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RESEARCH PAPER

Diversity and distribution of aquatic macrophytes with special reference to invasive species in Barak Valley, Assam, Northeast India

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ABSTRACT

Aquatic macrophytes (AMs) play a crucial role in modulating the aquatic ecology and environment because of their diversity and abundance. Survey and documentation of AMs would help in identifying the species which are important from ecological (e.g. invasion) or economic (e.g. useful species) point of view. The present study examines the diversity and distribution patterns of AMs with special reference to invasive species in different aquatic systems of Barak Valley, Assam, Northeast India. A total of 567 aquatic systems comprising of flood plain lakes and wetlands, ponds, water-logged areas, marshy/swampy areas, canals, streams, and rivers have been surveyed. The study revealed the presence of 58 species of AMs belonging to 30 families. Around 36% of the species are invasive. Overall, the richness of both non-invasive and invasive species was higher in floodplain lakes and wetlands compared to other aquatic systems. The skewed patterns in richness and distribution of AMs in the region hints at interesting underlying ecological processes, which deserves further study. We feel that there is a necessity of formulating strategies to control/manage the invasive species in the region.

KEYWORDS: Aquatic macrophytes, invasive species, management, Barak valley, Assam
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Introduction

Aquatic macrophytes (AMs) play a significant role in freshwater ecosystems as they provide food and shelter to invertebrates (Rejmankova, 2011) and stabilize sediments & shorelines thus reducing turbidity of aquatic systems (Bamidele and Nyamali, 2008). However, they can also be nuisance to the aquatic ecosystem, human health and economy when they turn out to be invasive. Invasive aquatic macrophytes (IAMs) can reduce species composition (Douglas and O'Connor, 2003; Perna *et al.* 2012; Amorim *et al.* 2015), affect habitat conditions (Crooks, 2002), change soil properties (Windham and Lathrop, 1999) and biogeochemical functions (Ravit *et al.* 2003); and disturb recreational activities like boating, swimming and fishing (Thum and Lennon, 2010).

Species survey and documentation is the most important aspect in ecological and biodiversity studies (Chiarucci *et al.* 2011). It helps in identifying species important from ecological (e.g. invasion) or economic (e.g. useful species) point of view as well as estimate their abundance (Ferreira *et al.* 2011; Dienye, 2015). This helps the researchers, planners, and decision makers to plan further studies or future course of action (Rao, 2016).

The Barak Valley region of Assam in northeast India is dotted with wetlands, lakes, rivers, and numerous other big and small aquatic systems (Rajbongsi and Das, 2016). This can be attributed to its unique topography and characteristic precipitation patterns. We hypothesize that interplay of all of these factors is expected to create numerous ecological niches leading to high diversity of aquatic macrophytes in the region. However, efforts to document this diversity has been fragmentary, and thus not adequate for decision-making. Also, the intensity of land use change and anthropogenic disturbances in the region has escalated over the years (Kar *et al.* 2008), plausibly leading to high number of invasive species. Considering the above, the present study aims to study the diversity and distribution of aquatic macrophytes in the region.

Materials and methods

Study area

The Barak Valley region of Assam – which is a part of the Indo-Burma biodiversity hotspot - comprises of three districts viz., Cachar, Hailakandi and Karimganj covering an area of 6922 km^2. The valley is characterized by an undulating topography comprising of small hills/hillocks and floodplains. Because of its topography, most of the low land areas are endowed with numerous aquatic systems such as wetlands, rivers, lakes, swamps and ponds.

Methodology

Field surveys were undertaken in various aquatic systems of Barak Valley viz., floodplain lakes, floodplain wetlands, water logged areas, marshy and swampy areas, and agricultural fields besides canals, streams, rivers, and ponds to collect, identify, and document the macrophytes. The occurrences of the species were mapped using Global Positioning System (GPS) and ArcGIS software.

