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Distribution of mangrove species reported as rare in Andaman and Nicobar islands with their taxonomical notes

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ABSTRACT

Ragavan P, Ravichandran K, Jayaraj RSC, Mohan PM, Saxena A, Saravanan S, Vijayaraghavan A. 2014. Distribution of mangrove species reported as rare in Andaman and Nicobar islands with their taxonomical notes. Biodiversitas 15: 12-23. During the recent field survey it was found that among 15 rare mangroves in Andaman and Nicobar Islands, ten rare species i.e. *Acanthus ebracteatus, Acrostichum speciosum, Bruguiera cylindrica, Cynometra iripa, Cynometra ramiflora, Lumnitzera racemosa, Rhizophora* hybrids, *Sonneratia alba, Sonneratia griffithii* and *Xylocarpus mekongensis* are present in Andaman and Nicobar islands. In addition to *Acanthus volubilis, Brownlowia tersa* and *Sonneratia ovata* are recorded after their first report.

Key words: Andaman and Nicobar islands, mangroves, rare species

INTRODUCTION

Rarity in natural systems is common and is most often defined by two attributes: a species' distribution and its abundance. Species are considered rare if their area of occupancy or their numbers are small when compared to the other species that are taxonomically or ecologically comparable (Flather and Sieg 2007). Mangrove forests are unique plant communities of the critical interface between terrestrial, estuarine, and near-shore marine ecosystems in tropical and subtropical regions (Polidoro et al. 2010). Despite its ecological and economical values, globally mangrove areas are disappearing at the rate of approximately 1% per year (FAO 2003, 2007). However, little is known about the effects of either widespread or localized mangrove area loss on individual mangrove species or populations due to the lack of species information. The mangroves of Andaman and Nicobar islands (ANI) are gregarious, dense and diverse in nature and found along the tidal creeks, bays and lagoons. However, the mangrove plant diversity in many areas of ANI has not drawn much attention. Only few references are available regarding the mangrove diversity in ANI (Sahni 1957; Blasco 1977; Mall et al. 1987; Dagar et al. 1991; Singh and Garge 1993; Debnath 2004; Mandal and Naskar 2008; Kathiresan 2008). Among them Dagar et al. (1991) critically surveyed the mangroves of ANI and listed out 34 true mangrove species. After that Kathiresan (2008) reported the occurrence of 36 mangrove species in ANI; of which 15 species were rare i.e. *Acanthus ebracteatus, Acrostichum speciosum, Aegialitis rotundifolia, Bruguiera cylindrica, Bruguiera sexangula Ceriops decandra, Cynometra iripa, Cynometra ramiflora, Kandelia candel, Lumnitzera racemosa, Rhizophora lamarckii, Sonneratia alba, Sonneratia apetala, Sonneratia griffithii and Xylocarpus mekongensis.* After that no such detailed survey has been taken place in ANI and the occurrence of certain mangroves species *viz. Aegialitis rotundifolia*, *Aglaia cucullata*, *Rhizophora x lamarckii*, *Sonneratia griffithii*, *Xylocarpus mekongensis* and *Acanthus volubilis* were doubted by earlier studies (Mall et al 1987; Dagar et al 1991; Debnath 2004). Further, the mangroves of rare occurrence are poorly understood for their ecology and biology (Kathiresan 2008). So it became necessary to find out the truth behind the existence and distribution of these rare species, because species composition of mangroves is a basic and important prerequisite to understanding all the aspects of their structure and function, as well as their biogeographical affinities for their conservation and management (Jayatissa et al. 2002; Wang et al. 2003).

MATERIALS AND METHODS

Random survey was carried out in major creeks/ mangroves areas in 8 forest division of Andaman and Nicobar islands (ANI), Bengali bay, India (Figure 1; Table 1). The total of 30 sites was visited and it was achieved using a combination of road plus small boat transportation

to gain access to the extensive range of mangrove area. Further searching was done along the edge of the mangrove forest and inside the mangrove area by walking. Even in some small islands such as Havelock and Neil, the exploration was done by walking around the beaches and by boat around the island. Targeted species was counted in each observed site. The status of each species was assessed based on the frequency of occurrence in sampling sites (Kathiresan 2008). As we adapted random survey to cover extensive range of area, each site was considered as single sample unit and species status was assessed based on percentage frequency of each species (Table 2). All sites have been visited at least once at the time of flowering of the different species to cross-check identification with flower-based diagnostic features. As many as 2-5 specimens for each species were sampled, each sample was supposed to have flowers and hypocotyls/ fruits, and grouped according to the morphological characters. The collected plants were packed separately in polythene bags and brought to lab for analyzing taxonomically with prior assessments (Duke and Bunt (1979), Tomlinson (1986), Duke and Jackes (1987), Banerjee et al. (1989), Duke (1991, 2006), Kathiresan (2000, 2002), Debnath (2004), Dagar et al. (1991), and Giesen et al. (2006). Herbarium was prepared for each observed species and deposited at Botanical Survey of India (BSI), Regional Centre at Port Blair.

