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COMMUNICATION

Phytodiversity of chasmophytic habitats at Olichuchattam Waterfalls, Kerala, India

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Abstract: The present study was conducted to analyse the Phytodiversity of Chasmophytic habitats at Olichuchattam waterfalls, Kerala, India. The studies on the plants in such special type of habitats are very less. Hence the present study will help to know more about them. Field exploration and observations were made, plants were collected, identified and herbarium was prepared. Analysis of plants and soil samples from different regions of the study area based on altitudinal variations was also done. As a result of the study, a total of 120 plant species that belonging to 49 families and 93 genera were documented. Of these 5 species are bryophyte, 10 species are pteridophytes and 105 species are angiosperms. The ornamental potentiality of the plants in the study area was also analysed and it shows that a total of 47 species have ornamental potentialities. The present study also highlighted some threatening factors can affect the distribution of plants in the present study area. The present study highlights that, the rocky cliffs and crevices serves as an excellent habitat for many interesting plant groups. The plants in these habitats are very unique and are attractive.The rocky cliffs and crevices represents a good indicator of rich biodiversity within small areas.

Keywords: Floristic diversity, chasmophytes, Olichuchattam, invasive species, threats.

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Author contribution: AC—conducted the field trip, collection, Identification and compilation of various datas on chasmophytic plants in the study area. BT—planned the outline of this research work and provided necessary guidelines for the research.

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INTRODUCTION

Floristic diversity refers to the variety and variability of plants in a given region. It refers to the number of types or taxa in a given region or group. India is one of the 12 mega diversity centres of the world where the Western Ghats and the Himalayan region constitute two of the 34 biodiversity hotspots representing a storehouse of several promising economically important plants (Myers 1990). Species richness and endemism are, however, not uniformly distributed along the Western Ghats. The southernmost regions which have the most favourable climatic conditions with high, but not excessive rainfall and short dry season are the ones with the highest biodiversity and contain the highest number of endemic species (Pascal et al. 2004). Southern Western Ghats is one of the two mega endemic centres in Western Ghats (Nair & Daniel 1986; Nayar 1996). Kerala forms a major species-rich part of southern Western Ghats harbouring a total of 4,679 flowering plants (Sasidharan 2004).

The vegetation on the surface of rocks or stones are lithophytes, while the vegetation in the crevices of rocks are chasmophytes (Schimper 1898). Rock crevices form a major habitat for many plants and host rich biodiversity within a small area. The rocky habitat provides an extremely harsh physical environment for plants that leads to the development of specialized plant communities with endemic and habitat specific species. Microhabitats like rock crevices possess diverse forms of plants, which are mainly seasonal herbs. These habitats differ from each other due to changes in geographical terrain and soil cover (Porembski 2000).

Chasmophytes are plants rooted in clefts of rocks that are filled with detritus. In these clefts, particles of earth conveyed by wind and water accumulate. The amount and rate of accumulation depends upon the width and situation of the clefts (Davis 1982). The soil thus constituted facilitates plants to establish and their dead fragments further add to the supply of the nutritive material in the clefts (Bashan et al. 2002). Rocky cliffs are microhabitats which are slightly mineral rich and can support the growth and survival of many chasmophytic species. The occurrence of such habitats ultimately depends on a number of factors such as geographical location, levels of exposure, high evaporation rates, nature of soil geology, and water runoff during the rainy season (Danin et al. 1982). The chasmophytic species growing on rock crevices and cliffs have to deal with an extremely inhospitable environment. Therefore, they have developed several adjustments such as strong roots and reduced life form structure. This root system supports them on the cliffs and allows for maximum exploitation of the little water and nutrients contained in minimal soil. This habitat is also susceptible to strong winds and full sunlight, as there is no tall vegetation to protect it from these climatic factors (Binu & Rajendran 2012).

The growth of chasmophytic plants mainly depends on the availability of water and depth of soil with nutrients. The number of plants is more during the wet season than during the dry season. The rocky cliffs and crevices represent a good indicator of rich biodiversity within small areas (Binu et al. 2012). The pioneering plants such as lichens, mosses, ferns & fern allies, small herbs, and grasses grow in the weathered soil in the rock crevices and loosen the weathered particles of rocks and add an organic material to the developing soil. These plants trap water and wind-blown soil and can add soil content in the crevices. Finally, dead organic matter of such a pioneer community can add more suitable substrata for the growth of the next community (Roy et al. 1983).

The objectives of the present study were: (i) to document the chasmophytic diversity of the study area, (ii) to study the various factors affecting the growth and survival of chasmophytes in the study area, and (iii) to characterize the chasmophytic plants in the study area.