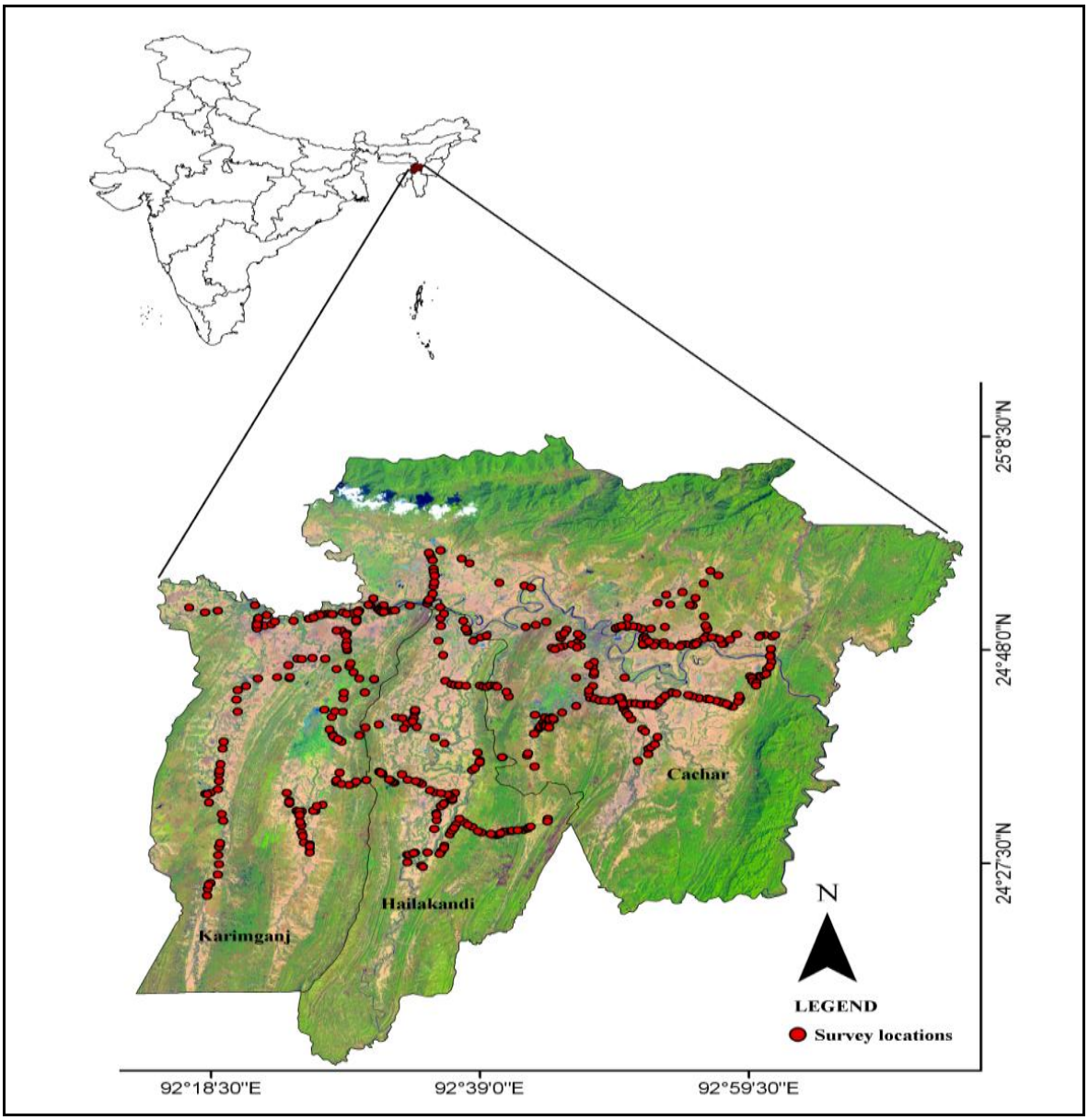

Figure 1. Map showing survey locations for studying the diversity and distribution of aquatic macrophytes including the invasive species in Barak Valley, Assam.

