Floristic Studies of Sasihithlu Estuary of Dakshina Kannada, Karnataka, India

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Abstract Estuaries constitute the unique wetland ecosystems possessing the floristic richness. They are an abode of diverse and unique flora. The present study is aimed to document the floristic diversity of Sasihithlu estuary which is a pre-requisite to understand the vegetation structure. Random quadrat method was employed for floral documentation. The species were identified using standard taxonomic methods. The results of the study have shown the occurrence of 88 species of 81 genera belonging to 46 families. Among these, 11 true mangroves and nine mangrove associates were documented. The occurrence of one endangered species and one vulnerable species has been catalogued.

Keywords: flora, mangrove, wetland, estuary, Sasihithlu

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1. Introduction

Vegetation studies form an essential component of evaluation of the quality of ecosystems. Vegetation studies help in the enhancement of sustainability and ecological restoration. Studies of floral taxonomy and composition provide valuable information about ecology and the ecosystem. It is also important to assess the ecological health and well-being of ecosystems and is a foundation for biodiversity conservation and natural resource management [1]. The floral composition of an area serves as the most conspicuous ecological feature [2]. Estuaries are complex, dynamic and highly productive ecosystems. These unique ecosystems form the transition zone between freshwater and marine environments. Estuaries host a greater biodiversity compared to sea and river ecosystems [3]. The unique conditions of estuaries harbour mangroves [4]. Mangroves are a vital segment of estuarine ecosystem. They store and cycle nutrients, filter pollutants from land run-offs [5,6]. They are of prodigious ecological and socio-economic significance [7] and provide various socio-economic services to mankind [8,9,10,11]. They help in the stabilization of shoreline by trapping sediments and controlling erosion [12]. Mangroves and associated wetlands shelter a wealth of genetic and species diversity [13]. Mangroves are classified into two types based on their habitat use; true mangroves which specifically grow in intertidal regions and mangrove associates which occur in littoral or terrestrial habitats. India has rich mangrove density and diversity which accounts for about three percent of the world's mangroves [14,15,16]. Withal, India has lost 40% of the mangrove area in the last century and National Remote Sensing Agency has registered a decline of 7000 ha of mangrove between 1975 to 1981 [17]. Estuaries are under great strain caused by natural and anthropogenic reasons [7] which has led to a rapid loss in floristic diversity and changing vegetation patterns. Understanding the species composition of mangroves is elemental for assessing the quality of estuarine ecosystems and helps in their management [18,19]. Scientific information regarding the floristics of Sasihithlu is lacking. Considering the vast array of ecosystem services of estuaries, the present commentary has been undertaken to document the floral diversity which can be used as a baseline data for formulating management and conservation strategies.

2. Study Area

Sasihithlu estuary is a confluence point of rivers Nandini and Shambhavi which originates in Western Ghats (Figure 1). It is a cardinal area from environmental, ecological and biological points of view. It is located 25 Km north of Mangaluru city (13.02°N & 74.47°E) with an average elevation of 3 m above mean sea level. The climate and weather pattern of the area is prototypical to that of a coastal region. The temperature varies between 26°C and 42°C with an annual precipitation of about 3,500 mm. The mouth of the estuary is dominated by sand whereas the mid and the upper reaches of the estuary is dominated by silt and clay sediments. The estuary is hugely influenced by tidal inundations exhibiting
semidiurnal tides and hence the water is brackish throughout the year. Five sampling sites were selected in Delta Point (mouth of the estuary), Hejmady and Chitrapu (parts of Shambhavi river) and Kollachikambla (part of Nandini river) (Table 1) with a minimum distance of 500 m from each other to ensure Quasi independence [20].

![Figure 1. Map and google image of the study area](image)

| Sl No. | Study Sites       | Habitat                          | Latitude        | Longitude       | Elevation (m) |
|--------|-------------------|----------------------------------|-----------------|-----------------|---------------|
| 1.     | Site 1            | Mangrove island                  | 13° 3'49.91"N   | 74°46'52.42"E   | 4             |
| 2.     | Site 2            | Mangroves and associated wooded area | 13° 4'0.81"N   | 74°46'54.64"E   | 3             |
| 3.     | Site 3            | Mangrove patch                   | 13° 4'21.73"N   | 74°46'51.28"E   | 2             |
| 4.     | Site 4            | Mangrove patch                   | 13° 4'41.42"N   | 74°47'2.03"E    | 4             |
| 5.     | Site 5            | Mangroves and associated wooded area | 13° 5'11.70"N   | 74°46'39.25"E   | 4             |
3. Materials and Methods

Five study sites with varying floral composition were selected along the estuary. Periodic field surveys were carried out using random or scattered quadrat method covering an area of approximately 0.9 ha. 10m x 10m quadrats were laid in the study sites and within each quadrat, all individual flora were identified and documented using authentic information, data, field keys and standard taxonomic methods [21,22,23,24,25,26,27]. Canon EOS 70D and 600D DSLR cameras with 18 - 135 mm lens was used to photograph the flora. Garmin Etrex 30X GPS machine was used to take the waypoints (latitude and longitude) and altitude of the area.

