Species Composition, Richness, Density and Distribution of Climbers in Relation to Salinity in Sundarbans Mangrove Forest of Bangladesh

Gazi Mosharof Hossain, Mohammad Sayedur Rahman, and Saleh Ahammad Khan

Abstract—In this study we examined the climbers of Sundarbans mangrove forest of Bangladesh (SMFB) in its 32 representative sites. The climbers of SMFB were comprised of 53 species belonging to 46 genera under 20 families. 44 species were recognized as vines and 9 species were lianas. 25 species of the climbers were non-mangrove, 19 mangrove associates and 9 mangrove species. Species richness of the climbers was higher in the sites of oligohaline zone than those of mesohaline or polyhaline zones. Climber density was higher at the forest edges than in the interior forest and found as gradually decreasing with the increase in distance from the edge. DAFOR scale recognized 46 species in rare category. Distribution of climbers exhibited a wide variation in different gradient of saline zones. 16 climber species were found as aggressive invasive affecting the growth, development and regeneration of many other species of SMFB.

Keywords— Bangladesh, climbers, salinity, Sundarbans.

I. Introduction

CLIMBERS are a group of vascular plants that germinate on floor and grow for part of their life by winding ground, anchoring or adhering to other plants [1] to attain great stature [2]. Climbers are constituted with more than 110 families which share nearly one-quarter of the total vascular plants [3].

Climbing plants show a great diversity in their climbing mechanism [1], [4], depending on which they are classified as root climbers, hook climbers, tendril climbers, leaf or stem climbers or twiners [5]-[8]. Few studies on climbers have distinguished three categories of climbing plants, namely woody climbing plants (lianas), herbaceous climbing plants (vines) and climbing shrub [9]. But most authors consider the climbing shrubs as lianas and therefore, recognize lianas and vines as the main groups of climber [10], [11]. Climbing plants are found in numerous ecosystems, but are more abundant and diverse near the equator [12], [13] in low elevation tropical forests than in temperate forests [14], [15]. Climbers represent respectively 7% and 20% of the local flora in temperate and tropical forests [12]. In tropical rain forest, they comprise about 25-30% of species diversity [13]. In tropical forests at least 50% of the trees contain lianas [16].

Climbers play important ecological roles in the forest ecosystem dynamics [17] and functioning [5], [18] and species diversity [13]. Other roles of climbers include suppressing tree regeneration, increasing tree mortality, providing a valuable food resource for animals, physically linking trees together, thereby providing canopy-to-canopy access for arboreal animals [19], [13]. Climbers often play important roles during forest succession after natural and anthropogenic disturbances [20] that act as the catalysts [21] for accelerating the establishment of alien species [22]. The host plants or trees that provide mechanical supports to climbers are effective competitor for light and space [23], [24] and water and nutrients [14]. The giant climbers or lianas can cause mechanical damage to their host plants. Recent studies have even demonstrated the increasingly important role of lianas in forest regeneration, species diversity and ecosystem-level processes and in socio-economic life of human beings [4], [18], [25]. Some climbers might be invasive due to their luxuriant growth [26]. Invasive climbers might have negative influence on native plant species and can act as one of the greatest threats to the ecological and economic well-being of the planet [27].

Though climbers have some important roles, the research works on this group are nearly neglected [7], [28]. Reference [19] led to renew the interests on this group probably after [29] and thereafter climber related research began slowly to increase [13]. Recently, interest on climber related studies has been notably increased [7]. Some ecological studies on the climbers are now available from the forests of different countries [30]-[35].

The Sundarbans mangrove forest is remarkably important for its floristic and faunal composition, wildlife habitats, and ecological values due to which it was declared by UNESCO as the world's 560th Ramsar Wetlands Site and 798th World Heritage Site in 1992 and 1999, respectively [36]. But any detail study on the flora of Sundarbans mangrove forest of Bangladesh (SMFB) has not yet been completed after [37]. Inventories on the climbers of this mangrove forest are not available, though a study on the species richness of climbers

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in a plain land forest has been completed [38]. We conducted this study on the climbers of SMFB to get the insights on species composition, richness, density and distribution of climbers in relation to salinity levels.

