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Cover: A male Scarlet Skimmer perching on vegetation by the banks of a waterbody. Ink and watercolour illustration by Anandita Pascal.

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Restoring biodiversity: case studies from two sacred groves of Kozhikode District, Kerala, India

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Abstract: Floristic studies were conducted at Mannur Shiva Temple (MST) and Vadayil Kavu (VDK), two eco-restoration sites (*Pachathuruthu*) established by the Haritha Keralam Mission of the Government of Kerala in the sacred groves of Kadalundi Grama Panchayath, Kozhikode District, Kerala, India. A total of 171 plant species were identified from both the study areas, of which 41 were found in both sites. Most of these plants were Indo-Malesian in distribution. Tropical American or Pantropical distribution came in second and third. There were 45 medicinal plants and 25 endemics in MST, compared to 49 medicinal plants and nine endemics in VDK. About 25 species reported from MST, and 17 from VDK were not represented in the published Flora of Calicut. All these indicate the conservation importance of the area. The importance of conducting comprehensive biodiversity research, continuous monitoring, need for maintenance, and expansion of these eco-restoration zones, and the conservation value of such "Pachathuruthu" are also discussed.

Keywords: Conservation, eco-restoration sites, floristic studies, Haritha Keralam Mission, Kadalundi, Mannur Shiva Temple, Pachathuruthu, Vadayil Kavu.

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INTRODUCTION

Biodiversity is important for a variety of reasons, including enhancing the aesthetic value of the natural environment and advancing our material well-being through utilitarian values by supplying food, fuel, fodder, lumber, medicine, and other resources (Rawat & Agarwal 2015). Effective conservation of biodiversity is essential to the survival of humans and environmental processes (Paoli et al. 2010). Due to human activity, thousands of species are in danger of becoming extinct. Future population growth and economic prosperity are expected to push extinction to previously unheard-of levels (Tilman et al. 2017). Future extinction rates will be ten times higher than present rates if every species currently classified as threatened goes extinct during the next century (Pimm et al. 1995). In this context, ecological restoration is becoming increasingly popular worldwide.

Ecological Restoration and The 'Pachathuruthu' Project of Kerala State

The UN General Assembly in New York announced in 2019, that the years 2021–2030 will be known as the "UN Decade on Ecosystem Restoration" (Waltham et al. 2020; Singh et al. 2021). The goal of this call to action is to raise awareness of the urgent need to combat climate change, restore damaged ecosystems worldwide at a dramatically accelerated pace, improve food security, ensure clean water, and safeguard the planet's biodiversity. The Haritha Keralam Mission formed by the Kerala Government has also launched an ecological restoration initiative known as 'Pachathuruthu' which translates to 'Green Islands' (In Malayalam: Pacha = green, thuruthu = island).

In addition to creating and maintaining natural biodiversity groves by incorporating distinctive trees and native flora, the Pachathuruthu project seeks to identify and preserve arid areas, especially those found in public spaces. It is implemented with the cooperation of local self-governing bodies, several government funded schemes, various government departments, environmental organizations, educational institutions, and people's representatives.

This project is planned to be implemented in 500 acres of land spread across 250 village panchayats. Saplings of indigenous trees and plants are planted in fallow lands and vacant spots available in public places, which are identified by the local bodies (Seema 2019, 2020). According to government records, a total of 3,551 Pachathuruthu have been established across the State of Kerala by November 2024, covering about 1,073 acres of land to date (https://nkp.kerala.gov.in, https://haritham.kerala.gov.in).

In Kozhikode District, there are 224 Pachathuruthu which are spread over a total area of 54.92 acres (2,22,253 m^2). Among these, there are big Pachathuruthu areas such as Navodaya Vidyalayam (Maniyoor), Devaharitham 1 (Kodiyathur), Devaharitham 2 (Mavooor), and Kallikkunnu (Kozhikode corporation) which have an area of 200 cents (~8,100 m^2) to small areas such as Ormmathuruth (Valayam), Payimbra school (Kuruvattoor), and Makkootam (Kunnamangalam) which have only one cent (40.5 m^2) area. Some of these conservation areas are located in well protected sacred groves, which are patches of forests preserved by communities as sanctified natural spaces, often associated with spiritual beliefs and cultural traditions (Seema 2020). After the establishment of various Pachathuruthu areas in Kerala (mostly in 2019), only a single survey was conducted to evaluate their status. In Kozhikode District, this survey was conducted in February 2021 during the COVID period by the author himself, as per the request of the Haritha Keralam Mission. Since it was summer, the majority of the herbaceous and other ephemeral plants were either in the dried or dead condition. Hence, a comprehensive picture of the biodiversity was lacking in the report published after the survey by the Government of Kerala (Seema 2022).

It was in this context, this study was planned to cover both the monsoon and winter seasons, so that the paucity of the information is resolved. Moreover, this study conducted in two sacred groves where eco-restoration is done, will help to bring out the biodiversity potential of these areas. If such studies are carried out in all the Pachathuruthu areas of the state, they will yield good information on these ecorestoration areas, thereby helping the authorities to plan environmentally sustainable policies and programmes for their conservation and management.

Study Area

Both the Pachathuruthu areas where the studies were conducted are located in the Kadalundi Gram Panchayat of Kozhikode District, Kerala State, India. The panchayat is situated in a coastal zone, facing the Arabian Sea on the west and Kadalundi River on the south. It has an area of 11.83 km^2. According to the 2011 census, the population of the panchayat is 42,516 (Ref: https://dop.lsgkerala.gov.in).

