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A preliminary assessment of the angiospermic plants of "Kapla beel" wetland of Barpeta district of Assam, India

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Abstract

The present paper deals with the study of wetland plants in "Kapla beel" area of the Barpeta district of Assam (India). A total of 107 angiospermic plant species belonging to 80 genera, 37 families, and 21 orders are taken into consideration. Treatment of taxa according to the APG-IV system of classification reveals the existence of 4 ANA-grade species. The clade Magnoliids has been recorded with only a single species. The clade Commelinids is recorded with 50 species under 37 genera, 12 families and 5 orders. Asterids under the principal clade Eudicots and Superasterids respectively have been recorded with 31 species distributed under 27 genera, 13 families and 6 orders. Another major clade, *viz.* Rosids under the principal clade Eudicots and Superrosids respectively have been found with 8 species belonging to 6 genera, 5 families and 4 orders. Ranunculales and Proteales are recorded as the smallest group under Eudicots comprising only 1 species each. Caryophyllales have been recorded with 10 species belonging to 4 genera and 2 families. The habitat condition of the wetland has been found to favour the growth of marshy amphibious species in a large amount.

Keywords

ANA-grade, Asteraceae, commelinids, eudicots, marshy amphibious, Poaceae, Kapla beel

Introduction

Wetlands are the rich assemblage of a variety of floristic and faunistic elements contributing to the biodiversity of a region. Being a complex habitat influenced by a variety of physical, chemical and biological processes, wetlands are supporting the lives of different micro and macrophytes including phytoplanktons, algae, bryophytes, pteridophytes, gymnosperms and angiosperms and a variety of animals like fishes, amphibians, insects, reptiles, birds and mammals apart from acting as a reservoir of genetic material (1, 2). Wetlands are the natural capital substituting the policies for flood control including the construction of dykes, embankments and dams (3). Wetlands can also be regarded as an amphibious habitat since they are in a transitional position between terrestrial and aquatic habitats where the water is near the land surface or the land remains submerged partly or wholly throughout the year (4, 5).

Despite having innumerable roles of the wetlands in supporting plant and animal lives and contributing towards richer biodiversity of a region, wetlands are facing serious threats of shrinkage and loss of both area and

dependent lives on the habitat. According to one estimate, more than 50% of wetlands were lost at the global level during the last 20th century (6) and the same trend is being continued in the current century also reflecting a loss of about 33% at the global level during last 2 decades (7). In India, the scenario of wetland loss is of serious concern. India comprises a total of 27403 recognized wetlands of which 2-3% of the same are disappearing every year. The factors responsible for the loss have been assessed to be overfishing, agriculture, deforestation, introduced species, climate change, water drainage, land encroachment and urban development (8).

India is bestowed with a diverse land mass ranging from low-altitude places like deserts to high-altitude places including mountain chains of the Himalayas. That uneven topography embraces a variety of ecosystems in the Indian sub-continent from aquatic to terrestrial. In between these 2 extremes, the wetlands being an amphibious type of ecosystem comprises the marsh, swamp, bog and fen. According to the latest estimate, Indian wetland diversity is blessed with a total of 75 Ramsar sites (9) apart from having several dead rivers, lakes, pools, ditches, ponds and other water reservoirs covering a maximum of 5% of the total geographical areas and supporting nearly 5th (20%) of the total biodiversity of the country (10).

In Assam, there are about 7755 wetlands, locally known as 'beels', located both inside and outside the reserved forest which are excluding the rivers and tributaries of both Brahmaputra and Barak valleys. The total wetland area of the state is estimated to be 1110789.41 ha. The district of Barpeta possesses about 25 recognized wetlands with 2455.26 ha area (11).

Macrophytes, also known as hydrophytes, are the major components of the wetlands occurring in the margins, surface water and shallow and deep water of the wetland. They may be emergent rooted or rootless, floating or completely submerged with varieties of ecological adaptations (12, 13). They produce enormous biomass and play a significant role in productivity and nutrient cycling in the ecosystem and affect the species diversity (14, 15). Apart from the ecological roles of the macrophytes, they have a key contribution towards the economy and livelihood of the human population by providing fish, food, fodder, fibre, medicine, cultural materials and other resources in India and different parts of the world (2, 13, 16, 17).