II. Study Site

The Sundarbans is the single largest chunk of productive mangrove forest ecosystems in the world [39] which is located in south of the Tropic of Cancer at the northern limits of the Bay of Bengal and may be classified as tropical moist forests, covering a vast area nearly about 10,029 km^2 in the territory of Bangladesh and India [40]. Bangladesh Sundarbans lies between latitudes 21°30′N and 22°30′N and longitudes 89°00′E and 89°55′E [40], [41]. The total area of Bangladesh Sundarbans is about 6,017 km^2 (62% of the total) which is composed of the landmass of 4,143 km^2 [42] and water bodies of 1874 km^2 in the forms of complex network of rivers, canals and tidal creeks [43], [44].

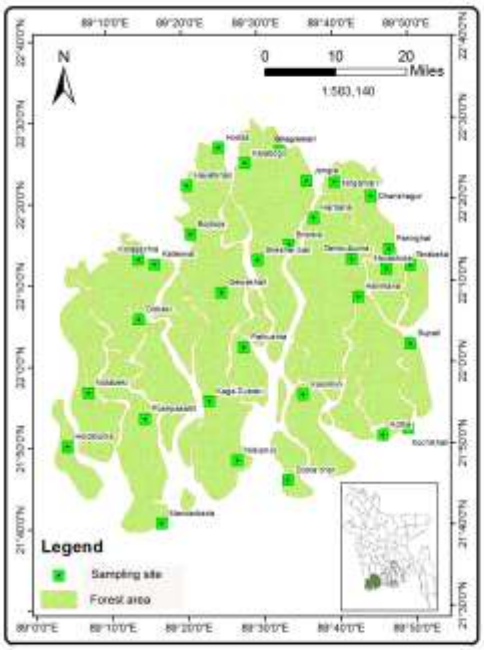

Fig. 1 Map of Sundarbans mangrove forest showing the location of sites [Terabeka (S_1), Panirghat (S_2), Supati (S_3), Kochikhali (S_4), Kotka (S_5), Dhanshagor (S_6), Morabhola (S_7), Kokilmini (S_8), Tambulbunia (S_9), Mrigamari (S_{10}), Jongra (S_{11}), Harbaria (S_{12}), Ghagramari (S_{13}), Harintana (S_{14}), Hodda (S_{15}), Kalabogi (S_{16}), Gewakhali (S_{17}), Shekherbari (S_{18}), Patkushta (S_{19}), Nilkomol (S_{20}), Bojboja (S_{21}), Hayetkhali (S_{22}), Bhodra (S_{23}), Kolagachia (S_{24}), Kateswar (S_{25}), Kaga Dubeki (S_{26}), Dobeki (S_{27}), Pushpakathi (S_{28}), Notabeki (S_{29}), Dubla Char (S_{30}), Mandarbaria (S_{31}), Holdibonia (S_{32})].

III. Sample Collection

Based on different forest types, salinity levels and geo-spatial locations, 32 representative sites (Fig. 1) were selected in the SMFB. Representative specimens of different climber species occurring in the selected sites were collected following standard quadrat method [45], [46] and herbarium techniques. The quadrat size 10m × 10m was standardized on the basis of species-area-curve method [47]. In each site, 10 quadrats were applied in two different transect lines each of 250m long from border to interior of the forest with a subsequent interval of 50m between each two quadrats. Number of climber individuals on the host plant/s of each quadrat was counted. Collected plant specimens were processed and preserved following standard herbarium techniques [48], [49] and deposited at the Herbarium of Botany department of Jahangirnagar University, Savar, Dhaka.

All plant specimens collected from the study area were identified through consulting the experts and matching with relevant voucher specimens preserved at JUH/DACB, taxonomic descriptions and keys available in the relevant literatures [37], [50]-[59] and type images available in the websites of different international herbaria.

IV. Data Analysis

Density and frequency of the climbing plants were determined by using the formulae described by [60], [61]. DAFOR (dominant, abundance, frequent, occassional and rare) scale as described by [62] was applied for knowing the status of the recorded climber species. Jackknife species richness of the studied sites was estimated through the following formula described as [63]:

$$\hat{S} = s + \left(\frac{n-1}{n}\right)^k$$

Where, $\hat{S}$ = Jackknife estimation of species richness,
s = Observed total no. of species present in n quadrats,
n = Total no. of quadrats sampled,
k = No. of unique species.

