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ORIGINAL ARTICLE

ARBUSCULAR MYCORRHIZAL ASSOCIATION AND MORPHOLOGY OF PLANT SPECIES IN SHOLA FORESTS OF KODAIKANAL

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ABSTRACT

The prevalence of Arbuscular mycorrhizal fungal association has been well reported from several natural ecosystems, information on AM fungal association and their abundance are unknown for Shola ecosystems. In the present study, 71 plant species (in 35 families) examined all the families were colonized by AM fungi except two species in a genus *Psychotria*. AM association was observed in members of supposedly non-mycorrhizal families Commelinaceae, Cleomaceae and Convolvulaceae. Thirty four of the plant species had *Arum*-type morphology, 25 had Intermediate- type and 12 had typical *Paris*-type morphology. There were large differences in the extent of AM colonization and root lengths with AM fungal structure between plant species.

Keywords: : AM fungi, Arum-type, Shola forest

1.INTRODUCTION

Mycorrhiza is the mutualistic symbiosis (non-pathogenic association) between certain soil-borne fungi and plant roots (Sieverding, 1991). Plant roots have evolved to accommodate, utilize and control mycorrhizal fungi. Both molecular and fossil evidence indicate that the earliest land plants were mycorrhizal (Redecker et al., 2000). Arbuscular mycorrhizal morphology is distinguished into *Arum* – type and *Paris* – type. The *Arum*-type association is characterized by intercellular hyphal growth in the root cortex, with short lateral branches into cortical cells forming arbuscules (Smith and Smith, 1997). Intracellular–hyphal coils frequently having intercalary arbuscules spreading cell to cell in the cortex characterize the *Paris*– type association, has been found to be more frequent in natural ecosystems (Yamato and Iwasaki, 2002; Ahulu et al., 2005; Tsuyuzaki et al., 2005). Arbuscular mycorrhizal fungi occur in all kind of landforms including mountains (Shi et al., 2007), plateaus (Pan et al., 1997), hills, plains (Gai et al., 2006), islands (Liu et al., 2001) and basins (Wang et al., 2006).

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The unique combination of forests and grassland comprise the Shola forest. They are stunted evergreen forest found as patches in grasslands especially in Valleys. The Sholas are dark damp throughout the year, because Shola soil absorbs and retains water like a sponge. However, wide diversity and unique floral distribution, no systematic investigation has been carried out to explore the root fungal associations in plant species of shoal forests. When compare to other ecosystems, shoals are poorly explored for AM fungal distribution. In shoals of Western Ghats region, 29 plant species has been studied for AM fungal association (Bagyalakshmi et al., 2010). The root fungal associations of 107 medicinal and aromatic plant species have been assessed in Western Ghats region (Muthukumar et al., 2006). Six plant species in shoal forest of Velliangiri hills, Western Ghats, Southern India, has been examined for AM fungal association and spore numbers (Muthukumar et al., 2018). Mycorrhizal status of sixteen epiphytic and terrestrial ferns has been explored from Kodaikanal Hills of Southern India (Raju et al., 1995). Arbuscular mycorrhizal association of 60 ferns and lycophytes were observed from Palni hills, Western Ghats region southern India (Muthukumar rt al., 2014). These studies insist that the importance of mycorrhizal research which deserves much attention is the investigation of more plant species for their mycorrhizal status. In addition, the

results of this investigation are primarily used for revegetation programs in shoal forest. The seasonal dynamics of AM fungi is essential to quantify the functioning and ecological significance of AM in natural ecosystems. Therefore the present investigation was carried out to report the incidence and the types of AM association in shola plant species.

2.MATERIALS AND METHODS

Study site

The characteristic of the study sites (Kodaikanal' longitude 77° 26' to 77° 33' E and latitude 10° 12' to 10° 15'N, altitudes ranging from 360m – 2550m, annual rainfall 1300 mm, temperatures 13 to 24°C in summer and winter ranged from 7 to 16°C.

Sampling

Roots were collected from five individuals at different stages of growth (vegetative and reproductive). Care was taken during collection that roots of shrubs and tree species could be positively identified. For this reason, samples of herbs were usually made by uprooting the plants. Roots were washed and stained within 24h or preserved in formalin acetic acid-alcohol (5:5:90; V/V) (FAA) before staining.