MATERIALS AND METHODS

Study Area

The study area Olichuchattam is situated in Thiruvambady Panchayath of Kozhikode District of Kerala State, India (11.435˚N & 76.079˚E; Figure 1, Image 1). Olichuchattam area comes under the jurisdiction of Vellarimala Forest Range which is a part of the Western Ghats. Most of the hill range falls in the Meppadi Forest Range of South Wayanad Division, with some parts falling in the Thamarassery Range of Kozhikode Division (Image 2–5). Olichuchattam is a waterfall of Iruvanji River situated in evergreen forests on the way to Vellarimala Hills. The hill ranges are accessible on foot from Muthappanpuzha, a small town which is about 50km from Kozhikode. By trekking for about 4–5 km (approximately three hours) one can explore the Olichuchattam Waterfalls. By trekking from Olichuchattam to the upper foothills one can explore different places like Vellarimala, Vavulmala, and Masthakappara. From the top of Olichuchattam itself one can clearly notice the changes in vegetation and the changes in the landscape because of the altitudinal

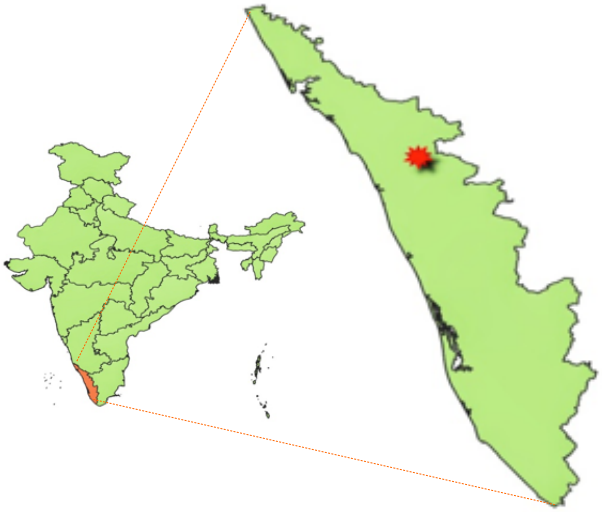

Figure 1. Map of India and Kerala State (Source: GIS)

Image 1. Satellite image of the study area (Souce: Google Map)

variations. The entire waterfall area and adjacent areas are full of wet and moist rocky patches especially in the monsoons and become dry during the summer. This characteristic habitat enables different plants to survive and adapt in a special way based on the different seasons.

Data collection and analysis

The current study was based on extensive exploration and field observations during the period September 2017–February 2018. In the present study an attempt was made to document and analyse the chasmophytic vegetation of Olichuchattam Waterfall areas of Kozhikode District, Kerala. The documentation was mainly based on field observations, discussions with local people as well as scrutinizing the literature. For effective and accurate study, the area was visited and analysed in different climatic conditions in different periods such as rainy season, winter season, and summer season. The study was mainly based on the rock crevices in nearby areas of the upper regions of the waterfalls (1,400m), near the waterfalls (1,250m), and the lower foothills of the waterfalls (700m) which showed considerable variations in their altitudes ranging 700–1,400 m.

During the field visits, the plant specimens were collected to prepare herbariums. The collected specimens were identified taxonomically with the help of available floras and literature (Gamble 1915–1936; Sasidharan 2004). The specimens were processed for the preparation of the herbarium by standard methods. The voucher specimens are deposited in the Herbaria of PG & Research Department of Botany, St. Joseph's College, Kozhikode (DEV) for future reference. Photographs of the study area in different seasons as well as the images of plants were taken. In addition to these, suitable maps, tables, figures, and images are given in appropriate places.

RESULTS AND DISCUSSIONS

Chasmophytic diversity

Results of the present study reveal 120 species (106 native species and 14 non-native species) belonging to 49 families and 93 genera documented in general (Table 1). Of these, five species are bryophytes of five families and five genera. Similarly, in pteridophytes, a total of 10 species belonging to nine families and nine genera are recorded. Angiosperms are dominant among these groups, which include 105 species that belong to 35 families and 79 genera (Table 2, Figure 2).

The dominant native chasmophytic plant families of the study area are analysed. The dominant native families are as follows, Poaceae with 15 species followed by Balsaminaceae with seven species, Asteraceae and Commelinaceae with six species each, Malvaceae and Melastomataceae with five species each, and Scrophulariaceae represented by three species (Figure 3).

Similarly, the analysis of the dominant native genera reveals that the genus *Impatiens* dominates with seven species followed by *Blumea, Cyanotis, Eriocaulon*, and *Arundinella* each with three species, respectively (Figure 4).

