

Diversity of Carnivorous Plants in Kanyakumari Wild life Sanctuary, Southern Western Ghats

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Abstract

Biodiversity has always been an interesting and untamed parts of the earth for human beings even they are much closer to each other. The magical parts of biodiversity, plants play the major role. Like several animals, various plant species are carnivorous, that they consume insects and other small animals for a primary source of minerals and nutrients for growth. Instead of actually eating insects, carnivorous plants trap them by various means, depending upon the kind of plant. Carnivorous plants are on the verge of extinction the world over. The Western Ghats is a global biodiversity hotspot and a world heritage site. Kanyakumari forests form the southernmost ranges of Agasthiyamalai, a compact forested tract in southern Western Ghats. This study aimed at surveying and assessing the Kanyakumari Wildlife Sanctuary for carnivorous plants and resulted in the collection of 13 species. Among the species, 10 taxa belonging to the family Lentibulariaceae, and 3 taxa belonging to the family Droseraceae. *Utricularia babui* S.R.Yadav, Sardesai & S.P.Gaikwad was new distributional record was found in the Western Ghats of India where it grows along small streams in open places. Owing to its significant geographic position in the southern end of the Western Ghats, varied climate and altitude Kanyakumari Wildlife Sanctuary possesses a very rich and diverse flora, especially carnivorous plants. This study gains importance because of the study area faces a lot of threats, mostly anthropogenic, such as summer fires, collection of non-timber forest products, conversion of forest lands into monoculture (rubber plantation), hydroelectric power projects, etc.

Keywords - Western Ghats, Carnivorous plants, *Drosera*, *Utricularia*.

Introduction

Diversity of plant species creates a rainbow in our mind having millions of color compositions. Human beings gave the name of a plant species as per their behavior, utilization, habitat and distinct features. Commonly herbivorous consume plant species but some group of plant species consume small animals and insects. They play the role of predators in living kingdom of biodiversity. Animals such as flies, grass-hoppers, and spiders are trapped, a pool of enzymes secreted by the plant digests the prey (Kumar *et al.*, 2018).

Carnivorous plants have evolved the ability to capture and ingest animal prey, thereby overcoming nutrient limitation in moist habitats. All carnivorous plants, grow in nutrient poor soil (Juniper *et al.*, 1989; Clarke, 1997) Approximately, 700 species of insectivorous plants under 20 genera of 12 families were reported in this world (Fleischmann, 2012; Dash, 2016). There is no one correct classification system agreed upon by botanists (Szesze, 2018). But the families Nepenthaceae and Sarraceniaceae are the best known and largest groups of pitcher plants.

In India, a total of five genera of carnivorous plants are reported with 44 species; *viz.* *Utricularia* (38 species), *Drosera* (3), *Nepenthes* (1), *Pinguicula* (1), and *Aldrovanda* (1) (Santapau and Henry, 1976; Singh and Sanjappa, 2011; Zaman *et al.*, 2011; Kamble *et al.*, 2012). They belong to mainly three families. They Droseraceae, Lentibulariaceae, Nepenthaceae. The most common insectivorous plants are *Drosera burmanii*, *Drosera indica*, *Utricularia pubescens*, *Drosera peltata*, *Utricularia aurea*, *Utricularia bifida*, *Utricularia reticulata*, *Utricularia hirta*, *Utricularia scandens*, *Nepenthes khasiana*, etc (Kumar *et al.*, 2018).

Lentibulariaceae

The largest family comprising carnivorous plants is Lentibulariaceae with 325 species in three genera (*Genlisea*, *Pinguicula*, *Utricularia*) (Muller *et al.*, 2006). *Utricularia* is a cosmopolitan genus of small carnivorous herbs of wet habitats with minute submerged suction traps (Ridley, 1923). This plant group was first described by Linnaeus in “Species Plantarum” with seven species (Linnaeus, 1753). The first monograph of this genus was published (Taylor, 1989). This was then followed by several discoveries of new taxa (Janarthanam and Henry, 1992; Yadav *et al.*, 2000; Parnell, 2005; Rahman, 2005; Yadav *et al.*, 2005; Hu *et al.*, 2007; Lowrie *et al.*, 2008; Zamudio and Olvera, 2009). The genus *Utricularia* for India reported 35 species (Janarthanam and Henry, 1992). In Kerala, the genus is represented by 24 species (Nayar *et al.*, 2006).

Droseraceae

The genus *Drosera* known as Sundews. It is the most useful medicinal plants in India and the first of insectivorous plants to be recorded. It is distributed throughout northern and eastern Australia, India, Japan, China, and South-east Asia. The family comprises nearly 200 species with two monotypic genera *Aldrovanda* and *Dionaea* and one large genus *Drosera* (popularly named as sundew) with a maximum number of species (Juniper, 1989; McPherson, 2010; Krol *et al.*, 2012). In India, *Drosera* species are found in some parts of the Northeastern region, Deccan

peninsular region, Southern India and along regions in West Bengal (Ellison and Gotelli, 2009; Jeyaram and Prasad, 2006; Majumdar, 2011).

Of the three known *Drosera* species (*D. burmanii* Vahl., *D. indica* L. and *D. peltata* Thund.) reported in India, two are found in Meghalaya i.e., *D. burmanii* and *D. peltata* (Joseph and Joseph, 1986). The genus *Drosera* contains valuable secondary metabolites called “naphthoquinones” that are considered as the main constituents involved in the medicinal activity. Plumbagin is the major naphthoquinone present in relatively large amounts in several species of *Drosera* (Jeyaram and Prasad, 2006).