Preparation of roots and AM assessment

Fixed roots were washed free of formalin acetic acid alcohol. The roots were cut into 1-cm fragments and cleared in 2.5% KOH (Koske and Gemma 1989). Then acidified with 5 N HCl and stained with trypan blue (0.5% in lactoglycerol) overnight. Roots that remained dark after clearing were bleached in alkaline H_2O_2 prior to the acidification. The stained roots were examined with a compound microscope (X 200–400) for AM fungal structures and the percentage of root length colonization was estimated according to the magnified intersection method (Mc Gonigle et al. 1990). In addition, the number of hyphae, arbuscule and vesicle intersections were noted. It was thus possible to quantify both the root length colonized by AM structures and total root length colonization. Only species in which arbuscules found were considered to have arbuscular mycorrhizae.

AM fungal morphology

The AM-morphology was classified as *Arum*- or *Paris*-type based on whether the fungal hyphae were present mainly as hyphae running through intercellular spaces or within cells as coils respectively following descriptions of Dickson (2004). Since we examined whole and squashed roots, we could not reliably distinguish among the intermediate sub-type morphologies as described and classified by Dickson (2004). However, wherever the parallel running hyphae were seen intracellular, the morphology was designated as the Intermediate- type.

Life-history attributes and plant nomenclature

Each plant species recorded during the survey was categorized for life-form and life-cycle attributes as determined from the literature (Parin 1981a,b; Toby and Hodd 1982; Nair and Henry 1983; Henry et al. 1987,1989) or field observations. Nomenclature and authorities are as used by Nair and Henry (1983) and Henry et al. (1987, 1989).

3.RESULTS

Occurrence of AM association

Of the 71 plant species (in 35 families) examined, all the families were colonized by AM fungi except two species in a genus *Psychotria* (Table 1). AM association was observed in members of supposedly non-mycorrhizal families. Only those species which found arbuscules or arbusculate coils were considered to have AM association. The fungal entry into roots was characterized by the presence of appressorium (Plate 1). Further invasion of the roots varied depending upon the AM types.

AM morphology

Thirty four of the plant species had *Arum*-type morphology, 25 had Intermediate- type and 12 had typical *Paris*-type morphology. The *Arum*-type was characterized by the presence of intercellular hyphae, vesicles and intracellular arbuscules. Intracellular hyphal coils, arbusculate coils and intracellular vesicles characterized the *Paris*-type morphology. The Intermediate-type had intracellular hyphal coils, as well as intercellular hyphae, arbuscules / arbusculate coils and inter / intracellular vesicles (Figure 1).

AM morphology in life forms

In herbs 20 species had *Arum* type morphology, 10 had *Paris* type morphology and 14 had Intermediate type morphology. In Shrubs, 8 species had *Arum*, one species had *Paris* and 5 species had Intermediate type morphology. In Tree species 4, 1 and 6 plant species had *Arum*, *Paris* and Intermediate type morphology respectively (Figure 2).

Extent of AM association

There were large differences in the extent of AM colonization and root lengths with AM fungal structure between plant species. Total root length colonization (%RLTC) ranged from 25.84 % (*Commelina benghalensis*, Commelinaceae) to 95.14% (*Impatiens campanulata*, Balsamiaceae) and varied significantly among plant species ($F_{70,213}$= 44.49; P<0.001)(Figure 3). The percentage root length with inter or intracellular hyphae (%RLH) ranged from 3.96% (*Oxalis ausensis*, Oxalidaceae) to 43.23% (*Halorrhena antidysenterica*, Apocynaceae) and varied significantly amoung plant species ($F_{410, 213}$ = 55.38; P<0.001). Similarly percentage root length with hyphal coils (%RLHC) ranged from 1.13 % (*Justicia tranquebariensis*, Acanthaceae) to 33.55% (*Eragrostis nigra*, Poaceae) and varied significantly amoung plant species ($F_{70,213}$ = 68.86; P<0.001). In colonized plants, percentage root length with arbuscules (%RLA) ranged from 1.67% (*Hybanthus enneaspermus*, Violaceae) to 24.08% (*Curculigo orchioides*, Amaryllidaceae) and varied significantly among plant species ($F_{70, 213}$ = 35.55; P<0.001). The percentage root length with vesicles (%RLV) ranged from 0.42% (*Anaphalis lawii*, Asteraceae) to 26.81% (*Impatiens campanulata*, Balsamiaceae) and varied significantly among plant species ($F_{70,213}$ = 54.15; P<0.001). The percentage of root length with arbusculate Coils (%RLAC) ranged from 1.67% (*Echinocola colona*, Poaceae) to 22.67% (*Anaphalis lawii*, Acanthaceae) and varied significantly among plant species ($F_{70,213}$ = 17.13; P<0.001) (Table 1).