The wetlands support the existence of very rich flora and fauna throughout the year. Especially the study of wetland angiospermic macrophytes in terms of taxonomy throws light on the knowledge of biodiversity on one hand and of regional flora and the constituent elements on the other. For assessing biodiversity, the taxonomic study of the aquatic flora (macrophytes) may be a powerful tool (1, 18, 19). But very lesser work in connection with wetland macrophytic taxonomy is available and the scenario is not quite satisfactory even at the regional level too (10). The state of Assam, although known for its rich biodiversity and existence of a diverse group of wetlands (including beels) housing a wide range of floristic and faunistic elements, is very scantily represented by the works of taxonomic treatment of wetland plants. Most of the taxonomic studies on wetlands are scattered elsewhere in general floristic works (20-27). However, some fragmented studies restricted largely within a narrow political boundary (district, block, township) were undertaken in connection with taxonomic, ethnobotanic, socio-economic and in many a case, ecological surveys, which mainly contributed towards the general flora of the region without any significant contribution towards aquatic (hydrophytic) flora. Furthermore, the situation has been found worse in the present study area of the district since no comprehensive taxonomic treatment is recorded after going through the available literature. Keeping this in view, a taxonomic survey was undertaken for 2 years in the year 2020 and 2021 to explore the angiospermic plants and to record their habitat condition in the Kapla beel area of the Barpeta district of Assam.

Materials and Methods

The Study area

Geologically Barpeta district of Assam, India is a part of the Himalayan foreland basin which was formed due to the uplifted Himalayas and subsequently filled up by the sediments generated from the Himalayan catchment and brought down by numerous transversely flowing rivers (28). The district enjoys a hot summer (maximum temperature being 34.3 ^{0}C) with high atmospheric humidity (up to 85 %) and a cold winter (minimum temperature being 12.3 ^{0}C). The district experiences rainfall almost throughout the year at an average of 143.92 mm with 192.2 rainfall days per year (29).

The Kapla beel is situated in the Sarthebari subdivision of the Barpeta district of Assam. As far as the geographical position is concerned, the beel extends between 26^0 18/ 12// N to 26^0 25/ 7// N latitude and 91^0 8/ 42// E to 91^0 14/ 50// E longitude and covers an area of about 91 ha (30). Being mainly the community-managed wetland, the beel is being used chiefly for the fishing purpose by the local community apart from collecting the plant resources for a variety of purposes including food, fodder, medicine and decoration. The area is mainly covered by paddy fields and cultivation is practiced throughout winter, autumn and summer season (from March-April to October-November) leaving the fields uncultivated only for 2-3 months (December to February). The beel is connected by an inlet towards the eastern side with the Chilla beel and Hablakhowa beel and an outlet of the beel, which runs towards the western side, finally meets the mighty river Brahmaputra (Fig. 1).

Data collection and laboratory work

The survey was conducted for consecutive two years in the year 2020-2021 to cover the angiospermic plant species of the Kapla beel area of the Barpeta district of Assam. The specimens were collected in different seasons of the year from all the habitat conditions and preserved in the form