The analysis of the overall plant habits/growth form reveals that herbs are the dominant with 100 species,

Image 2–5. Different views of the study area. © Arun Christy.

followed by 16 species of shrubs and four species of climbers.

Distribution pattern of chasmophytic plants

The diversity and distribution of the recorded 120 chasmophytic plants in the study area reveals that there are only about 25 species which are commonly distributed. Fifty-eight species are uncommon or sporadically distributed and 37 of them are very rarely occurring in the study area. The high number of uncommon and rare plants in the study area indicates that they need very specific ecological conditions.

It was observed the distribution of the plants greatly vary with respect to the different seasons. In the monsoon season, the diversity of water loving chasmophytic plants are seen more. The taxa like *Impatiens, Sonerila, Eriocaulon, Utricularia* are dominant vegetation cover during this period. While in the summer period, fewer species survive in the area but grasses and some weedy species are seen thriving well. Also with the variations in the altitudes, the vegetation changes. Plants like *Pellaea falcata, Bolbitis appendiculata, Impatiens* sp., *Sonerila* sp., *Osbeckia* sp., *Arundinella* sp., *Pouzolzia*

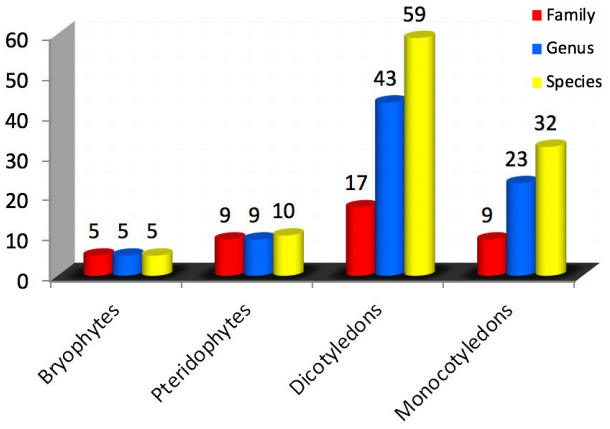

Figure 2. Floristic analysis of native chasmophytes in the study area.

Table 1. Total plant checklist of the study area.

