Floral composition and taxonomy of mangroves of Andaman and Nicobar Islands

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Actual number of mangrove species found in the Andaman and Nicobar Islands outnumber the number of species recorded to occur there. Present study consists reviewing the literature on mangrove floral composition and distribution as well as highlighting the causes of such apparently large species numbers and apparently incorrect identification of some of the mangrove species in the Andaman and Nicobar islands. Mangrove survey indicates that there are 33 exclusive ‘mangrove species’, at least 27 ‘mangrove associates’ that occur on the islands.

[Keywords: Andaman and Nicobar Islands, Mangroves, Floral composition, Taxonomy]

Introduction

Mangrove forests are among the world’s most productive ecosystems, situated at the interface between land and sea in the tropical and subtropical latitudes\(^1\)\(^2\). Despite its ecological and economical values, globally mangrove areas are disappearing at the rate of approximately 1% per year\(^1\)\(^4\). However, there is very little known about the effects of either widespread or localized mangrove area loss on individual mangrove species or populations due to the lack of species specific information\(^7\). Though 39 true mangrove species known to occur in India, the actual number of mangrove flora that exists in different regions of India is not fully known due to scattered data, the absences of their comprehensive compilation and lack of extensive field survey\(^6\).

Species composition of mangroves is a basic and important prerequisite to understanding all the aspects of structure and function of mangroves, as well as their bio geographical affinities and their conservation and management\(^7\)\(^8\).

Andaman and Nicobar islands (ANI) are located in the Bay of Bengal, off the eastern coast of India, between 6°N to 14°N latitude and 92° E to 94°E longitude and bestowed with dense mangrove cover\(^9\). Approximately 89% of the mangrove cover falls under the category of either very dense mangrove (with more than 70% canopy density) or moderately dense mangrove (with canopy density between 40% and 70%). Mangroves in these islands mostly fringe the creeks, backwater and muddy shores. According to the latest estimate of the Forest Survey of India\(^9\), the
photographic evidence also collected for all the species. All mangroves species encountered during the field survey were identified based on their key characters. All sites were visited four times in a year to record the floral composition. Figure 1 and Appendix 1 shows the location of surveyed sites of ANI in this study.

Results and Discussion

It is observd that 33 true mangrove species and 27 mangrove associates in this study. Most controversial species among researchers are Acrostichum sp, Acanthus sp, Pemphis acidula, Phoenix paludosa, Cynometra sp and Dolichandrone spathacea. a as mangrove associate species and Acrostichum sp and Pemphis acidula as minor element. Duke included all the above mentioned species as a mangrove species except Acanthus volubilis. Kathiresan and Bingam considered Cynometra sp, Dolichandrone spathacea and Pemphis acidula as mangrove species and Acrostichum sp, Acanthus sp, Phoenix paludosa are not considered as mangroves. Giesen et al. classified Acrostichum sp and Acanthus sp and Pemphis acidula as true mangrove species and Phoenix paludosa and cynometra sp as mangrove

Only few field based studies had been carried out on floral composition of mangroves of ANI. In earlier references such as Kloss and Parkinson mangrove species were reported in their work on forest flora of Andaman’s. Afterwards Sahni and Blasco have reported 28 mangrove species. Mall et al. have reported 26 exclusive mangrove species. Dagar et al. have reported total of 34 exclusive mangrove species among 17 genera and 13 families. Later Singh reported 28 exclusive mangrove species. More recently Debnath and Mandal and Naskar, observed 59, and 61 species from ANI, including some salt marsh and associated plants. Singh and Garge reported 27 exclusive mangrove species. Present study aims to provide an up-to-date list of the floral composition of mangrove of the ANI.