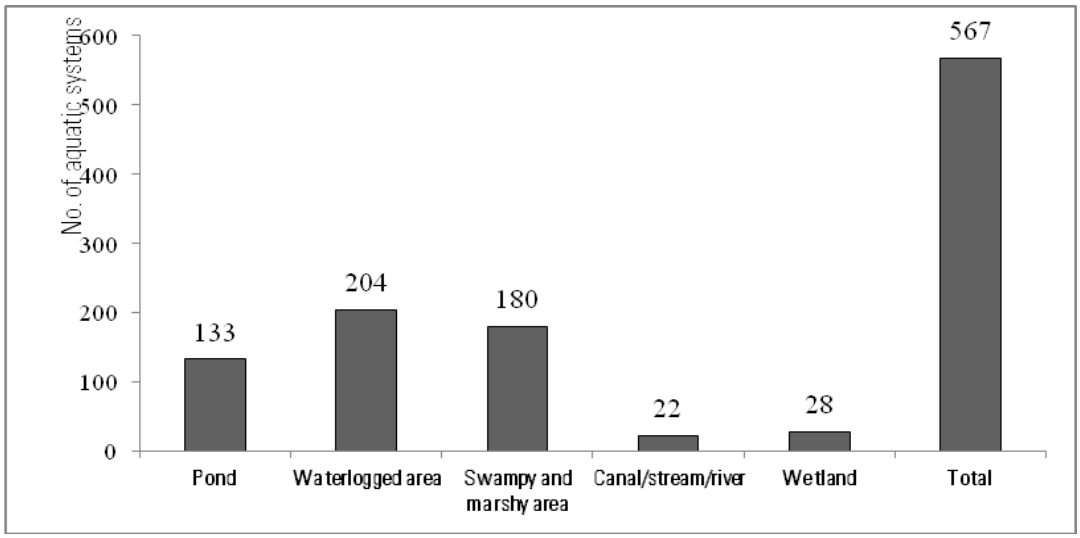

Figure 2. Total surveyed aquatic systems for studying diversity and distribution of aquatic macrophytes including the invasive species in Barak Valley, Assam.

The identity of the macrophytes was ascertained following relevant scientific literature (Biswas and Calder, 1984; Cook, 1996; Fassett, 2000 and Majid, 2000) and online resources (www.kew.org and www.tropicos.org). Invasive species were identified consulting the global data base on invasive species (www.issg.org) and the ENVIS database (www.bsienvis.nic.in/Database/Invasive_Alien_species_15896.aspx). Overall, the surveyed locations (Fig. 1) comprised of a total of 567 aquatic systems covering 545 lentic systems viz. flood plain lakes and wetlands (28), ponds (133), water-logged areas (204), marshy and swampy areas (180), and 22 lotic systems comprising of canals, streams, and rivers (Fig. 2).

Results

A total of fifty eight species of AMs has been recorded (Table 1). They belong to thirty families viz. Acanthaceae, Alismataceae, Amaranthaceae, Aponogetonaceae, Araceae, Asteraceae, Azollaceae, Ceratophyllaceae, Commelinaceae, Convolvulaceae, Cyperaceae, Haloragaceae, Hydrocharitaceae, Lemnaceae, Lentibulariaceae, Marsileaceae, Menyanthaceae, Mimosaceae, Najadaceae, Nelumbonaceae, Nymphaeaceae, Onagraceae, Poaceae, Polygonaceae, Pontederiaceae, Potamogetonaceae, Salviniaceae, Scrophulariaceae, Sphenocleaceae and Trapaceae. Of these, 17 species are listed in the global invasive species database, and four species are reported to be invasive in India.

Species richness of both AMs and IAMs varied from one aquatic system to the other (Table 1).

Species richness of AMs showed the following sequence with respect to the different aquatic systems: *Floodplain lakes and wetlands>ponds>water logged areas> swampy and marshy areas >canals/streams/rivers*. Species richness of IAMs showed the following sequence with respect to the different aquatic systems:

Floodplain lakes and wetlands > ponds > canals / streams / rivers > water logged areas > swampy and marshy areas.