	Botanical name	Family	Native/ Non-native
Bryophytes			
1	*Bryum argenteum* Hedw.	Bryaceae	Native
2	*Campylopus flexuosus* (Hedw.) Brid.	Dicranaceae	Native
3	*Cyathodium cavernarum* Kunze	Targioniaceae	Native
4	*Pogonatum aloides* (Hedw.) P. Beauv.	Polytrichaceae	Native
5	*Riccia crystallina* L.	Ricciaceae	Native
Pteridophytes			
1	*Adiantum raddianum* C. Presl	Adiantaceae	Native
2	*Bolbitis appendiculata* (Willd.) K. Iwats.	Dryopteridaceae	Native
3	*Drynaria quercifolia* (L) J. Sm.	Drynariaceae	Native
4	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	Native
5	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Native
6	*Parahemionitis cordata* (Roxb. *ex* Hook. & Grev.) Fras.	Hemionitidaceae	Native
7	*Pellaea falcata* (R.Br.) Fee	Pteridaceae	Native
8	*Pteridium aquilinum* (L.) Kuhn.	Dennstaedtiaceae	Native
9	*Selaginella involvens* (Sw.) Spring	Selaginellaceae	Native
10	*Selaginella tenera* (Hook. & Grev.) Spring	Selaginellaceae	Native
Angiosperms			
1	*Abelmoschus angulosus* Wall. ex Wight & Arn.	Malvaceae	Native
2	*Aeschynomene americana* L.	Fabaceae	Non-native
3	*Apluda mutica* L.	Poaceae	Native
4	*Arundina graminifolia* (D. Don) Hochr.	Orchidaceae	Native
5	*Arundinella leptochloa* (Nees *ex* Steud.) Hook. F.	Poaceae	Native
6	*Arundinella metzii*Hochst. *ex* Miq.	Poaceae	Native
7	*Arundinella pumila* (Hochst. *ex* A. Rich.) Steud.	Poaceae	Native
8	*Barleria courtallica* Nees	Acanthaceae	Native
9	*Blumea barbata* DC.	Asteraceae	Native
10	*Blumea belangeriana* DC.	Asteraceae	Native
11	*Blumea membranacea* Wall. *ex* DC.	Asteraceae	Native
12	*Bulbophyllum sterile* (Lam.) Suresh	Orchidaceae	Native
13	*Burmannia coelestis* D. Don	Burmanniaceae	Native
14	*Canscora diffusa* (Vahl) R. Br. *ex* Roem. & Schult.	Gentianaceae	Native
15	*Canscora perfoliata* Lam.	Gentianaceae	Native
16	*Christisonia tubulosa* (Wight) Benth. *ex* Hook. f.	Orobanchaceae	Native
17	*Chromolaena odorata* (L.) King & Robins.	Asteraceae	Non-native
18	*Chrysopogon hackelii* (Hook.f.) C.E.C. Fisch	Poaceae	Native
19	*Cleome burmannii* Wight & Arn.	Capparaceae	Native
20	*Cleome viscosa* L.	Capparaceae	Native
21	*Commelina benghalensis* L.	Commelinaceae	Native
22	*Commelina clavata* Clarke	Commelinaceae	Native
23	*Costus speciosus* (Koenig) J.E. Smith	Zingiberaceae	Native
24	*Crassocephalum crepidioides* (Benth.) S. Moore	Asteraceae	Native
25	*Cyanotis arachnoidea* Clarke	Commelinaceae	Native
26	*Cyanotis cristata* (L.) D. Don.	Commelinaceae	Native
27	*Cyanotis papilionacea* (Burm. f.) Schult. f.	Commelinaceae	Native
28	*Cymbopogon flexuosus* (Nees *ex* Steud.) Wats.	Poaceae	Native
29	*Cyperus tenuispica* Steud.	Cyperaceae	Native
30	*Drymaria cordata* (L.) Willd.	Caryophyllaceae	Native
31	*Emilia sonchifolia* (L.) DC.	Asteraceae	Native
32	*Eriocaulon quinquangulare* L.	Eriocaulaceae	Native
33	*Eriocaulon rhodae*Fyson	Eriocaulaceae	Native
34	*Eriocaulon xeranthemum* Mart.	Eriocaulaceae	Native
35	*Euphorbia vajravelui*Binoj. & Balakr.	Euphorbiaceae	Native
36	*Geissaspis cristata* Wight & Arn.	Fabaceae	Native
37	*Glinus oppositifolius* (L.) A. DC.	Aizoaceae	Native
38	*Hemidesmus indicus* (L.) R. Br.	Apocynaceae	Native
39	*Heteropogon contortus* (L.) P. Beauv. *ex* Roem. &Schult.	Poaceae	Native
40	*Hibiscus hispidissimus* Griff.	Malvaceae	Native
41	*Homonoia riparia* Lour.	Euphorbiaceae	Native
42	*Hyptis suaveolens* (L.) Poit.	Lamiaceae	Non-native
43	*Impatiens cordata* Wight	Balsaminaceae	Native
44	*Impatiens diversifolia* Wall. *ex* Wight & Arn	Balsaminaceae	Native
45	*Impatiens gardneriana* Wight	Balsaminaceae	Native
46	*Impatiens herbicola* Hook. f.	Balsaminaceae	Native
47	*Impatiens modesta* Wight	Balsaminaceae	Native
48	*Impatiens scapiflora* Heyne *ex* Roxb.	Balsaminaceae	Native
49	*Impatiens viscosa* Bedd.	Balsaminaceae	Native
50	*Ipomoea deccana* Austin	Convolvulaceae	Native
51	*Isachne bourneorum* C.E.C. Fisch.	Poaceae	Native
52	*Isachneglobosa* (Thunb.) O. Ktze.	Poaceae	Native
53	*Ischaemum dalzelii* Stapf *ex* Bor	Poaceae	Native