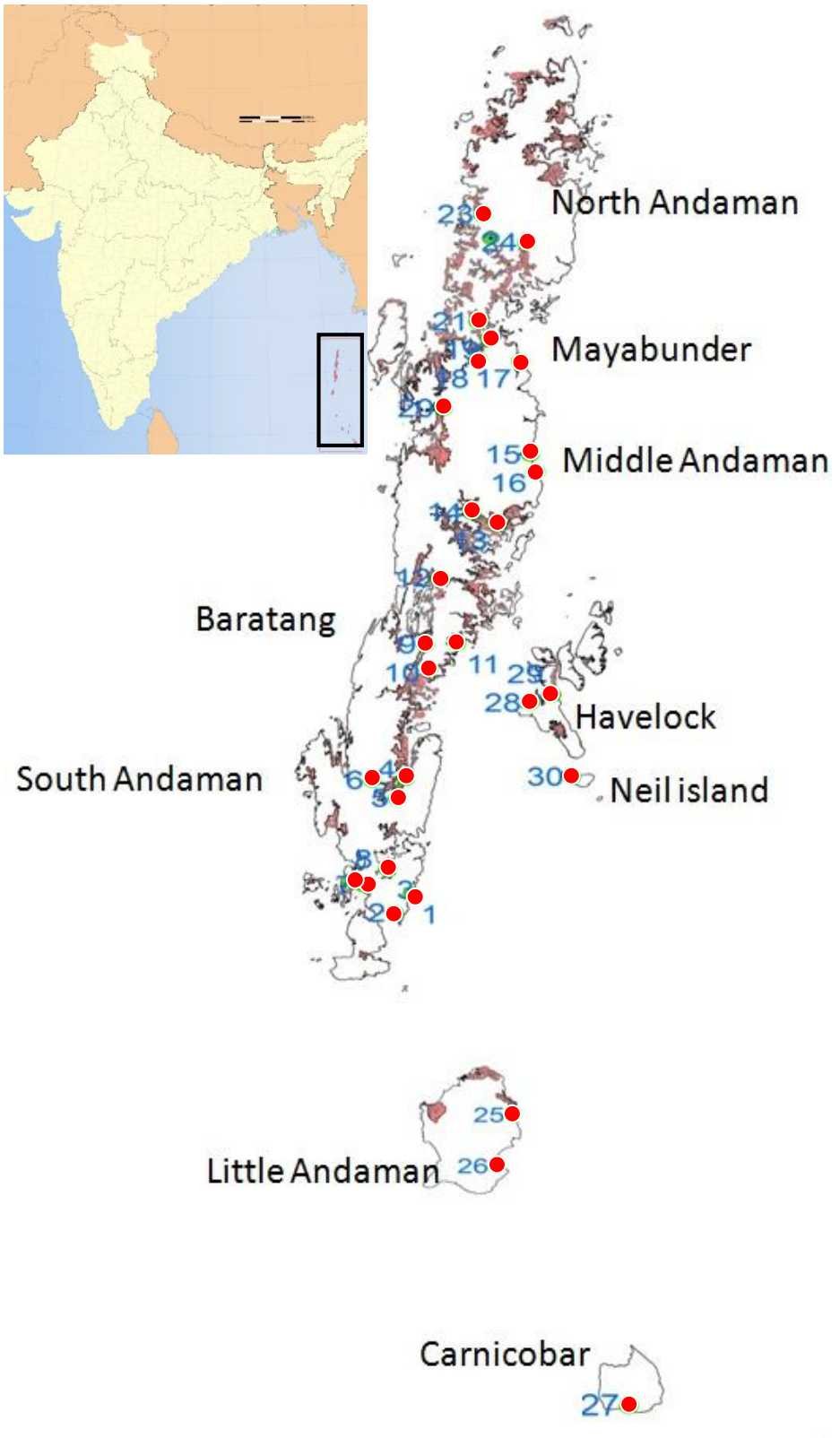

Figure 1. Sampling site in Andaman and Nicobar islands (ANI), Bengali bay, India. 1. Burmanallah, 2. Chediyatapu, 3. Sippighat, 4. Shaolbay creek, 5. Wrightmyo creek, 6. Jirkatang, 7. Manglutan, 8. Wandoor, 9. Middle strait, 10. Wrafter creek, 11. Baludera, 12. Kadamtala creek, 13. Yerrata creek, 14. Shayamkund creek, 15. Dhaninallah creek, 16. Pachwati creek, 17. Karmatang creek, 18. Tugapur creek, 19. Austin creek, 20. Chainpur creek, 21. Mohanpur creek, 22. Parangara creek, 23. Kishorinagar creek, 24. Kalighat creek, 25. V.K.pur creek, 26. Hut bay, 27. Kimous bay, 28. Radhanagar, 29. Govindnagar, 30. Neil island

Table 1. Distribution of rare mangrove species in ANI

Division	Site	Species recorded (values within bracket indicate number of individual trees recorded)
South Andaman	Burmanallah	*Sonneratia ovata* (7), *Cynometra irripa* (4) *Lumnitzera racemosa* (5), *Bruguiera cylindrica* (13), *Sonneratia alba* (13)
	Chediyatapu	*Sonneratia alba* (31), *Sonneratia ovata* (15), *Rhizophora* hybrids (2), *Bruguiera cylindrica* (8), *Cynometra ramiflora* (1)
	Sippighat	*Bruguiera cylindrica* (16), *Sonneratia alba* (7), *Acanthus ebracteatus* (small patches)
	Shaolbay creek	*Sonneratia ovata* (17), *Rhizophora* hybrids (1), *Bruguiera cylindrica* (18), *Acanthus volubilis* (small patches), *Acrostichum speciosum* (small patches), *Cynometra iripa* (5), *Sonneratia alba* (31), *Acanthus ebracteatus* (small patches)
	Wrightmyo creek	*Bruguiera cylindrica* (13), *Acrostichum speciosum*, *Sonneratia alba* (19), *Cynometra iripa* (3)
	Jirkatang	*Acanthus volubilis* (Small patches), *Acrostichum speciosum* (small patches), *Bruguiera cylindrica* (17), *Cynometra iripa* (4), *Sonneratia alba* (12)
	Manglutan	*Sonneratia ovata* (4), *Bruguiera cylindrica* (11), *Sonneratia alba* (7)
	Wandoor	*Sonneratia ovata* (2), *Bruguiera cylindrica* (7), *Sonneratia alba* (7)
Baratang	Middle strait	*Bruguiera cylindrica* (57), *Sonneratia alba* (29), *Cynometra iripa* (8)
	Wrafter creek	*Xylocarpus mekongensis* (6), *Bruguiera cylindrica* (87), *Sonneratia alba* (32), *Cynometra iripa* (6)
	Baludera	*Xylocarpus mekongensis* (1), *Bruguiera cylindrica* (5)
Middle Andaman	Kadamtala creek	*Rhizophora* hybrids (13), *Sonneratia ovata* (1), *Sonneratia alba* (16), *Cynometra iripa* (11), *Bruguiera cylindrica* (16)
	Yerrata creek	*Rhizophora* hybrids (5), *Lumnitzera racemosa* (34), *Xylocarpus mekongensis* (41), *Bruguiera cylindrica* (24), *Sonneratia alba* (14), *Cynometra iripa* (12)
	Shayamkund creek	*Brownlowia tersa* (small patches), *Bruguiera cylindrica* (21), *Xylocarpus mekongensis* (3), *Sonneratia alba* (15), *Cynometra iripa* (16)
	Dhaninallah creek	*Sonneratia griffithii* (34), *Xylocarpus mekongensis* (7), *Lumnitzera racemosa* (4), *Bruguiera cylindrica* (7), *Sonneratia alba* (21), *Cynometra iripa* (9)
	Pachwati creek	*Sonneratia griffithii* (7), *Sonneratia alba* (3), *Cynometra iripa* (7)
Mayabunder	Karmatang creek	*Bruguiera cylindrica* (17), *Lumnitzera racemosa* (29), *Xylocarpus mekongensis* (5), *Cynometra iripa* (7)
	Tugapur creek	*Xylocarpus mekongensis* (3), *Bruguiera cylindrica* (16), *Cynometra iripa* (4), *Sonneratia alba* (5)
	Austin creek	*Rhizophora* hybrids (16), *Cynometra iripa* (7), *Bruguiera cylindrica* (14), *Sonneratia alba* (7)
	Chainpur creek	*Xylocarpus mekongensis* (4), *Cynometra iripa* (9), *Bruguiera cylindrica* (17),
	Mohanpur creek	*Xylocarpus mekongensis* (7), *Cynometra iripa* (13), *Bruguiera cylindrica* (18), *Sonneratia alba* (14), *Sonneratia griffithii* (1)
Diglipur	Parangara creek	*Xylocarpus mekongensis* (13), *Cynometra iripa* (5), *Bruguiera cylindrica* (14), *Sonneratia griffithii* (13),
	Kishorinagar creek	*Cynometra iripa* (9), *Bruguiera cylindrica* (11), *Sonneratia alba* (7)
	Kalighat creek	*Sonneratia griffithii* (8), *Cynometra iripa* (4), *Bruguiera cylindrica* (11), *Sonneratia alba* (9)
Little Andaman	V.K. Pur creek	*Sonneratia alba* (11), *Sonneratia caseolaris* (17), *Cynometra iripa* (16), *Bruguiera cylindrica* (14)
	Hut bay	*Sonneratia griffithii* (1),
Carnicobar	Kimous bay	*Rhizophora* hybrids (4), *Lumnitzera racemosa* (5)
Havelock	Radha nagar	*Sonneratia ovata* (7), *Bruguiera cylindrica* (4)
	Govindnagar	*Bruguiera cylindrica* (13), *Sonneratia alba* (18), *Rhizophora hybrids* (11)
	Neil island	*Rhizophora* hybrids (6)