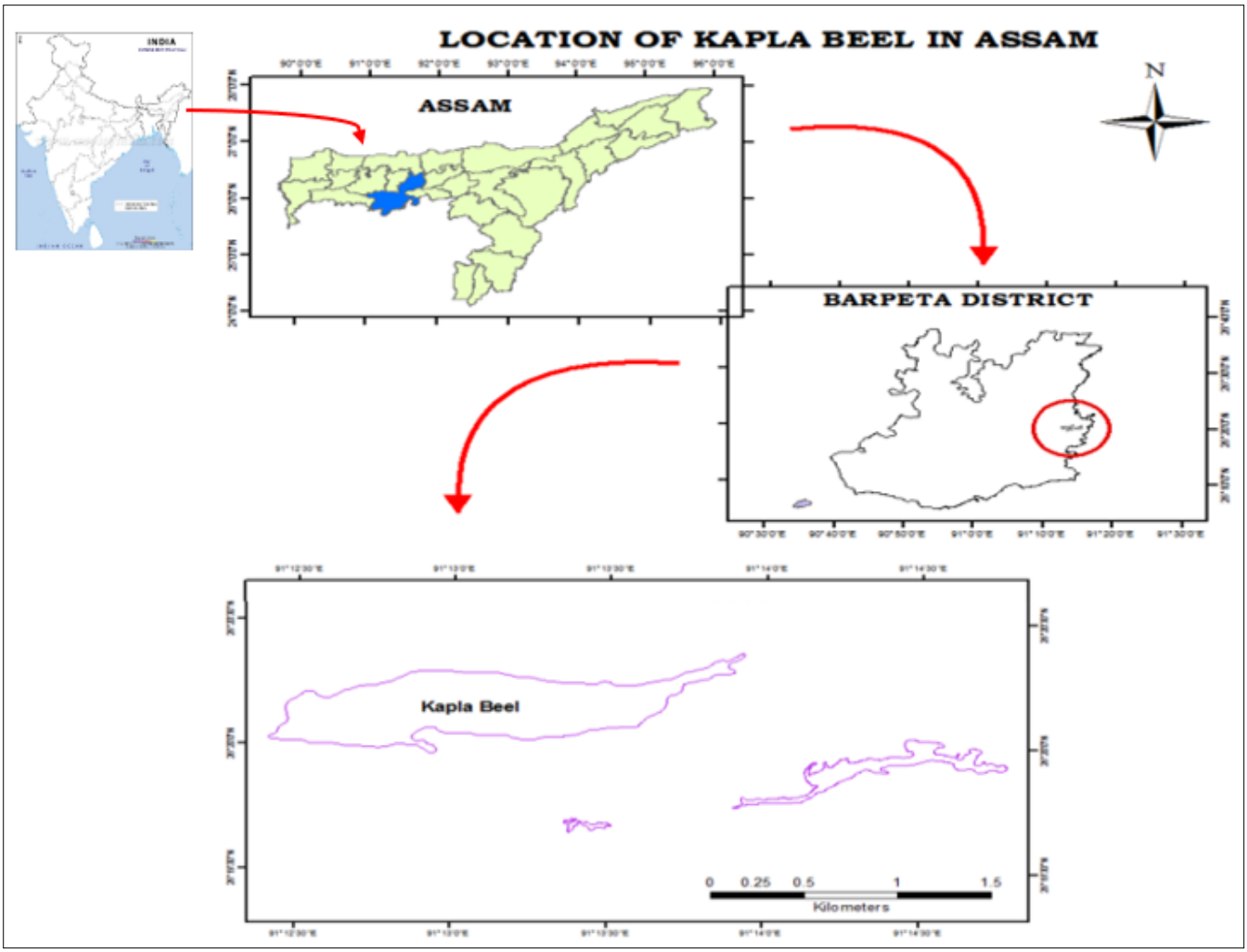

Fig. 1. Location map of the study area (© August, 2015, IJPAB).

of herbarium sheets following the standard method (31). Flowers and fruits, not suitable for preservation as herbarium specimens, were preserved as museum specimens following conventional methods (32). All specimens were identified properly after thorough consultation with the Herbarium of Gauhati University, Guwahati and nomenclature was cross-checked and confirmed by consulting the Flora of Assam (33-35), Flora of British India (36), e-Flora of India (37) and the plant identification websites (38, 39). Identified specimens were deposited in the Herbarium of the PG Department of Botany, M.C. College (Gauhati University), Barpeta, Assam.

Species are arranged according to the APG system (40) of classification in tabular form.

The habitat condition of each species was also recorded in the field and presented in tabular form against each species (41). The following habitat classes were taken into consideration for the current study:

(i) Anchored floating: Rooted plants with floating leaves.