Top soil salinity of the studied sites were analyzed following the procedure described by [64]. These studied sites were categorized on the basis of salinity scale into three saline zones, i.e., oligohaline, mesohaline and polyhaline zones [65]. Effects of climbing plants were recorded through visual observation from field investigation. Principal Component Analysis (PCA) was conducted through GENSTAT 5.5 software.

V. Results And Discussion

Species Composition

In this study a total of 53 species belonging to 46 genera and 20 families were identified as climber from the studied sites of SMFB (Appendix I, available on request). 45 (84.91%) of these species were dicotyledones, 6 (11.32%) were monocotyledones and only 2 (3.77%) Pteridophytes. The family Fabaceae with 15 species was found as the most abundant which was followed by Convolvulaceae with 7 species, Asclepeadaceae with 6 and Vitaceae with 4 species (Fig. 2). These findings are mostly similar to those of [66], but in [66] the families Arecaceae and Caesalpiniaceae and Menispermaceae were found as the large families next to Febaceae instead of Convolvulaceae, Asclepeadaceae. 44 (83.02%) climber species were found as vine including two parasites and the rest 9 (16.98%) species were lianas. Among the climbers, 25 (47.17%) species were recognized as non-mangrove, 19 (35.85%) species as mangrove associate and 9 (16.98%) species as mangrove in nature. The non-mangrove species, that assumed to be introduced into the Sundarbans from other localities, were found comparatively in higher number than the mangrove or mangrove associate species in Sundarbans.

Species Richness

The highest Jackknife species richness value 26.59 was recorded from Terabeka site (S_1), which was followed by 19.67, 15.81, 15.73, 13.73 and 12.73 respectively from Kotka (S_5), Dhansagor (S_6), Panirghat (S_2), Nilkomol (S_{20}) and Kochikhali (S_4) sites. The lowest species richness value 3.00 was found in two sites- Holdibunia (S_{32}) and Notabeki (S_{29}) that belong to mesohaline or polyhaline zones Species richness values of the climbing plants were generally found as higher in the sites of oligohaline zone than that of the sites of mesohaline or polyhaline zones (Fig. 3). The sea-facing sites like Kotka (S_5), Nilkomol (S_{20}), Dubla char (S_{30}) and Mandarbari (S_{31}) of higher salinity were affected by some natural and anthropogenic disturbances but showed higher peak of species richness value. This observation is consistent with the finding of [67] and supports the statements of [68] on the impact of anthropogenic and natural disturbances on forest species. Our finding of Fabaceae as the most species rich family is consistent with [69], but unsupported by the references [70] and [71] which show that Bignoniaceae and Annonaceae were the most species rich family of climbers, respectively, in a semideciduous and a coastal hill forest. The PCA illustrates the distribution of different sites according to their species richness in relation to salinity levels (Fig. 4).

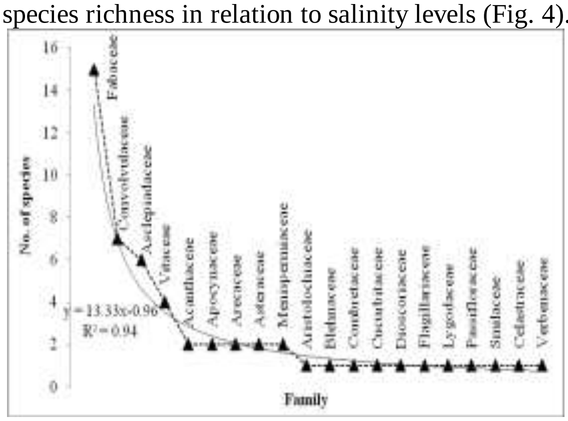

Fig. 2 Family-wise species composition of the recorded climbing plants of SMFB

Species Density

The highest mean density was recorded from the sites along or near the forest edges and it was followed by that recorded from the sites respectively at 70m, 130m and 190m distance from the forest edge along the transect. The lowest mean density was recorded from the site at 250m distance from the forest edge (Fig. 5). It means climber density showed a regular pattern of gradual decreasing with the increase of distance from forest edge, i.e. forest edges are relatively more suitable than the forest interior. This finding is corroborated with that of [72]. It supports the conclusion of several studies that climbing plants are preferentially distributed in open sites [14], [73], [74]. The results of PCA show that some sites (e.g. S_{16}, S_{18}, S_{21}, S_{24}, S_{25} and S_{26}) are correlated in both of species richness and density of climbers (Fig. 6).