Medicinal value

The extracts of *Drosera* species have been used in traditional medicines for various ailments (Juniper *et al.*, 1989). The primary constituent of this plant namely, plumbagin, a naphthoquinone is known to possess antimicrobial activity (Heble *et al.*, 1974), anticancerous activity (Kreher *et al.*, 1990) and used in the treatment of chronic obstructive pulmonary disease (Murali *et al.*, 2006). In ethno medicine, macerated *Drosera* leaves were used externally to treat warts, corns and Sunburn (Lewis *et al.*, 1977). Extracts or teas made from the leaves were used to treat internal disorders including tuberculosis, catarrh of the lower respiratory tract, arteriosclerosis, eye and ear inflammations, liver pain, morning sickness, dropsy, various stomach maladies, syphilis, toothaches, intestinal problems, as a tranquilizer, diuretic and it was believed to have some aphrodisiacal properties (Grigson, 1958). *Drosera peltata* is reported to be used by Ayurvedic practitioners in the preparation of “gold-bhasma” that is considered an antisyphilitic and a tonic (Chopra *et al.*, 1986). The crushed leaves of *Drosera burmanii* are considered to be a powerful rubefacient (Lewis *et al.*, 1977).

Study Area

The Western Ghats

A global biodiversity hotspot and a world heritage site, the Western Ghats (08°19'18" to 21°16'24"N and 72°56'24" to 78°19'40" E) is considered as the faulted edge of the Deccan Plateau. These mountain ranges extend for more than 1,600 km covering an area of 1,64, 28 km², which is 5% of the total geographical area of India. They start downwards from the Tapti river in Gujarat, travel about 15-50 km inland, almost parallel to the west coast of India, and run through the states of Maharashtra, Goa, Karnataka, Kerala and reach Kanyakumari in Tamilnadu. These ranges harbour some of the finest tropical forests in the world and are home to more than 1270 endemic plant species.

The Kanyakumari Forest Division

Kanyakumari forests form the southernmost ranges of Agasthiyamalai, a compact forested tract in southern Western Ghats. Adjacent to this are Neyyar, Peppara and Chendurany sanctuaries on the Kerala side and Kalakkad and Mundanthurai sanctuaries on the Tamilnadu side. These include a long stretch of continuous forests, forming the southernmost knot of

Western Ghats. The forested area of Kanyakumari could be divided into three natural divisions, the uplands, midlands and the coastal zone. The uplands include many reserve forests, whereas the midlands and coastal zone are closely mixed, as most of the regions of Kanyakumari district fall within 50 km of the coast.

At present the forests of this district have been divided into three territorial ranges, i.e. Azhagiapandipuram (14,296 ha), Kulasekaram (18,860 ha) and Boothapandy (12,621 ha); the eight reserve forest areas are, Therkkumalai East and West (2093 ha), Thadakamalai (675 ha), Poigaimalai (775 ha), Mahendragiri (4376 ha), Velimalai (1282 ha), Veerapuli (24,971 ha), Kilamalai (6129 ha) and Asambu (3986 ha). Apart from these, Pechiparai A and B (59 ha), Kalkulam Block I and II (83 ha), Thodalikadu R.L. (154 ha) and Kottaikarai R.L. are also included under this division. As per the latest records, only 44,651 ha of land is under forest cover (Raj, 2009). The destruction of these forests is still on because of the high population density and unemployment prevailing in this district.

Forest types

The forests of Kanyakumari district are verdant and are said to be 75 million years old (Raj, 2004). According to Champion and Seth (1964), 14 types of forests ranging from luxuriant Tropical Wet Evergreen to Tropical Thorn Forests are found in the Kodayar and its environs of Kanyakumari Wildlife Sanctuary, because of diverse factors (edaphic and biotic); annual rainfall varies from 103 to 310 cm and elevation from sea level to 1829 m above sea level (a.s.l.) (Table 1).

Table 1. Forest types in Kodayar and its environs

No.	Forest Type	Locality
1A/C3	Southern Hill-top Tropical Evergreen Forests	Veerapuli RF
1A/C4	West Coast Tropical Evergreen Forests	Asambu RF, Veerapuli RF
2A/C2	West Coast Tropical Semi-evergreen Forests	Veerapuli RF, Klamalai RF
3B/C1(b)	Moist Teak Forests	Veerapuli RF, Klamalai RF
3B/C1(e)	Slightly Moist Teak Forests	Poigaimalai RF, Velimalai RF, Veerapuli RF, Asambu RF
3B/C2	Southern Moist Mixed Deciduous Forests	Thadakamalai RF, Klamalai RF, Poigaimalai RF, Veerapuli RF, Asambu RF
5a/C1(b)	Dry Teak Forests	Asambu RF, Velimalai RF, Klamalai RF
5A/C3	Southern Dry Mixed Deciduous Forests	Mahendragiri RF
5/DS2	Dry Savannah Forests	Therkumalai RF (East & West)
6A/C2	Carnatic Umbrella Thorn Forests	Mahendragiri RF

6A/C1	Southern Thorn Forests	Mahendragiri RF
6A/DS1	Southern Thorn Scrub	Mahendragiri RF
8A/C1	Southern Sub-tropical Hill Forests	Mahendragiri RF
8A/E1	Ochlandra Reed Breaks	Veerapuli RF

General pattern of vegetation

The prevalence of 14 different forest types in this district, within a relatively small area, i.e. 1684 sq km, amply reflects the heterogeneity of the physical environment. Lofty trees, festooning climbers, shrubs, medicinally valuable herbs, orchids and canes are found in these forests (Sukumaran et al., 2021). The floristic composition varies from place to place and also according to the altitude. In higher altitudes trees are covered with lichens, mosses, ferns, orchids and various other epiphytes. Many species of lianas and climbers are found in the lower elevation of the forests. Reeds and canes are found to form a short boundary between shola and nearby grasslands in many places.