Mannur Siva Temple Pachathuruthu (Image 1)

Established on 25 September 2019, it consists of 20 cents of land and is situated in the Ward – 6 (Vadakkumbad ward) of the Panchayat. The site is located at the entrance of the Mannur Shiva temple, on its left side (Image 1). This old and beautiful Shiva temple is very unique in its shape, having a sanctum sanctorum in the shape of the backside of an elephant. It is about 5 km away from the Feroke railway station and 18 km away from Karippur International Airport. It is located at an altitude of 11.58 m in the geo-cordinates of 11.152° N & 75.833° E.

About 55 seedlings of different species were planted here during 2019, at the time of its establishment. During the survey conducted by the author on 13 February 2021, a total of 37 species which included two herbs, six shrubs, three climbers, and 26 trees could be enumerated (Seema 2022).

Vadayil Kavu Pachathuruthu (Image 2)

The Pachathuruthu, which consists of 50 cents of land was established on 07 September 2020 and is situated in the Ward – 14 (Kadalundi East) of the panchayat. It is situated on the premises of the Vadayilkavu Bhagavathy temple, less than 1 km away from the Kadalundi Railway gate. Towards the south, it is bordered by the Kadalundi River with a lot of mangrove species growing in the borders. It is located at an altitude of 11.52 m in the geo-cordinates of 11.132^{0}N & 75.830^{0}E. During monsoon, the area near the shores remain flooded.

Approximately 180 seedlings of various species were planted in this area in 2020 as part of an active restoration effort, but many failed to establish due to saltwater intrusion. During the survey conducted by the author on 13 February 2021, a total of 22 species which included four herbs, two shrubs, one climber, and 15 trees were enumerated (Seema 2022).

MATERIALS AND METHODS

Several field trips were conducted to both the study areas, especially during the monsoon and winter seasons of 2022–2023 to enumerate the ephemerals and

Image 1. Mannur Siva Temple Pachathuruthu – location photos. © K. Kishore Kumar.

Image 2. Vadayil Kavu Pachathuruthu – location photos. © K. Kishore Kumar.

annuals (a tree survey during summer was conducted in 2021 also). The Haritha Keralam Mission authorities and ward members were interviewed to learn the history of the locality and to collect other relevant information regarding the planting activities done in the area. The plants were identified using the floras by Manilal & Sivarajan (1982), Sasidharan (2004), and Gamble & Fischer (1915–1936); their world distribution statuses were collected from the websites such as powo.science.kew.org, keralaplants.in, eflorakerala.com and indiabiodiversity.org. The threatened and endemic plants were evaluated using publications such as Henry et al. (1979), Ahmedulla & Nayar (1987), Basha & Nair (1991), Karunakaran et al. (1991), and online information systems like Environmental Information System (ENVIS). The medicinal plants were analyzed using Neshamani (1985) and Sasidharan (2011).

RESULTS AND DISCUSSION

Altogether a total of 171 species of angiosperms, one gymnosperm, and seven pteridophytes were enumerated from both the study areas (Table 1). The species are tabulated in the alphabetical order of family and species names, and their presence in the study areas is indicated by an asterisk (*) mark. The phenology and world distribution of the species is also provided. The study areas, Mannur Siva Temple Pachathuruthu and Vadayil Kavu Pachathuruthu are abbreviated as MST and VDK respectively. Other abbreviations used in the table are H—Herb, S—Shrub, T—Tree, C—Climber, M—Medicinal, E—Endemic, TTY – Throughout the year, MST—Mannur Siva Temple Pachathuruthu, and VDK—Vadayil Kavu Pachathuruthu.

Habit and Family Status

At Mannur Siva Temple Pachathuruthu (MST), 59 species of herbs, 18 shrubs, 15 climbers, and 34 small or medium trees could be enumerated. At the same time, at Vadayil Kavu Pachathuruthu (VDK), there were 36 species of herbs, 11 shrubs, 10 climbers, and 29 small or medium trees.

At MST, there were 126 flowering plant species, which belonged to 118 genera under 52 families. There were 105 dicots and 21 monocots. The most dominant dicot family was Fabaceae, represented by 12 species, followed by Asteraceae (11), Poaceae (10), and Euphorbiaceae (7), while the most dominant genera were *Lindernia*, *Blumea, Dioscorea, Leucas, Phyllanthus, Spermacoce,* and *Terminalia*. Among the monocots, there were eight families, the dominant ones being Poaceae (10 spp.), Araceae (3 spp.), and Commelinaceae (2 spp.). There were five pteridophyte species and one gymnosperm species (*Cycas circinalis*) also.

At VDK, 86 flowering plant species (61 dicots and 25 monocots) could be enumerated, which belonged to 81 genera under 37 families. The most dominant family was Poaceae, represented by 12 species, followed by Fabaceae (9), Asteraceae (7), and Euphorbiaceae (4), while the most dominant genera were *Terminalia*, *Clerodendrum, Cyperus* and *Eragrostis*. Two pteridophyte species (*Stenochlaena palustri* and *Acrostichum aureum*) could also be enumerated.

Distributional Status of The Species and Endemism

At MST, the majority of the plants studied exhibited Indo-Malesian distribution (25 nos. / 20% of the total). Sixteen species (12.7%) had tropical American distribution and 13 (10.3%) species showed pantropical distribution.