Table 2. Species status based on percentage frequency

Species	Number individuals recorded	Number of sites in which species occurred	Total number of sites	Percentage of frequency	Status
Acanthus volubilis	Small patches	2	30	6.67	Rare
Acanthus ebracteatus	Small patches	2	30	6.67	Rare
Acrostichum speciosum	Small patches	3	30	10	Rare
Bruguiera cylindrica	469	26	30	86.7	Abundant
Cynometra iripa	159	20	30	66.7	Frequent
Cynometra ramiflora	1	1	30	3.33	Rare
Lumnitzera racemosa	77	5	30	16.7	Rare
Rhizophora hybrids	58	8	30	26.7	Rare
Sonneratia alba	328	22	30	73.3	Frequent
Sonneratia griffithii	64	6	30	20	Rare
Sonneratia ovata	53	7	30	23.3	Rare
Xylocarpus mekongensis	90	10	30	33.3	Common
Brownlowia tersa	Small patches	1	30	3.33	Rare
Sonneratia caseolaris	17	1	30	3.33	Rare

Note: Abundant (a): if the species is present in 81-100% of sampling points; Frequent (f): if the species is present in 61-80% of sampling points; Common (c): if the species is present in 31-60% of sampling points; Rare (r): if the species is present in 1-30% of sampling points

RESULTS AND DISCUSSION

The results of present study confirm the occurrence of 10 out of the 15 rare mangroves reported earlier. Remaining five species namely *Aegialitis rotundifolia, Bruguiera sexangula, Ceriops decandra, Kandelia candel* and *Sonneratia apetala* were not recorded in this study. Contrary to earlier reports in this study *Avicennia alba* was not recorded and *Sonneratia caseolaris* was recorded in only one site; both species are reported as frequent in ANI by Kathiresan (2008). *Acanthus volubilis, Brownlowia tersa and Sonneratia ovata* are reported after their first report, i.e. Parkinson (1923) and Dam Roy et al. (2009). In the discussion below, we highlighted the diagnostic features of each mangrove species and their distribution in ANI.

Acanthus volubilis Wall. is the only climber known to occur in mangroves and considered as true mangrove species (Duke 2006; Polidoro et al. 2010). *A. volubilis* was first reported from ANI by Parkinson (1923) after that it was included in the mangrove species list by several authors (Thothathri 1962; Mall et al. 1987; Dagar et al.1991; Debnath 2004; Mandal and Naskar 2008). But, Mall et al. (1987) mentioned that he included this species based on Parkinson (1923) report and he has not encountered in any sites. Once *A. volubilis* was considered as an extinct species in India, but recently it has been recorded again with its very limited population from Sunderbans (Mandal and Naskar 2008). Kathiresan (2008) did not include this species in his report. Dam Roy et al. (2009) reported this species from ANI, but description and photographs given for *A. volubilis* reveal that the only character of the observed specimen used to identify the species is spineless leaves and stem; however, this can be a feature of *A. ilicifolius* as well (Jayatissa et al. 2002). Moreover herbarium deposited by Thothathri (1962) in BSI, Regional centre at Port Blair also resembles the same. Thus *A. volubilis* reported here after its first report (i.e. Parkinson 1923). In this study *A. volubilis* was reported at two sites i.e. Shoalbay creek and Jirkatang in South Andaman. In both sites, it was observed in small patches along with *Acrostichum aureum* and *Acrostichum speciosum* on the landward edge. *A. volubilis* was easily identified by its smooth (without stem axial spines) and twining with delicate sprawling stems, spineless leaves, terminal inflorescences and white flowers without bracteoles (Figure 2.A-2.D).

In India *Acanthus ebracteatus* Vahl. is known to occur in Andaman and Nicobar Islands and Kerala (Kathiresan 2008). But the details about their status and distribution are inadequate, because the taxonomical discrimination between the *A. ebracteatus* and *A. ilicifolius* are still not clear (Kathiresan 2010). For instances, Remadevi and Kumar (2000) argued that many specimen identified and indexed as *A. ilicifolius* in Indian herbarium are actually *A. ebracteatus*. In contrast, Anupama and Sivadasan (2004) questioned the identification made by Remadevi and Kumar (2000). In this study *A. ebracteatus* was recorded at two sites i.e. Shaolbay creek and Sippighat in South Andaman. Generally *A. ebracteatus* is identified by its white colored flowers, but some ecological variants of *A. ilicifolius* exhibit white colored flowers with unarmed leaves and stems (Jayatissa et al. 2002). Hence, identification based on flowers may cause misidentification in the field. During the present study, it was found that position of inflorescences and direction of stem axial spines at nodes helps the rapid differentiation of *A. ilicifolius* from *A. ebracteatus* apart from flower color and presence of bracteoles. *A. ebracteatus* is distinguished from other *Acanthus* spp. by its highly serrated leaves, white colored flowers, absence of bracteoles, stem with auxiliary spines facing downwards and terminal inflorescences (Figure 2.E-2.J). But in *A. Ilicifolius'* leaves and stems are either armed or unarmed, flower color is blue or white (rarely white), inflorescences are both axial and terminal and stem with auxiliary spines facing upwards (Figure 2.K-2.N)

Species of *Acrostichum* are usually called mangrove ferns. In ANI *Acrostichum aureum* L. is a common species, in contrast, *Acrostichum speciosum* Willd. is rare. In the present survey *A. speciosum* was recorded at three sites i.e Shoalbay creek, Wrightmyo creek, and Jirkatang. In all the sites, *A. speciosum* was observed at the mangrove understory, and just at the margins of high intertidal zones. These areas are frequently inundated by tides and are usually shady. It was also observed on the landward edges along with *A. aureum* in Shoalbay creek. In fields, *A. aureum* and *A. speciosum* are easily distinguished based on frond shape and texture. The frond of *A. speciosum* narrows gradually to a pointed tip and papery (Figure 2.O, 2.Q), while that of *A. aureum* has a broadly rounded end and thickly coriaceous fronds (Figure 2.R). Recently Dam Roy et al. (2009) reported this species in Wandoor and Burmanallah, but description and photographs given for *A. speciosum* reveal that the only character of the observed specimen used to identify the species was pointed leaf tip; however, this can be a feature of *Stenochlaena palustris* as well (Giesen et al. 2006). *S. palustris* differ from *A. speciosum* by its serrated leaflet margin and parallel venation (Figure 2.S).

