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Research Article

STUDY ON DISTRIBUTION, TAXONOMY AND ECONOMIC VALUATION OF THE MANGROVE GENUS ACANTHUS L. IN BHITARKANIKA NATIONAL PARK, ODISHA

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ABSTRACT
Present study is the first taxonomic identification about occurrence of three herbaceous mangrove species (i.e., *Acanthus ilicifolius* L., *Acanthus ebracteatus* Vahl., and *Acanthus volubilis* Wall.) from Bhitarkanika National Park and Wildlife Sanctuary (Odisha), India. Among these species, *A. ilicifolius* L. is most common but both *Acanthus ebracteatus* Vahl. and A. *volubilis* Wall were recorded as rare and site specific species of the genus Acanthus L.. The field investigation showed *A. volubilis* Wall. is frequently occur in association with other mangrove species like *Heritiera fomes* Buch.-Ham., *Avicennia officinalis L.*, *Excoecaria agallocha* L. as it is a climber species and need a host for its growth. The global distribution of these species shows they are mostly confined to South Asian countries. The present study emphasizes on taxonomic identification, site distribution, distinguishing and differentiating among the species and analysis of habitat suitability by studying soil physico-chemical requirements of each individual species.

Keywords: *Mangrove-Acanthus sp.- Identification-Bhitarkanika*

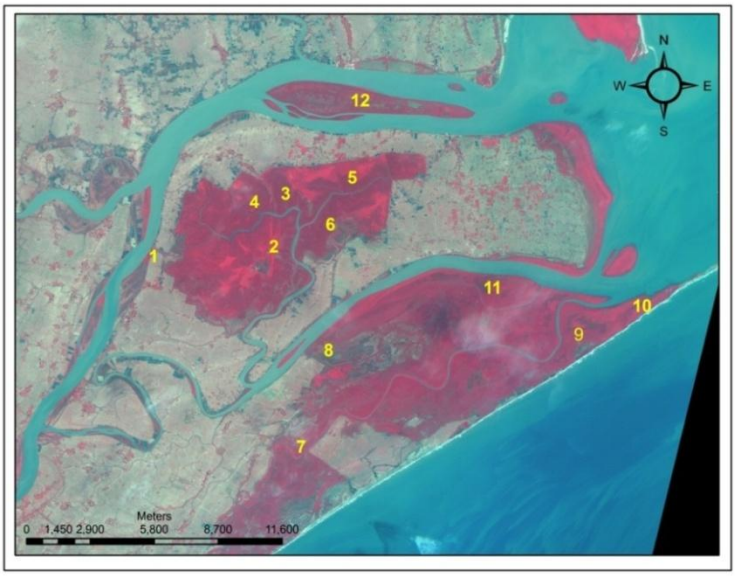
INTRODUCTION
Mangroves are unique creature in nature which includes a group of flowering plants with strong adaptation and resilience to cope the extreme physico-chemical estuarine habitats along the tropical and sub tropical countries. True or exclusive mangroves are those that occur only in such habitats, or only rarely elsewhere (Hogarth, 2015). Mangrove taxonomy is one of the least studied areas due to poor accessibility to the mangrove ecosystem. There are about ten taxonomic genus which bear three or more mangrove species and all belongs to tree in habit beside the genus, Acanthus L. which is herb in habit. The genus Acanthus L. has almost 300 species in tropical Asia and Africa with a centre of diversity in the Mediterranean but only three species is considered as mangroves, viz., *Acanthus ilicifolius* L., *A. ebracteatus* Vahl. and *A. volubilis* Wall (Singh and Odaki, 2004; Duke, 2012). The name of genus is derived from the word 'Acantha' means thorn or thistle (in Greek) and refers to the spiny leaves of some species (Duke, 2012). The mangrove species of Acanthus L. are not evenly distributed throughout the world and mostly confined to South Asian countries. Among the South Asian countries, the occurrence of these species has been variously reported. Spalding (2010), included only two species as mangrove, (i.e., *A. ilicifolius* L. and *A. ebracteatus* Vahl.) and both species were recorded from China & Taiwan, India east, Indonesia, Malaysia, Philippines, Thailand, Vietnam but no information was given for occurrence of *A. volubilis* Wall. Till date, *Acanthus ebracteatus* Vohl. has not been reported from Sundarbans (Naskar, 2004; Rajendran and Sanjeevi, 2004; Ragavan *et al.*, 2015). All three species has been reported from Philippines (Rotaquio *et al.*, 2007; Sinfuego and Inocencio, 2008), Singapore (Yang *et al.*, 2011) and Andaman and Nicober Islands (Rajendran and Sanjeevi, 2004; Ragavan *et al.*, 2015). Polidoro *et al.*, (2010) listed all three species in IUCN red least categories of least concerned. *Acanthus ebracteatus* Vahl. resembles *Acanthus ilicifolius* L., but all parts are smaller (Giesen *et al.*, 2007). *A. ebracteatus* Vahl. mostly found in association with fern *Acrostichum aureum* L. (Singh and Odaki, 2004). The