Geology and soil

The underlying rocks of Kodayar and its environs belong to the granitoid or gneissic series. The geographical formation of Archaean age represented by quartz, gneisses, limestone and pegmites. The soils of Kanyakumari district are broadly classified into two major groups namely red soil and alluvial soil and further into 13 subtypes.

Climate

Tropical moderate bi-xeric bio-climate occurs along the lower elevations of the Kanyakumari Wildlife Sanctuary (Figure 1). Here the temperature is more than 20°C throughout the year. But the rainfall varies from 500 to 1000 mm with five to six dry months annually. The dry season is interrupted by a very short rainy season which occurs in the month of May. This bio-climate is a variant of the tropical moderate bio-climate. Attenuated bio-climate prevails in elevations receiving 1000-2000 mm rainfall with three to four dry months. This condition is common in the Kerala side of the Western Ghats, which promotes the growth of a different type of forest.

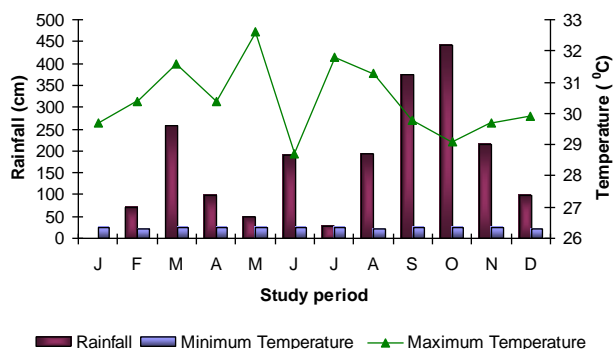


Figure 1. Climatogram of the study area.

Moist tropical bio-climate prevails in locations where there are one to two dry months; the western slopes of the high-elevation hills have such bio-climatic conditions, which favour the growth of some moist forests. Tropical low montane bio-climate occurs in locations where the rainfall is more than 1500 mm with two or three dry months. These conditions occur on the hill slopes and plateau between 1000 and 1500 m a.s.l. In these depressions also a different climatic condition prevails which favours the growth of low-level shola forests. Tropical montane bio-climate occurs on the hills above 1500 m a.s.l. where the dry period is almost nil, and the rainfall is more than 1500-2000 mm. Here shola forests are seen.

Field survey

Fortnightly pedestrian surveys were conducted from 2020 to 2021 (i.e. during the period from August 2020 to May 2021), in the forest areas falling under the Kanyakumari Wildlife Sanctuary, viz. Pechiparai, Kilamalai, Alambari, Mahendragiri, Maramalai, Veerapuli, Muthukuzhivayal, Thadagamalai. An estimated 70–120 man hours were spent in the study area. Collection trips were organized during all seasons covering the entire study area. Trails and trail-less portions of the study area were walked randomly. The duration of each study tour ranged from 2 to 3 days.

The structural formation and vegetation association at each location were also recorded. As a precaution, where similar species were difficult to determine in the field, vouchers were collected as replicates. Hence, sometimes more vouchers were collected than the number of species on the site. The plants were collected in different reproductive stages) to prepare herbarium specimens. All vouchers were taken to the laboratory for identification, as some species could be determined only using microscopic features. Detailed field data were collected during the field trips. Information such as family and binomial, date of collection, locality, habit, short description, conservation status of the voucher plant and those characteristics which cannot be observed from the pressed specimens were recorded.

Preparation of herbarium specimens

For the preservation of vouchers brought from the study area, the wet method (Fosberg and Sachet, 1965) using 70% methylated alcohol and 5% formaldehyde was employed. Processed specimens were mounted on white mounting cards of dimension 29 × 43 cm. The specimens were mounted in such a way that they resembled 'Portrait'. Specimens were attached to the mounting card, using glue or with tape. Large specimens were glued to the centre and in case of small plants multiple specimens were fixed in evenly spread rows. Labels were kept in the right corner of the mounting card, including details such as the family, binomial, collector's name, date of collection and locality of collection of the specimen. Processed herbarium specimens were deposited in the Herbarium of Scott Christian College, Nagercoil. Photo documentation of the plants in the field condition was also done (Plate 1)

Identification

Plants which can be identified in the field were recorded and all other specimens were critically observed; flowers of unidentified plants were preserved and dissected. They were checked with descriptions available in *Flora of the Presidency of Madras* (Gamble, 1915-1936), *Bladderworts of India* (Janarthanam and Henry, 1992), *Flora of Tirunelveli Hills* (Manickam *et al.*, 2008) and *Flora of Western Ghats* (Nair *et al.*, 2014).

Herbarium consultation

Identification was further confirmed after matching the specimens with authentic or type sheets available at the Center for Biodiversity and Biotechnology (CBB), St.Xavier's College, Palayamkottai and Tropical Botanical Garden and Research Institute (TBGRI), Palode, Kerala. A few rare unidentified specimens were identified with the help of taxonomists at TBGRI.