Materials and Methods

During 2009-2011, field surveys were carried out on six islands namely South Andaman, Havelock, Middle Andaman, North Andaman (Mayabunder and Diglipur), Little Andaman and Car Nicobar (Fig. 1). On each Island a minimum of two sites (mangrove creeks) was selected and a total of 25 sites surveyed. In each site minimum 10 quadrates (10 m X10 m) were laid randomly in order to cover all the zones of the mangroves. All vascular plants and ferns encountered during the survey were identified in the field using Duke and Bunt, Tomlinson, Duke and Jackes, Banerjee et al., Duke, Duke, Kathiresan, Kathiresan, Debnath, Dagar et al., and Giesen et al. Herbarium is prepared for all encountered true mangrove species and deposited in Botanical survey of India (BSI). Regional centre at Port Blair, the total area under mangrove cover in India is 4663 km², 617 km² of which (13% of the total mangrove area of the Indian Territory) occurs in the ANI. In Andaman district, the area under mangroves is 614 km², while in Nicobar district mangroves occupy only 3 km² reported by FSI. The area under mangrove cover in has decreased significantly during the last decade FSI possibly leading to change in floristic composition and local extinction of some species. According to FSI about 43 km² of mangrove cover decreased between 2003 and 2007 in the ANI.

Figure 1 Acanthus species; (a-b) A. ebracteatus (a) White colour flowers (b) fruits (c-j) A. ilicifolius (c) Flowering spike (d) Violet colour petals of A. ilicifolius (e) Fruits (f) spine less narrow leaves A. ilicifolius (g) spine less leaves and spines at nodes (h) spine less leaves and absences of spines at nodes (i) Spine less broad leaves of A. ilicifolius (j) Fruits of A. ilicifolius with unarmed stem and leaves (k-n) Acanthus volubilis (k) White colour flowers (l) Flower spike with unarmed stem and leaves (m) Fruits (n) leaves of A. volubilis with salt crystals.
associate. Among the Indian researches Dagar et al.\textsuperscript{16}, Singh\textsuperscript{17} and Dam Roy et al.\textsuperscript{31}, classified Acanthus sp, Cynometra sp and Phoenix paludosa as mangrove species and Acrostichum sp, Pemphis acidula and Dolichandrone spathacea are considered as mangrove associates. While Debnath\textsuperscript{18} classified Acrostichum sp., Cynometra sp and Pemphis acidula as mangrove species and Acrostichum sp, Pemphis acidula and Dolichandrone spathacea as facultative mangrove species, Mandal and Naskar\textsuperscript{19} included all the above mentioned controversial species in his list except Acrostichum speciosum and Pemphis acidula, but he has not classified the mangrove as true and associates. Recently based on leaf trait and salt content Wang et al.\textsuperscript{32}, classified that Acrostichum sp, Heritiera littoralis and Excoecaria agallocha as mangrove associates and Xylocarpus granatum, Acanthus sp. and Pemphis acidula as true mangrove species. Though the uncertainty still persist, present study, included Acanthus sp, Acrostichum sp., Cynometra sp., Dolichandrone spathacea, Pemphis acidula and Phoenix paludosa as exclusive mangrove species by reconciling Tomlinson\textsuperscript{22}, Dagar et al\textsuperscript{16}, Duke\textsuperscript{25}, Kathiresan and Bingham\textsuperscript{1} and Debnath\textsuperscript{18} and based on the abundances and occurrence within the mangroves areas of ANI. List of true mangroves species reported by various authors in ANI are given in Table 1. Appendix 2 provides details of the locations of each true mangrove species recorded in ANI.

During the survey we could not encounter seven previously reported species namely Aegialitis rotundifolia, Aglaia cucullata, Ceriops decandra, Kandelia candel, Bruguiera sexangula, Cynometra ramiflora and Sonneratia apetala. However we found wide variety of morphological variations of its similar species and this suggests that these species might have been misidentified by earlier work or authors\textsuperscript{16, 18}. Moreover, the wide variation within the same species is indication of increasing environmental stresses and epigenetic changes among the population of the same species\textsuperscript{33}. So there is likelihood that some of these species might have become extinct from this region. Singh et al.\textsuperscript{34} noted that some of the above mentioned species are endangered and vulnerable. Singh\textsuperscript{17} also did not report aforementioned mangrove species in 2003. Contemporary to this study, Dam Roy et al.\textsuperscript{31}, in 2009 reported 25 true mangrove species with some uncommon mangrove associates. He also did not report above mentioned species except Bruguiera sexangula. Although Dam Roy et al.\textsuperscript{31} provided the identification guide for 25 true mangrove species, he appears to have misidentified Acanthus illicifolius as Acanthus volubilis, Barringtonia racemosa as Barringtonia asiatica, Finlaysonia obovata as Sarcolobus carinatus, Stenochlaena palustris as Acrostichum speciosum and illustration of Bruguiera sexangula similar to variations of Bruguiera gymnorhiza. Present study described the key diagnostic characters of each species and interesting morphological variations among the individuals of the same species, as follows.