At VDK also, the majority of the plants exhibited Indo-Malesian distribution (20 nos. / 23% of the total). Ten species (11.6%) had pantropical distribution and eight (9.3%) species showed tropical American distribution. For details see Tables 1 & 2.

At MST, out of the total 126 species, 25 were endemics. Three species were endemic to India (*Dipteracanthus prostratus, Dioscorea alata*, & *Olea dioica*), while seven species had an extended distribution to Sri Lanka. About six species had distribution extending from Peninsular India to Sri Lanka. While four species had distribution restricted to the Western Ghats, another three endemic species were found only in the southern Western Ghats region.

At VDK, out of the total 86 species, nine were endemics. One species was found endemic to India (*Olea dioica*), while six species had an extended distribution to Sri Lanka. The wild orchid *Bulbophyllum sterile* is a peninsular Indian endemic, while the poisonous tree *Holigarna arnottiana* is a narrow endemic, found only in the southern Western Ghats region (Ahmedullah & Nayar 1987). For details see Tables 1 & 2.

Upon comparing the list of the collected species with Manilal & Sivarajan (1982), it was found that 25 species enumerated from MST were not reported in it. Similarly, 17 species enumerated from VDK were also not represented in the flora (Table 1). These species would have been remained overlooked in this study, or may be recenty introduced to this areas.

Table 1. Details regarding the flora of Mannur Siva Temple and Vadayil Kavu Pachathuruthus.

A. ANGIOSPERMS

	Scientific name	Habit	Family	Flowering & Fruiting	World distribution	MST	VDK	Remarks
1	*Acanthus ilicifolius*	S	Acanthaceae	Dec–Jul	Indo-Malesia and Australia		*	
2	*Andrographis paniculata*	H	Acanthaceae	Mar–Dec	Peninsular India and Sri Lanka	*		M, E
3	*Asystasia dalzelliana*	H	Acanthaceae	Sep–Jan	Tropical Asia and Africa	*	*	
4	*Dipterocanthus prostratus*	H	Acanthaceae	Oct–Apr	India	*		E
5	*Justicia procumbens*	H	Acanthaceae	Jun–Dec	Indo-Malesia and Australia	*	*	NR
6	*Rhinacanthus nasutus*	S	Acanthaceae	Nov–Feb	India, Sri Lanka, Java, and Madagascar	*		M
7	*Achyranthes aspera*	H	Amaranthaceae	Oct–Mar	Pantropical	*		M
8	*Alternanthera bettzickiana*	H	Amaranthaceae	Oct–Feb	Native of tropical America; now invasive in Asia	*	*	NR
9	*Pancratium triflorum*	H	Amaryllidaceae	Mar–May	India and Sri Lanka	*		M, E
10	*Anacardium occidentale*	T	Anacardiaceae	Nov–Apr	Native of South America; now widely cultivated in Asia and Africa	*		M
11	*Holigarna arnottiana*	T	Anacardiaceae	Jan–Jul	Southern Western Ghats	*	*	M, E
12	*Alstonia scholaris*	T	Apocynaceae	Oct–Feb	Southern and southeastern Asia to Australia	*		M
13	*Cerbera odollam*	T	Apocynaceae	Jul–Nov	Indo-Malesia		*	M
14	*Ichnocarpus frutescens*	C	Apocynaceae	Aug–Mar	Indo-Malesia and Australia	*	*	M
15	*Tabernaemontana divaricata*	S	Apocynaceae	TTY	Native of southern Himalaya	*		
16	*Thevetia peruviana*	S	Apocynaceae	TTY	Native of tropical Peru, widely invasive	*		
17	*Arisaema leschenaultii*	H	Araceae	Jul–Sep	Southern Western Ghats	*		M, E, NR
18	*Colocasia esculenta*	H	Araceae	May–Oct	Pantropical	*	*	M
19	*Pothos scandens*	C	Araceae	Oct–Nov	India to Malesia and Madagascar	*	*	
20	*Areca catechu*	T	Arecaceae	TTY	Cultivated from India to the Solomon Islands and less commonly in Africa and tropical America		*	M
21	*Caryota urens*	T	Arecaceae	Jan–Apr	Indo-Malesia	*		
22	*Cocos nucifera*	T	Arecaceae	TTY	Cultivated throughout the tropic,		*	M
23	*Ageratum conyzoides*	H	Asteraceae	Aug–Dec	Pantropical	*	*	M
24	*Blumea axillaris*	H	Asteraceae	Jan–Nov	Indo-Malesia to Australia and Africa	*		
25	*Blumea oxyodonta*	H	Asteraceae	Oct–May	Indo-Malesia and southern China	*		
26	*Chromolaena odorata*	S	Asteraceae	Nov–May	Native of America; naturalised in Tropical Asia	*		
27	*Eclipta prostrata*	H	Asteraceae	TTY	Pantropical	*	*	M
28	*Elephantopus scaber*	H	Asteraceae	Jan–Oct	Pantropical	*	*	M
29	*Eleutheranthera ruderalis*	H	Asteraceae	May–Nov	Native of tropical America; now established in several Asian countries		*	NR
30	*Emilia sonchifolia*	H	Asteraceae	Jul–Dec	Tropical and subtropical Africa and Asia	*		M
31	*Sphaeranthus indicus*	H	Asteraceae	Jan–Apr	Indo-Malesia, Australia, and Africa	*		M
32	*Synedrella nodiflora*	H	Asteraceae	TTY	Native of West Indies	*		
33	*Tridax procumbens*	H	Asteraceae	TTY	Native of tropical America; now widespread throughout tropics and subtropics	*	*	
34	*Vernonia cinerea*	H	Asteraceae	TTY	Pantropics	*	*	M
35	*Sphagneticola trilobata*	H	Asteraceae	Jun–Sep	Native of tropical America		*	NR
36	*Avicennia officinalis*	T	Avicenniaceae	Apr–Nov	Indo-Malesia to Pacific Oceans		*	M
37	*Impatiens flaccida*	H	Balsaminaceae	Jul–Oct	Southern India and Sri Lanka	*		E
38	*Tecoma stans*	S	Bignoniaceae	Dec–Apr	Native of South America; now widely cultivated	*		
39	*Cleome burmannii*	H	Capparaceae	Feb–Aug	Indo-Malesia	*		