inflorescence of *A. volubilis* Wall. are usually with fewer flowers and shorter than other two species (Tomlinson, 2016). The flowers of *A. ilicifolius* L. are probably pollinated by birds and insects. *Acanthus ilicifolius* L. may be common along banks of creeks and in disturbed areas (Gieson *et al*., 2007). Banerjee and Rao, (1990) explained about occurrence of *A. ilicifolius* L. from Mahanadi delta (Bhitarkanika) of Odisha but no information was given regarding occurrence of other two species from this delta. Recently, *A. ebracteatus* Vahl. has been reported from Bhitarkanika mangrove NP and Wildlife Sanctuary (Pradhan *et al.*, 2016; Panda *et al*., 2017).

The present work emphasizes to give comparative information regarding the occurrence, distribution, taxonomic identification, flower visitors, habitat preference and economic uses of mangroves of the genus Acanthus L. from Bhitarkanika National Park (Odisha), India.

MATERIALS AND METHODS

Bhitarkanika Wildlife Sanctuary and mangrove National Park is situated between longitudes 86º 30'– 87º 6' E and latitude 20º 30'– 20º 50' N in Kendrapara district of state Odisha along the east coast of India. The mangrove forest is influenced by two major rivers of Odisha, i.e., Brahmani and Baitarani River. The National Park hosts one of the most species diverse mangroves of the world and the ecosystem is naturally protected by occurrence of huge number of salt water crocodiles (Crocodilus porosus) in almost all the river networks flowing inside the mangrove forests.



Map 1: Field Investigated Areas in Bhitarkanika National Park (Odisha), India; 1: Khola 2: Bhitarkanika 3: Dangmal 4: Ragrapatia 5: Mahishamunda (N) 6: Mahishamunda (S) 7: Satabhaya 8: Bagapatia 9: Habelikhati 10: Ekakula 11: Maipura river basin, 12: Kalibhanjadia

For present study, field surveys were carried out on seasonal basis at different locations within Bhitarkanika National Park (Odisha) between 2014 and 2016. Most of the mangrove forest sites had been visited and phenological growth stage of mangroves recorded (leafing, flowering and fruiting). The sites bearing species (*Acanthus ebracteatus* Vahl., *Acanthus ilicifolius* L., *Acanthus volubilis* Wall.) of the family, Acanthanceae were recorded and regularly visited. Identification of species was done on the basis of taxonomic variation of characters in leaf, stem, flower parts (shape, size, color) and roots etc. The data were co-related to previous works and reviewed with available literatures. All photographs were taken in-situ using the camera, Sony α 58Y, DSLR for photographic identification and separation between species. Soil samples were collected and analyzed to study the habitat suitability of all the three species of the genus Acanthus L.

RESULTS AND DISCUSSION

Bhitarkanika National Park (Odisha, India) hosts one of the most species rich mangrove floras of the world. The mangrove flora consists of 29 true mangroves and 71 mangrove associates (Panda *et al*., 2017). Out of these mangroves the plant family Acanthaceae bears three mangrove species (i.e., *Acanthus ebracteatus* Vahl., *Acanthus ilicifolius* L. and *Acanthus volubilis* Wall.) throughout the globe and all the three species presently recorded from Bhitarkanika NP (Plate 1) which shows the wide environment suitability for mangrove establishment in the deltaic wetland of Brahmani and Baitarani river basin.

Field Identification of Acanthus sp.

Key to distinguish mangrove species of the genus Acanthus L. (Naskar, 2004; Singh and Odaki, 2004; Tomlinson, 2016).