**Acanthus**

Genus Acanthus (Fig. 2) has three distinct mangrove species i.e. Acanthus Acanthus ilicifolius L., Acanthus ebracteatus Vahl and Acanthus volubilis Wall. All the three species were previously reported from ANI. However, the existence of A. volubilis is considered as doubtful in ANI by previous researchers\textsuperscript{15-17} because A. volubilis is not recorded.
further after the first record by Parkinson\textsuperscript{12} and Thothathri\textsuperscript{35}. Moreover there was dispute on identification of \textit{A.ilicifolius} and \textit{A.ebracteatus} among the Indian researchers\textsuperscript{6}. But in this study we located all three species. \textit{A.ilicifolious} is very common and easily differentiated from \textit{A. ebracteatus} by its violet or purple coloured flowers. Most interestingly we have noticed marked differences in serration of leaves among the population of \textit{A. ilicifolius}, in many sites it possess spineless leaves and shape of the leaves varies from needle like to broad acute and spines at the nodal region is either present or absent. This observation insists that there must be a warrant varietal species among the population of \textit{A. ilicifolius}. \textit{A. ebracteatus}, is located in two sites i.e sippighat and shoal bay (South Andaman), has white flowers which turn to brown when it’s mature. Important characters by means of which we used to distinguish \textit{A. ilifolius} and \textit{A. ebracteatus} is inflorescences and position of spine at nodal region. Inflorescence is terminal in \textit{A. ebracteatus} and \textit{A. ilifolius} exhibits both axial and terminal inflorescences. Spines at nodes are facing downward in \textit{A. ebracteatus} and upward in \textit{A. ilicifolius}. Another distinguishing character is bracteoles, which is present in \textit{A. ilicifolius} and inconspicuous in \textit{A. ebracteatus}. \textit{Acanthus volubilis} is easily identified by its unarmed and twine nature and white color flowers. We located \textit{A. volubilis} only in shoal bay and its occurrence in ANI is confirmed. Although Dam Roy \textit{et al.}\textsuperscript{31} identified \textit{A. volubilis} from ANI the illustration resembles the \textit{A. ilicifolius} with spineless broad leaves with acute tip and without spines at nodal region.

\textit{Avicennia}

Two species of the genus \textit{Avicennia} (Fig. 3) i.e. \textit{Avicennia marina} (Forsk.)Vierh and \textit{Avicennia officinalis} L. were known to Occur in ANI\textsuperscript{16,18} and the occurrence of \textit{Avicennia alba} Bl. in ANI is uncertain because only Mandal and Naskar\textsuperscript{18} in their review work included \textit{A. alba} in the floral list. We also not encountered \textit{A. alba} but we found variation within the population of \textit{A. marina}. Particularly in Junglighat area we have noticed marked differences in leave size and shape, position of anthers in relation to stigma and the presence and absence of beak in fruits among the individuals of \textit{A.marina}. According to Duke\textsuperscript{26} the above mentioned characters are key feature for the differentiation of \textit{Avicennia} species. Some of the \textit{A. marina} exhibit small flower, narrow elliptic leaves and stigma positioned below lower edge of anthers and beaked fruits like \textit{A. alba} with capitate inflorescences. But \textit{A. alba} possess spicate inflorescences unique within the genus (other \textit{Avicennia} species possess capitate inflorescences). So it appears that ecological variants of \textit{A. marina} might have been misidentified as \textit{A. alba} by Mandal and Naskar\textsuperscript{19}. Moreover except, Mandal and Naskar\textsuperscript{19} no records are available for the presence of \textit{A. alba} in ANI. The key diagnostic features to distinguish \textit{A. officinalis} from \textit{A. marina} are the rounded leaf tips and large flower. Generally \textit{A. marina} exhibit leaves with acute tip with small flowers. In addition to that \textit{A. officinalis} is distinguished from \textit{A. marina} by its propagules with slightly curved beak whereas \textit{A. marina} exhibit very short beak and style length is relatively longer that \textit{A. marina} and radicle is glabrous in \textit{A. marina} whereas hairy in \textit{A. officinalis}.