	Scientific name	Habit	Family	Flowering & Fruiting	World distribution	MST	VDK	Remarks
40	*Carica papaya*	T	Caricaceae	TTY	Native of Tropical America cultivated in the topics and subtropics	*	*	M
41	*Calycopteris floribunda*	C	Combretaceae	Jan–May	Indo-Malesia	*		M
42	*Terminalia bellirica*	T	Combretaceae	Dec–Jan	Indo-Malesia	*	*	M
43	*Terminalia catappa*	T	Combretaceae	Mar–Jan	Malaysia to northern Australia and in the tropic		*	
44	*Terminalia chebula*	T	Combretaceae	Feb–Aug	South Asia		*	M, NR
45	*Terminalia cuneata*	T	Combretaceae	Nov–Jun	India and Sri Lanka	*		M, E, NR
46	*Commelina paludosa*	H	Commelinaceae	Nov–Dec	Himalaya and India	*		NR
47	*Cyanotis arachnoidea*	H	Commelinaceae	Aug–Nov	Peninsular India and Sri Lanka	*		E, NR
48	*Connarus wightii*	S	Connaraceae	Mar–May	Western Ghats	*		E, NR
49	*Costus speciosus*	H	Costaceae	Jul–Oct	Indo-Malesia	*	*	M
50	*Cyperus iria*	H	Cyperaceae	Nov–Dec	Tropical Asia and eastern Africa; introduced in U.S.A and West Indies	*	*	
51	*Cyperus tenuispica*	H	Cyperaceae	TTY	Tropical and subtropical Africa and Asia		*	
52	*Fimbristylis dichotoma*	H	Cyperaceae	Mar –Dec	Pantropical		*	
53	*Kyllinga nemoralis*	H	Cyperaceae	Jul–Nov	Pantropical	*		M
54	*Dioscorea alata*	C	Dioscoreaceae	TTY	India	*		M, E, NR
55	*Dioscorea bulbifera*	C	Dioscoreaceae	Sep–Oct	Paleotropics	*		M
56	*Dioscorea spicata*	C	Dioscoreaceae	Aug–Dec	India and Sri Lanka		*	E, NR
57	*Elaeocarpus serratus*	T	Elaeocarpaceae	Apr–Sep	Indo-Malesia	*		NR
58	*Antidesma montanum*	T	Euphorbiaceae	Jan–Dec	Indo-Malesia and eastern Himalaya	*	*	
59	*Briedelia retusa*	T	Euphorbiaceae	Aug–Dec	Indo-Malaya	*		
60	*Euphorbia hirta*	H	Euphorbiaceae	TTY	Native of tropical America; now pantropical		*	M
61	*Macaranga peltata*	T	Euphorbiaceae	Jan–Feb	India, Sri Lanka and Andamans	*	*	M
62	*Mallotus philippensis*	T	Euphorbiaceae	Oct–Mar	Indo-Malesia and Australia	*		M
63	*Microstachys chamaelea*	H	Euphorbiaceae	Jul–Dec	Indo-Malesia to Australia	*		M, NR
64	*Phyllanthus emblica*	T	Euphorbiaceae	Jul–Feb	Throughout the tropics	*		M
65	*Phyllanthus urinaria*	H	Euphorbiaceae	Jul–Oct	Native of tropical eastern Asia; now a circumtropical weed	*		M
66	*Tragia involucrata*	H	Euphorbiaceae	Jul–Dec	India and Sri Lanka		*	M, E
67	*Saraca asoca*	T	Fabaceae	Feb–Aug	India and Myanmar	*		
68	*Bauhinia variegata*	T	Fabaceae	Sep–May	Possibly native of China; wild in sub Himalaya and India	*		NR
69	*Cassia fistula*	T	Fabaceae	Feb–Sep	Indo-Malesia	*	*	M
70	*Saraca asoca*	T	Fabaceae	Feb–Aug	India and Myanmar		*	M
71	*Abrus precatorius*	C	Fabaceae	Oct–May	Pantropical		*	M NR
72	*Centrosema molle*	C	Fabaceae	Sep–Jan	Native of America, indroduced in India	*		
73	*Dalbergia latifolia*	T	Fabaceae	Aug–Sep	Indo-Malesia		*	NR
74	*Derris trifoliata*	C	Fabaceae	Jan–Oct	Paleotropic		*	M
75	*Desmodium triflorum*	H	Fabaceae	Jul–Dec	Indo-Malesia and Australia	*		M
76	*Galactia tenuiflora*	C	Fabaceae	Oct–Feb	Indo-Malesia, Australia, and Africa	*		NR
77	*Gliricidia sepium*	T	Fabaceae	Mar–May	Native of South America; Introduced and now widely grown in India	*		
78	*Pongamia pinnata*	T	Fabaceae	Apr–Dec	Indo-Malesia	*	*	M
79	*Pterocarpus marsupium*	T	Fabaceae	Sep–Oct	India and Sri Lanka	*	*	M, E, NR
80	*Vigna umbellata*	C	Fabaceae	Oct–Dec	Indo-Malesia	*		NR
81	*Adenanthera pavonina*	T	Fabaceae	Jan–Sep	Sri Lanka, North East India, Myanmar, China Thailand and Malesia	*	*	

