ $(2\bar{d})2$

Where, $\bar{d}$ = mean distance between the sampling point and its nearest individual

Canopy coverage of trees was determined using a spherical densitometer equipped with a convex mirror etched with squares. The percentage of canopy coverage was computed based on the ratio of observed hits to total hits, multiplied by 10.

Canopy coverage (%) = (Number of observed hits)/( Total number of hits )× 100

Ground vegetation cover was assessed through visual estimation of the total foliage of shrubs and herbs along a 100m transect. In the Core Zone, the Diameter at Breast Height (DBH) was measured for thirty trees and classified into ten DBH categories, each spanning 10 cm intervals. Vegetation cover was not determined for ECZ and EZ due to the sparse distribution of trees.

*2.4. Collection of soil and root samples*

Samples were collected by Belt transact method from the site from November 2018 to March 2019. From each zone, 30 soil samples were collected and thoroughly mixed to make a composite sample. A total of three composite samples were prepared, one for each zone. Rhizosphere soil was collected up to a depth of 15 cm. Additionally, root samples of well-grown, visible, dominant representative plant species from each zone were carefully collected, washed, and preserved in FAA solution.

*2.5. Determination of physical and chemical properties of soil*

Various physico-chemical properties of soil were determined by following standard methods. Soil temperature was recorded using a soil thermometer. Texture was determined by the Hydrometric method. Bulk density was measured by a core method using metal rings of different lengths (5-15cm) and porosity was calculated accordingly. WHC was measured by Keen's box method. pH was determined by the Potentiometric method. Soil OC, available N, available P, and available K were calculated by standard methods given by Walkley and Black (1934), Subbiah and Asija (1956), Bray and Kurtz (1945), and Hanway and Heidel (1952) respectively.

*2.6. Quantification of AMF root infection*

AMF root infection was quantified as per the method of Phillips and Hayman (1970) modified by Koske and Gemma (1989). Washed roots segments of 1 cm length were soaked in 10% KOH solution and heated at 90°C for 2 h for root clearing. The roots were then treated with 1% HCl solution, either by heating for 1 h or soaking overnight. Next, they were stained with trypan blue solution (500 ml glycerol, 450 ml $H_2O$, and 50 ml 1% HCl containing 0.05% trypan blue) by heating at 90°C for 30 min. Extra stain was removed with a de-staining solution (500 ml glycerol, 450 ml $H_2O$, and 50 ml 1% HCl) at room temperature. Root segments with mycelium, vesicles, and arbuscules were considered positive infection. Percent root infection was calculated as:

*Root infection (%) = (number of AM positive segment)/(Total number of segment examined) ×100*

*2.7. Determination of inoculum potential*

The inoculum potential of the soil (AMF infectivity of soil) was determined by using the Most Probable Number (MPN) bioassay (Alexander, 1982) following serial soil dilution technique (Porter, 1979).

*2.8. Quantification of AMF spore population in soil*

Spores were isolated from soil samples by Wet sieving and decanting methods (Gerdemann and Nicholson, 1963). A suspension of 100 g air-dried soil in 1000 ml water was poured through a series of stacked sieves of pore sizes 800, 500, 300, 150, 90, and 40 µm. Isolated spores were counted manually under a Stereomicroscope (Nikon SMZ 800), and spore population was expressed as the number of AM spores per 100 g of soil sample.

*2.9. Identification of AMF*

AMF species were identified on the basis of morphological characteristics of the spores using identification keys available on the INVAM website, and referencing the identification manual authored by Schenck and Perez (1990).

*2.10. Statistical analysis*

The statistical analysis of the data was performed using a One-way analysis of variance (ANOVA) with a significance level set at 0.05. Post-hoc comparisons between groups were conducted using the Least Significant Difference (LSD) test.