Species richness of IAMs based on invasive species database of India showed the following sequence with respect to the different aquatic systems:

Ponds > water logged areas = swampy and marshy areas > canals / streams / rivers = Floodplain lakes and wetlands.

Species richness of total IAMs based on global invasive species database and invasive species database of India showed the following sequence with respect to the different aquatic systems:

Floodplain lakes and wetlands > ponds > water logged areas = canals / streams / rivers > swampy and marshy areas.

It is important to mention that *E. crassipes* and *I. carnea* are the only species which are found in all types of the aquatic systems (Table 1). Forty five numbers of species of the AMs are native to Asia/India (Fig. 3A) and 37 species are non-

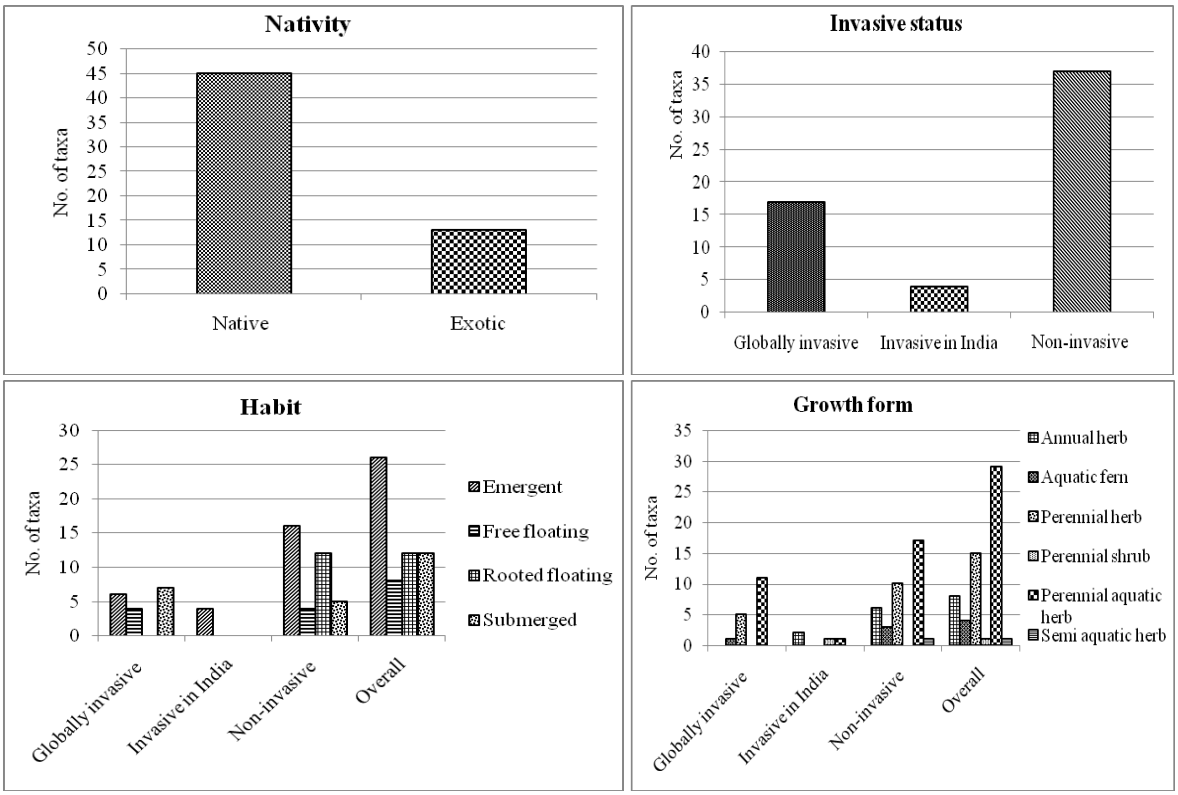

Figure 3. Nativity (A), invasive status (B), habit (C), and growth forms (D) of aquatic macrophytes including the invasive species in Barak Valley, Assam.