\textit{Bruguiera}

\textit{Bruguiera} (Fig. 4,5,6) is the largest genus in the \textit{Rhizophoraceae}\textsuperscript{22,36-39}.With the exception of \textit{Bruguiera exaristata} Ding Hou and \textit{Bruguiera hainessii} C.G.Rogers the remaining four \textit{Bruguiera} species i.e \textit{Bruguiera gymnorrhiza} (L.) Savigny, \textit{Bruguiera parviflora} (Roxb.)W.A. ex Griff., \textit{Bruguiera cylindrica} (L.)Bl.and \textit{Bruguiera sexangula}
were recorded from ANI 16, 18-19. B. cylindrica and B. parviflora possess small and erect flowers whereas B. gymnorrhiza and B. sexangula possess large, recurved flowers 22, 40. In earlier references of Mall et al. 15 B. cylindrica is mentioned as rare species in ANI but in this survey we have recorded this in most of the sites. The Key character of B. cylindrica is in three flowered inflorescences and dark green leaves, folded when mature. B. parviflora is distinguished by its small yellowish green leaves and pencil like propagules with persistent calyx tube and its common in ANI (Fig. 4).

In ANI information about Bruguiera sexangula is very limited due to the lack of detailed taxonomical survey. B. sexangula from ANI was reported by Singh et al. 41 and no further collections are available 18 . Mall et al. 15 and Singh and Garge 20 also mentioned that only few number of B. sexangula was observed only from Brumanallah area in south Andaman. Moreover, the records of B. sexangula from ANI by previous authors appear to be doubtful as they followed the calyx color as key character to distinguish B. sexangula and B. gymnorrhiza. In addition Dagar et al. 16 mentioned that calyx colour of B. sexangula is initially green and turns to yellow when mature. According to Duke 26 the presence and absence of petal spine and number of petal bristles at the apex of the petal lobe are the key characters to distinguish Bruguiera species. Generally in B. sexangula petal spine is shorter than the petal lobe and petal bristles are absent or minute 26 .

In the present study we could not identify B. sexangula based on the number of petal bristles and petal spine, rather we found wide variation...
in calyx color, number of petal bristles and length of petal spine among the individual specimens of *B. gymnorhiza*. We have observed different colors of calyx tubes of *B. gymnorhiza* like reddish, greenish orange, yellowish, orange, pale green and shady white (Fig. 5). Calyx with yellowish colour is key character of *B. sexangula*, whereas pale green is calyx colour of *B. hainesii*. But the all the flowers exhibit petal bristles with 2-3 mm long, characteristic of *B. gymnorhiza*. We also observed this color variation in matured propagules with persistent calyx tubes (Fig. 5). Petiole color also varies like green, reddish and yellowish green (Fig. 5). According to Duke\(^{26}\) petal spine of *B. gymnorhiza* is shorter than the petal lobe, petal bristles are three in number and greater than 2mm long but we have observed three groups of *B. gymnorhiza* based of the length of petal spine i.e. petal spine equal to petal lobe, petal spine shorter than the petal lobe and petal spine greater than the petal lobe (Fig.6). Although this observation shows unreliability of petal spine and bristles as key to identification of *Bruguiera* species, Sheue et al.\(^{42}\) illustrate that the petals of *B. gymnorhiza* with petal spine greater than the petal lobe and the petal bristles vary from 2-3. This indicates that there could be two forms of *B. gymnorhiza*. These observations may infer that *B. sexangula* might be misidentified or extinct in ANI if previous authors’ reports are considered to be correct. Singh et al.\(^{34}\) also described that *B. sexangula* is endangered in ANI.