Table 1. Extent of arbuscular Mycorrhizal (AM) fungal colonization and spore numbers in plant species of shola forests of Kodaikanal.

	% Colonization					
Family/Plant species	**RLH**	**RLV**	**RLA**	**RLAC**	**RLHC**	**RLTC**
Acanthaceae						
Justicia adhatoda	25.15 ± 1.66	20.13 ± 1.26	15.80 ± 0.59	6.92 ± 1.26	2.52 ± 0.63	50.60 ± 4.00
Justicia txanquebariensis	19.77 ± 1.13	14.12 ± 0.56	12.43 ± 1.49	1.69 ± 0.98	1.13 ± 1.13	35.40 ± 4.34
Rungia repens	27.83 ± 0.16	19.26 ± 0.54	12.47± 0.77	3.89 ± 1.31	2.75 ± 0.97	47.26 ± 2.18
Thunbergia fragrans	8.52 ± 1.19	2.92 ± 0.97	11.27 ± 0.64	6.76 ± 1.21	22.94 ± 1.12	52.41 ± 2.49
Acorus calamus	7.64 ± 2.67	0.00 ± 0.00	2.31± 0.55	4.32 ± 0.62	25.34 ± 1.82	39.61 ± 2.84
Amaranthaceae						
Achyranthus aspera	26.54 ± 0.70	20.77 ± 0.16	18.46 ± 0.68	11.53 ± 0.09	10.38 ± 0.08	66.94 ± 0.52
Aerva lanata	26.94 ± 1.29	18.64 ± 1.40	12.30 ± 0.61	6.08 ± 1.30	3.84 ± 1.00	49.50 ± 3.51
Amaryllidaceae						
Curculigo orchioides	12.45 ± 1.22	0.00 ± 0.00	24.08 ± 0.84	8.64 ± 0.97	2.46 ± 0.61	47.63 ± 2.00
Annonaceae						
Annona squamosa	28.27 ± 1.84	20.25 ± 1.26	8.86 ± 0.73	7.60 ± 1.27	8.02 ± 1.12	53.12 ± 1.50
Apiaceae						
Centella asiatica	3.48 ± 0.59	4.86 ± 1.48	15.68 ± 1.94	6.92 ± 2.18	21.31 ± 1.47	52.25 ± 4.59
Apocynaceae						
Cascable thevetia	36.21 ± 4.34	19.54 ± 1.15	10.92 ± 0.58	3.45 ± 1.99	1.72 ± 0.00	52.29 ± 4.49
Holarrhena antidysenterica	43.23 ± 1.38	10.42 ± 2.27	8.34 ± 2.60	6.25 ± 1.80	7.81 ± 3.25	66.71 ± 4.58
Aristolochiaceae						
Aristolochia bracteolata	27.68 ±0.23	19.16 ± 0.53	12.42 ± 0.90	5.02 ± 0.73	2.72 ± 0.94	48.15 ± 2.27
Aristolochia indica	31.22 ± 0.25	22.77 ± 0.57	12.66 ± 0.79	9.69 ± 0.78	8.02 ± 0.48	61.76 ± 0.90
Asclepiadaceae						
Gymnema sylvestre	31.75 ± 1.19	18.31 ± 0.85	12.18 ± 0.55	10.15 ± 0.72	6.52 ± 0.50	60.76 ± 1.01
Asteraceae						
Anaphalis lawii	11.10 ± 0.74	0.42 ± 0.42	15.78 ± 1.69	22.76 ± 2.49	25.41 ± 2.14	75.47 ± 0.49