Bruguiera cylindrica (L.) Bl. was mentioned as a rare species by Dagar et al. (1991) and Kathiresan (2008). But in the present study it was observed in 26 sites and total 469 individual were recorded. So it is noteworthy that *B. cylindrica* is now abundant in Andaman Islands. It is small tree generally found inside the mangroves and occasionally forms pure stands that appear similar in appearance to those of *B. parviflora*. *B. cylindrica* is distinguished from other *Bruguiera* species by its small flowers, three flowered inflorescences and calyx with fully reflexed calyx lobes (Figure 2.T-2.V). In field it is easily distinguished from *B. parviflora* by its dark green leaves, folded when mature and reflexed calyx lobes, whereas *B. parviflora* possess small yellowish green leaves, long ribbed calyx with small adpressed lobes and thin propagule (Figure 2.W-2.Y).

Brownlowia tersa (L.) Kosterm. is generally found on the soft mud of intertidal estuarine banks and can be recognized in the field by its grayish brown branches, lanceolate leaves with dull silvery under surface, yellowish pink color flowers (Figure 3.A-3.C) and pear-shaped woody fruits with two valved carpels (Kathiresan 2010). It

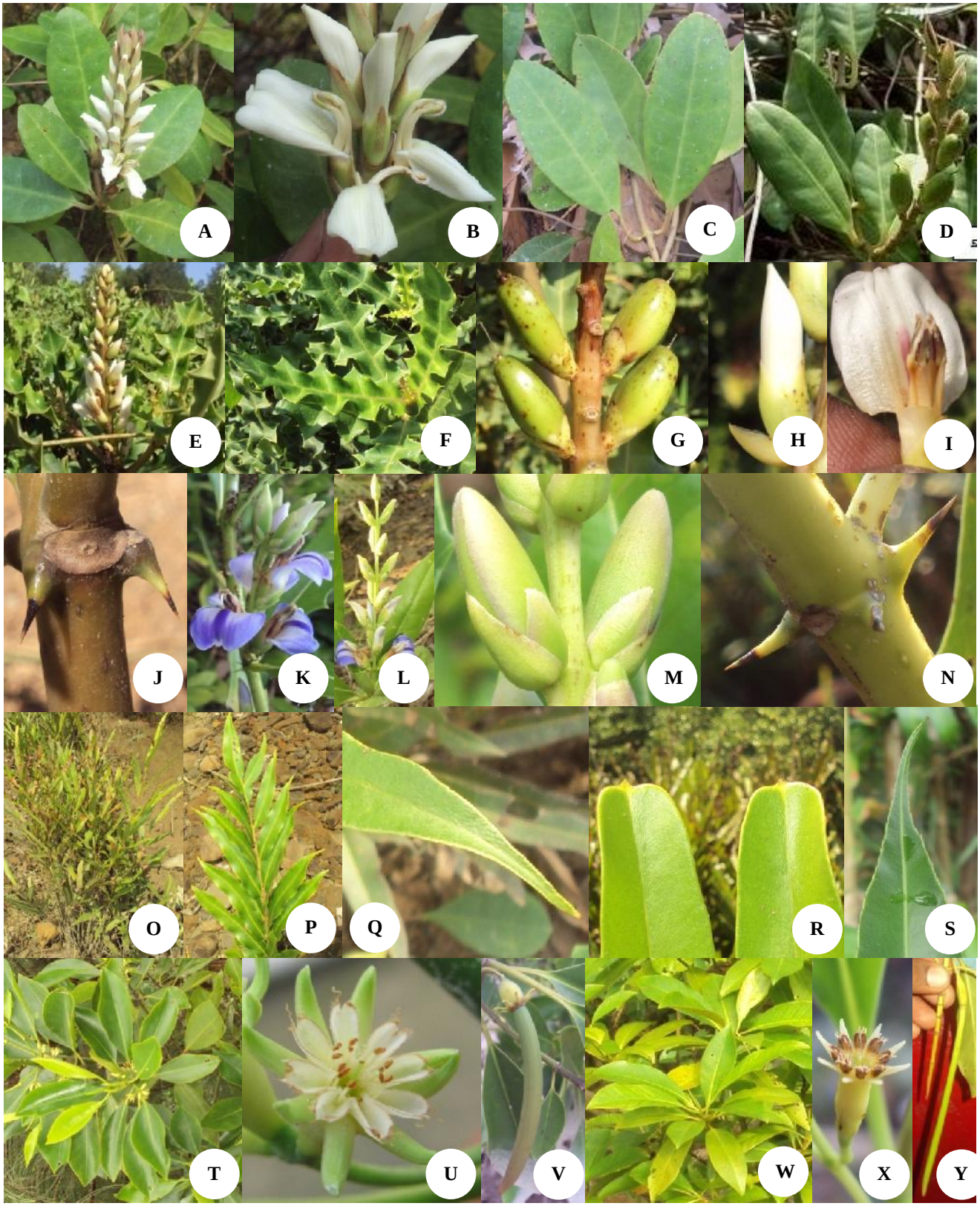

Figure 2. (A) Terminal inflorescences (B) white flower with bract (C) smooth leaves and (D) fruits of *Acanthus volubilis* (E) terminal inflorescences (F) highly serrated leaves (G) fruits (H) mature bud without bracteoles (I) white flower and (J) downward facing stem axial spines of *Acanthus ebracteatus* (K) terminal and (L) axillary inflorescences with purple flowers (M) bud with bract and bracteoles and (N) upward facing stem axial spines of *Acanthus ilicifolius* (O) habitat (P) sterile leaves with narrowly pointed leaflets and (Q) pointed tip of *Acrostichum speciosum* (R) blunt leaf tip of *Acrostichum aureum* (S) serrated margin of leaflet of *Stenochlaena palustris* (T) dark green leaves (U) flowers and propagule of *Bruguiera cylindrica* with reflexed calyx lobes (W) yellowish green leaves (X) flowers and (Y) propagule of *Bruguiera parviflora* with long calyx tube.