Enumeration of the species

Citations of the taxa were obtained from the databases such as the International Plant Names Index (IPNI) (<http://www.ipni.org>), 'w3 Tropicos' (<http://www.tropicos.org>) and The Plant List Version 1 (2010), (<http://www.theplantlist.org>) available online. The nomenclature of the plant was updated using the above online databases and by referring to the latest taxonomic literature. For each species, correct botanical name was given which was followed by basionym and important synonyms wherever necessary, by relating the name with *The Flora of Western Ghats* and other relevant literature. This was followed by a short description of the flowering and fruiting phenology of the plant. Efforts were made to indicate the local name and economic utility of the species wherever possible.

Plan of presentation of data

The arrangement of families of angiosperms is after Bentham and Hooker system of classification with necessary alterations. All the species are arranged alphabetically under each family. Artificial dichotomous bracketed keys are provided for families, genera, species and subspecies variety. Each genus with author citation and species is provided with the correct name and author citation. Short description, flowering and fruiting phenology of the species are also given. Selected colour photographs of species are provided to show habitats, association and their occurrence in various vegetation types.

Results

Analysis of the Flora

Intensive and extensive floristic exploration tours conducted in all seasons covering various ecosystems of Pechiparai, Kilamalai, Mahendragiri, Maramalai, Muthukuzhivayal, Veerapuli, Alambarai, Thdagamalai and its environs of Kanyakumari Wildlife Sanctuary resulted in the collection of 13 species (Table 2). Binomial and author citation of the entire collected voucher specimens were verified. Taxonomic Key was prepared for the characterization and

identification of specific species. Among the species, 10 taxa belonging to the genus *Utricularia* (family: Lentibulariaceae), and 3 taxa belonging to the genus *Drosera* (family: Droseraceae).

Table 2. Taxonomic diversity of the carnivorous plants in the study area.

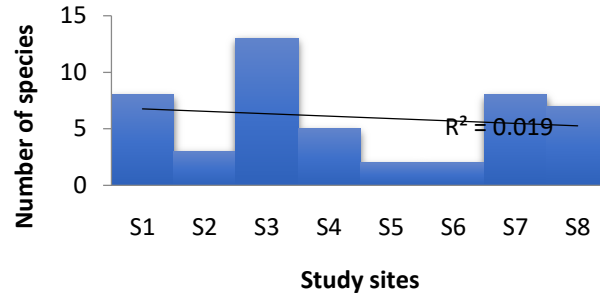
Family	Genera	Taxa	%
Lentibulariaceae	<i>Utricularia</i>	13	76.92 %
Droseraceae	<i>Drosera</i>	3	23.07 %

Species richness of carnivorous plants shows that, Almaparai was floristically rich in terms of carnivorous species richness 13 species. Pechiparai hills and Thadagamali hills contributes 8 species each, followed by 7 species from Muthukuzhivayal, five species from Mahendragiri hills, 3 species in Kilamalai, whereas 2 species each were reported from Maramalai and Veerapuli hills of Kanyakumari Wildlife Sanctuary (Table 3).

Table 3. Floristic Richness of the Study Area

Study Area	Family	<i>Utricularia</i>	<i>Drosera</i>	Total no of Species
Site I (Pechiparai)	2	6	2	8
Site II (Kilamalai)	2	1	2	3
Site III (Alambarai)	2	10	3	13
Site IV (Mahendragiri)	1	5	-	5
Site V (Maramalai)	1	-	2	2
Site VI (Veerapuli)	1	1	1	2
Site VII (Muthukuzhivayal)	2	6	1	7
Site VIII (Thadagamalai)	2	6	2	8

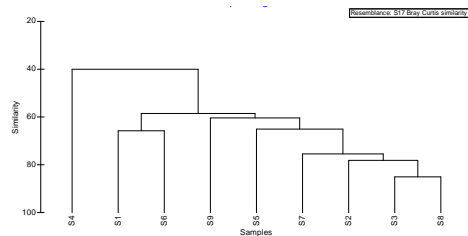
Regression analysis showed that species richness of carnivorous plants significantly varied across the sites ($R^2 = 0.02$). The maximum number of species was recorded from Alamparai (S3), whereas the minimum from Maramalai and Veerapuli hills (S5 and S6 - 2 species each). Altitudinal variation plays a major role in species richness of carnivorous plants. In the present study, species richness of carnivorous plants was found to show an increasing trend with an increase in altitude (Graph 1).



Graph 1: Site-wise distribution of plant species of the study area.

Bray-Curtis cluster analysis

Bray-Curtis cluster analysis of the species richness of carnivorous plants of the eight study sites of Kanyakumari wildlife sanctuary, produced three distinct groups. Site S4 was found to be the most speciose and was quite distantly placed; sites S1 and S6 formed one group; and the other sites which were relatively less species-rich formed another group (Graph 2).



Graph 2. Percentage of species similarity between study sites

Habitat of Carnivorous plants

Sundews (*Drosera*) are commonly found growing in wet shallow and poor nutrient soils, overlaying rocks and in wet muds, in swamps, marshes, pools and streams, and in open humid soils. Bladderworts (*Utricularia*) grows on wet rocks, soil covered boulders and grassy slopes. It grows on primary or secondary bare rocky areas of the study area. It is dominant on basalt and lateritic rock outcrops and forms ephemeral flush vegetation. Other common habitats are marshes, swamps and stream sides.