	Botanical name	Family	Native/ Non-native
54	*Isodon lophanthoides* (Buch.-Ham. *ex* D.Don) H.Hara	Lamiaceae	Native
55	*Jansenella griffithiana* (C. Muell.) Bor	Poaceae	Native
56	*Justicia japonica* Thunb	Acanthaceae	Native
57	*Knoxia sumatrensis* (Retz.) DC.	Rubiaceae	Native
58	*Lantana camara* L.	Verbenaceae	Non-native
59	*Leucas ciliata* Benth. *ex* Wall.	Lamiaceae	Native
60	*Lindernia ciliata* (Colsm.) Pennell	Scrophulariaceae	Native
61	*Lindernia crustacea* (L.) F.v. Muell.	Scrophulariaceae	Native
62	*Melastoma malabathricum* L.	Melastomataceae	Native
63	*Melochia corchorifolia* L.	Sterculiaceae	Native
64	*Merremia umbellata* (L.) Hall.	Convolvulaceae	Native
65	*Microstachys chamaelea* (L.) Muell.-Arg.	Euphorbiaceae	Native
66	*Mimosa diplotricha* C. Wight ex Sauvalle	Mimosaceae	Non-native
67	*Mimosa pudica* L.	Mimosaceae	Non-native
68	*Mitracarpus hirtus* (L.) DC.	Rubiaceae	Non-native
69	*Mollugo pentaphylla* L.	Aizoaceae	Native
70	*Murdannia semiteres* (Dalz.) Sant.	Commelinaceae	Native
71	*Naregamia alata* Wight & Arn.	Meliaceae	Native
72	*Oldenlandia corymbosa* L.	Rubiaceae	Native
73	*Osbeckia aspera* (L.) Blume	Melastomataceae	Native
74	*Osbeckia virgata* D. Don *ex* Wight & Arn.	Melastomataceae	Native
75	*Peliosanthes teta* Andr. ssp. *humilis*	Haemodaraceae	Native
76	*Pennisetum polystachyon* (L.) Schult.	Poaceae	Native
77	*Peperomia pellucida* (L.) Kunth	Piperaceae	Non-native
78	*Pilea microphylla* (L.) Liebm.	Urticaceae	Non-native
79	*Pogonatherum crinitum* (Thunb.) Kunth	Poaceae	Native
80	*Pouzolzia wightii* Bennett,	Urticaceae	Native
81	*Rotala malampuzhensis* Nair *ex* Cook	Lythraceae	Native
82	*Rungia pectinata* (L.) Nees	Acanthaceae	Native
83	*Scoparia dulcis* L.	Scrophulariaceae	Non-native
84	*Sida alnifolia* L.	Malvaceae	Native
85	*Smithia gracilis* Benth.	Fabaceae	Native
86	*Sonerila rheedei* Wight & Arn.	Melastomataceae	Native
87	*Sonerila versicolor* Wight var. axillaris	Melastomataceae	Native
88	*Spermacoce latifolia* Aubl.	Rubiaceae	Non-native
89	*Spilanthes radicans* Jacq.	Asteraceae	Non-native
90	*Stemodia verticillata* (Mill.) Sprague	Scrophulariaceae	Non-native
91	*Strobilanthes lanatus* Nees	Acanthaceae	Native
92	*Themeda sabarimalayana* Sreek. & V.J. Nair	Poaceae	Native
93	*Themeda triandra* Forssk.	Poaceae	Native
94	*Torenia bicolor* Dalz.	Scrophulariaceae	Native
95	*Tridax procumbens* L.	Asteraceae	Non-native
96	*Triumfetta annua* L.	Tiliaceae	Native
97	*Triumfetta rhomboidea* Jacq.	Tiliaceae	Native
98	*Urena lobata* L ssp. *lobata*	Malvaceae	Native
99	*Urena lobata* L. ssp. *sinuata*	Malvaceae	Native
100	*Utricularia graminifolia* Vahl.	Lentibulariaceae	Native
101	*Utricularia striatula* Smith	Lentibulariaceae	Native
102	*Vernonia cinerea* (L.) Less.	Asteraceae	Native
103	*Xenostegia tridentata* (L.) Austin & Staples	Convolvulaceae	Native
104	*Xyris indica* L.	Xyridaceae	Native
105	*Zeuxine longilabris* (Lindl.) Benth. *ex* Hook. f.	Orchidaceae	Native

Table 2. Analysis of chasmophytic diversity in the study area.

Analysis of plant diversity		Families		Genera		Species	
Bryophyta		5		5		5	
Pteridophyta		9		9		10	
Dicotyledons	**Polypetalae**	12	26	20	56	*29(3)	73
	Gamopetalae	11		30		*26(9)	
	Monochlamydae	3		6		*4(2)	
Monocotyledons		9		23		32	
Total		**49**		**93**		**120**	

*—native species | ()—Non-native species

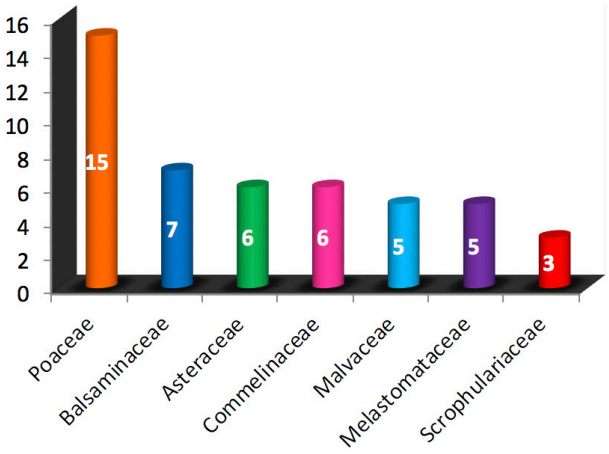

Figure 3. Analysis of dominant native families of angiosperms.