Figure 3. (A) Habitat, (B) flowers and (C) leaves with slivery grey underside *of Brownlowia tersa*; (D) Leaves, (E) flowers and (F) fruits of *Cynometra iripa*; (G) Leaves and (H) fruits of *Cynometra ramiflora*; (I) Axillary Inflorescences (J) white flowers with small stamens and (K) fruits of *Lumnitzera racemosa*; (L) Red flowers of *Lumnitzera littorea* with long stamens; (M) Mature bud with smooth green bract, (N) broad leaves, (O) presence of stamens in two distinct whorls in *Rhizophora* hybrids.

is common in West Bengal and Odisa; but rare in ANI and Godavari estuary of Andhra Pradesh. Hajra et al. (1999) have also mentioned that *B. tersa* was reported, some 80 years ago, to be found abundant near large creeks of Middle Andaman like Dhanikhari creek, but is now rare there. In the present, it was recorded from Shyamkund area in Middle Andaman along the landward edges of mangroves with *Acanthus* sp and *Acrostichum* sp. It is one of the near threatened species (Kathiresan 2010).

Two species of genus *Cynometra* i.e. *Cynometra iripa* Kostel. and *Cynometra ramiflora* Linn. are commonly called as wrinkle pod mangroves. Both species were known to occur in ANI and are rare (Dagar et al. 1991; Kathiresan 2008). In the present survey, 159 mature trees of *Cynometra iripa* were recorded from 20 locations and *C. ramiflora* was recorded only from one site (Chediyatapu). In the field, *Cynometra* species is easily recognized by its off-centered mid-veins on leaves (Figure 3.D and 3.G). *C. iripa* and *C. ramiflora* are differentiated based on the position of beaks in the pods. *C. iripa* has prominent lateral beak because the style is bent in it (Figure 3.E-3.F), whereas *C. ramiflora* has sub-terminal beak (Figure 3.H)

because it has straight style. Ovary is densely hairy in *C. iripa* (Figure 3.E) and smooth in *C. ramiflora.* These two species not easily differentiates without fruiting and flowering.

Lumnitzera racemosa Wild. is easily identified by its white flowers, light green succulent narrowly elliptic leaves and dark roughly fissured stem. It is distinguished from *L. littorea* by its axillaries racemes of flowers with white petals and stamens shorter than petals (Figure 3.I- 3.K) whereas *L. littorea* exhibit terminal racemes of flowers with red petals and stamens longer than the petal (Figure 3.L). We have recorded this species in 4 sites in Andaman Islands and one site in Carnicobar. Total 77 mature individuals were recorded.

In ANI *Rhizophora* hybrid was first recorded by Singh et al. (1987). He recorded this hybrid taxon from Havelock Island and described it as *Rhizophora x lamarckii* present in the mixed stands of *R. apiculata* and *R. mucronata*, but *R. x lamarckii* is a hybrid between *R. apiculata* and *R. stylosa*. Due to nomenclature uncertainty between *R. x lamarckii* and *R. x annamalayana* (Lo 2003), in the present study this taxon has been described as *Rhizophora* hybrid. *Rhizophora* hybrids are easily identified by their height, a large number of flowers with smooth bract (Figure 3.M-3.O) and rare occurrence of propagules. In this study, *Rhizophora* hybrids have been observed in 8 sites *viz.* Havelock, Neil, Chediyatapu, Shoalbay creek, Austin creek, Yerrata creek, Kadamtala creek in Andaman islands and Kimous bay in Carnicobar island, total 58 mature individual were recorded. Except in Havelock the occurrence of *Rhizophora* hybrids in other places have been reported first time in this study. In Austin creek, Kadamthala creek, Shoalbay creek and Yerrata creek *Rhizophora* hybrids were present in the mixed stands of *R. apiculata* and *R. mucronata;* in other places hybrids are present along with *R. apiculata*, *R. mucronata* and *R. stylosa*. So, it may be concluded that both *R. x lamarckii* (*R. apiculata x R. stylosa*) and *R. x annamalayana* (*R. apiculata x R. mucronata*) might be present in ANI. As natural hybrids play a very important role in evolution of novel gene combinations and in the process of speciation, it is important to conserve the natural hybrids of the genus *Rhizophora*. Moreover, *Rhizophora* hybrids rarely produce seeds, making their propagation very difficult. One of the unique features of Indian *Rhizophora* hybrids is the presence of stamens in two distinct whorls i.e. outer longer stamens and inner smaller stamens (Ragavan et al. 2011).

In contrast to Dagar et al. (1991) and Kathiresan (2008), in this study, *Sonneratia alba* J. Smith. was observed in 22 sites; altogether with 328 individuals were recorded, whereas *Sonneratia caseolaris* (L.) Engl. was recorded only in V.K. pur creek, Little Andaman. It was found from this study that taxonomical distinction between *S. caseolaris* and *S. alba* was not clear in ANI; for instance, Dagar et al. (1991) mentioned that *S. caseolaris* was most common in Andaman islands and exhibit rough bark. But based on the present study, it was found that rough bark is the feature of *S. alba* and *S. alba* is common in Andaman islands, whereas in *S. caseolaris* bark is smooth and grey in color and it is rare in ANI. *S. alba* is distinguished from *S. caseolaris* by its drop shaped leaves with rounded leaf tip, broad mucronate, flowers with white petals and stamens, cub shaped calyx with lobes tinged red inside, rough fissured bark, conical pneumatophores and sickle shaped seeds (Figure 4.A-4.D). However, we observed great deal of morphological variation amongst populations of *S. alba* in Andaman islands. *S. caseolaris* is identified by its willow tree like appearance, leaves are elliptic in shape with pointed mucro, smooth or lightly fissured flaky bark, flowers with ribbon like red petals, numerous red stamens (rarely white), flattened calyx and irregular seeds (Figure 4.E-4.I). *S. alba* and *S. caseolaris* are ecologically two different entities. *S. alba* is a pioneering species in the mangrove habitat, intolerant of long periods of exposure to fresh water, usually occur in downstream of tidal creeks and offshore island embayments. *S. caseolaris* occur only in upstream areas dominated with river or freshwater inputs. *S. caseolaris* individuals were recorded at V.K. Pur creek (little Andaman) in upstream of the creek with *Barringtonia racemosa* (fresh water mangrove).