	Scientific name	Habit	Family	Flowering & Fruiting	World distribution	MST	VDK	Remarks
82	*Mimosa pudica*	H	Fabaceae	Jul–Jan	Native of South America; now Pantropical	*	*	M
83	*Canscora pauciflora*	H	Gentianaceae	Oct–Nov	Endemic to Western ghats	*		M, E
84	*Rhynchoglossum notonianum*	H	Gesneriaceae	Jul–Dec	South West India and Sri Lanka	*		E
85	*Curculigo orchioides*	H	Hypoxidaceae	Jun–Dec	Indo-Malesia		*	M
86	*Hyptis suaveolens*	S	Lamiaceae	Aug–Feb	Originally from America now Pantropical	*		
87	*Leucas aspera*	H	Lamiaceae	Sep–Jan	Indo-Malesia	*		M
88	*Leucas lavandulifolia*	H	Lamiaceae	Jul–Oct	Indo-Malesia and East Asia	*		M, NR
89	*Ocimum tenuiflorum*	S	Lamiaceae	TTY	Palaeotropic	*	*	M
90	*Platostoma hispidum*	H	Lamiaceae	Sep–Dec	Indo-Malesia	*		
91	*Pogostemon atropurpureus*	S	Lamiaceae	Feb–May	Southern Western Ghats	*		M, E, NR
92	*Careya arborea*	T	Lecythidaceae	Feb–Jul	Tropical Areas	*		M
93	*Asparagus racemosus*	C	Liliaceae	Jul–Aug	Paleotropical		*	M
94	*Gloriosa superba*	C	Liliaceae	Jul–Dec	Paleotropical		*	M
95	*Hugonia mystax*	C	Linaceae	Aug–Oct	India and Sri Lanka	*		M, E
96	*Strychnos nux-vomica*	T	Loganiaceae	Mar–Dec	Indo-Malesia		*	M
97	*Lagerstroemia speciosa*	T	Lythraceae	Mar–Nov	Indo-Malesia	*		M
98	*Hibiscus rosa-sinensis*	S	Malvaceae	TTY	Native of Pacific Islands; cultivated in tropical and subtropical countries	*	*	M
99	*Malvaviscus penduliflorus*	S	Malvaceae	TTY	Native of tropical America	*		
100	*Sida cordata*	H	Malvaceae	Jan–Apr	Pantropical	*		M
101	*Thespesia populnea*	T	Malvaceae	Mar–Jun	Pantropical		*	M
102	*Azadirachta indica*	T	Meliaceae	Feb–Sep	Indo-Malesia	*		M
103	*Swietenia macrophylla*	T	Meliaceae	Apr–Mar	Native of Central America		*	NR
104	*Anamirta cocculus*	C	Menispermaceae	Aug–Dec	Indo-Malesia	*	*	M
105	*Cyclea peltata*	C	Menispermaceae	Apr–May	India and Sri Lanka	*		M, E
106	*Tiliacora acuminata*	C	Menispermaceae	Apr–Dec	India, Sri Lanka, and southeastern Asia		*	M
107	*Artocarpus heterophyllus*	T	Moraceae	Nov–Apr	Widely cultivated in the tropics, origin probably southern India	*		
108	*Artocarpus incisus*	T	Moraceae	Jan–Jun	Native of Pacific Islands		*	
109	*Ficus religiosa*	T	Moraceae	Nov–Feb	Eastern Himalaya; invasive in India and neighbouring countries	*	*	M
110	*Musa paradisiaca*	H	Musaceae	TTY	Cultivated throughout the tropic		*	M
111	*Syzygium cumini*	T	Myrtaceae	Dec–Apr	Indo-Malesia	*	*	M
112	*Jasminum angustifolium*	C	Oleaceae	Nov–Mar	Peninsular India and Sri Lanka		*	M, E
113	*Jasminum malabaricum*	S	Oleaceae	Mar–Nov	Western Ghats	*		E
114	*Olea dioica*	T	Oleaceae	Nov–Apr	India	*	*	M, E
115	*Cansjera rheedei*	C	Opiliaceae	Nov–Feb	India through Malaya to Hong Kong and North Australia	*		
116	*Bulbophyllum sterile*	H	Orchidaceae	Dec –Jan	Peninsular India		*	E, NR
117	*Vanda testacea*	H	Orchidaceae	Apr–May	India, Myanmar, and Sri Lanka	*		M, NR
118	*Biophytum sensitivum*	H	Oxalidaceae	Feb–Sep	Peninsular India and Sri Lanka	*		M, NR
119	*Peperomia pellucida*	H	Piperaceae	Sep–Dec	Native of tropical America; now Pantropical	*		
120	*Piper nigrum*	C	Piperaceae	Jul–Mar	Peninsular India and Sri Lanka		*	M, E
121	*Alloteropsis cimicina*	H	Poaceae	Jul–Nov	Paleotropical		*	
122	*Axonopus compressus*	H	Poaceae	TTY	Tropics and subtropics	*		NR
123	*Bambusa bambos*	S	Poaceae	Jul–Feb	India and Sri Lanka	*		M, E
124	*Brachiaria miliiformis*	H	Poaceae	Jul–Oct	Indo-Malesia		*	NR