4. Results and Discussion

Sasihithlu estuary is a mosaic of natural and cultivated flora. In the present study, 88 floral species belonging to 81 genera and 46 families were documented from the five selected sites of the study area. This included 11 true mangrove species belonging to six families (Table 2). Out of this, 18.18% were shrubs and the rest were trees. Nine species of mangrove associates belonging to nine families (Table 3) were also recorded. 44.44% of the documented mangrove associates were herbs, 22.22% were climbers and creepers, 11.11% were shrubs and 22.22% of them were trees. Fabaceae was found to be the dominant family with seven species. Of the documented flora, 29.76% were trees, 19.04% were shrubs, 42.85% were herbs and 8.33% were climbers or creepers (Figure 2). The floral growth of trees, 19.04% were shrubs, 42.85% were herbs and 8.33% were climbers or creepers, 11.11% were shrubs and 22.22% of them were trees. Fabaceae was found to be the dominant family with seven species. Of the documented flora, 29.76% were trees, 19.04% were shrubs, 42.85% were herbs and 8.33% were climbers or creepers (Figure 2). The floral growth of the estuary can be differentiated based on the zones. These were classified into oligohaline, polyhaline, and euryhaline zones based on the salinity and nutrient content [28,29,30]. Highly saline euryhaline zones were colonised by Avicennia officinalis, Rhizophora apiculata and Rhizophora mucronata. This can be attributed to their high tolerance to fluctuating and hostile conditions. Polyhaline zones with medium salinity were dominated by Bruguiera cylindrica (Figure 3), Bruguiera gymnorrhiza, and Lumnitzera racemosa. Sonneratia alba (Figure 4), a species threatened in India [31] and Aegiceras corniculatum were documented in Site 4 from the banks of riverine system. Population of this threatened mangrove species in the study area was very less. Acanthus ilicifolius, Excoecaria agallocha and Kandelia candel were documented from the low saline mesohaline zones. The oligohaline zones with high freshwater influx and low salinity was occupied by Acrostichum aureum, Derris trifoliata (Figure 5), Pandanus odoratissimus and other mangrove associates. Sesuvium portulacastum, Spinifex littoreus and Ipomoea pes-carpae were noted growing on the sand banks among the mangroves. Canavalia rosea dominated the sand banks adjacent to river Shambhavi. Lantana camara was documented from the degraded mangrove patches and human frequented areas. Scamelea taccada was restricted to the sandy stretches of beach and was completely absent from riverine and estuarine systems. Occurrence of species like Biophytum reinwardtii, Impatiens minor, Impatiens oppositifolia (Figure 6), Cyanotis cristata, Cleome rutidosperma and Talinum cuneifolium was seasonal. They were recorded predominately during monsoon and post-monsoon season. Curculigo orchioides (Figure 7), an endangered species and Santalum album, a vulnerable species was documented from the terrestrial habitats in study site 3 next to river Nandini. The study has also revealed some threats to the mangroves and the estuary. Mangroves in the area are exploited for timber, fuel wood, manure and occasionally for fodder. Over fishing and extraction of shells, conversion of mangroves and wetlands into aquaculture ponds for fish and shrimp farming, dredging, solid waste deposition by rivers and sea, water pollution, riverine and coastal erosion and increased human interference caused by tourism are the major threats to the area.