**Ceriops**

Two species of genus *Ceriops* (Fig. 7) namely *Ceriops tagal* (Perr.) C.B. Rob. and *Ceriops decandra* (Griff.) DingHou have been reported from Andaman and Nicobar Islands\(^{16,18}\). We, however, could not encounter *C. decandra* in this survey. Previous authors also mentioned that *C. decandra* is rare species\(^{16}\). *C. decandra* is easily distinguished from *C. tagal* by its short peduncle, calyx lobe facing downwards, sharply ridged short hypocotyl warty towards apex and hypocotyls always in upright position. *C. tagal* possesses long peduncle, long propagule with yellow color collar and calyx lobes facing upwards. *C. tagal* is most common in Andaman group of islands. As it is very difficult to distinguish *C. decandra* from *C. tagal* without flowering and fruiting it is understood that *C. tagal* might have been misidentified by previous authors\(^{16,18}\). So the occurrence of *C. decandra* in ANI is still doubtful. Mall et al.\(^{15}\), Singh\(^{17}\) and Dam Roy et al.\(^{31}\) also did not report *C. decandra*.

**Sonneratia**

Earlier four species of genus *Sonneratia* (Fig. 8) i.e. *Sonneratia apetala* Buch.-Ham, *Sonneratia alba*...
J. Smith, Sonneratia caseolaris (L.) Engl. and Sonneratia griffithii (Kurz.) have been reported from ANI 16, 19. In the present survey we have identified four species namely S. alba, S. caseolaris, S. griffithii and S. ovata. We did not encounter S. apetala which is easily differentiated from other Sonneratia species by its narrowly elliptic leaves, apetalous flowers, calyx with four lobes and large umbrella shaped stigma. Similarly Debnath 19 and Dam Ray et al. 31, did not record this species, though it was reported by certain previous authors like Dagar et al. 16 and Singh 17. So the existence of S. apetala in ANI needed to be confirmed whether it is extinct or misidentified by previous authors. S. caseolaris is easily differentiated by its reddish stamens whereas S. alba, S. griffithii and S. ovata have white stamens. S. ovata is distinguished from S. alba and S. griffithii by its enveloped calyx and almost round leaves. Although Dam Roy et al. 31 reported S. ovata as a new record from ANI, he found that species only in Havelock islands but in this study we observed S. ovata in four sites i.e Havelock, Indira nagar, Wandoor and Shoal bay in South Andaman. S. alba is easily identified by its broadly drop-shaped leaves and persistent sepals whose tips bend back towards the stalk (refluxed). S. alba is most common in ANI. S. griffithii can be distinguished from other species by its obovate leaves, absences of petals and larger globose fruits flattened or depressed at apex. S. griffithii is one of the globally threatened species 43. In this study we recorded this species in three sites Mohanpur, Dhaninallah creek and Parangara creek (North Andaman). S. caseolaris was recorded only in V.K Pur Creek in Little Andaman.

**Lumnitzera**

Within the genus Lumnitzera (Fig. 9), Lumnitzera littorea (Jack.) Voigt. is most common in South and Middle Andaman and easily identified by its red colored flowers. Lumnitzera racemosa Willd is common in Mayabunder, Diglipur (North Andaman) and Car Nicobar (Kimous bay) and indentified by its white colored flowers. L. rosea, a putative hybrid between L. littorea and L. racemosa, was not encountered during the survey although both the parents occur together in many sites. L. rosea exhibits rose colored flowers.

**Rhizophora**

Genus Rhizophora is common in the Indo-West Pacific region. Among the five Rhizophora species in this region, four species (Fig. 10, 11, 12) namely, Rhizophora apiculata Bl., Rhizophora mucronata Poir., Rhizophora stylosa Griff and Rhizophora lamarckii Montr., have been reported from ANI 16, 18-19, 41. Genus Rhizophora is easily differentiated from other mangrove species by its
stilt roots. *R. apiculata* is easily identified by its narrow elliptic leaf with acute tip and two flowered inflorescence with short peduncle and corky brown bract (Fig. 10). Flower with small style (0.5 to 1.1 mm) and 9–15 stamens\(^{21}\). *R. mucronata* and *R. stylosa* have peduncle length longer than the petiole length and both looks very similar. One of the key characters that distinguish the *R. stylosa* from *R. mucronata* is style length (Fig. 10). In *R. stylosa* style length is more than 2.5 mm\(^{26}\), whereas in *R. mucronata* the style length varies from 0.6 to 2 mm\(^{21}\). Apart from style length, leaf shape and color, propagules length are also used to distinguish these two species. *R. mucronata* has yellowish green broad leaves and propagules length varies between 40 and 80 cm whereas *R. stylosa* has dark green slightly broad leaves and propagules length varies between 26 cm and 65 cm\(^{21}\). Fig. 11 depicts the propagules of *Rhizophora* species and variation in leaf color and shape of the *R. mucronata* and *R. stylosa* in ANI. However, the taxonomical distinction between *R. stylosa* and *R. mucronata* is still unclear, because intermediate forms are also present in many places which are difficult to assign to either taxa\(^{44}\).