invasive in nature (Fig. 3B). However, amongst the remaining invasive group seventeen species have been reported as globally invasive and remaining four species have been reported as invasive in India (Fig. 3B). The habit of all the recorded AMs showed that most of the species (26) belonged to emergent group, followed by rooted floating (12), submerged (12), and free floating groups (8) (Fig. 3C). Amongst the invasive group, most of the globally IAMs belonged to submerged and emergent (6) groups followed by free floating groups (4) (Fig. 3C). On the other hand, the species which are reported as invasive in India falls exclusively under the emergent group (4) (Fig. 3C). Growth forms of all the recorded AMs showed that most of them (29) belonged to perennial aquatic herb followed by perennial herb (15), annual herb (8), aquatic fern (4), perennial shrub (1), and semi-aquatic herb (1) (Fig. 3D). Amongst invasive group, most of the globally IAMs belonged to perennial aquatic herb (11) followed by perrenial herb (5) and aquatic fern (1) (Fig. 3D) whereas the species which are reported as invasive in India belonged to annual herb (2) followed by perrenial shrub (1) and perrenial aquatic herb (1) (Fig. 3D).

Discussion

The present study revealed presence of diverse assemblages of aquatic macrophytes in the aquatic systems of Barak Valley. This conforms to our hypothesis that interplay of the environmental factors viz., topography and rainfall, which is expected to create numerous ecological niches can lead to a high diversity of aquatic macrophytes. A total of fifty eight species of AMs have been recorded out of which seventeen species belonged to IAMs based on global invasive species database and four species to IAMs based on invasive species database of India. Amongst all the aquatic systems, species richness of both AMs and IAMs were more in floodplain lakes and wetlands. This may be attributed to higher habitat heterogeneity in floodplain lakes and wetlands which facilitates more species to colonize such systems (Esteves, 1998; Rolon *et al.* 2010). The predominance of *E. crassipes* and *I. carnea* in all types of aquatic systems indicate broader niche breadth of these species. Higher richness of emergent group amongst AMs a may be attributed to their better survival strategies. Their roots remain attached permanently to sediments, which do not allow

Table 1. Distribution of aquatic macrophytes (AMs) and invasive aquatic macrophytes (IAMs) in different aquatic systems of Barak Valley, Assam