Sonneratia ovata Backer. was first reported in ANI by Dam Roy et al. (2009) from Havelock islands. During the present survey *S. ovata* were recorded in seven sites *viz.* Havelock, Burmanallah, Chediyatapu, Kadamtala, Shoalbay creek, Manglutan and Wandoor. This species is not reported in any other part of India. *S. ovata* is easily distinguished from other *Sonneratia* species by its enveloped calyx lobes with its fruits, fissured bark and rounded leaf (Figure 4.J-4.M). *S. ovata* is one of the near threatened species (Polidoro et al. 2010). In all the sites we located this species just above the high tide mark along with *Ceriops* sp., *Excoecaria agallocha* and *Bruguiera cylindrica*. Total 53 mature individuals were recorded.

In India *Sonneratia griffithii* Kurz is known to occur rarely on the muddy banks of estuarine mouths under tidal inundation in Sundarbans, Odisa and Andaman islands (Kathiresan 2010). *S. griffithii* was first reported from ANI by Parker (1925). After that there are no reports of the species from ANI. No herbarium specimen is also available in ANI. In this study, *S. griffithii* was recorded at 6 sites, *viz.* Dhaninallah creek, Parangara creek, Panchwati, Kalighat creek, Mohanpur and Hut bay. Total 64 individuals were recorded in this study. *S. griffithii* is distinguished from other species of *Sonneratia* by its obovate leaves, large solitary white flowers with white stamens, absence of petals and larger globose fruits with a depression at the apex and short style (Figure 4.N-4.Q). Another important key character to distinguish *S. griffithii* is the shape of buds. Shape of the bud is smooth and rounded in *S. griffithii*. *S. griffithii* is rare and is a critically endangered species (Kathiresan 2010; Polidoro et al. 2010). Among the 30 countries in the Indian Ocean region, *S. griffithii* has been reported only from Malaysia, Thailand, Myanmar and India (Kathiresan and Rajendran 2005) and is locally extinct in a number of areas throughout its range

Three species of genus *Xylocarpus* i.e., *Xylocarpus granatum* Koenig, *Xylocarpus mekongensis* Pierre and *Xylocarpus moluccensis* (Lamk.) M. Roem was known to occur in Andaman islands (Hajra et al. 1999; Debnath 2004; Dagar et al. 1991). In this study, the former two species were observed. Based on critical field observations

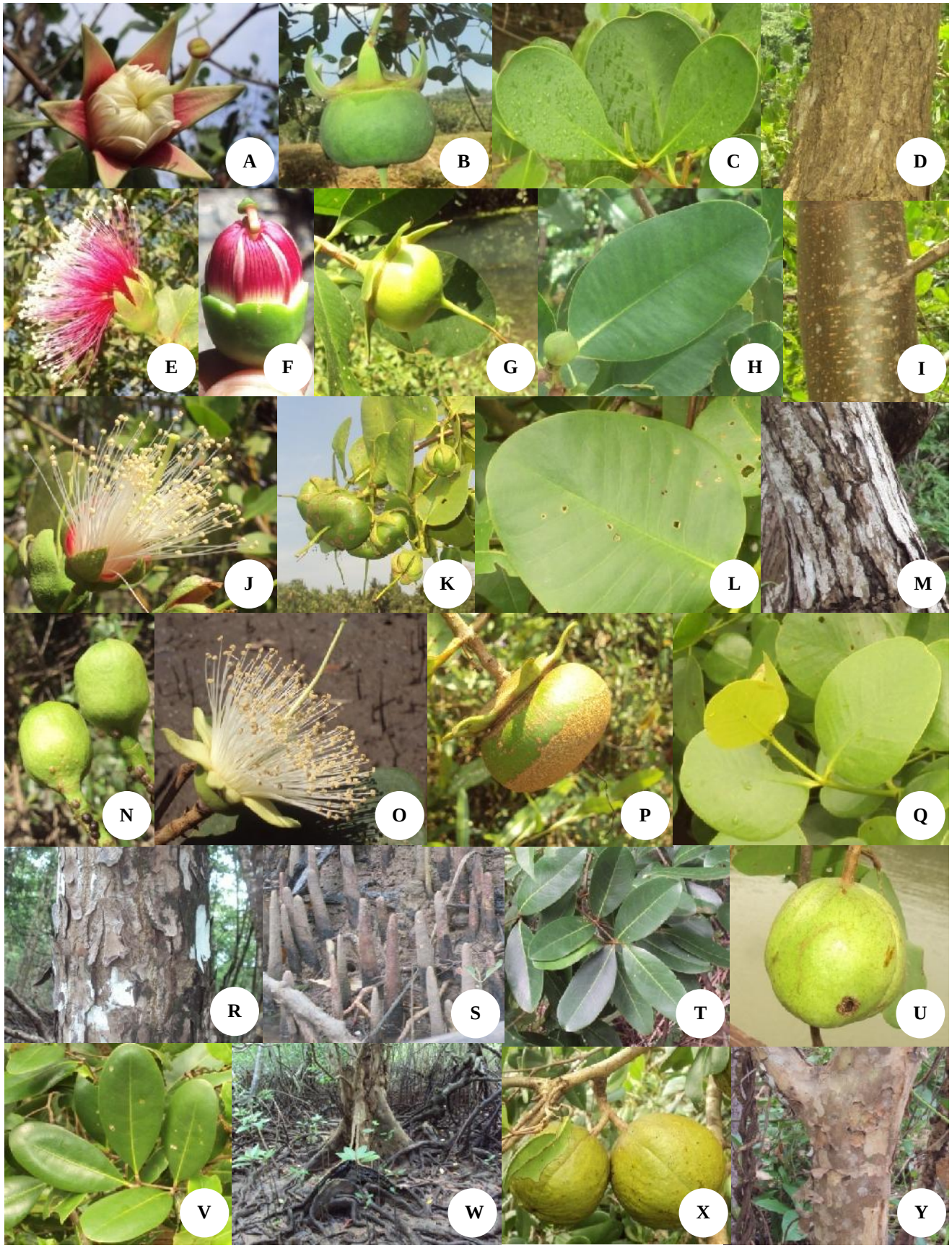

Figure 4. (A) flowers, (B) fruits (C) leaves and (D)bark of *Sonneratia alba*, (E) flowers (F)red petal (G) fruits (H) leaves and (I) smooth bark of *Sonneratia caseolaris* (J) flowers, (K) fruits (L) leaves (M) bark of *Sonneratia ovata* (N) mature bud (O) flower (P) fruit and (Q) leaves of *Sonneratia griffithii*; (R) peeling bark, (S) pneumatophores, (T) leaves and (U) fruits of *Xylocarpus mekongensis* (V) leaves (W)buttresses and planks root (X) fruits and (Y) bark of *Xylocarpus granatum*.