Present study also recorded *Rhizophora* hybrids in two sites, Havelock and Car Nicobar. In Havelock Island we recorded 10 hybrid individuals whereas in Car Nicobar *Rhizophora* hybrids are available in good numbers. In Andaman and Nicobar Islands *Rhizophora* hybrids were first identified by Singh et al.\(^{41}\) from Havelock islands of South Andaman. Thereafter no records are available for *Rhizophora* hybrids in ANI\(^{18}\). For the first time here we recorded the *Rhizophora* hybrids in Kimous Bay, Car Nicobar. Although Ragavan et al.\(^{45}\) described *Rhizophora* hybrids in Havelock islands based on the style length, the taxonomical distinction between *R. lamarckii* and *R. annamalayana* is still unclear. Hence in the present communication, we describe these taxa as *Rhizophora* hybrids which are differentiated from other *Rhizophora* species by their tallness, well developed stilt roots, plenty of flowers and rare occurrence of propagules. Flowers of *Rhizophora* hybrids are similar to flowers of *R. apiculata*, only difference is that the bracts are corky brown and inflorescence is two flowered in *R. apiculata* whereas in *Rhizophora* hybrids bracts are smooth and green in color and inflorescences are two to four flowered (Fig. 12). One of the unique features of Indian *Rhizophora* hybrids is the presence of stamens in two distinct whorls, outer with longer stamens and inner with smaller stamens\(^{45}\).

**Figure 11** *Rhizophora* hybrids (a) *Rhizophora* hybrids (left) with *Rhizophora mucronata* (right) (b) well developed stilt root of *Rhizophora* hybrids (c–e) 2–4 flowered inflorescences with smooth green bract (f) arrangement of stamens in two rows, inner small and outer large stamens (g) Hybrids with more than 2 mm style length (h) less than 2 mm style

**Figure 12** *Cynometra iripa* (a) Leaves with off centered mid vein (b) Flowers (c) Wrinkled pod like fruits with lateral beak

**Cynometra**

Within the genus *Cynometra*, two species i.e. *Cynometra ramiflora* Linn and *Cynometra iripa Kostel* (Fig. 13) are recognized as mangroves and considered as rare species in ANI\(^{16}\). In the present survey we have identified only *C. iripa* and it is very common in Andaman Islands. *Cynometra* species is easily identified by its leaf with off-centered mid vein and wrinkled pods. Two species of *Cynometra* are
Brownish A. speciosum. The easiest diagnostic feature is the leaf tips, which are generally blunt, but with a small point in A. aureum, and elongate-pointed in A. speciosum. Although previous authors mentioned that both the species are abundant in ANI. In this study we encountered A. speciosum in three sites only (Wright myo, Shoal bay and Parangara creek). But in the field we had problems in identifying the A. speciosum because of its similarity with Stenochlaena palustris. Stenochlaena palustris is climbing fern present abundantly in all sites surveyed and exhibit leaves similar to A. speciosum. Though Dam Roy et al. reported Acrostichum speciosum the photographs in his report was Stenochlaena palustris. So it’s understood that the abundance of A. speciosum in ANI by previous authors was due to the misidentification Stenochlaena palustris as A. speciosum.

Pemphis acidula

It is the only mangrove species having very small leaf. In field Pemphis acidula Forst is (Fig. 15) easily identified by its appearance very similar to meanganthi tree and mostly occur on coral sand area (Fig. 15). In this study we recorded this species only in Havelock Island and Carbyn cove area.