Herbs or shrubs, simple and opposite leaves, zygomorphic, sympetalous, usually conspicuous flowers with four (five) stamens, ovary bilocular; superior. Fruits usually a capsule and thought to disperse seeds by Jaculator mechanism of bursting. Seeds not viviparous (Crypto-viviparous). Only tap roots, pneumatophores absent ……..…… 1 (**Acanthaceae)**

1A. Leaf margins usually deeply toothed and tipped with rigid sharp spines; flowers in terminal spikes; usually longer than 10 cm; open flower 3.5-4 cm long; corolla two- lipped; tube short; blue or violet; bracteoles persistent; in fruit up to 1 cm long. Ripe fruits 2.5-3 cm long or longer; seed approximately 10 mm in diameter. ……..……
……..….. ***Acanthus ilicifolius* L.**

1B. All flower parts smaller than *A. ilicifolius* L. Open flower 2-2.5 cm; Corolla mostly white, Bracteoles small, Inconspicuous; early deciduous or absent. Ripe fruit shorter than 2.0 cm; seed 5-7 mm in diameter. Inflorescence variable……..…. 2

2A. Plants usually spiny with thick stems. Leaves usually widest above the middle. Bract distinctly shorter than the calyx; deciduous before flowering. Bracteoles usually present but early deciduous …….…. ***A. ebracteatus* Vahl.**

2B. Plants usually unarmed, with slender delicate sprawling stems. Leaves usually widest above the middle. Bract always longer than the calyx; deciduous during flowering. Bracteoles absent…….……..
***A. volubilis* Wall.**

***Acanthus ilicifolius* L.** ***Acanthus ebracteatus* Vahl.** ***Acanthus volubilis* Wall.**

Plate 1: Inflorescence of three Acanthus sp. Recorded from Bhitarkanika National Park

Among these three species, first two (i.e., *Acanthus ebracteatus* Vahl., *Acanthus ilicifolius* L.) are standing herb and the last one (*Acanthus volubilis* Wall.) is a climber.

In Bhitarkanika NP, the distribution of these three Acanthus sp. is not even. *A. ilicifolius* L. is the most common species and found in all forest sites of Bhitarkanika NP and Wildlife Sanctuary. This species is mostly dominated at sites like Khola, Ragrapatia and Satabhaya reserve forest sites where fresh water ingression towards land is of common event in comparison to other sites (Map 1). *A. ilicifolius* L. form pure patches at all these sites.

At Khola, the species form huge continuous understory patch below the canopy of the mangrove species, *Sonneratia apetala* Buch-Ham. Here, *S. apetala* Buch-Ham. is a long height mangrove of about 12-17 meter tall and average diameter at breast height of 45-60 cm.

In our present study *A. ebracteatus* Vahl. has been recorded only from Khola and Ragrapatia forest blocks of Bhitarkanika Wildlife Sanctuary. *A. volubilis* Wall. has been recorded from Satabhaya, Bhitarkanika, Habelikhati, Kalibhanjadiya Island, Ragrapatia and Mahisamunda forest blocks but more common at Bhitarkanika and Satabhaya sites. *A. volubilis* Wall., found more commonly as a landward mangrove and prefer to be associated with the dominant mangrove species like, *Excoecaria agallocha* L., *Heritiera fomes* Buch-Ham and *Avicennia officinalis* L. of Bhitarkanika National Park. *A. volubilis* Wall. is a climber and depends on these host species for its growth and establishment.

A. ilicifolius L. and *A. ebracteatus* Vahl., occur as riverine mangroves and both need more or less fresh water input for their healthy growth. *A. ebracteatus* Vahl., generally found mixed with *A. ilicifolius* L. and thus, it is very difficult to identify the species in its vegetative stage and need flowering stage for distinguishing both species in the field conditions. *A. volubilis* Wall. is different in habit (i.e., climber nature, leaf shape and texture) and thus, easy for identification in the field conditions (Table 2; Plate 1). Both *A. ebracteatus* Vahl. and *A. volubilis* Wall. were recorded as rare and showed somehow site restricted distribution inside Bhitarkanika NP.

The global distribution and their position whether they are true mangrove or mangrove associate is always a matter of controversy (Table 1 and Table 3).

The world distribution of these three species shows that it is mostly endemic to Asia and Oceania mangrove forests (Table 1).

The study for distribution of Acanthus sp. in South Asian countries showed *A. ilicifolius* L. and *A. ebracteatus* Vahl. were the most common species to all countries but *A. volubilis* Wall. showed rare type of occurrence (Table 4).