According to DAFOR scale of frequency classes, maximum number of species (46) was found in rare category due to their narrow distribution in specific saline zone. Five species namely, *Dalbergia candentensis*, *Finlaysonia obovata*, *Salacia chinensis*, *Stenochlaena palustris* and *Vitis trifoliata* were represented in occasional category, whereas *Sarcolobus globosus* in abundant and *Derris trifoliata* in frequent categories (Fig. 7) which indicates that these two species were distributed wide range of saline habitats.

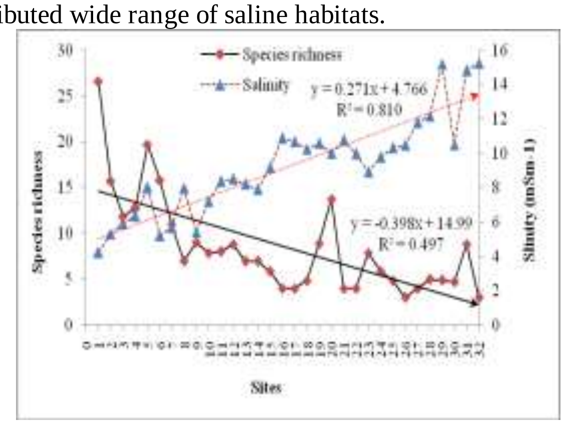

Fig. 3 Species richness of the climbing plants recorded from different site in relation with salinity.

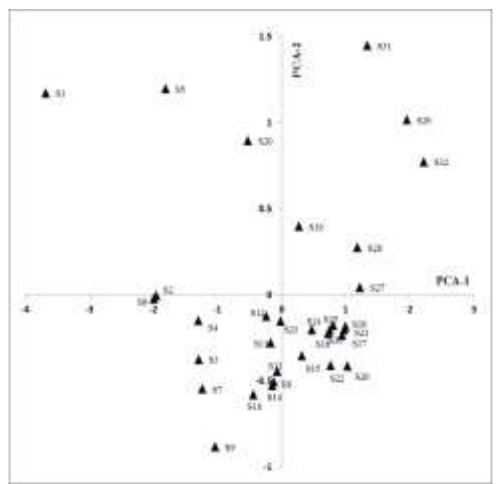

Fig. 4 PCA illustrating the distribution of different sites according to the species richness of climbers in relation to salinity

Distribution of climbers in different saline zones of SMFB was different but with similar pattern of occurrence, i.e., in higher number in the forest edge and gradually in lower number towards the interior forest. In the study area 9 climber species (e.g., *Derris trifoliata*, *Dalbergia candentensis*, *Finlaysonia maritima* and *Sarcolobus globosus*) were found to be distributed in all saline zones that mean they are adapted to all ranges of saline habitats. Distribution of 15 species in oligohaline to mesohaline zones (e.g., *Entada phaseoloide*, *Flagellaria indica* and *Mucuna gigantea*, *Stenochlaena palustris*) shows that they are adapted with wider but specific ranges of saline habitats. Occurrence of only one species (*Tylophora indica*) in mesohaline to polyhaline zones indicates that these ranges of saline habitat are not suitable for climbers (Fig. 8). The distribution of 23 species (e.g., *Mikania cordata*, *Stictocardia tilifolia* and *Calamus tenuis*) restricted to oligihaline zone only and five species to mesohaline zone (e.g., *Acanthus volubilis*, *Canavalia maritima* and *Vigna marina*) indicates that these species groups have been adapted with a very narrow range of saline habitat in SMFB. These findings have established the fact that the oligohaline haline zone of SMFB harbors most of climber species, whereas the mesohaline zone a good number and the polyhaline zone the lowest number of climber species.

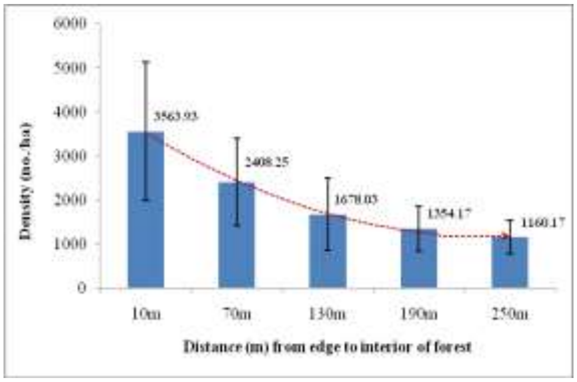

Fig. 5 Average density values of the recorded climbing plants of SMFB.