Acrostichum

According to Tomlinson Acrostichum aureum L. and Acrostichum speciosum Willd are (Fig.14) considered as minor mangroves but Dagar et al. has not included it in his list. It is the only fern which occurs in mangroves. Generally the occurrence of Acrostichum sp in mangroves is considered as a sign of degradation as its changes the acidity of the soils. In general, A. aureum is taller than A. speciosum, and the young plants are more reddish than the Aegiceras

Two species of Genus Aegiceras i.e Aegiceras floridum Roemer & Schultes and Aegiceras corniculatum (L.)Blanco (Fig. 16) are considered as mangrove species, but only A. corniculatum is present in Indian subcontinent. A. floridum is similar to A. corniculatum, but differs due to its smaller leaves, branched (compound) flower clusters (not branched in A. corniculatum) and only slightly curved fruit. Little is known about this species recorded in Malaysia (Sabah), Indonesia (Java, the Moluccas, Sulawesi, Borneo, and Papua), Cambodia, Vietnam,
the Philippines and Papua New Guinea. A. corniculatum is easily identified by its rotten banana like fruits often called as Banana of mangroves. Although its leaves are similar to leaf of Ceriops species it is easily differentiated by it apical notch at the tip of leaf which is absent in Ceriops. A. corniculatum is common in Andaman Islands (Fig. 16).

**Excoecaria**

Among the two mangrove species of genus Excoecaria (Fig. 17), Excoecaria agallocha L. is recorded from ANI. This species can be readily distinguished in the field by its light green and reddish leaves with wavy margin, axillary inflorescence, and poisonous milky latex. Leaves turn orange to a bright shade of red before they are shed, and this gives the entire tree a reddish appearance. Most common in Andaman Islands present in land ward edges of the mangroves. Sometimes occur along with Rhizophora and Bruguiera species. Excoecaria indica is not reported from ANI. It is typically distinguished from E. agallocha L. by its green fruit the size of a cherry, and by its thorny trunk. Moreover, fruits in E. agallocha are three lobed whereas in E. indica fruits are round. E. agallocha is only mangrove member which exhibit dioecious condition i.e. male and female reproductive organs borne on separate individuals of the same species. (Fig. 17).

**Heritiera**

Although Heritiera fomes Buch. Ham and Heritiera globosa Kostermans (Fig. 18) occur in the

Indian subcontinent, our observations of an extended fruit with a single ridge (longitudinal) infer that Heritiera littoralis Dryn is the only representative species of its genus in ANI (Fig. 18). H. fomes has sub-globose fruits with longitudinal and transverse ridges whereas H. globosa has rough globose fruits devoid of any ridges.

**Scyphiphora hydrophyllacea Gaertn.f.**

Scyphiphora hydrophyllacea (Fig. 19) is easily identified by its polished leaf surface and bunch of flowers at the axial of leaves (Fig. 19). This species is most common in Andaman Islands but it’s very rare in other parts of the India.

**Mangrove palms**

Nypa fruticans Wurmb and Phoenix paludosa Roxb. (Fig. 20) are the only mangrove members of the family Palmaceae. Nypa fruticans is exclusive mangrove species whereas Phoenix paludosa is found in landward edges of the mangroves. Both the species are easily identified based on their palm like leaves (Fig. 20). Both are most common in Andaman Islands.

**Xylocarpus**

Only two species of the genus Xylocarpus (Fig. 21) are recognized as mangrove species namely Xylocarpus granatum Koen and Xylocarpus mekongensis (Prain) Pierre. Most of the previous researchers in ANI reported three species with an addition of Xylocarpus molluccensis or Xylocarpus
whereas in X. granatum 1-2 pairs of leaflets are present. One more Xylocarpus species which we encountered during the survey is Xylocarpus rumphii (Kostel.) Mabb (Fig. 22). It is beach vegetation recorded in Havelock Island. As it is very rarely found in mangrove swamp it’s generally not considered as mangroves species.