(ii) Free-floating: Surface water plants, float freely.

(iii) Rooted-Emergent: Plants with well-developed rhizomes embedded within the mud, the lower part of the stem remains submerged in water and the upper part of the stem and the leaves remain aerial.

(iv) Submerged floating: Plants remain submerged in water and without roots.

(v) Rooted submerged: Plants rooted but remain submerged in water.

(vi) Marshy amphibious: Plants growing in shallow water or in muddy soil.

(vii) Terrestrial-damp soil: Plants growing directly on soil with high moisture content.

Results

The present study exhibits a rich diversity of wetland angiospermic plants in the Kapla beel wetland region of the Barpeta district of Assam with a total of 107 species belonging to 80 genera and 37 families under 21 orders (Supplementary Table). Out of all species, 4 species belong to the ANA grade (Amborellales, Nymphaeales and Austrobaileyales) as per the APG system of classification (The Angiosperm Phylogeny Group 2016) constituting the Basal angiosperms (Table 1). The recorded 4.76% ANA grade order includes 2.70 % families, 2.50 % genera and 3.74 % species among all recorded taxa (Table 2).

Only 1 species (0.93 %), *viz. Peperomia pellucida* (L.) Kunth belonging to the family Piperaceae and the order Piperales undergoes the Magnoliids clade (Table 2, Fig. 2).

Table 1. Distribution of taxa under different clades according to the APG-IV system of classification

Clades					Number of Order	Number of Family	Number of Genus	Number of Species
Angiosperms	ANA Grade				1	1	2	4
	Magnoliids				1	1	1	1
	Monocotyledons	Commelinids			5	12	37	50
	Eudicots	Ceretophyllales			1	1	1	1
		Ranunculales			1	1	1	1
		Proteales			1	1	1	1
		Superrosids	Rosids	Fabids	3	3	4	4
				Malvids	1	2	2	4
			Caryophyllales		1	2	4	10
		Superasterids	Asterids	Campanulids	2	3	17	18
				Lamiids	4	10	10	13
Total					**21**	**37**	**80**	**107**

Table 2. Percent Distribution of taxa under major clades/groups

Sl. No.	Clads/orders	Order	Family	Genus	Species
1	ANA	4.76	2.70	2.50	3.74
2	Magnoliids	4.76	2.70	1.25	0.93
3	Commelinids (Monocots)	23.81	32.43	46.25	46.73
4	Ceretophyllales	4.76	2.70	1.25	0.93
5	Ranunculales	4.76	2.70	1.25	0.93
6	Proteales	4.76	2.70	1.25	0.93
7	Rosids (Fabids + Malvids)	1905	13.51	7.50	7.48
8	Caryophyllales	4.76	5.41	5.00	9.35
9	Asterids (Campanulids + Lamids)	28.57	35.14	33.75	28.97
Total		**100.00**	**100.00**	**100.00**	**99.99**