	Scientific name	Habit	Family	Flowering & Fruiting	World distribution	MST	VDK	Remarks
125	*Cynodon dactylon*	H	Poaceae	Mar–Oct	Tropical and warm temperate regions of the world	*	*	M
126	*Cyrtococcum trigonum*	H	Poaceae	Sep–Oct	Southeastern Asia, Sri Lanka, and Peninsular India		*	
127	*Dactyloctenium aegyptium*	H	Poaceae	TTY	Native of South America, invasive in Paleotropics	*	*	M
128	*Eleusine indica*	H	Poaceae	TTY	Pantropical	*	*	
129	*Eragrostis tenella*	H	Poaceae	Jul–Nov	Paleotropic, introduced in America		*	
130	*Eragrostis unioloides*	H	Poaceae	TTY	Southeastern Asia, India, and Africa	*	*	
131	*Isachne miliacea*	H	Poaceae	TTY	India, China, and southeastern Asia		*	NR
132	*Oplismenus burmannii*	H	Poaceae	Sep–Nov	Pantropical	*	*	
133	*Pennisetum polystachyon*	H	Poaceae	Apr–Dec	Paleotropical	*		
134	*Sacciolepis indica*	H	Poaceae	Jun–Feb	Tropical Asia, Australia and introduced in Africa and America		*	
135	*Setaria pumila*	H	Poaceae	Jul–Oct	Paleotropical	*	*	
136	*Ziziphus oenoplia*	S	Rhamnaceae	Nov–Mar	Tropical Asia and Australia. Throughout the hotter parts of India	*		M
137	*Bruguiera cylindrica*	T	Rhizophoraceae	Dec –Oct	Indo-Malesia		*	NR
138	*Carallia brachiata*	T	Rhizophoraceae	Oct–Apr	Indo-Malesia and Australia	*	*	
139	*Chassalia curviflora* var. *ophioxyloides*	S	Rubiaceae	Jul–Feb	Indo-Malesia	*	*	NR
140	*Ixora coccinea*	S	Rubiaceae	TTY	Peninsular India and Sri Lanka		*	M, E
141	*Knoxia sumatrensis*	H	Rubiaceae	Aug–Sep	Indo-Malesia and Australia	*	*	NR
142	*Mitracarpus hirtus*	H	Rubiaceae	Jul–Dec	Tropical Africa and America	*		
143	*Morinda citrifolia*	S	Rubiaceae	Jul–Nov	Indo-Malesia		*	M
144	*Oldenlandia corymbosa*	H	Rubiaceae	Apr–Sep	Pantropical	*		M, NR
145	*Spermacoce latifolia*	H	Rubiaceae	Aug–Oct	Native of tropical America; now established in tropical Africa and Asia	*		
146	*Spermacoce ocymoides*	H	Rubiaceae	Nov–Dec	Indo-Malesia and tropical Africa	*		
147	*Aegle marmelos*	T	Rutaceae	Mar–May	India and Sri Lanka; widely cultivated in South East Asia	*		M, E
148	*Zanthoxylum rhetsa*	T	Rutaceae	Mar–Nov	Indo-Malesia	*		M
149	*Santalum album*	T	Santalaceae	Nov–Dec	Peninsular India and Malesia	*		M
150	*Allophylus subfalcatus* var. *distachyus*	S	Sapindaceae	Nov–Mar	India, Bangladesh, and Indo-Malaya	*		NR
151	*Cardiospermum halicacabum*	C	Sapindaceae	Jul–Feb	Pantropical	*		M
152	*Chrysophyllum cainito*	T	Sapotaceae	Jul–Sep	Native of West Indies		*	
153	*Mimusops elengi*	T	Sapotaceae	Dec–Aug	Indo-Malesia		*	M
154	*Lindernia anagallis*	H	Scrophulariaceae	Jul–Dec	Indo-Malesia	*	*	
155	*Lindernia ciliata*	H	Scrophulariaceae	Jun–Oct	Indo-Malesia	*		
156	*Lindernia crustacea*	H	Scrophulariaceae	Aug–Nov	Africa, America, and tropical and subtropical Asia	*		
157	*Scoparia dulcis*	H	Scrophulariaceae	TTY	Native of tropical America; now pantropical	*		M
158	*Helicteres isora*	S	Sterculiaceae	Sep–Mar	Indo-Malesia, China, and Australia		*	M
159	*Melochia corchorifolia*	H	Sterculiaceae	Jul–Apr	Pantropical	*		
160	*Sterculia guttata*	T	Sterculiaceae	Sep–Mar	Indo-Malesia	*		M
161	*Grewia nervosa*	S	Tiliaceae	Aug–Apr	Tropical Asia	*		M
162	*Trema orientalis*	T	Ulmaceae	Sep–Dec	Tropical Africa, Asia, and Australia	*		
163	*Pouzolzia zeylanica*	H	Urticaceae	Aug–Dec	Tropical Asia	*	*	M