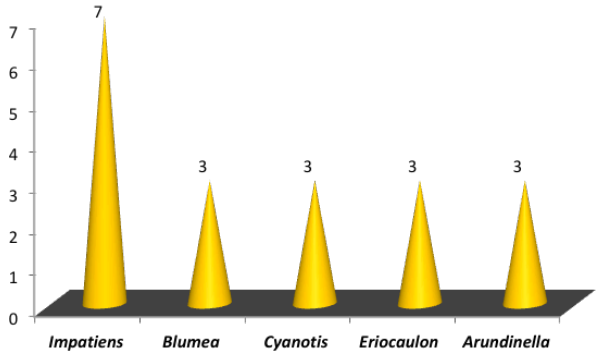

Figure 4. Analysis of dominant native genera.

wightii, Strobilanthes lanatus, Arundina graminifolia, and *Themeda* sp. are distributed in high altitude areas (1,200–1,400m).

Ornamental chasmophytes

The present study analysed that 47 species of plants have ornamental potential. Among the 47 species, four of them are pteridophytes and the rest of the 43 species are angiosperms. Of the 47 species distributed in the area, family Balsaminaceae is dominant with seven species followed by Melastomataceae and Commelinaceae with five species each, Scrophulariaceae and Convolvulaceae with three species each. Considering the ornamental potential of the plants of documented chasmophytes, 32 species have a good looking habit, seven species have attractive foliage and about 37 species have good looking flowers (Table 3). The colour of the flowers along with good looking habit of many chasmophytic plants is an aspect of ornamental potentiality, therefore, such taxa has also been identified for possible cultivation in rock gardens or rockeries for ornamental purposes (Binu et al. 2012).

Impatiens for rockery/rock gardening

Balsams or *Impatiens* are often called 'Jewel Weeds' or 'Orchid Balsams'. They are handsome plants bearing curious and variously coloured flowers. Southern Indian species of *Impatiens* have a wealth of new and ornamentally desirable flower colours like red, pink, orange, scarlet, yellow and may have different combinations of these colours. This beautiful wild flower can be seen on wet perpendicular rocks or old walls in the hills of high elevations. The balsam thrives best during monsoon months (June–September) and the best collections can only be acquired in the monsoon. Developing a normal garden for balsams will not be effective because many balsams (especially scapigerous species) cannot survive in normal greenhouses. So there is a need for a special type of gardening for balsams. Bhaskar (2012) developed special gardening methods for balsams by providing splash watering, water drippings, and shady conditions which are essential for developing the *Impatiens'* microclimate inside greenhouses (Image 6).

Invasive chasmophytes

The present study also observed that, there are 14 plant species, which are introduced from various countries as well as different regions of the world and now they are naturalized in chasmophytic habitats of the present study area. The nativity of these species includes central America, South America, tropical America, and tropical Africa (Sasidharan 2004). These species are invasive in our country and have established themselves, thereby a threat to other native flora (Table 4).

Soil analysis

Soil samples from different regions of the study area (three samples were collected based on altitudinal variations such as lower, middle, higher altitudes) were used for the soil analysis. Soil samples were analysed with the help of Indian Institute of Spices Research, Kozhikode as per the methods adopted by Jackson (1971). The parameters analysed are pH value, percentage of organic Carbon, amount of Nitrogen, Phosphorous, and Potassium and the results are presented in Table 5 (Furley 1968).

The soil analysis indicates that the rocky crevices of the lower foothills (700m) is more nutrient rich than the middle and high altitude soils. This may be due to the washing of the soil and nutrients from the high altitude areas to low altitude areas and the subsequent

Table 3. List of ornamental chasmophytes from the Olichuchattam area of Kozhikode District, Kerala.