Ageratum conyzoides	8.64 ± 0.50	6.05 ± 0.95	21.29 ± 3.09	8.18 ± 0.31	4.83 ± 1.45	48.99 ± 2.07
Balsamiaceae						
Impatiens campanulata	38.23 ± 0.47	26.81 ± 0.93	9.27 ± 0.43	2.92 ± 0.21	17.91 ± 0.44	95.14 ± 0.39
Begoniaceae						
Begonia malabarica	8.52 ± 0.59	5.29 ± 0.55	4.36 ± 0.59	5.76 ± 1.84	29.26 ± 1.25	53.18 ± 3.65
Caesalpinaceae						
Cassia fistula	30.80 ± 0.42	22.78 ± 0.73	13.08 ± 0.42	9.70 ± 0.84	8.01 ± 0.42	61.74 ± 1.43
Delonix regia	25.15 ± 1.66	20.13 ± 1.26	15.80 ± 0.59	6.92 ± 1.26	2.52 ± 0.63	50.60 ± 4.00
Cleomaceae						
Cleomy gynandra	26.65 ± 1.63	21.42 ± 1.08	17.28 ± 0.15	10.84 ± 0.07	7.51 ± 1.10	62.65 ± 0.69
Combretaceae						
Terminalia arjuna	21.82 ± 0.34	9.86 ± 0.70	7.02 ± 0.57	3.50 ± 0.67	3.65 ± 0.76	36.25 ± 1.87
Commelinaceae						
Commelina benghalensis	15.34 ± 2.26	9.65 ± 0.52	6.31 ± 1.06	2.08 ± 0.10	2.08 ± 0.10	25.84 ± 2.00
Convolvulaceae						
Evolvulus alsinoides	27.95 ± 1.71	14.63 ± 1.01	10.35 ± 0.75	5.33 ± 1.09	2.75 ± 0.57	46.56 ± 1.70
Ipomoea batatas	5.15 ± 1.19	0.00 ± 0.00	22.38 ± 0.45	8.18 ± 0.32	3.80 ± 1.37	39.51 ± 1.30
Cucurbitaceae						
Mukia leiosperma	14.97 ± 1.58	2.89 ± 0.94	19.51 ± 0.53	6.31 ± 0.89	8.53 ± 0 55	52.21 ± 2.81
Euphorbiaceae						
Acalypha indica	26.38 ± 0.49	22.18 ± 0.04	17.62 ± 0.94	12.64 ± 0.52	10.21 ± 0.16	66.90 ± 0.40
Euphorbia hirta	29.88 ± 2.97	22.43 ±0.13	12.92 ± 0.95	10.22 ± 1.70	8.07 ± 0.63	61.30 ± 0.81
Jatropha gossypiifolia	25.18 ± 0.88	15.24 ± 0.78	11.89 ± 1.02	3.29 ± 0.63	3.32 ± 0.68	43.92 ± 0.93
Phyllanthus amarus	27.41 ± 0.95	20.77 ± 0.16	18.46 ± 0.68	11.48 ± 0.08	10.38 ± 0.08	67.76 ± 0.38
Phyllanthus maderaspatensis	28.25 ± 1.61	23.26 ± 2.81	8.85 ± 0.67	7.16 ± 1.51	8.04 ± 1.21	52.71 ± 1.67
Labiatae						
Leonotis nepetiifolia	29.33 ± 0.77	13.33 ± 0.77	12.00 ± 0.77	12.00 ± 0.77	11.11 ± 1.18	64.84 ± 1.63