Conservation status

A considerable percentage of the large number of indigenous carnivorous species of Kanyakumari Wildlife Sanctuary is rare and threatened. With increasing utilization of land and natural resources, it is feared that many of these threatened taxa will become yet rarer, more vulnerable and endangered, and in several cases may finally become extinct, as any disturbance or imbalance in their narrowly confined ecosystems is liable to lead to their extermination. In the present study, the conservation status of the species was analyzed based on *The IUCN Red List of Threatened Species 2018* (<http://dx.doi.org/10.2305/IUCN.UK.2018->

[2.RLTS.T168864A19632217.en](#)). This led to the categorization of two groups, namely endangered and threatened; of the 13 taxa collected from the Kanyakumari Wildlife Sanctuary, 11 species are fall under 'Least Concern' category, whereas the remaining 2 species are commonly distributed in the Alamparai hills of the study area. Trapping action of the *Drosera* is an active mechanism with sticky tentacles and *Utricularia* species had suction type of insect trapping mechanism.

Flowering and fruiting phenology

Reproductive phenology of carnivorous plants of Kanyakumari Wildlife Sanctuary was monitored through fortnightly visits for a period of one year. Three species were found to be flowering throughout the year, whereas the remaining species were flowered during monsoon season and its extends up to spring season. A considerable variation was found in flowering and fruiting behaviour that could be partly attributed to abiotic factors. Peak flowering activity was at its peak in the first rainy season in order to utilize the available soil moisture for seed germination and seedling establishment. Phenological behaviour displayed by the species is an adaptation to the surrounding abiotic and biotic environment (Table 4)

Threat status

The carnivorous flora of Kanyakumari Wildlife Sanctuary is under severe threat due to various anthropogenic factors like forest fragmentation, construction of hydro-electric power projects, conversion of forest into monoculture rubber plantation, conversion of paddy fields, invasion of alien species and forest encroachments. Moreover, the collections of rare taxa by Botany students for academic purposes are also responsible for the loss of these species in their habitats.

New distributional records

Utricularia babui S.R. Yadev was first described from the forest of Kolhapur in the Western Ghats of India where it grows along small streams in open places by (Yadav *et al.*, 2005). This species is easily recognized by its blue flowers with short conical straight spur, long linear leaves, and ovoid-globose seeds with a reticulate testa. Additional occurrences of *Utricularia babui* S.R. Yadev in Kanyakumari Wildlife Sanctuary is reported. This shows that its extended distribution of this species from northern to southern Western ghats.

Discussion

Of the 25 ecological hotspots of the world, two are present in India, viz. Western Ghats and Himalayas. The Western Ghats is one of the mega endemic centres in India and has been regarded as a treasure trove of flowering and non-flowering plants. Bladderworts and Sundews are the most important vascular plants in plant kingdom. About 700 species of extant carnivorous plants have been recorded globally, of which, India represents 44 (4 species belongs to Droseraceae, 39 species belongs to Lentibulariaceae and a species belongs to the family Nepenthaceae) species in its tropical, subtropical and warm temperate regions (Krol, 2011). Of

these 13 species were reported solely from Kanyakumari Wildlife Sanctuary. Three species of genus *Drosera* have been recorded in India and they are *Drosera burmannii*, *Drosera indica* and *Drosera peltata* (Gamble, 1935). That the three species found in the site III Alambarai. *Drosera indica* is assessed as an endangered and classified in the red data book. *Drosera peltata* is found to be endemic and recorded only in a few places.

Sine Hooker (1863), studies of the carnivorous plants of different parts of India have been made by a number of researchers (Santapau and Henry, 1976; Janarathanam and Henry, 1992; Yadav *et al.*, 2005; Singh and Sanjappa, 2011; Kamble *et al.*, 2012). It is worth mentioning that Kanyakumari district is rich in diversity of carnivorous plants. In the present study a colony of *Utricularia babui* was found to be growing well in the riffle pools of Aalamparai hills of Kanyakumari Wildlife Sanctuaty. The luxuriant growth of these populations was also observed from Veerapuli hils. The collection of these rare species from many localities emphasizes the need for a thorough search before determining the rarity of a species. It is worth mentioning the collection of the species in the study area, which has been reported for the first time in South India. The Agathiyamalai ranges of Western Ghats, which include Kanyakumari Wildlife Sanctuary house rich carnivorous flora and hence is a priority hotspot for conservation.