	Botanical name	Family	Ornamental characters
Pteridophytes			
1.	*Adiantum raddianum* C. Presl	Adiantaceae	Good looking habit and attractive foliage.
2.	*Bolbitis appendiculata* (Willd.) K.Iwats.	Dryopteridaceae	Good looking habit and attractive foliage.
3.	*Pellaea falcata* (R.Br.)	Pteridaceae	Good looking habit and attractive foliage.
4.	*Selaginellainvolvens* (Sw.) Spring	Selaginellaceae	Good looking habit and attractive foliage.
Angiosperms			
1.	*Abelmoschus angulosus* Wall. ex Wight & Arn.	Malvaceae	Attractive large pink coloured flowers
2.	*Arundina graminifolia* (D.Don) Hochr.	Orchidaceae	Good looking pink/purple coloured flowers also have a good looking habit
3.	*Barleria courtallica* Nees	Acanthaceae	Attractive light blue coloured flowers.
4.	*Burmannia coelestis* D.Don.	Burmanniaceae	Attractive light pink coloured flowers.
5.	*Canscora diffusa* (Vahl) R.Br. ex Roem. & Schult.	Gentianaceae	Good looking habit
6.	*Canscora perfoliata* Lam.	Gentianaceae	Beautiful cream coloured flowers
7.	*Christisonia tubulosa* (Wight) Benth. ex Hook.f.	Orobanchaceae	Attractive purple-white tinged-yellow coloured flowers
8.	*Commelina benghalensis* L.	Commelinaceae	Beautiful blue flowers with good looking habit.
9.	*Commelina clavata* Clarke	Commelinaceae	Good looking blue coloured flowers with attractive creeping plant habit.
10.	*Crassocephalum crepidioides* (Benth.) S.Moore	Asteraceae	Good looking yellow-orange coloured flowers and also have attractive pappus hairs.
11.	*Cyanotis arachnoidea* Clarke	Commelinaceae	Attractive blue coloured flowers and also have attractive habit
12.	*Cyanotis papilionacea* (Burm.f.) Schult.	Commelinaceae	Attractive blue coloured flowers and nice habit.
13.	*Eriocaulon quinquangulare* L.	Eriocaulaceae	Attractive plant habit with good looking white headed flowers.
14.	*Eriocaulon xeranthemum* Mart.	Eriocaulaceae	Attractive plant habit with good looking white headed flowers.
15.	*Euphorbia vajravelui* Binoj. & Balakr.	Euphorbiaceae	Good looking plant habit.
16.	*Geissaspis cristata* Wight & Arn.	Fabaceae	Good looking habit, with delicate flowers and persistent fimbriate bracts
17.	*Impatiens cordata* Wight	Balsaminaceae	A good habit and pink coloured flowers.
18.	*Impatiens diversifolia* Wall. ex Wight	Balsaminaceae	Attractive pink coloured flowers.
19.	*Impatiens gardneriana* Wight	Balsaminaceae	Attractive plants with a good habit and pink coloured flowers.
20.	*Impatiens herbicola* Hook. f.	Balsaminaceae	Small attractive white coloured flowers
21.	*Impatiens modesta* Wight	Balsaminaceae	Attractive plants with rose coloured flowers.
22.	*Impatiens scapiflora* Heyne ex Roxb.	Balsaminaceae	Attractive habit and light rose coloured flowers.
23.	*Impatiens viscosa* Bedd.	Balsaminaceae	Attractive small pink flowers and an attractive habit.
24.	*Ipomoea deccana* Austin	Convolvulaceae	Good looking purple coloured flowers and attractive habit.
25.	*Leucas ciliata* Benth. ex Wall.	Lamiaceae	Good looking white flowers.
26.	*Lindernia ciliata* (Colsm.) Pennell var. *ciliata*	Scrophulariaceae	Good looking purple flowers with attractive habit.
27.	*Lindernia crustacea* (L.) Muell.	Scrophulariaceae	Good looking purple flowers.
28.	*Melastoma malabathricum* L.	Melastomataceae	Attractive large rose coloured flowers.
29.	*Merremia umbellata* (L.) Hall. f.	Convolvulaceae	Attractive white coloured flowers.
30.	*Murdannia semiteres* (Dalz.) Sant.	Commelinaceae	Attractive plant habit
31.	*Naregamia alata* Wight & Arn.	Meliaceae	Good looking white coloured flowers.
32.	*Osbeckia aspera* (L.) Blume var. *aspera*	Melastomataceae	Attractive large pink coloured flowers and a good looking habit.
33.	*Osbeckia virgata* D. Don ex Wight & Arn.	Melastomataceae	Attractive large pink coloured flowers with good looking habit.
34.	*Pogonatherum crinitum* (Thunb.) Kunth	Poaceae	Attractive plant habit and nice foliage
35.	*Rotala malampuzhensis* Nair ex Cook	Lythraceae	Attractive plant habit with good looking foliage.
36.	*Smithia gracilis* Benth.	Fabaceae	Attractive yellow flowers and a good looking habit.
37.	*Sonerila rheedei* Wight & Arn.	Melastomataceae	Attractive pink coloured flowers
38.	*Sonerila versicolor* Wight var. *axillaris* (Wight) Gamble	Melastomataceae	Attractive pink coloured flowers with good looking habit which have leaves with white dots on it.
39.	*Torenia bicolor* Dalz.	Scrophulariaceae	Attractive dark purple-yellow coloured flowers.
40.	*Utricularia graminifolia* Vahl.	Lentibulariaceae	Attractive plants with a good habit and blue coloured flowers.
41.	*Utricularia striatula* Smith	Lentibulariaceae	Attractive plants with pink-yellow coloured flowers.
42.	*Xenostegia tridentata* (L.) Austin & Staples	Convolvulaceae	Attractive cream to yellow coloured flowers.
43.	*Xyris indica* L.	Xyridaceae	Good looking plants with beautiful yellow flowers.