Leucas aspera	29.21 ± 0.78	14.60 ± 0.71	11.94 ± 0.72	11.51 ± 0.91	10.61 ± 0.73	63.52 ± 0.74
Plectranthus caninus	4.11 ± 1.07	0.00 ± 0.00	30.89 ± 1.68	13.46 ± 0.59	4.81 ± 1.12	53.26 ± 1.85
Malvaceae						
Abutilon indicum	28.28 ± 0.51	18.18 ± 1.51	14.65 ± 0.50	5.56 ± 1.01	3.54 ± 1.33	52.47 ± 2.68
Sida acuta	33.41 ± 2.26	19.21 ± 0.39	12.55 ± 0.39	10.20 ± 0.39	7.06 ± 0.68	63.44 ± 1.71
Sida cordifolia	28.07 ± 1.68	12.17 ± 0.27	10.42 ± 0.38	3.43 ± 0.94	2.86 ± 0.46	44.93 ± 0.33
Mimosaceae						
Mimosa pudica	28.87 ± 0.73	17.61 ± 1.35	14.45 ± 1.03	6.44 ± 1.01	4.29 ± 0.59	54.26 ± 2.38
Prosopis cineraria	25.45 ± 1.05	12.73 ± 1.82	6.66 ± 0.61	3.03 ± 0.61	1.21 ± 0.61	36.57 ± 1.07
Acacia pinnata	27.10 ± 1.77	19.83 ± 1.50	12.40 ± 0.94	4.50 ± 0.50	4.52 ± 1.13	48.90 ± 3.99
Myrtaceae						
Syzygium cumini	25.44± 0.69	13.30 ± 1.43	7.61 ± 0.95	2.38 ± 0.40	1.92 ± 0.09	37.37 ± 0.99
Nyctaginaceae						
Boerhavia diffusa	24.71 ± 0.15	12.26 ± 1.26	6.49 ± 0.63	2.91 ± 0.52	1.77 ± 0.07	35.90 ± 0.09
Oxalidaceae						
Biophytum intermedium var. pulneyensis	43.72± 2.04	9.21 ± 0.62	0.64 ± 0.04	5.09 ± 0.17	8.43 ± 0.29	67.09 ± 2.48
Oxalis ausensis	3.96 ± 0.94	5.86 ± 1.76	34.75 ± 2.76	5.51 ± 1.01	5.44 ± 0.63	55.51 ± 5.62
Papilonaceae						
Desmodium triflorum	27.83 ± 0.16	19.20 ± 0.48	12.47 ± 0.77	3.89 ± 1.31	2.75 ± 0.97	47.26 ± 2.18
Indigofera tinctoria	25.29 ± 1.36	13.87 ± 2.33	8.83 ± 1.59	3.16 ± 0.62	1.90 ± 0.02	39.18 ± 3.45
Acacia melanoxylon	10.50 ± 1.01	3.38 ± 0.55	1.94 ± 1.36	4.65 ± 1.19	38.49 ± 2.25	58.96 ± 3.94
Passifloraceae						
Passiflora leschenaulti	22.63 ± 4.03	14.76 ± 1.39	17.60 ± 2.17	16.87± 1.20	8.81 ± 0.86	80.67 ± 3.78
Poaceae						
Bambusa bambos	28.95 ± 0.76	13.16 ± 0.76	11.84 ± 0.76	11.74 ± 0.85	10.87 ± 1.18	63.79 ± 1.99
Cynodon dactylon	27.26 ± 0.63	16.17 ± 1.31	10.37 ± 0.37	3.90 ± 0.10	2.57 ± 0.57	44.29 ± 1.08
Echinochloa colona	19.44 ± 0.56	15.55 ± 1.47	14.44 ± 2.42	1.67 ± 0.96	1.67 ± 0.96	37.54 ± 2.95

Setaria verticillata	32.54 ± 0.40	21.72 ± 3.28	13.09 ± 0.69	9.52 ± 0.69	7.54 ± 0.79	62.94 ± 1.95
Eragrostis nigra	2.50 ± 0.66	1.85 ± 0.33	2.63 ± 0.62	2.31 ± 0.32	33.55 ± 2.15	42.84 ± 3.04
Polygonaceae						
Polygonum glabrum	7.49 ± 1.08	0.00 ± 0.00	1.78 ± 0.34	4.49 ± 1.07	31.13 ± 2.19	44.89 ± 3.22
Rubiaceae						
Hedyotis puberula	27.41 ± 0.95	20.77 ± 0.16	18.46 ± 0.68	11.54 ± 0.09	10.38 ± 0.08	67.82 ± 0.35
Lacianthus acminatus	42.60 ± 1.10	3.12 ± 0.11	6.22± 0.25	10.32 ± 0.45	9.43 ± 0.52	71.69 ± 0.51
Psychotria octosulcata	13.33 ± 0.48	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	13.33 ± 0.48
Psychotria nilgriensis var. astephana	23.21 ± 0.26	2.63 ± 0.20	1.92 ± 0.11	0.00 ± 0.00	4.44 ± 0.47	32.20 ± 0.69
Psychotria nilgiriensis	8.67 ± 0.25	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	8.67 ± 0.25
Lasianthus attenuatus	23.04 ± 1.10	2.64 ± 0.12	0.00 ± 0.00	0.65 ± 0.07	1.31 ± 0 .09	27.64 ± 1.05
Morinda tinctoria	29.66 ± 0.43	19.55 ± 0.45	14.88 ± 1.03	5.28 ± 1.33	4.17 ± 0.99	54.33 ± 2.54
Rutaceae						
Toddalia asiatica	10.27 ± 1.33	0.00 ± 0.00	22.53 ± 4.16	17.94 ± 2.48	22.76 ± 2.30	73.51 ± 6.99
Sapindaceae						
Cardiospermam helicacabum	7.27 ± 0.42	3.51 ± 0.72	2.16 ± 0.55	8.31 ± 1.29	26.60 ± 1.28	47.84 ± 1.21
Solanaceae						
Solanum pubescens	30.87 ± 0.33	22.06 ± 0.73	16.20 ± 1.00	9.11 ± 0.99	6.36 ± 0.39	62.67 ± 1.48
Solanum giganteum	13.88 ± 1.66	8.87 ± 2.17	23.40 ± 1.52	6.42 ± 0.67	1.19 ± 0.14	53.75 ± 2.07
Urticaceae						
Elatostema sessile	26.67 ± 0.54	0.67 ± 0.09	0.00 ± 0.00	0.00 ± 0.00	6.00 ± 0.79	33.34 ± 1.03
Verbenaceae						
Clerodendrum phlomides	21.10 ± 0.59	15.16 ± 1.03	13.16 ± 0.82	2.97 ± 0.50	2.36 ± 0.46	39.75 ± 1.44
Lantana camara	28.27 ± 1.84	20.25 ± 1.26	8.86 ± 0.73	7.60 ± 1.27	8.02 ± 1.12	53.12 ± 2.15
Lippia javanica	10.71 ± 0.88	4.68 ± 1.39	13.61 ± 1.91	5.81 ± 1.90	1.76 ± 0.23	36.57 ± 1.54
Violaceae						
Hybanthus enneaspermus	6.20 ± 0.88	3.41 ± 0.60	1.67 ± 0.39	2.98 ± 0.99	29.10 ± 1.12	43.36 ± 0.71