In India, *A. ilicifolius* L. is the most common species and found in all mangrove forests in comparison to other two species (Table 4). *A. volubilis* Wall is very rare and only reported from Sundarbans and mangals of Andaman and Nicober Islands (Naskar, 2004; Raghvan *et al.*, 2016).

Table 1: Distribution of Acanthus sp. in 6 Geographical Areas (Singh and Odaki, 2004)

Name of the Species	Asia	Oceania	West Coast of Americas	East Coast of Americas	West Coast of Africa	East Coast of African Middle East
Acanthus ebracteatus Vahl.	+	+				
Acanthus ilicifolius L.	+	+				
Acanthus volubilis Wall.	+					
Total number of species	46	38	07	07	07	09

Table 2: Differentiation of Three Acanthus L. Species of Bhitarkanika National Park, (Odisha), India (Refer: Plate 1)

Characters	*Acanthus ilicifolius* L.	*Acanthus ebracteatus* Vahl.	*Acanthus volubilis* Wall.
Habit	Herb; erect; up to 2.5 m long; form dense and clumping growth; Older one show branching from base of the main stem. Perennial and deciduous	Herb; erect; 1.5-2 m long; Found mixed with *A. ilicifolius* L. Older plants have short number of branching from base of the stem. Perennial and deciduous	Climbing herb; attaining a height more than 4 m; with a number of branches. Perennial
Leaves	Leaves simple; opposite decussate; with both down and upward marginal spines; lamina elliptic oblong; 10-14 cm long; 3.5-5 cm width; acute tip; short petiole; Green in color; Salt gland present, reticulate venation	Leaves simple; opposite decussate; with downward facing spines; lamina elliptic oblong; 10-12 cm long; 3.5-5 cm width, acute tip; short petiole; green in color; Salt gland present, reticulate venation	Leaves simple; opposite; without spine; thick fleshy; oblong lanceolate; 7-10 cm long and 4-5 cm width; succulent; have blunt tip; long petiole (up to 3.5 cm); Pink in color; Salt gland absent, reticulate venation
Stem	Green but older one is brown, Spines face upward	Green or Pink, Spines face downward	Brown or grey; Hairy; Spines absent
Root	Tap roots, occasionally stilt roots	Tap roots	Tap roots
Inflorescence	Terminal and axial, up to 17 cm long	Terminal and axial, shorter than 15 cm	Terminal and axial, between 8-10 cm
Flowers	Flower buds arranged in opposite decussate pattern; Bracteate; Sepals 5; polysepalous; twisted; Bilabiate corolla; Light blue or violet color; Flower size: Size of individual flower varies from 3-4 cm, Tip of petal face downward, Stamen 4, Stamens encloses Style	Flower buds arranged in opposite decussate pattern; Ebracteate; Sepals 4; polysepalous; Bilabiate corolla; White color; Flower size: long 2-3 cm, Petals face upward, Stamen 4, Stamens encloses Style	Flower buds arranged in opposite decussate pattern; Ebracteate; Sepals 4; polysepalous; Bilabiate corolla; White color; Flower size: 1.5-2 cm, Petals show facing downward, Stamen 4, Stamens encloses Style
Fruits	Fruits 2.5 to 3.5 cm, 4 ridged	Fruits shorter than 2 cm, 4 ridged	Fruits shorter than 2 cm, Ridge absent
Flowering and fruiting	March-April-May	April-May	April-May
Fruit ripening	September/October	September	July/August
Flower visitors and Pollinators	Bird and Insects (Bee, Ants, Beetles & Wasp)	Insects (Bee, Ants, Wasp & Spider)	Insects (Bee, Ants, Wasp)
Germination	Epigeal	Epigeal	Epigeal
Ecology	Common in river banks	River banks along with *A.*	Inland mangrove, love

	with tidal influence	*ilicifolius* L.	dryness and sandy texture
Distribution in Bhitarkanika NP	Common to all mangrove sites	Ragrapatia and Khola forest sites	Common at Bhitarkanika and Satabhaya forest sites
Uses	Fuel, fruit pulp used as blood purifier, Leaf in rheumatism, roots are useful for Asthma, paralysis and diabetes, fire wood	Unknown	Unknown

Table 3: Controversies on Classification of Acanthus sp. as True Mangrove or Mangrove Associate