# 3. Results

A total of 55 frequently occurring plant species were identified at the study site, including 21 trees, 15 shrubs, 15 herbs species, and 3 climbers (Table 1). The plant species mostly belonged to families such as Asteraceae, Meliaceae, and Fabaceae. Vegetation in the EZ was largely herbaceous with a few scattered shrubs. The ECZ was also herbaceous with sparsely distributed tree species. The CZ exhibited a more balanced distribution of herbs, shrubs, and trees. Dominant plants in the EZ were *Cynodon dactylon*, *Eleusine indica*, *Persicaria chinensis*, and *Salix disperma*. In ECZ, common plants were *Alpinia nigra*, *Imperata cylindrica*, *Leea asiatica*, and *Saccharum spontaneum*. In CZ, the dominant tree species were *Aglaia spectabilis*, *Albizia procera*, *Bombax ceiba*, *Kydia calycina*, and *Magnolia hodgsonii*, along with other dominant shrubs such as *Boehmeria platyphylla*, *Callicarpa longifolia*, *Casearia glomerata*, *Castanopsis indica*, and *Oplismenus Burmannii*. Both EZ and ECZ shared four plant species (*Papaver dubium*, *Ranunculus* sp., *Saccharum spontaneum*, and *Urena lobata*), while ECZ and CZ shared two species (*Chromolaena odorata* and *Mikania micrantha*). There were only two herbaceous species, namely *Dennstaedtia punctilobula* and *Matteuccia struthiopteris* common across the zones (Table 2).

Table 1. Plants present in various zones of the study site

| Zone | Habit | Plant name | Family |
|---|---|---|---|
| 1 | Grass | *Cynodon dactylon* | Poaceae |
| 1 | Grass | *Eleusine indica* | Poaceae |
| 1 | Climber | *Persicaria chinensis* | Polygonaceae |
| 1 | Shrub | *Salix disperma* | Salicaceae |
| 1 | Shrub | *Tamarix dioica* | Tamaricaceae |
| 2 | Herb | *Ageratum conyzoides* | Asteraceae |
| 2 | Herb | *Alpinia nigra* | Zingiberaceae |
| 2 | Grass | *Imperata cylindrica* | Poaceae |
| 2 | Shrub | *Lantana camara* | Verbenaceae |
| 2 | Shrub | *Leea asitica* | Vitaceae |
| 2 | Tree | *Syzygium kumini* | Myrtaceae |
| 2 | Tree | *Zizyphus mauritiana* | Rhamnacea |
| 3 | Climber Herb | *Ardisia* sp. | Primulaceae |
| 3 | Climber Shrub | *Piper mullesua* | Piperaceae |
| 3 | Grass | *Oplismenus Burmannii* | Poaceae |
| 3 | Herb | *Amischotolype hookeri* | Commelinaceae |
| 3 | Herb | *Cucurbitaceae* sp. | Cucurbitaceae |
| 3 | Herb | *Maesa indica* | Asteraceae |
| 3 | Shrub | Unidentified sp. 1 | |
| 3 | Shrub | *Begonia amphioxus* | Begoniaceae |
| 3 | Shrub | *Boehmeria penduliflora* | Primulaceae |
| 3 | Shrub | *Boehmeria platyphylla* | Urticaceae |
| 3 | Shrub | *Callicarpa longifolia* | Lamiaceae |
| 3 | Shrub | *Coffea benghalensis* | Rubiaceae |
| 3 | Shrub | *Ixora* sp. | Rubiaceae |
| 3 | Shrub | *Phyllanthus reticulatus* | Phyllanthaceae |
| 3 | Shrub | *Tetrastigma planicaule* | Vitaceae |
| 3 | Shrub | *Urtica dioica* | Urticaceae |
| 3 | Tree | *Didymocheton spectabilis* | Meliaceae |
| 3 | Tree | *Aglaia spectabilis* | Meliaceae |
| 3 | Tree | *Albizia procera* | Fabaceae |
| 3 | Tree | *Alstonia* sp. | Apocynaceae |
| 3 | Tree | *Bombax ceiba* | Malvaceae |
| 3 | Tree | *Casearia glomerata* | Malvaceae |
| 3 | Tree | *Castanopsis indica* | Fagaceae |
| 3 | Tree | *Cinnamomum bejolghota* | Lauraceae |
| 3 | Tree | *Combretum* sp. | Combretaceae |
| 3 | Tree | *Dillenia indica* | Dilleniaceae |
| 3 | Tree | *Elaeagnus pyramidalis* | Elaeagnaceae |
| 3 | Tree | *Faramea* sp. | Rubiaceae |
| 3 | Tree | *Ficus citrifolia* | Moraceae |
| 3 | Tree | *Kydia calycina* | Malvaceae |
| 3 | Tree | *Litsea polyantha* | Lauraceae |
| 3 | Tree | *Loranthus* | Loranthaceae |
| 3 | Tree | *Magnolia hodgsonii* | Magnoliaceae |
| 3 | Tree | *Morus australis* | Moraceae |
| 3 | Tree | *Unidentified* sp. 2 | |
| 1,2 | Herb | *Papaver dubium* | Papaveraceae |
| 1,2 | Herb | *Ranunculus* sp. | Ranunculaceae |
| 1,2 | Grass | *Saccharum spontaneum** | Poaceae |
| 1,2 | Shrub | *Urena lobata* | Malvaceae |
| 1,2,3 | Herb | *Dennstaedtia punctilobula* | Dennstaedtiaceae |
| 1,2,3 | Herb | *Matteuccia struthiopteris* | Onocleaceae |
| 2,3 | Herb | *Chromolaena odorata* | Asteraceae |
| 2,3 | Climber | *Mikania micrantha* | Asteraceae |