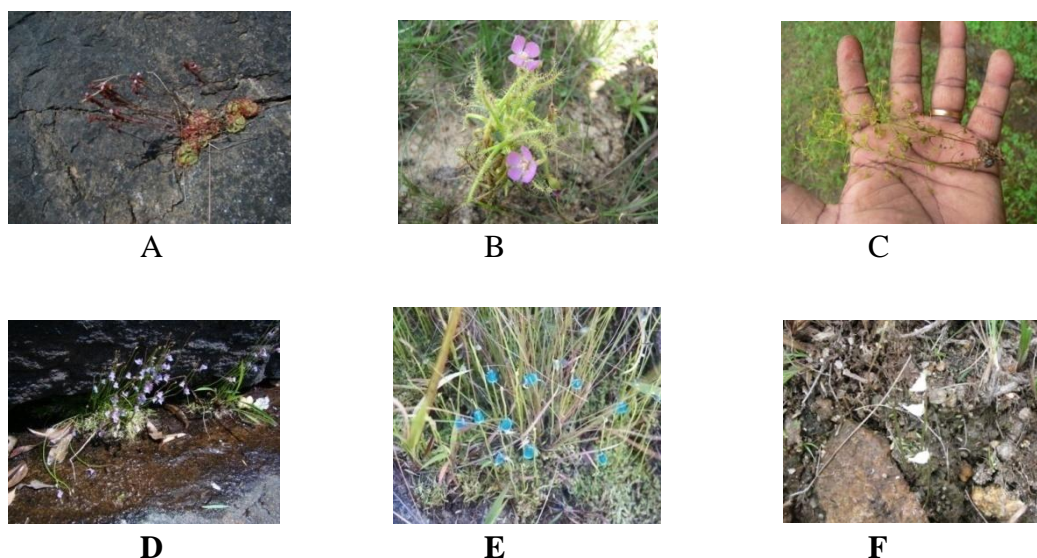


Plate 1: Carnivorous plants: A. *Drosera burmannii*, B. *Drosera indica*, C. *Drosera peltata*, D. *Utricularia babui*, E. *Utricularia caerulea*, F. *Utricularia polygaloides*.

Table 4. Habit, phenology and conservation status of carnivorous plants of the study area.

Binomial	Habit	Trap type	Flowering and Fruiting	IUCN Status
Family: Droseraceae				
<i>Drosera burmanni</i> Vahl	Herb	Sticky	Throughout the year	Least Concern
<i>Drosera indica</i> L.	Herb	Sticky	Sep - Nov	Least Concern

<i>Drosera peltata</i> Thunb.	Climbing Herb	Sticky	Aug - Apr	Least Concern
Family: Lentibulariaceae				
<i>Utricularia aurea</i> Lour.	Floating Herb	Suction	Oct - Apr	Least Concern
<i>Utricularia babui</i> S.R. Yadav, Sardesai & S.P. Gaikwad	Herb	Suction	Aug - Dec	Least Concern
<i>Utricularia caerulea</i> L.	Herb	Suction	Nov - Mar	Common
<i>Utricularia chrysantha</i> R.Br.	Herb	Suction	Throughout the year	Least Concern
<i>Utricularia graminifolia</i> Vahl	Herb	Suction	Aug - Sep	Least Concern
<i>Utricularia minutissima</i> Vahl	Herb	Suction	Nov - Sep	Least Concern
<i>Utricularia polygaloides</i> Edgew.	Herb	Suction	Nov - Feb	Common
<i>Utricularia scandens</i> Benj.	Herb	Suction	Throughout the year	Least Concern
<i>Utricularia striatula</i> Sm.	Herb	Suction	July - Dec	Least Concern
<i>Utricularia uliginosa</i> Vahl	Herb	Suction	Throughout the year	Least Concern

Systematic Key of the carnivorous plants

- A. Seeds enclosed in fruit wall **ANGIOSPERMAE**
- B. Floral whorls (pistil often excepted) in 5s, less often 4s, seldom 3s.
 Vascular bindles in a concentric ring, enclosing a central pith.
 Bark separable, cotyledons 2 **Dicotyledons**
- C. Polypetaloid dicots with superior ovary.
 Stamens more than twice as many petals **Droseraceae**
1. Stemless herbs, Leaves oblanceolate-spathulate,
 Ovary 1-2 mm long..... ***D. burmannii***
1. Prostrate herbs. Leaves subulate-linear. Ovary 5-6mm long... ***D. indica***
2. Leaves margins with spreading gland-tipped cili..... ***D. peltata***
2. leaves margin without gland-tipped cilia
- CC. Gamopetalous dicots with epipetalous stamens..... **Lentibulariaceae**
1. Rhizoids absent
2. Aquatic, submerged. Foliar organs dissected. Bracteoles 0 ***U. aurea***
2. Terrestrial, erect/trailing. Foliar organs entire. Bracteoles present
1. Rhizoids present
3. Rhizoids up to 2 cm long..... ***U. uliginosa***
3. Rhizoids up to 2.5cm long..... ***U. graminifolia***

- 4. Corolla yellow
 - 5. Scape erect. Fruiting pedicel erect. Spur curved upwards.
 - 5. Scape twinin. Fruit pedicel reflexed. Spur curved downwards ..*U. scandens*
- 4. Corolla other than yellow
 - 6. Foliar organ reniform; seeds glochidiolate.
Calyx- lobes purple.....//*U. striatula*
 - 6. foliar organs linear- lanceolate; seeds smooth or reticulate. Calyx- lobes green\ brown
 - 7. Bracts medified. Flowerind scape brown. Flowers blue, Cream\purple marked with yellow spot on the throat *U. caerulea*
 - 7. Bracts basifixed. Flowering scape green.
Flowers dark blue\ greenish yellow or with white spot on the throat *U. chrysantha*
 - 8. Fruiting calyx obtuse
 - 9.Upper lip of corolla longer than upper calyx-lobe, incurved..... *U. minutissima*
 - 9. upper lip of corolla not, or scarcely longer than, upper calyx-lobe
 - 8. Fruiting calyx acute or acuminate
 - 10. Scape 3-8 flowered. Bracteoles linear..... *U. polygaloides*
 - 10. Scape 1-4 flowered. Bracteoles triangular..... *U. babui*

Conclusion

In conclusion, the high diversity of carnivorous plants of Kanyakumari Wildlife Sanctuary is due to its richness of various habitats resulting from an extended altitudinal range and a luxuriant montane evergreen forest with high precipitation. Even that a complete inventory of the carnivorous plants of Kanyakumari Wildlife Sanctuary is unlikely to be completed in the near future and considering the rate at which forest destruction is proceeding in the district, a conservation strategy for carnivorous plants focussing on the most species-rich forest areas currently appears to be the most practical approach. Fortunately, much of the tropical forest sites of Western Ghats have already been included in several national parks, although most of these are under various degrees of anthropogenic pressure.