Table 2. Checklist of true mangroves recorded during the study

| Sl. No. | Scientific Name          | Family           | Common Name        | Habit  |
|--------|--------------------------|------------------|--------------------|--------|
| 1.     | Acanthus ilicifolius L.  | Acanthaceae      | Holy Mangrove      | Shrub  |
| 2.     | Avicennia officinalis L. | Polypodiaceae    | Indian Mangrove    | Tree   |
| 3.     | Lumnitzera racemosa Willd.| Combretaceae     | White-flowered Black Mangrove | Tree  |
| 4.     | Excoecaria agallocha L. | Euphorbiaceae    | Milky Mangrove     | Tree   |
| 5.     | Sonneratia alba Sm.     | Lythraceae       | Sweet-scented Apple Mangrove | Tree  |
| 6.     | Aegiceras corniculatum (L.) Blanco | Primulaceae | River Mangrove     | Shrub  |
| 7.     | Bruguiera gymnorrhiza (L.) Lam. | Primulaceae | Black Mangrove     | Tree   |
| 8.     | Bruguiera cylindrica (L.) BL. | Rhizophoraceae | White Burma Mangrove | Tree  |
| 9.     | Kandelia candel (L.) Druce | Rhizophoraceae   | Narrow-Leafed Kandelia | Tree  |
| 10.    | Rhizophora mucronata Lam. | Rhizophoraceae   | Loop-root Mangrove/Red Mangrove | Tree  |
| 11.    | Rhizophora apiculata Bl. | Rhizophoraceae   | Tall-Stilt Mangrove | Tree   |

Table 3. Checklist of mangroves associates recorded during the study

| Sl. No. | Scientific Name          | Family           | Common Name        | Habit  |
|--------|--------------------------|------------------|--------------------|--------|
| 1.     | Sesuvium portulacastum (L.) L. | Aizoaceae      | Sea Purslane       | Herb   |
| 2.     | Ipomoea pes-carpae (L.) R.Br. | Convolvulaceae  | Beach Morning Glory| Creeper|
| 3.     | Fimbristylis ferruginea (L.) Vahl | Cyperaceae    | Rusty Sedge        | Herb   |
| 4.     | Derris trifoliata Lour.  | Fabaceae         | Common Derris      | Climber|
| 5.     | Volkameria inermis L.    | Lamiaceae        | Glory Bower        | Shrub  |
| 6.     | Thespesia populnea (L.) Sol. ex Correa | Malvaceae | Indian Tulip tree | Tree   |
| 7.     | Pandanus odoratissimus L. | Pandanaceae     | Pandanus           | Tree   |
| 8.     | Aeluropus lagopoides (L.) Thwaites | Poaceae      | Mangrove Grass     | Herb   |
| 9.     | Acrostichum aureum L.    | Polypodiaceae    | Mangrove Fern      | Herb   |
| Habit            | Count |
|------------------|-------|
| Herb             | 45    |
| Shrub            | 20    |
| Climber and Creeper | 10  |
| Tree             | 30    |