Zone 1: Emergent zone, Zone 2: Ecotone zone, Zone 3: Core zone

Table 2. Common plants among the zones of the study site

| EZ and ECZ | ECZ and CZ | EZ, ECZ and CZ |
|---|---|---|
| *P. dubium* | *C. odorata* | *D. punctilobula* |
| *Ranunculus* sp. | *M. micrantha* | *M. struthiopteris* |
| *S. spontaneum* | - | - |
| *U. lobata* | - | - |

EZ - Emergent, ECZ - Ecotone, CZ - Core zone

In the CZ, the tree density was 208.80 per 100 m², with 83%canopy coverage and 44.7%ground coverage. Majority of trees fell into the 11-20 cm followed by the 0-10 cm DBH class (Figure 2). Vegetation cover in the EZ and ECZ was not measured due to the sparse distribution of trees. The soil texture varied across the three zones: EZ and ECZ were sandy loam, while CZ was sandy clay loam (Table 3). The soil temperature varied a little across three zones, the maximum being 23 °C in EZ and the minimum 20 °C in CZ.

A significant heterogeneity in soil properties was observed across three zones (Table 3). Except for moisture content, other soil physical parameters varied significantly. The ECZ exhibited the highest WHC (85.3%), followed by CZ (73.5%) and EZ (41.3%). Soil moisture content was similar across all three zones, ranging from 23-24%. Bulk density was highest in the EZ (1.58 g cm-3) and lowest in the CZ (1.17 g cm-3), while porosity was highest in the CZ and lowest in the EZ.

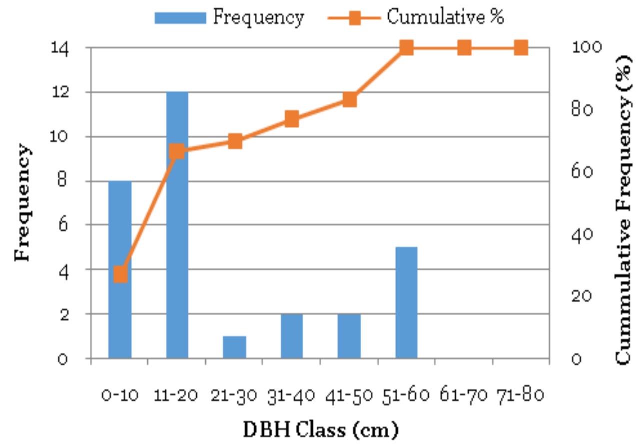


Figure 2: Frequency distribution of DBH classes of trees in the Core Zone of the study site

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Table 3. Soil physico-chemical properties in different zones of the study site