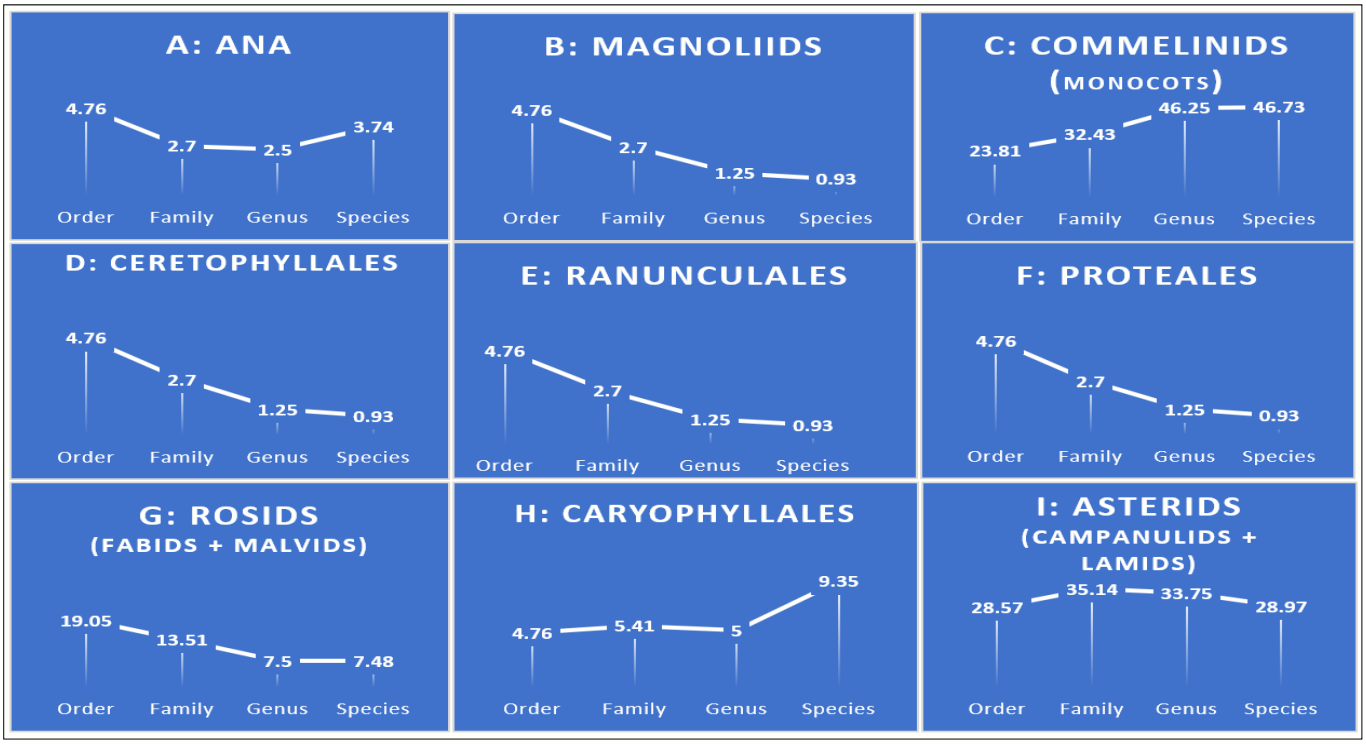

Fig. 2. Graphical representation of distribution of taxa under major clades/groups (A – I).

Monocotyledons show a very rich diversity under the clade Commelinid comprising 50 species (46.73%) under 37 genera (46.25%), 12 families (32.43%) and 5 orders (23.81%) thereby indicating a rich reservoir of monocotyledonous plants in the wetland. Poaceae being the richest family contains 15 genera and 17 species (Table 2, Fig. 2).

Ceretophyllales, being the sister group of Eudicots, was found to possess a single species *Ceratophyllum demersum* L. belonging to the only extant genus *Ceratophyllum* under the extant family Ceratophyllaceae (Table 1).

Next to the clade Commelinid, the clade Eudicots has also been recorded with a sizable number of taxa including 51 species, 39 genera, 22 families and 13 orders. Under Eudicots, the clade Rrosids has been recorded with 8 species (7.48 %), 6 genera (7.50 %), 5 families (13.51 %) and 4 orders (19.05 %) as against 31 species (28.97 %), 27 genera (33.75 %), 13 families (35.14 %) and 6 orders (28.57 %) under the clade Asterids (Table 2). The order Ranunculales and Proteales were recorded with a single family, a single genus and a single species each *viz*, *Ranunculus aquatilis* L. and *Nelumbo nucifera* Gaertn. respectively (Table 1).

Caryophyllales have been recorded with very poor representation of taxa (9.35 % species, 5.00 % genera, 5.41 % families and 4.76 % orders) (Table 2, Fig. 2).

Of all the recorded families, Poaceae among Commelinids (monocots) has been found to possess the highest number of species (17 spp.) followed by Cyperaceae (9 spp.), Araceae (5 spp.), Hydrocaritaceae (4 spp.) etc. Among Eudicots (true dicotyledons), the family Asteraceae is the largest family with 14 numbers of species followed by Amaranthaceae and Polygonaceae (5 spp. each) and others (Table 1).