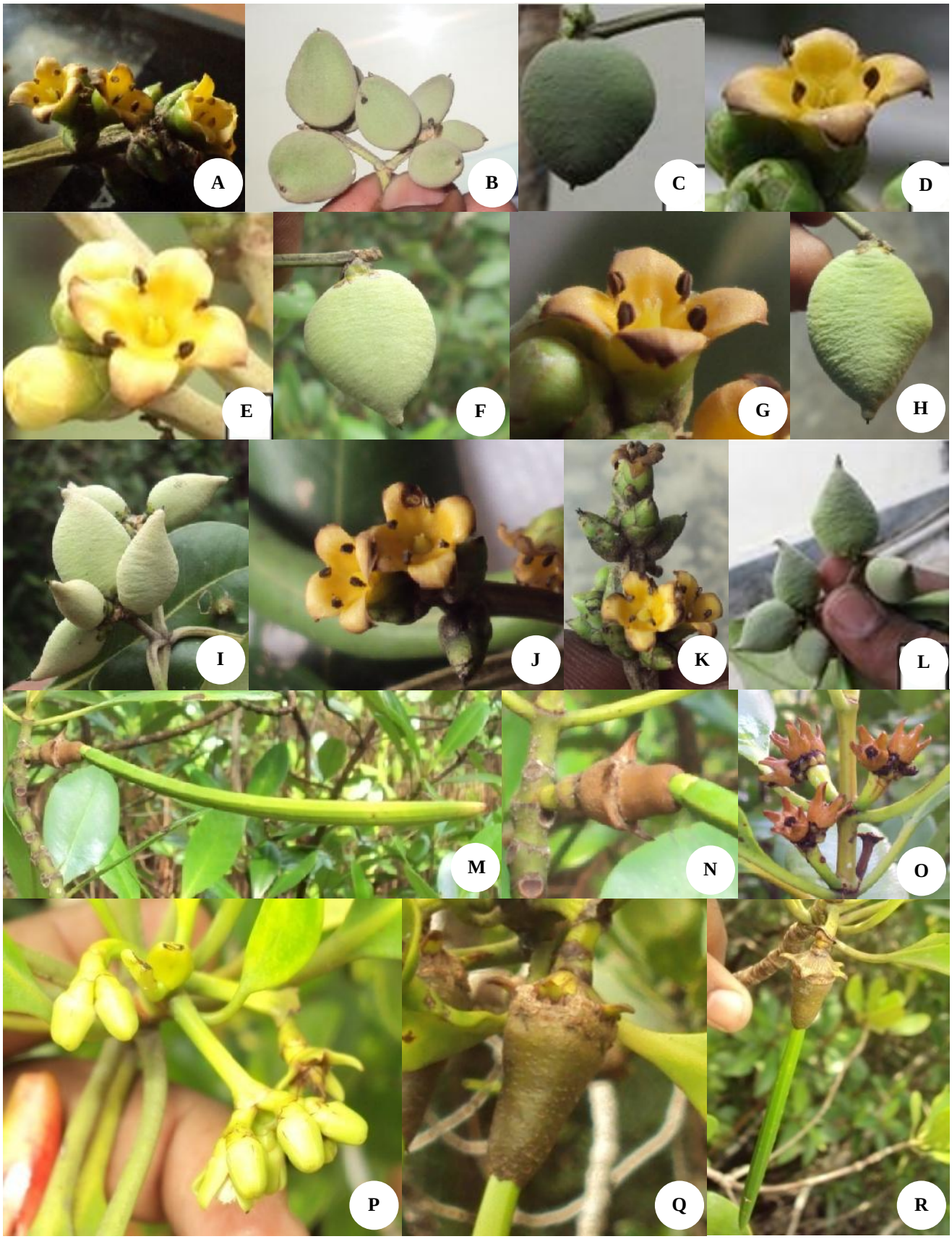

Figure 5. Variation in *Avicennia marina* (A-D) flowers with style length equal to base of the stamen and fruits without beak; (E-H) flowers with style length equal to base of anther and fruits with small beak; (I-L) flowers with small style and fruits with prominent beak (M) upright propagule (N) downward facing calyx lobes and (O) short peduncle of *Ceriops decandra* (photos taken in Pichavaram (P) long peduncle (Q) reflexed calyx lobes and (R) hanging propagules of *Ceriops tagal.*