| | Zones | | |
|---|---|---|---|
| | EZ | ECZ | CZ |
| Temperature (°C) | 23 | 21 | 20 |
| Soil type | Sandy loam | Sandy loam | Sandy clay loam |
| Sand (%) | 64 | 67 | 62 |
| Silt (%) | 21 | 18 | 17 |
| Clay (%) | 15 | 15 | 21 |
| Bulk density (g/cm³) | 1.6±0.0 | 1.4±0.0 | 1.2±0.0 |
| Porosity (%) | 40.2±1.2 | 48.3±1.7 | 55.7±1.0 |
| WHC (%) | 41.3±1.3 | 85.3±1.3 | 73.3±1.3 |
| Moisture Content (%) | 23.7±1.3 | 22.6±1.9 | 24.2±3.9 |
| pH | 6.6±0.0 | 6.5±0.0 | 6.1±0.0 |
| OC (%) | 0.3±0.0 | 0.5±0.0 | 0.8±0.0 |
| Av. Nitrogen (kgha⁻¹) | 50.2±0.5 | 69.0±0.6 | 56.4±1.4 |
| Av. Phosphorus(kgha⁻¹) | 39.2±1.1 | 35.8±1.0 | 42.6±0.3 |
| Av. Potassium(kgha⁻¹) | 341.6±1.3 | 318.1±0.6 | 543.2±1.0 |

WHC - Water Holding Capacity, OC - Organic Carbon, Av. – Available

Chemical parameters of soil differed significantly across the zones (Table 3). Soil pH was highest in the EZ, and lowest in the CZ. Organic carbon, available phosphorus, and available potassium contents were highest in the CZ and lowest in the EZ. The ECZ exhibited the highest available nitrogen, followed by the CZ and the EZ.

The CRSs collected from all three zones exhibited mycorrhizal infection, characterized by the presence of hyphae, vesicles and arbuscules inside the root (Figure 3). Arbuscules were less frequent than hyphae and vesicles. The highest root infection was recorded for the CZ (83.3%), while the lowest root infection was recorded for the EZ (50%) (Figure 4).

Dominant plants were collected from different zones and quantified for AMF root infection. Root infection was detected in two out of three dominant plants from EZ, in all three plant species from ECZ, and three out of four plant species from CZ. The extent of root infection across three zones did not show any definite pattern (Table 4).

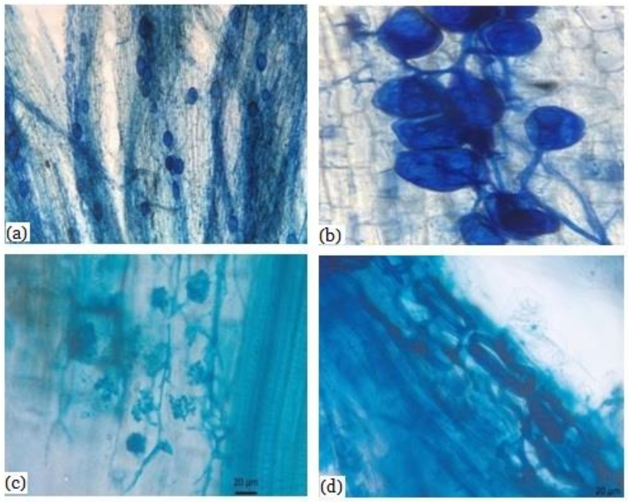


Figure 3. (a) AM root infection (b) Vesicles (c) Arbuscules (d) Hyphal coils

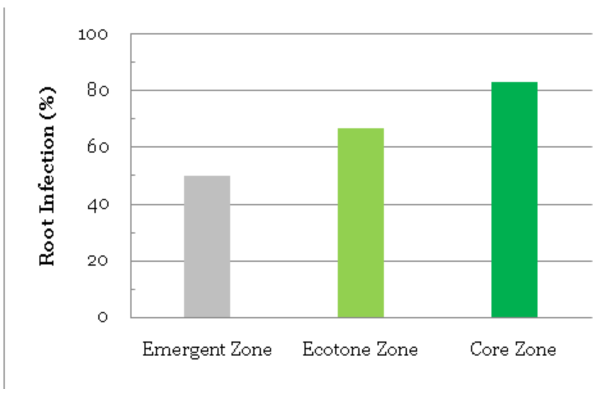


Figure 4. Root infection (%) in composite root samples

Table 4. Mycorrhizal status of dominant plant species in the study site

| Plant name | RI (%) | Zone |
|---|---|---|
| *Unidentified* sp. 1 | 30 | 1 |
| *Persicaria chinensis* | 60 | 1 |
| *Salix disperma* | 0 | 1 |
| *Saccharum spontaneum* | 20 | 2 |
| *Leea asitica* | 60 | 2 |
| *Alpina nigra* | 60 | 2 |
| *Boehmeria platyphylla* | 20 | 3 |
| *Piper mullesua* | 60 | 3 |
| *Oplismenus Burmanni* | 0 | 3 |
| *Mikania micrantha* | 50 | 3 |

The spore population (No. of spores $100^{-1}$g soil) of AMF also varied significantly across the zones. It was almost similar in the CZ and ECZ (114 and 106 spores respectively) but very low in the EZ (58 spores). However, the number of infective propagules of AMF in the soil (IP) was much higher in the CZ (56 g$^{-1}$ soil) in comparison to both EZ and ECZ (Table 5).