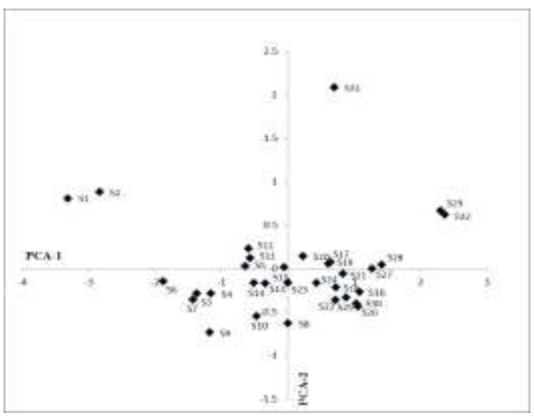

Fig. 6 The PCA showing the distribution of different sites according to the density of climbers in relation to salinity.

Though most of climber species seem to contribute in the development of the biodiversity of SMFB, 16 climber species were found as aggressive invasive affecting the growth, development and regeneration of other species (e.g., *Heritiera fomes* and *Excoecaria agallocha*) through twisting or spreading over their branches, competing for moisture, light and nutrients, and sometimes causing direct physical damage etc. These invasive species are also changing the pattern and ranges of distribution of other species and the ecosystems of SMFB. These species include- *Clerodendrum inerme*, *Cuscuta reflexa*, *Dalbergia candentensis*, *Derris scandens*, *Derris trifoliata*, *Entada phaseoloides*, *Finlaysonia maritima*, *Flagellaria indica*, *Hoya parasitica*, *Mikania cordata*, *Mucuna gigantea*, *Salacia chinensis*, *Sarcolobus globosus*, *Stenochlaena palustris*, *Tylophora indica* and *Vitis trifoliata* etc. Six of these species were previously recognized by [75] as invasive with different levels of invasiveness, such as, highly invasive (*Derris trifoliata*), invasive (*Entada phaseoloides* and *Mikania cordata*) and potential invasive (*Hoya parasitica*, *Flagellaria indica* and *Sarcolobus globosus*).

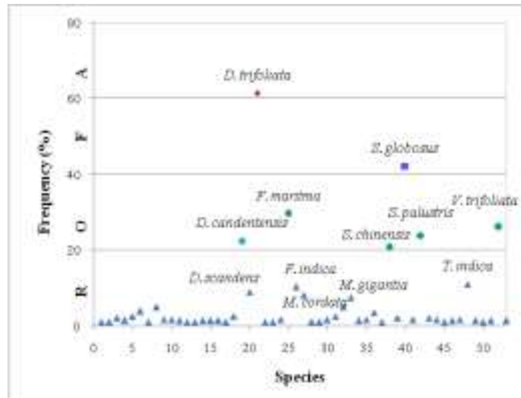

Fig. 7 DAFOR scale of frequency classes of the recorded climbing plants in SMFB (A= abundant, F= frequent, O= occasional, R= rare).

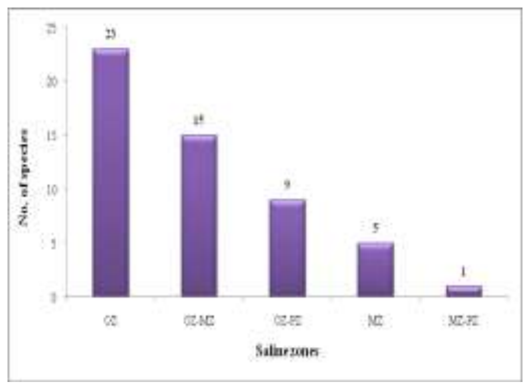

Fig. 8 Distribution of the climbing plants in different saline zones of SMFB (OZ= oligohaline zone, MZ= mesohaline zone, PZ= polyhaline zone).

The findings of this study would be helpful for further research to make sure the proper management of climbers and their host plants and the ecosystems of Sundarbans mangrove forest of Bangladesh.

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