Species	True Mangrove	Mangrove Associate
Acanthus ebracteatus Vahl.	Santisuk (1983), Singh & Odaki (2004), Giesen *et al.*, (2007), Wang *et al.*, (2010), Panda *et al.*, (2017)	Masagca (2008), Spalding *et al.*, (2010), Tomlinson (2016)
Acanthus ilicifolius L.	Santisuk (1983), Naskar (2004), Singh & Odaki (2004), Giesen *et al.*, (2007), Wang *et al.*, (2010), Panda *et al.*, (2017)	Masagca (2008), Spalding *et al.* (2010), Tomlinson (2016)
Acanthus volubilis Wall.	Naskar (2004), Ravishankar *et al.*, (2004), Singh & Odaki (2004), Giesen *et al.*, (2007)	Tomlinson (2016), Panda *et al.*, (2017)

Table 4: Distribution of Acanthus Species in South Asian Countries and in India (Based on Giesen *et al.*, 2007 and Naskar, 2004)

South Asian Countries		*A. ebracteatus* Vahl	*A. ilicifolius* L.	*A. volubilis* Wall.
Brunei		+	+	
Cambodia		+	+	+
Indonesia		+	+	+
Malaysia		+	+	+
Myanmar		+	+	+
PNG		+	+	+
Philippines		+	+	
Singapore		+	+	+
Thailand		+	+	+
Timor-Leste			+	
Viet Nam		+	+	
India	**Andaman**	+	+	+
	Bhitarkanika		+	
	Godavari & Krishna Delta		+	
	Cauvery Delta		+	
	Sundarbans		+	+
	West Coast of India		+	

The economic evaluation of these species is not properly investigated besides the species, *A. iliciflolius* L. The medicinal use of *A. iliciflolius* L. has been variously estimated but data is lacking for other two

species. *A. iliciflolius* L. show antidiabetic properties, anticancer activity, and antimicrobial activity against a wide range of pathogenic bacteria (Arora *et al.*, 2014; Sreenivasa *et al.*, 2015). *A. iliciflolius* L. has strong inhibitory action against *Bacilus subtilis*, *Staphylococcus aureus*, *Candida albicans*, *Aspergillus fumigates* and *Aspergillus niger* (Khajure and Rathod, 2010). The leaves of *A. ilicifolius* L. bear a number of salt glands which secrets salts and accumulate anti-stress compounds (i.e., glycine betain, cholin-o-phosphate) (Hutchings and Saenger, 1987).

The habitat suitability study showed *A. ilicifolius* L. and *A. ebracteatus* Vahl. prefer more or less similar type of habitat conditions. The soil physic-chemical parameter study showed both species require high pH, can tolerate wide salinity range, more silt and clay but less sand, less organic carbon, wide range of available soil nitrogen in comparison to the habitat condition needed by *A. volubilis* Wall. *A. volubilis* Wall. prefers more sandy, low pH, more organic matter than other two species (Table 5).

Table 5: Soil Chemistry of Collected Samples below each Acanthus sp. (Bhitarkanika NP, Odisha)

Soil Properties	***Acanthus ilicifolius* L.**	***Acanthus ebracteatus* Vahl.**	***Acanthus volubilis* Wall.**
pH	6.2-6.7	6.2-6.8	5.9-6.4
Salinity	3-14	4-12	4-8
Texture % (Sand, Silt & Clay)	44, 25, 31	45,26, 29	56, 30,14
% Organic carbon	0.85-1.2	0.85-1.08	1.12-1.24
Ava. N_2/hector (kg)	200-250	250-300	220-240

The Bhitarkanika mangrove forests are not exception to global coastal habitat change. Many sites in Bhitarkanika NP which are close to sea front are experiencing long duration saline water inundation. This will impose stress for maintenance of present mangrove diversity of Bhitarkanika NP. The rare and very small population of *A. ebracteatus* Vahl. and *A. volubilis* Wall. show that they are under pressure of their present status. Habitat loss and rise of salinity may become the possible factor for loss of mangrove species (Naskar, 2004) and *A. volubilis* Wall. is thought to become more prone for its existence and development. The wide occurrence of *A. ilicifolius* L. is due to its strong adaptation mechanism for high salt tolerant and wide habitat range. Thus, *A. ilicifolius* L. somehow has more resilience then other two species. So, there is an urgent need for conservation of mangrove flora and to evaluate its ecological and economic value before they may go extinct from their natural habitats like Bhitarkanika National Park (Odisha), India.

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