**Figure 2.** Habit ratio of documented flora

**Figure 3.** Flowers of *Bruguiera cylindrica*

**Figure 4.** Fruit of *Sonneratia alba*

**Figure 5.** Inflorescence of *Derris trifoliata*
Table 4. Checklist of general flora recorded during the study

| Sl. No. | Scientific Name                        | Family           | Common Name          | Habit  | Conservational Status |
|---------|---------------------------------------|------------------|----------------------|--------|------------------------|
| 1       | Thunbergia erecta (Benth.) T. Anderson | Acanthaceae      | Bush Clockvine       | Shrub  | -                      |
| 2       | Asystasia gangetica (L.) T. Anderson  | Acanthaceae      | Ganges Primrose      | Herb   | -                      |
| 3       | Justicia procumbens L.                | Anacardiaceae    | Water Willow         | Herb   | -                      |
| 4       | Alternanthera ficoides (L.) Sm.       | Anacardiaceae    | Joseph's Coat        | Herb   | -                      |
| 5       | Lannea coramandelica (Houtt.) Merr.   | Anacardiaceae    | Indian Ash Tree      | Tree   | -                      |
| 6       | Calotropis procera (Aiton) W. T. Aiton | Apocynaceae      | Indian Milkweed      | Shrub  | -                      |
| 7       | Calotropis gigantea (L.) Dryand       | Apocynaceae      | Giant Milkweed       | Shrub  | -                      |
| 8       | Alostia scholaris (L.) R. Br.         | Apocynaceae      | Devil's Tree         | Tree   | -                      |
| 9       | Carya orchioides, an endangered (En) species | Hypoxidaceae | Golden Eye Grass     | Herb   | En                     |
| 10      | Borassus flabellifer L.               | Arecaceae        | Toddle Palm          | Tree   | -                      |
| 11      | Justicia procumbens L.                | Acanthaceae      | Doubt Palm           | Tree   | -                      |
| 12      | Cyanthillium cinereum (L.) H. Rob.    | Asteraceae       | Coconut Palm         | Tree   | -                      |
| 13      | Emilia sonchifolia (L.) DC. ex Wight  | Asteraceae       | Little Ironweed      | Herb   | -                      |
| 14      | Ageratum conyzoides L.                | Asteraceae       | Lilac Tasselflower   | Herb   | -                      |
| 15      | Impatiens minor (DC.) Bennet          | Balsaminaceae    | Lesser Balsam        | Herb   | -                      |
| 16      | Impatiens oppositifolia L.            | Balsaminaceae    | Opposite-leaved Balsam | Herb | -                      |
| 17      | Calophyllum inophyllum L.             | Calophyllaceae   | Mast Wood            | Tree   | -                      |
| 18      | Casuanrea quisquetilorum L.           | Calophyllaceae   | Australian Pine      | Tree   | -                      |
| 19      | Cleome rutilosperma DC.               | Cleomeaeae       | Fringed Spider Flower | Herb | -                      |
| 20      | Mordannia spirata (L.) G. Brük.       | Commelinaceae    | Asiatic Dewflower    | Herb   | -                      |
| 21      | Cyanotis cristata (L.) D.Don          | Commelinaceae    | Crested Dew-Grass    | Herb   | -                      |
| 22      | Cucusus reflexa Roxb.                 | Convolvulaceae   | Gaunt Dodder         | Climber-|                      |
| 23      | Evolvulus pullatus (L.) L.            | Convolvulaceae   | Roundleaf Bindweed   | Herb   | -                      |
| 24      | Cleiostocotus speciosus (J.Koenig) C.D.Speet | Costaceae  | Crepe Ginger         | Shrub  | -                      |
| 25      | Mukia maderaspatana (L.) M.Roem.      | Cucurbitaceae    | Madras Pea Pumpkin   | Climber-|                      |
| 26      | Cypresis rotundus L.                  | Cyperaceae       | Nut Grass            | Herb   | -                      |
| 27      | Dioscorea bulbifera L.                | Dioscoreaceae    | Air Potato           | Climber-|                      |
| 28      | Micrococcia mercurialis (L.) Benth   | Euphorbiceae     | Mercury Doughwood    | Herb   | -                      |
| 29      | Canavalia rosea (Sw.) DC.             | Fabaceae         | Beach Bean           | Climber-|                      |
| 30      | Crotalaria juncea L.                  | Fabaceae         | Indian Hemp          | Shrub  | -                      |
| 31      | Crotalaria verrucosa L.               | Fabaceae         | Blue Rattlepod       | Shrub  | -                      |
| 32      | Indigofera suffruticosa Mill.         | Fabaceae         | Small-leaved Indigo  | Shrub  | -                      |
| 33      | Lecaena leucocephala (Lam.) de Wit    | Fabaceae         | River Tamarind       | Tree   | -                      |
| 34      | Mimosa pudica L.                      | Fabaceae         | Touch-me-not         | Herb   | -                      |
| 35      | Smithia sensitiva Aiton               | Fabaceae         | Sensitive Smithia    | Herb   | -                      |
| 36      | Tephrosia purpurea (L.) Pers.         | Fabaceae         | Common Tephrosia     | Herb   | -                      |
| 37      | Scaveola taccada (Gaertn.) Roxb.      | Goodeniaceae     | Beach Cabbage        | Shrub  | -                      |
| 38      | Curculigo orchioides Gaertn.          | Hypoxidaceae     | Golden Eye Grass     | Herb   | En                     |
| 39      | Platostoma hispidum (L.) A.J.Paton    | Lamiaceae        | Hairy Gomphrena     | Herb   | -                      |
| 40      | Plectrantus scutellaroides (L.) R.Br.  | Lamiaceae        | Coleus               | Herb   | -                      |
| 41      | Mesophaeuncus suaveolens (L.) Kuntze  | Lamiaceae        | Pignut               | Shrub  | -                      |
| 42      | Clerodendrum indicum (L.) Kuntze      | Lamiaceae        | Boving Lady          | Shrub  | -                      |
5. Conclusions

Presence of 88 floral species along with the threatened species in the quantified area indicates that Sasihithlu estuary is qualitatively diverse providing conducive conditions for floral growth. The gathered data provides an insight about the floral composition of the area. Majority of the documented floral species are of great ecological and conservational importance. The study also revealed the threats to mangroves and the estuarine ecosystem. Environmental pollution, habitat loss and destruction along with various other intense anthropogenic activities have severe negative consequences on the ecosystem and biodiversity. Providing protection and incorporating better management practices can help in ecosystem management and biodiversity conservation. The baseline data from this study can be used as an effective tool for regular monitoring of habitats, mangrove regeneration initiatives and restoration programs. It can also be used for sustainable management and to formulate conservation strategies.

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Conflict of Interests

There is no conflict of interest with respect to this research article.

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