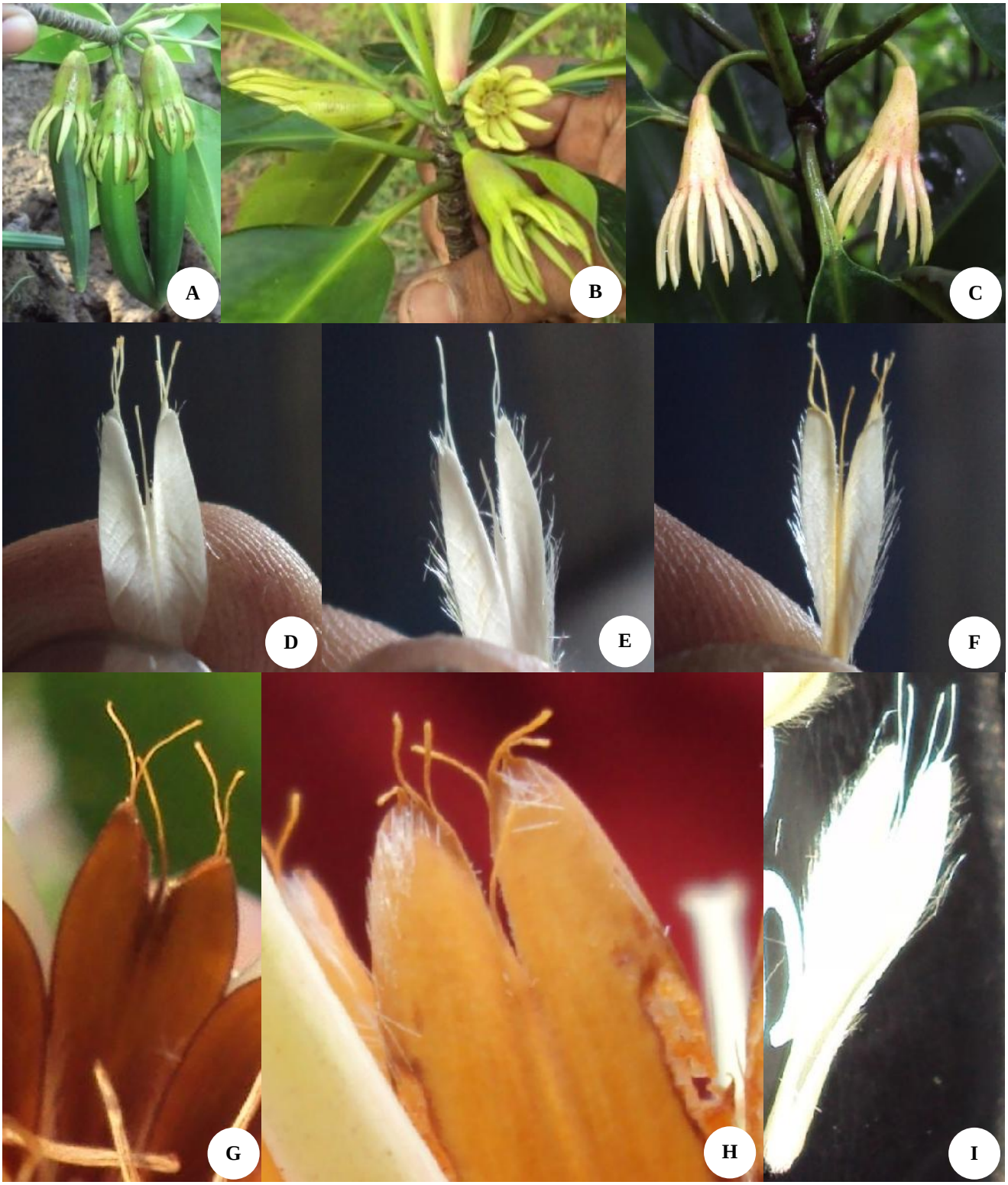

Figure 6. Variation in *Bruguiera gymnorrhiza* (A,B) green color calyx (C) pinkish white calyx (D) petal with petal spine equal to petal lobe (E) petal spine shorter than petal lobe (F) petal spine longer that petal lobe (G) petal apex with two bristles (H) three bristles (I) two bristles with small stub.

and literatures analysis (Giesen et al. 2006; Duke 2006) it is understood that *X. moluccensis*, *X. gangeticus* and *X. parvifolius* are synonyms of *X. mekongensis*. *X. granatum* is the most common in ANI and is easily identified by its buttressed stem with plank roots, light brown bark with thin flakes and large fruits with pyramidal seeds (Figure 4.V-4.Y). *X. mekongensis* is easily identified by its peg like pneumatophores, dark brown bark peeling in long thick narrow strips and small fruits (Figure 4.R-4.U). *X. mekongensis* was observed in 10 sites *viz.* Chainpur creek,

Yerrata creek, Tugapur creek, Shyamkund creek, Parangara creek, Dhaninallah creek, Wrafter creek, Karmatang creek, Mohanpur creek and Baludera ; total 90 individuals were recorded. In Yerrata creek alone, 41 individuals were recorded along with *Bruguiera* spp and *Lumnitzera* spp. In the rest of the sites, we located only few individuals were found along the banks of the creek with *Rhizophora* sp. and *X. granatum*.

Kathiresan (2008) and Mandal and Naskar (2008) noted the occurrence *Avicennia alba* Bl. in ANI without any taxonomical notes. Generally, *A. alba* is identified by its elongated and pointed propagules and spicate inflorescences unique within the genus, but in this study, marked variation have been observed amongst populations of *Avicennia marina* in the fruit beak, style length and its position relative to anther. We observed three kind of *A. marina* based on the beak i.e. fruits without beak, intermediate beak and prominent beak (Figure 5.A-5.L). This observation suggest the occurrence of varietal species amongst the populations of *A. marina* and identification of *A. alba* based on the prominent stylar beak is not reliable without consideration of other characters. So, it is stressed here that *A. alba* is not present in ANI. Moreover *A. alba* is not reported in most of the previous studies too (Dagar et al. 1991; Debnath 2004; Dam Roy et al. 2009; Mall et al. 1987).

Rest of the rare mangrove species i.e. *Aegialitis rotundifolia* Roxb., *Sonneratia apetala* Buch.-Ham**.** *Ceriops decandra* (Griff.) Ding Hou, *Kandelia candel* (L.) Druce and *Bruguiera sexangula* (Lour.) Poir were not observed in this study. Though *Sonneratia apetala* was reported by Dagar et al. (1991) from Chediyatapu (west), Burmanalla and Wandoor, in this study *S. apetala* could not be found in above mentioned sites, instead, *S. alba was* recorded. According to Dagar et al. (1991) *S. alba* was rare in ANI but in the present study, it was found recorded from most of the sites. This observation revealed the incorrect identification of *S. apetala* in the past, due to lack of extensive taxonomical studies. Moreover the above mentioned three species (*Aegialitis rotundifolia*, *Kandelia candel*, *Sonneratia apetala*,) were not recorded in recent times by other researchers too, such as Debnath (2004) and Dam Roy et al. (2009).

Without flowering and fruiting, species i.e. *Ceriops decandra* and *Bruguiera sexangula* cannot be differentiated from *Ceriops tagal* and *Bruguiera gymnorrhiza*, respectively. *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 (Figure 5.M-5.O). *C. tagal* possesses long peduncle, long propagules with yellow color collar and calyx lobes facing upwards (Figure 5.P-5.R). *C. tagal* is most common in Andaman group of islands. Mall et al. (1987), Singh (2003) and Dam Roy et al. (2009) did not report *C. decandra*.

B. sexangula from ANI was reported by Singh et al. (1987) and no further collections are available (Debnath 2004). Mall et al. (1987) and Singh and Garge (1993) observed only a few individuals of *B. sexangula* from Burmanallah area in South Andaman. The reports of *B. sexangula* from ANI by previous authors appeared doubtful as they followed the calyx color as key character to distinguish *B. sexangula* and *B. gymnorrhiza (*red/pink for *B. gymnorrhiza* and yellow for *B. sexangula).* Dagar et al. (1991) mentioned that calyx color of *B. sexangula* is initially green and turns yellow when mature. According to Duke (2006) 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 (Duke 2006). Sheue et al. (2005) have characterized *B. gymnorrhiza* with petal spine greater than the petal lobe and the petal bristles vary from 2-3. In the present study three groups of *B. gymnorrhiza* have been recorded based on 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 (Figure 6.D-6.I). This observation shows unreliability of petal spine and bristles as key to identification of *Bruguiera* species. This further indicates that there could be two forms of *B. gymnorrhiza.* Moreover, different colors of calyx were observed in *B. gymnorrhiza* (Figure 6.A-6.C). As it is very difficult to distinguish *C. decandra* and *B. sexangula* from *C. tagal* and *B. gymnorrhiza*, respectively, it is inferred that former species might have been misidentified due to lack of extensive taxonomical studies in the past.

CONCLUSION

All the mangrove species discussed in this study are threatened in India and rare in much of its range. In contrast to earlier report, two species i.e. *Sonneratia alba Cynometra iripa* were found to be frequent. *Bruguiera cylindrica* and *Xylocarpus mekongensis were* found to be abundant and common respectively, in ANI. At present, all these species are at serious risk as no systematic attempt has been made to conserve them. Hence immediate and effective conservation measures should be taken for their protection and propagation for recovery. In order to confirm the existence of other doubtful species and to avoid misidentification periodical surveys are required on the distribution and occurrence of mangrove species in ANI.

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