	Scientific name	Habit	Family	Flowering & Fruiting	World distribution	MST	VDK	Remarks
164	*Clerodendrum inerme*	S	Verbenaceae	Nov –Dec	Coastal India and Sri Lanka; now invasive on the shores of Myanmar, Australia, China		*	
165	*Clerodendrum infortunatum*	S	Verbenaceae	Dec–Feb	Indo-Malesia	*	*	M
166	*Gmelina arborea*	T	Verbenaceae	Jan–Jun	Indo-Malesia		*	M, NR
167	*Vitex negundo*	T	Verbenaceae	Feb–Jul	Indo-Malesia and China, cultivated in the tropics	*		M
168	*Ampelocissus indica*	C	Vitaceae	Mar–Sep	Peninsular India and Sri Lanka	*		M, E
169	*Cissus glyptocarpa*	C	Vitaceae	Apr–Oct	Peninsular India and Sri Lanka	*		E, NR
170	*Leea indica*	S	Vitaceae	Mar–Aug	Indo-Malesia, China, and Australia		*	M
171	*Zingiber nimmonii*	H	Zingiberaceae	Jul–Oct	Western Ghats	*		M, E, NR
Total number of species						**126**	**86**	

Abbreviations uses in the table: H—Herb | S—Shrub | T—Tree | C—Climber | M—Medicinal | TTY – Throughout the year | E—Endemic | MST—Mannur Siva Temple Pachathuruthu | VDK—Vadayil Kavu Pachathuruthu.

B. GYMNOSPERMS

	Scientific name	Habit	Family	World distribution	MST	VDK	Remarks
1	***Cycas circinalis***	T	Cycadaceae	Indo-Malesia and tropical eastern Africa	*		
Total number of species					**1**	**0**	

C. PTERIDOPHYTES

	Scientific name	Habit	Family	World distribution	MST	VDK	Remarks
1	***Adiantum philippense***	H	Adiantaceae	Tropics and subtropics	*		
2	***Drynaria quercifolia***	H	Polypodiaceae	Asia, Papua New Guinea, Fiji, Polynesia, and tropical Australia	*		
3	***Pteris confusa***	H	Pteridaceae	Tropics and subtropics of the world	*		
4	***Pteris quadriaurita***	H	Pteridaceae	Tropics and sub,tropics	*		
5	***Selaginella delicatula***	H	Selaginellaceae	Widely cultivated in India	*		
6	***Acrostichum aureum***	H	Pteridaceae	Tropics of the world		*	M
7	***Stenochlaena palustris***	C	Blechnaceae	Australia, Myanmar, Fiji, Malaysia, Polynesia and China		*	
Total number of species					**5**	**2**	

Phenological Status

In both the study areas, the majority of the species studied (nearly 30%) started flowering with the onset of the southwest monsoon period (June–August) and continued to bear flowers during the entire monsoon period. At MST, 25 species (~20%) started flowering during the north-east monsoon period while at VDK, 10 species (~12%) behaved like that. This shows that 40–50 % of the species start and often complete their reproductive cycles during the monsoon period before the area dries up, which highlights the importance of this study. In both areas, nearly 20% of species (mainly shrubs and tees) started flowering during the summer months and 16 species bear flowers throughout the year (Table 3).

Medicinal Uses

It is well known that out of the 5,679 documented species in Kerala, approximately 873 plants are used for various medicinal purposes (www.eflorakerala.com – 08 Nov 2024). This explains why the Ayurvedic medical system is so successful in Kerala State. It was understood that, in the Pachathuruthu areas under investigation, roughly 68 species (54% of the 126 listed) at the MST were medicinal plants (Sasidharan 2011). In the same way, 49 species (57% of the 86 species) in VDK were medicinal plants. This emphasizes how important it is to preserve these areas, when even the sacred groves face

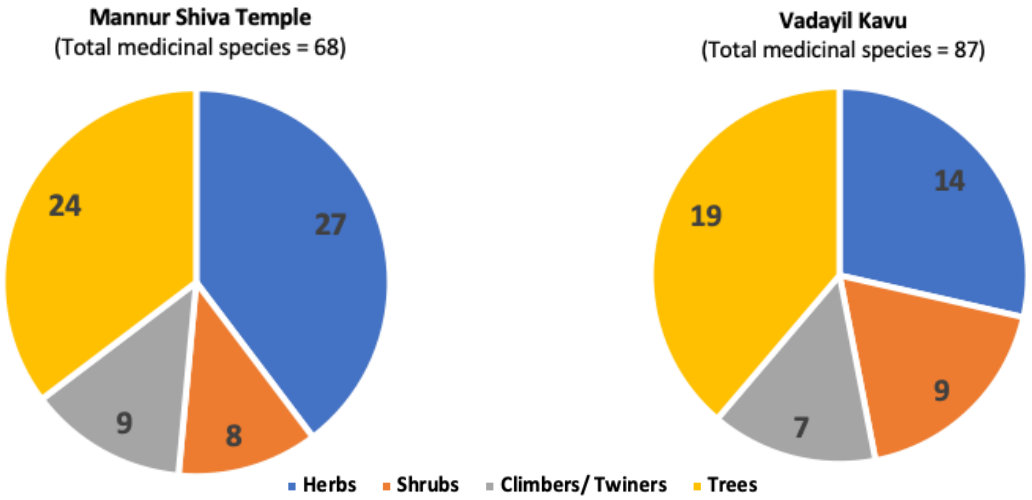

Figure 1. Habits of the medicinal plants enumerated from the two study areas.

Table 2. Distribution of the species enumerated from the two study areas.