Conservation

Carnivorous plants are on the verge of extinction the world over. In India, many species have been included in the *Red Data Book* as endangered plants. Their popularity with gardeners and traders of medicinal plants is one of the main causes for their decline. Habitat destruction is also rampant, the wetlands harbouring such plants being the main casualties during the expansion of urban and rural habitation. Pollution caused by effluents containing detergents, pesticides, fertilizers, sewage etc into the wetlands is yet another major cause for their decline, since insectivorous plants do not tolerate high nutrient levels, as they are well adapted to grow in

habitats poor in nutrients. Moreover, polluted water bodies are dominated by prolific water weeds which cause elimination of the delicate insectivorous plants. The insectivorous plants are these days coming into limelight of modern research because of their characteristic enzyme complexes, absent in other plants. Unfortunately, these plants are on the decline when they have the potential to open up new vistas in the field of medicine. An awareness need to be created among the student community and the public on this group of interesting plants. Their important distribution centres need to be catalogued and set aside for conservation (Ghosh, 2003).

The conservation of carnivorous plants could benefit many other taxa including humans. It also helps in preventing secondary extinction of other specialist species which rely on them. As the collection of the plants increases, it ultimately leads to decline in wild populations. *D. burmannii* has been tagged as vulnerable in India (Reddy *et al.*, 2001) Multiplication and conservation through tissue culture technique forms one of the major methods of protecting the species. Such conservation efforts would ensure continuous and ample supply of this valuable material which is in great demand by the pharmaceutical industries (Yanthan, 2017).

Strategies for conservation

Based on the findings of these studies, it is apparent that many of the carnivorous plants are at the verge of extinction. Thus strict measures should be taken for the conservation of these taxa. The species-rich areas of the Western Ghats of Kanyakumari Wildlife Sanctuary should be strictly protected for *in situ* conservation of the carnivorous plants. Moreover, collection of these rare and endangered species by Botany students for academic purpose has to be prevented, except for genuine research purposes.

References

1. Bernhard Kreher, Andras Neszmélyi and Hildebert Wagner. 1990. Naphthoquinones from *Dionaea muscipula*. *Phytochemistry* 29 (2): 605-606.
2. Clarke, C. 1997. *Nepenthes* of Borneo. *Carniv Plant Newsletter*, 41(2):67–76.
3. Dash, P. K. 2016. Carnivorous plants of Odisha. Odisha Biodiversity Board, Bhubaneswar.
4. Ellison, A.M. and Gotelli, N.J. 2009. Energetics and the evolution of carnivorous plants- Darwin's 'most wonderful plants in the world'. *J Exp Bot*, 60:19–42.
5. Fleischmann, A. 2012. The New *Utricularia* Species Described since Peter Taylor's Monograph. *Carnivorous Plant Newsletter* 41 (2): 67–76.
6. Fosberg, F. R. & M. Sachet. 1965. Manual for tropical herbaria. I.B.P.T. and N. Regnum Veget. 39: 1-132.
7. Gamble J. S (1935) Droseraceae. In 'Flora of the Presidency of Madras'. (Ed. JS Gamble) pp. 451–452. (Adlard & Son Ltd: London)
8. Gamble, J, S. 1915-1936. Flora of the presidency of Madras. 1-3. Adland and Son Ltd. 21, London.

9. Heble. M. R, Narayanaswamy. S, Chadha , M. S. 1974. Tissue differentiation and plumbagin synthesis in variant cell strains of *Plumbago zeylanica* L. in vitro. - Plant Science Letters. 2 (6): 405-409.
10. Hu, G. W., Long, C.L. and Liu, K. M. 2007. *Utricularia mangshanensis* (Lentibulariaceae), a new species from Hunan, China. *Annales Botanici Fennici*, 44: 389-392.
11. Janarthanam, M.K. and Henry, A.N. 1992. Bladderworts of India. Botanical Survey of India, Calcutta, 106-112.
12. Jayaram, K and Prasad, M.N. 2006. *Drosera indica* L. and *D. burmanii* Vahl., medicinally important insectivorous plants in Andhra Pradesh-regional threats and conservation. *Curr Sci*, 91(7): 943–947.
13. Joseph, J. and Joseph, K. M. 1986. Insectivorous Plants of Khasi and Jaintia Hills, Meghalaya, India: A Preliminary Survey. Calcutta: Botanical Survey of India
14. Juniper B.E., Robins R.J. and Joel D.M. 1989. The Carnivorous Plants. Academic Press, London.
15. Kamble, M.V., Harikrishnan, S. and Balakumar, P .2012. *Utricularia caerulea* (Lentibulariaceae): a new record to flora of Andaman & Nicobar Islands. *Rheedea* 22(2):116–118.
16. Król, E., Plachno, B.J., Adamec, L., Stolarz, M., Dziubinska, H. and Trebacz, K. 2011. Quite a few reasons for calling carnivores ‘the most wonderful plants in the world. *Ann Bot*, 109: 47–64.
17. Król, E., Plachno B.J., Adamec L., Stolarz M., Dziubinska H. and Trebacz K. 2012. Quite a few reasons for calling carnivores ‘the most wonderful plants in the world’. *Ann. Bot.* 109: 47– 64.
18. Kumar, G. D., Tulasi, C.D.S.L.N. and Ramakrishnaiah, G. 2016. Phytochemical screening and evaluation of in vitro antimicrobial activity of *Drosera spatulata* var *bakoensis*- an indigenous carnivorous plant against respiratory tract infectious microbes. *Asian J Phar Clin Res* 9(2): 274–283.
19. Linnaeus, C. 1753. *Species Plantarum* 1. Stockholm
20. Lowrie, A., Cowie, I. D. and Conran, J. G. 2008. A new species and section of *Utricularia* (Lentibulariaceae) from Northern Australia. *Telopea*, 12(1): 31–46.
21. Majumdar, K., Datta, B.K. and Shankar, U. 2011. Community structure and population status of *Drosera burmanii* Vahl. with new distributional record in Tripura, India. *J EcolNat Environ.* 3(13): 410–414.
22. Manickam V. S. 2008. Flora of Tirunelveli Hills- *Part 1 of Flora of Tirunelveli Hills: Southern Western Ghats.*
23. McPherson, S. 2010. Carnivorous plants and their habitats. Redfern Natural History Productions, Poole, Dorset, England: 2.