Table 4. List of invasive chasmophytes of study area.

	Botanical names	Family	Nativity
1.	*Aeschynomene americana* L.	Fabaceae	Central America
2.	*Chromolaena odorata* (L.) King	Asteraceae	Central America
3.	*Hyptis suaveolens* (L.) Poit.	Lamiaceae	Central America
4.	*Lantana camara* L.	Verbenaceae	Tropical America
5.	*Mimosa diplotricha* Wight ex Sanv.	Mimosaceae	Tropical America
6.	*Mimosa pudica* L.	Mimosaceae	South America
7.	*Mitracarpus hirtus* (L.) DC.	Rubiaceae	Tropical Africa
8.	*Peperomia pellucida* (L.) Kunth.	Piperaceae	Tropical America
9.	*Pilea microphylla* (L.) Liebm.	Urticaceae	South America
10.	*Scoparia dulcis* L.	Scrophulariaceae	Tropical America
11.	*Spermacoce latifolia* Aubl.	Rubiaceae	Tropical Africa
12.	*Spilanthes radicans* Jacq.	Asteraceae	Tropical America
13.	*Stemodia verticillata* Mill.	Scrophulariaceae	Tropical America
14.	*Tridax procumbens* L.	Asteraceae	Tropical America

Table 5. Analysis of soil samples from chasmophytic habitats.

Altitudes	pH	Organic carbon (%)	Nitrogen (mg/kg)	Phosphorous (mg/kg)	Potassium (mg/kg)
Lower altitude (700m)	5.00	5.95%	390	5.1	172
Middle altitude (1,250m)	4.71	5.90%	380	4.1	145
Higher altitude (1,400m)	4.52	5.85%	370	3.8	138

deposition. The soil samples of rock crevices are rich in organic carbon and nitrogen due to the weathering of rocks and the deposition of them into the crevices. The present study also highlights that the growth pattern of chasmophytes in the rock crevices mainly depends on the amount of essential elements in the soil of such micro habitats.

Threats to the chasmophytic habitats

Generally, habitat loss is due to the anthropogenic activities. It was noticed that compared to anthropogenic activities, the present study area was also affected by over grazing as well as unsustainable utilization of natural resources by natives. It may enhance the depth of threat

Image 6. Different species of *Impatiens* from the study area: a—*Impatiens cordata* Wight | b—*Impatiens gardneriana* Wight | c—*Impatiens scapiflora* Heyne ex Roxb | d—*Impatiens diversifolia* Wall. ex Wight | e—*Impatiens modesta* Wight. | f—*Impatiens viscosa* Bedd. © Arun Christy

Image 7. Selected images of chasophytes in the study area: a—*Cyathodium cavernarum* Kunze | b—*Adiantum raddianum* C.Presl. | c—*Osbeckia aspera* (L.) Blume | d—*Sonerila rheedei* Wight & Arn. | e—*Sonerila versicolor* Wight var. *axillaris* (Wight) Gamble |f—*Christisonia tubulosa* (Wight) Benth. ex Hook.f. | g—*Utricularia graminifolia* Vahl | h—*Utricularia striatula* Smith | i—*Euphorbia vajravelui* Binoj. & Balakr. | j—*Pilea microphylla* (L.) Liebm. |k—*Cyanotis arachnoidea* Clarke | l—*Murdannia semiteres* (Dalz.) Sant. © Arun Christy.

to the study especially during peak monsoon period by land slides and flooding of rivers. Invasive species are the biggest threat to many native chasmophytes in the study area. Tourists trekking the Vellarimala cause destruction to the existing ecosystem to some extent. There are also many study reports showing that the plants which were distributed earlier in the foothills of Olichuchattam area are disappearing due to the frequent land slides during the monsoon (Manudev et al. 2012).

CONCLUSION

Chasmophytes to some extent determine the vegetation of the valley. The rocky cliffs and crevices represent a good indicator of rich biodiversity within

small areas. The chasmophytic vegetation hasn't gained much attention because of the lack of research carried out in this field and the lack of knowledge about this particular vegetation.

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