Out of a total of 15 AMF species recorded from different zones of the study site (Figure 8), eleven species each were present in EZ and ECZ whereas nine species were present in the CZ indicating slightly low species diversity in CZ in comparison to EZ and ECZ. *Glomus* was the most frequently occurring genus in all three zones however in core zone it was closely followed by *Sclerocystis* and *Funneliformis*. There were a few common species across the zones while some species were exclusively observed in specific zones such as *Acaulospora laevis*, *Glomus* sp. 2 in EZ, *Glomus* sp. 1 in ECZ, and *A. scrobiculata* and *Sclerocystis taiwanensis* in CZ (Table 6). Among sites, the ECZ exhibited the highest values for both the Simpson and Shannon diversity indices, while CZ showed the highest levels of dominance and evenness (Table 7).

Table 5: AMF infective propagules

| Zone | IP (g$^{-1}$ soil) |
|---|---|
| EZ | .09 |
| ECZ | .66 |
| CZ | 56 |

Table 6. AMF diversity and spore population in different zones

| AMF species | AMF spore population in different zones | | |
|---|---|---|---|
| | EZ | ECZ | CZ |
| *Acaulospora laevis* | 2 | 0 | 0 |
| *Acaulospora scrobiculata* | 0 | 0 | 7 |
| *Funneliformis geosporum* | 7 | 14 | 21 |
| *Gigaspora candida* | 4 | 5 | 0 |
| *Gigaspora gigantea* | 3 | 6 | 12 |
| *Glomus ambisporum* | 10 | 11 | 15 |
| *Glomus macrocarpum* | 4 | 11 | 12 |
| *Glomus* sp. 1 | 0 | 9 | 0 |
| *Glomus* sp. 2 | 7 | 0 | 0 |
| *Glomus versiforme* | 4 | 7 | 0 |
| *Racocetra gregaria* | 8 | 6 | 5 |
| *Sclerocystis rubiformis* | 0 | 10 | 13 |
| *Sclerocystis taiwanensis* | 0 | 0 | 11 |
| *Scutellospora heterogama* | 3 | 7 | 0 |
| *Septoglomus constrictum* | 6 | 15 | 18 |
| Total spore population in the zone | 58 | 106 | 114 |
| No. of species present in the zones | 11 | 11 | 9 |

Table 7. Diversity indices of different zones of the study site

| Indices | EZ | ECZ | CZ |
|---|---|---|---|
| Taxa (S) | 11 | 11 | 9 |
| Individuals | 58 | 106 | 114 |
| Dominance (D) | 0.109 | 0.107 | 0.126 |
| Simpson (1-D) | 0.891 | 0.893 | 0.874 |
| Shannon (H) | 2.297 | 2.315 | 2.126 |
| Evenness (e) | 0.904 | 0.921 | 0.931 |