Figure 22 (a) Fruits of Barringtonia asiatica (b) Leaves of B. asiatica (c-f) Barringtonia racemosa (c) leaves (d) flowers (e) flowers in long spike (f) fruit (g-i) Cassine viburnifolia (g) capsule like fruits (h) leaves (i) Inflorescences (j-l) Finlaysonia obovata (j) leaves (k) flowers (i) fruits

Brownlowia tersa

Brownlowia tersa (Fig. 22) is one of the near threatened species. The species can be recognized in the field by its greyish brown branches, lanceolate leaves with dull silvery undersurface, and pear-shaped woody fruits with two valved carpels. It is one of the rare mangrove species in ANI. Hajra et al. also mentioned that B. tersa was reportedly some 80 years before, growing abundant nearer to large creeks of Middle Andamans and Dhanikhari creek is now rarely observed there. In the present study we observed this species in limited population at shayamkund area in Middle Andaman.

In this study Kandelia candel has not been recorded from any site. Although it is very similar to Rhizophora species it can easily be distinguished by its reflexed calyx lobes i.e sepals, spindle-shaped hypocotyls (thickest in the middle and tapering to both ends) and absence of above ground roots. Similarly Aegialitis rotundifolia and Aglaia cucullata also has not been recorded from any site. Singh and Dam...
Roy et al. also had not reported this species in ANI. So it may be inferred that Kandelia candel, Aglaia cucullata and Aegialitis rotundifolia might have become extinct from ANI. Dagar and Debnath also mentioned that the existence of Aegialitis rotundifolia, Kandelia candel and Aglaia cucullata are needed to be confirmed whether they become extinct or misidentified by previous authors. Other doubtful species in ANI are Ceriops decandra, Sonneratia apetala, Cynometra ramiflora and Bruguiera sexangula.

Among the 33 species reported six species i.e Acanthus volubilis, Xylocarpus mekongensis, Pemphis acidula, Brownlowia tersa, Sonneratia ovata and Sonneratia griffithii are very rare and confined to limited population. So immediate efforts should taken to protect and propagate the above mentioned species to prevent their local extinction. Also it is important to pay special attention to conserve the natural hybrids of genus Rhizophora because natural hybrids play a very important role in evolution of novel gene combinations and a mechanism of speciation. Moreover, Rhizophora hybrids rarely produce seeds, making its propagation very difficult.

**Mangrove associates**

There is no consensus opinion on mangrove associates among researchers due to the lack of proper definition to distinguish clearly between the mangrove and non-mangrove species. so it is not appropriate to compare species composition of mangrove associates with other authors. Following are the mangroves associates found most frequently in many sites: Ardisia elliptica, Barringtonia asiatica, Barringtonia racemosa, Caesalpinia bonduc, Caesalpinia crista, Calophyllum inophyllum, Cassine viburnifolia, Cerbera odollum, Clerodendrum inerme, Dalbergia candenatensis, Derris trifoliata, Derris scandens, Fimbristy lis ferruginea, Finlaysonia obovata, Flagellaria indica, Hibiscus tiliaceus, Hoya parasitica, Intsia bijuga, Ipomoea pes-caprae, Melastoma saigonense, Pandanus odoratissimus, Pluchea indica, Sarcocopus carinatus, Sarcolobus globosus, Scaevola sericea, Sesuvium portulacastrum and Thespesia populnea.

*Cassine viburnifolia* (Juss.) Ding Hou and *Barringtonia asiatica* (L.) Kurz are not reported by Debnath and Mandal and Naskar. We, however, recorded these species in the present study (Fig. 23). *C. viburnifolia* is recorded only in Baratang Island. *B. asiatica* is recoded in Havelock and Car Nicobar Island (Fig. 23). Most interestingly in most of the sites we observed that *Finlaysonia obovata* Wall. is present in the bank of creeks along with *Rhizophora, Bruguiera, Ceriops and Xylocarpus* species and these species experience tidal fluctuations similar to true mangrove species. However, Tomlinson treated *F. obovata* as mangrove associate; based on the present observation here we proposed the inclusion of *F. obovata* in minor components. *F. obovata* is easily identified by its obovate leaves and buffalo horn like fruits (Fig. 23).

**Fig. 23 to be given**

**Conclusion**

Present study needed standardization of fieldwork over the 2-year period of the study using the existing diagnostic identification keys and analysis of basis of identifications used by different researchers. In order to generate effective management plans for conservation and management of mangroves, it is necessary to monitor the important coastal vegetations on periodical intervals.

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**References**