Species name	Pond	Water logged area	Swampy and marshy area	Canal/Stream /river	Floodplain lakes/ wetlands
***Alternanthera philoxeroides* (Mart.) Griseb.	+	+	+	+	+
***Alternanthera sessilis* (L.) R. Br. ex DC.	+	+	+	-	-
Aponogeton appendiculatus H.Bruggen	-	-	-	-	+
Aponogeton natans (L.) Engl. & K. Krause	-	-	-	-	+
***Azolla pinnata* R. Br.	+	+	-	+	+
*** Ceratophyllum demersum* L.	-	-	-	-	+
Colocasia esculenta (L.) Schott	+	+	+	-	+
***Commelina benghalensis* L.	+	-	+	-	-
Commelina diffusa Burm. f.	+	-	-	-	-
***Cynodon dactylon* (L.) Pers.	+	+	+	-	+
Cyperus haspan L.	-	-	+	-	-
Cyperus imbricatus Retz.	-	-	+	-	-
Cyperus pilosus Vahl	-	-	+	-	-
Scirpus cyperinus (L.) Kunth	-	-	-	-	+
***Eichhornia crassipes* (Mart.) Solms	+	+	+	+	+
Eleocharis acuta R.Br.	-	-	+	-	+
Enhydra fluctuans Lour.	+	+	-	-	-
Euryale ferox Salisb.	-	-	-	-	+
***Hydrilla verticillata* (L. f.) Royle	-	-	-	-	+
Hygroryza aristata (Retz.) Nees	-	+	-	-	+
***Hygrophila polysperma* (Roxb.) T. Anderson	+	-	-	-	+
***Ipomoea aquatica* Forssk.	+	-	-	-	-
**Ipomoea carnea* Jacq.	+	+	+	+	+
Kyllinga brevifolia Rottb.	-	-	-	-	+
Lemna minor L.	+	+	-	-	-
***Limnophila sessiliflora* (Vahl) Blume	-	-	-	+	+
**Ludwigia adscendens* (L.) Hara	+	+	-	+	+
**Ludwigia perennis* L.	+	-	+	-	-
Marsilea quadrifolia L.	-	+	-	+	+
Monochoria hastata (L.) Solms	+	+	+	-	-
**Monochoria vaginalis* (Burm.f.) C.Presl	+	+	+	-	-
***Myriophyllum spicatum* L.	-	-	-	-	+
***Najas minor* All.	-	-	-	-	+
Nelumbo nucifera Gaertn	+	-	-	-	-
Neptunia oleracea Lour	-	+	-	-	-
Nymphaea pubescens Willd.	+	-	-	-	+
Nymphaea lotus L.	+	-	-	-	+
Nymphaea stellata Willd.	+	-	-	-	+
Nymphoides cristata (Roxb.) Kuntze	+	+	-	+	+
Nymphoides indica (L) Kuntze	+	+	-	+	+
Ottelia alismoides (L.) Pers.	+	+	-	-	-
***Pistia stratiotes* L. Royle	+	+	-	+	+
Persicaria barbata (L.) H.Hara	+	+	+	-	-
Persicaria hydropiper (L.) Delarbre	-	-	-	+	-
Persicaria lapathifolia (L.) Delarbre	+	-	-	-	-
***Potamogeton crispus* L.	-	-	-	-	+
Pseudoraphis spinescens (R.Br.) Vickery	-	+	+	-	+
Rhynchospora corymbosa (L.) Britton	-	-	+	-	-
Sacciolepis interrupta (Willd.) Stapf	-	-	+	+	+
Sagittaria guyanensis Kunth	+	-	-	-	-
***Sagittaria sagittifolia* L.	-	-	-	+	+
Salvinia cucullata Roxb.	+	+	-	+	+
Salvinia natans (L.) All.	-	-	-	+	-
Sphenoclea zeylanica Gaertn.	-	+	-	-	-
Spirodela polyrrhiza (L.) Schleid.	-	+	-	-	+
***Trapa natans* L.	+	-	-	+	+
Utricularia aurea Lour.	+	-	-	+	+
Vallisneria americana Michx.	+	-	-	-	+
Total species of AMs	**32**	**24**	**18**	**17**	**36**
Total species of IAMs reported in global invasive species database	**10**	**6**	**5**	**7**	**15**
Total species of IAMs reported in invasive species database of India	**4**	**3**	**3**	**2**	**2**
Total species of IAMs	**14**	**9**	**8**	**9**	**17**

'+ indicates presence and '-' indicates absence of the species concerned; '**' indicates the concerned species as IAM which has been reported in globally invasive species database; '*'indicates the concerned species as IAM which has been reported invasive species database of India.

them to be displaced by any external force; besides their ability to reproduce through rhizomes (Rejmankova, 2011) facilitate them to grow rapidly in any of their habitats. Higher richness of submerged group among IAMs may be due to the shallowness in most of the aquatic systems which provide adequate sunlight for their successful establishment (Jin *et al.* 2005). Higher richness of perennial aquatic herbs amongst all the AMs and IAMs which are globally invasive is due to their greater survival and regeneration capacity as these species can stay in the aquatic systems throughout the year.

Conclusion

The study shows that Barak Valley has diverse assemblages of AMs including the invasive species in different aquatic systems. The study revealed that amongst all the aquatic systems, wetlands harbor diverse species of both AMs and IAMs. The study entails a need for detail investigation on the ecology of IAMs especially in wetlands as these species are likely to significantly affect the native species and overall aquatic biodiversity in the region.

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