4.DISCUSSION

AM fungi colonize the roots of most land plants, where they facilitate mineral nutrient uptake from the soil in exchange for plant assimilated carbon. Though about 80% of the land plants are assumed to form AM association only slightly over 10,000 plant species i.e. around 3% of the known plant species have been examined for AM association (Wang and Qui, 2006). In recent years more information has been gathered regarding the mycorrhizal status of plants in natural ecosystems (Muthukumar *et al*., 2006; Tanumi Fuman and Monoranjan Ghose, 2008). In particular, there is evidence that AM fungi are common in plant groups once considered as non-mycorrhizal (Muthukmar *et al*., 2004; Radhika and Rodrigues, 2007). This study was intended to generate more information on the occurrence of AM fungal association in Shola plant species.

The incidence of mycorrhiza (97%) in plant species of Shola forest was higher than those reported for angiosperms by Trappe (1987) and Wang and Qui (2006). Seventy percent of the 6,500 angiosperms indexed by Trappe (1987) and 80% of the 2,964 angiosperms listed by Wang and Qui (2006) were mycorrhizal. The higher mycorrhizal incidence of angiosperms in the present study could be attributed to the low nutrient status of the soils along with high plant competition. Non-mycotrophy was low (3%) in this study compared with reports from other vegetation types worldwide (Zhao *et al*, 2001; Muthukumar *et al*., 2003). The phenomenon of non-mycotrophy is often associated with high levels of disturbance, or under extreme environmental conditions, the low incidence of non-mycotrophy in the present study is not surprising. However, plants that lacked mycorrhizae belonged to Commelinaceae, Cleomaceae and Convolvulaceae are reported as mycorrhizal plant families (Wang and Qui, 2006).

Surveys of earlier literature showed that *Paris* type colonization occurs more predominantly in wild angiosperms (Menoyo *et al*., 2007). In the present study, 35% (25/71) of mycorrhizal plant species had Intermediate-type of AM morphology and typical *Paris*-type morphology occurred only in 17% of the mycorrhizal species and 48% of the shoal species had *Arum*- type AM morphology. It has been shown that host plants control the morphological types of AM. Gerdemann (1965) demonstrated that the same species of AM fungi formed the *Paris*-type in *Liriodendron* and *Arum*- type in maize, respectively. Likewise, Jacquelinet – Jeanmougin and Gianinazzi – Pearson (1983) showed that the *Paris*- type in *Gentiana* was formed by the same fungus which formed the *Arum*- type in *Allium*. Brundrett and Kendrick (1990) suggested that the types of AM are determined by the presence of continuous longitudinal air-spaces in the root cortex, i.e. the Arum- type is formed in their presence and the *Paris*-type is formed in their absent. However, even though the fungal identity could determine the morphological types of AM in some cases, it still seems likely that only a single type is found in a plant in most cases, which indicates the morphological types of AM depend on the characteristics of plants rather than those of fungi (Yamato and Iwasaki, 2002).
In conclusion, AM fungal association was found to be wide spread in the plant species of shoal forests of Kodaikanal Hills, Western Ghats region. AM fungi can enhance root functions of native plants in natural ecosystems, where they are exposed to extreme competition. The future phase of this study is to entail experimental studies of these rare and economically important plant species to determine the effects of fungal inoculants on growth to restoration of shoal species in forestry.

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