24. Muller, K.F., Borsch, T., Legendre, L., Porembski, S. and Barthlott, W. 2006. Recent progress in understanding the evolution of carnivorous Lentibulariaceae (Lamiales). *Plant Biol*, 8: 748–757.
25. Murali, P.M., Rajasekaran,P., Paramesh, O.R., Krishnarajasekar,S.,Vasudevan, K., Nalini, S., Lakshmisubramanian, C., Deivanayagam, N.. 2006. Plant-based formulation in the management of chronic obstructive pulmonary disease: A randomized double-blind study. *Respiratory Medicine*, 100 (1); 39-45.
26. Nayar, T.S., Rasiya, B. A., Mohanan, N., Rajkumar, G. and Sibi, M. 2006. Flowering Plants of Kerala-A Handbook. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala, India: 1069.
27. Parnell, J.A.N. 2005. An account of the Lentibulariaceae of Thailand. *Thai Forest Bulletin (Botany)*, 33: 101–144
28. Rahman, M.O. 2005. A taxonomic account of *Utricularia* Linn. from Bangladesh. *Bangladesh Journal of Plant Taxonomy*, 12(2): 63-70.
29. Ridley, H.N. 1923. The Flora of the Malay Peninsula, L. Reeve & Co., Ltd., London 2: 490-495.
30. Roby, T. J., Jose, J., Nair P.V . 2014. Check list of flora of Myristica swamps- a critically endangered fresh water ecosystem of southern Western Ghats of Kerala, India.140 (6): 608 – 616.
31. Sanjeet Kumar, Sunil Thorat, Rajendra K. Labala, Jayanta Kumar Patra. 2018. Insectivorous Plants of India: Sources of Bioactive Compounds to Fight Against Antimicrobial Resistance. *Microbial Biotechnology*: 305-318.
32. Santapau, H., Henry, A. N. 1976. A Dictionary of the flowering plants in India. New Delhi: Publication and information Directorate.
33. Singh, P. and Sanjappa, M. 2011. *Flowering plants of Sikkim- An analysis*. In: Biodiversity of Sikkim - Exploring and Conserving a Global Hotspot. Arrawatia, M.L., and Tambe,S. (eds.). Department of Information and Public Relations,Government of Sikkim, Gangtok. 58 Carnivorous Plant Newsletter, 58: 65-88.
34. Sukumaran, S., Sujin, R.M., Geetha, V.S. and Jeeva, S., 2021. Ethnobotanical study of medicinal plants used by the Kani tribes of Pechiparai Hills, Western Ghats, India. *Acta Ecologica Sinica*, 41(5), pp.365-376.
35. Szesze M. 2018. Carnivorous Plants Growing & Care. *Carnivorous Plants Nursery*.
36. Taylor, P. 1989. The genus *Utricularia* – a taxonomic monograph. *Kew Bulletin Additional Series*, 14: 1-724.
37. Yadav, S.R., Sardesai, M.M. and Gaikwad, S.P. 2000. Two new species of *Utricularia* L. (Lentibulariaceae) from Peninsular India. *Rheedea* 10 (2): 107–112.
38. Yadav, S.R., Sardesai, M.M. and Gaikwad, S.P. 2005. A new species of *Utricularia* L. (Lentibulariaceae) from the Western Ghats, India. *Rheedea* 15 (1): 71–73.
39. Yadav, S.R., Sardesai, M.M. and Gaikwad, S.P. 2005. A new species of *Utricularia* L. (Lentibulariaceae) from the Western Ghats, India. *Rheedea* 15 (1): 71–73.

40. Zaman, M., Naderuzzaman, A. T. M., Hasan. M. and Naz, S. 2011. Ecology, morphology and anatomy of *Aldrovandavesiculosa* L. (Droseraceae) from Bangladesh. *BangladeshJ. Bot.*, 40(1): 85-91.
41. Zamudio, S. and Olvera. M. 2009. A new species of *Utricularia* (Lentibulariaceae) from Guerrero, Mexico. *Brittonia*, 61 (2): 119-125.