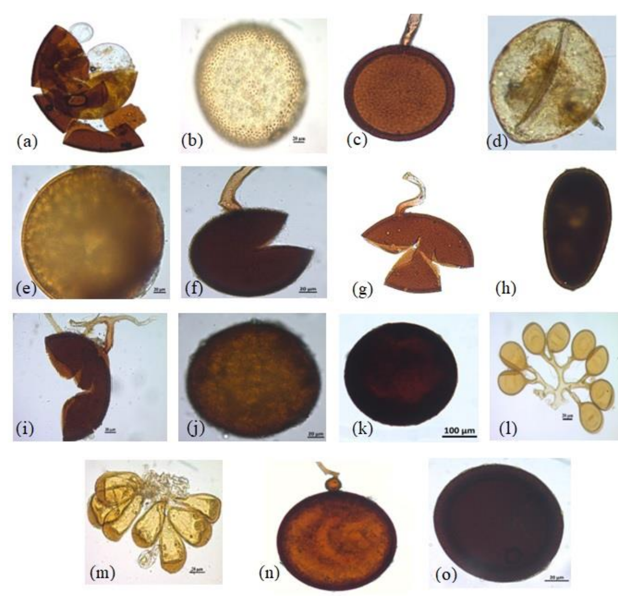


Figure 8. AMF species recovered from the study site
(a) *Acaulospora laevis* (b) *Acaulospora scrobiculata* (c) *Funneliformis geosporum* (d) *Gigaspora candida* (e) *Gigaspora gigantea* (f) *Glomus ambisporum* (g) *Glomus macrocarpum* (h) *Glomus* sp. 1 (i) *Glomus* sp. 2 (j) *Glomus versiforme* (k) *Racocetra gregaria* (l) *Sclerocystis rubiformis* (m) *Sclerocystis taiwanensis* (n) *Scutellospora heterogama* (o) *Septoglomus constrictum.*

# 4. Discussion

The Daying Ering Wildlife Sanctuary (DE-WLS), a river island representing a riparian ecosystem, has three discrete lateral transitional zones, the Emergent Zone (EZ), Ecotone Zone (ECZ), and Core Zone (CZ), each exhibiting a unique distribution pattern of plants. The EZ was dominated by herbs, ECZ largely by herbs, some shrubs and a few scattered small-sized tree species. The CZ was a forested area with high canopy cover, and many tall mature trees, about half of the ground cover occupied largely by shrubs and herbs reflecting a patchy distribution pattern. Thus, the CZ represents almost a stable community structure.

Frequent inundations of EZ and ECZ during high water levels in the river Siang seem to influence the soil physico-chemical properties, vegetation patterns and AMF diversity. The sandy loam texture of soil in these zones is most likely the outcome of inundation. The slightly higher soil moisture level in the CZ can be attributed to a denser canopy cover, litter deposited on the soil, and about half of the ground cover occupied by herbs and shrubs thereby preventing the soil from desiccation. Further, the sandy clay loam texture of the soil, and presence of comparatively more organic matter are the other supportive factors for higher moisture content and water holding capacity (WHC) of the soil in the CZ than the other two zones. Additionally, the EZ benefits from consistent water availability due to its proximity to the river, resulting in higher moisture content compared to the ECZ. A higher bulk density (BD) of soil in the EZ might be related to its lower clay content and organic carbon. Such a negative correlation between BD, organic carbon and clay content has also been reported by Chaudhari et al. (2013). Similarly, a lower WHC in the EZ could be a consequence of a lower organic carbon, porosity, and soil texture which corroborates with the findings of Deb et al. (2014).

Soil in the various zones was slightly acidic. The CZ had comparatively lesser soil pH which might be due to presence of higher organic matter which upon decomposition is known to produce organic acids thereby lowering the soil pH (Barraclough and Olsson, 2018; Hong et al., 2019). Furthermore, soil nutrients were more abundant in the CZ. This higher availability of organic carbon and nitrogen can be linked to the denser tree population, as greater vegetation tends to augment organic matter (Yan et al., 2018), and increased litter production, whose decomposition subsequently enriches the soil with nutrients (Wang et al., 2014). The low carbon content in the EZ may be attributed to the sandy loam texture of the soil as observed by Sandip et al. (2016). Fomenky et al. (2018) also found a lower carbon content in soils around some rivers in Cameroon. The CZ also exhibited significantly higher levels of available phosphorus, which can be attributed to increased recycling of phosphorus by tree species within the forest ecosystem, followed by subsequent recycling through the decomposition of litter residues (Reza et al., 2014). Given the more variable environmental conditions experienced by the EZ, its nutrient availability might be compromised.

Environmental factors and soil physico-chemical characteristics play vital roles in influencing the distribution, density, and composition of AMF species (Li et al., 2007; Tabin et al., 2014). Soil moisture is also considered one of the important factors influencing spore population and root colonization (Redhead, 1975). The present study observed a positive correlation between soil moisture and AMF status, aligning with the studies of Kumar et al. (2010). However, Bhardwaj and Chandra (2018) reported a negative correlation between soil moisture and spore population. Soil pH showed a negative influence on AMF spore population and root infection, consistent with the findings of Nongkling and Kayang (2017). Soil nutrients and porosity were also found to positively influence spore population and root infection, similar to other reports (Bodington and Dodd, 2000; Khanam et al., 2006) as because soil nutrients are considered vital for regulating the assembly of AMF communities (Johnson et al., 2015).