	Mannur Siva Temple (MST)			Vadayil Kavu (VDK)		
	Distribution	**No of species**	**%**	**Distribution**	**No of species**	**%**
1	India	3	2.4	East Himalaya	1	1.2
2	India and Sri Lanka	7	5.6	India	1	1.2
3	Indo-Malesia	**25**	**19.8**	India and Myanmar	1	1.2
4	Indo-Malesia and Australia	8	6.3	India and Sri Lanka	3	3.5
5	Indo-Malesia and China	3	2.4	India to Malesia and Madagascar	1	1.2
6	Indo-Malesia to Australia and Africa	5	4.0	India, China, and southeastern Asia	2	2.3
7	Native of China	1	0.8	Indo-Malesia	**20**	**23.3**
8	Native of Himalaya	2	1.6	Indo-Malesia and Australia	6	7.0
9	Native of Pacific Islands	1	0.8	Indo-Malesia, China, and Australia	2	2.3
10	Native of tropical America	**16**	**12.7**	Native of Pacific Islands	2	2.3
11	Paleotropics	4	3.2	Native of tropical America	**8**	**9.3**
12	Pantropics	**13**	**10.3**	Paleotropics	**7**	**8.1**
13	Peninsular India and Sri Lanka	5	4.0	Pantropics	**10**	**11.6**
14	Southern and southeastern Asia to Australia	2	1.6	Peninsular India	1	1.2
15	South India and Sri Lanka	3	1.6	Peninsular India and Sri Lanka	3	3.5
16	Southern Western Ghats	3	2.4	Southeastern Asia, Sri Lanka, and Peninsular India	3	3.5
17	Throughout the tropics	3	2.4	Southern Western Ghats	1	1.2
18	Tropical Asia	2	1.6	Tropics	3	3.5
19	Tropical Asia and Africa	3	2.4	Tropical Asia	3	3.5
20	Tropics and subtropics	1	0.8	Others	8	9.3
21	Western Ghats	4	3.2			
22	Others	13	10.3			
	TOTAL	**126**	**100**	**TOTAL**	**86**	**100**

Table 3. Phenological status of the species (adapted from Sasidharan 2011).

	Flowering months/ periods	Mannur Siva Temple		Vadayil Kavu	
		No of species	%	No of species	%
1	**June–August** (South-west monsoon)	**35**	**27.8**	**26**	**30.2**
2	**September** (Light rain, mild weather)	11	8.7	4	4.7
3	**October–November** (North-east monsoon)	**25**	**19.8**	**10**	**11.6**
4	**December–January** (Winter)	13	10.3	14	16.3
5	**February–May** (Summer)	**26**	**20.6**	**16**	**18.6**
6	**Throughout the year**	16	12.7	16	18.6
	TOTAL	**126**	**100**	**86**	**100**

severe threats of destruction nowadays.

The Asteraceae and Fabaceae families had the most number of medicinal plants at MST (6 spp. each), followed by the Euphorbiaceae (5) and Lamiaceae (4). However, the Fabaceae family possessed the most medicinal plants (7 spp.) at VDK, followed by the Asteraceae (4) and Euphorbiaceae (3), demonstrating the significance of these three families in terms of their adaptability and distribution in these areas. Moreover, a good majority of these species were herbs (Figure 1), which were neglected during the earlier studies, which highlights the importance of this study (Table 1).

Biodiversity Threats and Conservation Issues

From the study conducted, it became evident that both the study areas, MST and VDK being temple premises are considered highly sacred and do not have many conservation issues. Lack of funding for maintenance poses problems in the conservation efforts at MST. As a result, numerous weeds have overtaken the area, which limit the growth of seedlings that have been planted. Even though many medicinal plants (more than 50% of the total species) are flourishing in the region, improper care by removing the so-called 'unwanted plants' ruin the diversity.

In contrast, the number of planted seedlings and other species at VDK has significantly decreased as a result of routine cleaning and maintenance operations in the temple grounds, where many devotees congregate. As this Pachathuruthu is situated on the Kadalundi River's bank, saline water intrusion during monsoon and high tides, affects the growth of the plants.

CONCLUSIONS

It was understood that the conservation of these two ecorestoration areas, MST and VDK which are rich in rare, endemic, and medicinal plants holds profound ecological and cultural significance. Such areas, especially located in sacred groves, act as vital reservoirs of biodiversity, safeguarding unique species that are often adapted to specific ecological niches and are irreplaceable in their native environments. The preservation of rare and endemic plants contributes to the resilience of local ecosystems, supporting diverse wildlife and stabilizing soil and water quality. Additionally, medicinal plants in these areas are invaluable not only for traditional healing practices but also as sources for modern pharmaceuticals, offering untapped potential for new therapeutic compounds. Protecting and restoring this biodiversity-rich area is crucial to ensure ecological balance, preserving genetic resources, and sustaining the cultural and medicinal heritage that these plants embody.

It was also understood that there is a lack of proper funding for the maintenance and development, which poses problems in the conservation of these areas. Due to the negligence in maintenance, many weeds have invaded the area, thereby restricting the growth of the planted seedlings. Improper weeding done by inexperienced labourers, may also destroy the diversity, since a lot of medicinal plants (>50%) are found growing in the area.

It also became evident that, if similar studies are carried out in all the Pachathuruthu areas of the state, covering the monsoon, winter, and summer seasons, they will yield fantastic information about these eco-restoration areas, thereby helping the authorities to plan better environmentally sustainable policies and programmes for their conservation and management.

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