Composite root samples collected from all three zones, and also of the dominant plant species, harboured AMF infection characterized by the presence of hyphae, vesicles, and arbuscules. We observed prevalance of intra-radical hyphae in roots which were much more abundant than the arbuscules and vesicles. Similar finding has been reported by Belay et al. (2013).

In addition to varying vegetation and soil characteristics, other ecological factors such as seasonality, host specificity, and root exudation are also presumed to contribute to the distribution and diversity of AM fungi (Guadarrama et al., 1999; Tabin et al., 2014). A recovery of eleven AMF species perhaps indicate that propagules of AMF are deposited by river channel in these low-lying zones due to frequent flooding. However, these AMF species perhaps could not multiply and produce spores due to scanty population of host plants in EZ, and over dominance of two grass species (*I. cylindrica* and *S. spontaneum*) that are commonly encountered in low lying lateral zones along river channels in Arunachal Pradesh. Both the grass species produce abundant fibrous roots and thrive very well in sandy loam soil. It has been reported that grasses with profuse fibrous roots show lesser dependence on AMF for nutrient acquisition (Yang et al., 2011). Since the sampling in the present study was done post-flood period, the likelihood of getting viable spores deposited by river water increases. It is an established fact that as slope decreases, the deposition of sediments by river in its floodplains increases (Osterkamp, 1998). DE-WLS is the first large island created by the river Siang due to sediment deposition since time immemorial. The island experiences significant annual deposition of fresh sediments carried by the river from its source in Tibet, traversing through deep gorges.

Spore production among AMF is known to exhibit variability across different habitats, which is influenced by the soil factors, the host, and the fungus itself as highlighted by Songachan (2012). The very low inoculum potential recorded in the EZ and ECZ indicates that AMF multiplication is likely very slow in these zones due to scant vegetation and a stressful environment challenging their survival.
The ECZ exhibited the highest Simpson and Shannon diversity indices, thus reflecting a greater AMF diversity. The higher evenness observed in the CZ suggests that it might offer favorable conditions for the proliferation of AMF spores, resulting in a more balanced distribution of individuals among species (Table 7). The study found *Glomus* to be the most frequently occurring genus in all three zones. However, in CZ, it was closely followed by *Sclerocystis* and *Funneliformis*. Many studies have reported *Glomus* as the most prevalent genus in slightly acidic to neutral soils across diverse natural ecosystems (Manoharachary et al., 2005; Surendirakumar et al., 2016; Tripathi et al., 2022) due to its prolific sporulation within a brief time frame, and production of small size spores (Wang et al., 2019).

Overall, the distribution of AMF spores exhibited variability across zones, suggesting potential disparities in environmental conditions or associations with host plants that could influence their abundance. The presence and abundance of AMF spores in different zones imply differing levels of potential mycorrhizal activity and nutrient exchange with host plants.

# 5. Conclusion

The present work is an attempt to understand the ecological characteristics and mycorrhizal associations within a riparian floodplain characterized by distinct ecological zones (emergent, ecotone, and core zone). The findings reveal significant variations in soil properties, plant species distribution, and mycorrhizal infection among the zones. The emergent zone, subject to annual inundation, exposure to direct sunlight and poor soil nutrient content presents a stressful environment for plants and AMF. However, AMF appear to play a significant role in sustaining the above ground vegetation by alleviating the stress to a certain extent. The study highlights the inter-relationship between soil, plants, and mycorrhizal fungi, and provides an insight into the ecological dynamics in river corridors. Further studies on AMF diversity and distribution, soil factors, and prevailing vegetation may illustrate their ecological role in the stressful environment of river corridors.

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## Author(s) contribution

Both authors contributed to the study's conception and design. Ms. Mariyom Dai drafted the manuscript and Dr. Oyi Dai Nimasow reviewed and revised it.

## Conflict of interest

Authors declare no conflict of interest

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