The study of habitat condition of the wetland plants exhibited the predominance of marshy amphibious habitat confining 36.45 % of species under this class followed by terrestrial-damp soil dwelling (33.64 %), anchored floating (9.35 %), rooted submerged (7.48 %), free-floating (5.61 %), rooted emergent (4.67 %) and submerged floating (2.80 %) species (Table 3).

Discussion

The existence of 4 basal angiospermic species (40) belonging to ANA grade including *Nymphaea pubescens* Willd., *Nymphaea rubra* Roxb. ex Andrews, *Nymphaea nouchali* Burm. f. and *Euryale ferox* Salisb. indicates a suitable environment of the wetland for growth of the primitive plants. The clade Eudicots comprising both Superrosids and Superasterids with a good number of constituent taxa can be regarded as a successful group in the wetland environment. Noteworthy relationship between the 2 principal clades *viz.* Commelinids and Eudicots is that both clades include a nearly equal number of taxa in terms of genera and species (Table 1).

The assemblage of a high number of angiospermic plants including the macrophytes in the study area (Kapla beel) in comparison to other studies comprising of a district or a part of the province/state (13, 42-46) is indicative of richer phytodiversity in the area (Fig. 3, Fig. 4). This may be due to the perennial nature of the beel and also due to the location of the state of Assam in the Eastern Himalayan Biodiversity Region.

As far as the wetland study of a particular area is concerned, the predominance of dicotyledonous macrophytes over the monocotyledonous ones was reported (10, 13) thereby supporting the current finding where the number of dicotyledonous species (57 spp.) is found to be higher over its monocotyledonous counterpart (50 spp.).

The family Poaceae and Asteraceae can be regarded as the most successful taxa in terms of constituent species in the Kapla beel wetland area of the district. This finding corresponds to the findings proposed by previous workers (1, 10, 13, 19).

Angiosperms include over 295000 species belonging to 416 families and 64 orders (40). The present study represents only 0.04 % of species (107), 8.89 % of families (37) and 32.81 % (21) of orders in comparison to the APG system. As per the APG system of classification, nearly all angiospermic species are distributed among the Eudicots (75 %), Monocots (23 %) and Magnoliids (2 %), and the rest of the clades contain nearly 0.1 % (about 250 species) of the total phytodiversity. The present study has shown the

Table 3. Habitat condition of the angiospermic plants in the study area

Sl. No.	Habitat condition class	Number of species under habitat condition class	% of species under habitat condition class
1	Anchored floating	10	9.35
2	Free-floating	6	5.61
3	Rooted Emergent	5	4.67
4	Submerged floating	3	2.80
5	Rooted submerged	8	7.48
6	Marshy amphibious	39	36.45
7	Terrestrial-damp soil	36	33.64
	Total	**107**	**100**

Fig. 3. View of the Kapla beel area of Barpeta district (Assam) along with a few specimens. **A**. A part of the beel with human interference; **B**. A view of the Kapla beel; **C.** Part of the Kapla beel used for fishing purpose; **D**. *Ceratophyllum demersum*; **E.** *Croton bonplandianus*; **F.** *Gnaphalium polycaulon*; **G**. *Pontederia crassipes*; **H.** *Heliotropium indicum*; **I.** *Ipomoea carnea* ssp *fistulosa*; **J.** *Ludwigia octovalvis*; **K**. *Mikania micrantha* spread over *Pontederia crassipes*; **L.** *Nelumbo nucifera* grown along with *Pontederia crassipes;* **M.** *Nymphoides aquatica*; **N.** *Ottelia alismoides*; **O.** *Xanthium strumarium.*

following order of distribution of the clades in connection with their number of constituent species:

> Eudicots (Superasterids > Superrosids) ≥ Commelinids (monocots) > Magnolids

APG system recognizes Asteraceae, Orchidaceae, Fabaceae, Rubiaceae and Poaceae as the largest families with 32581, 28237, 20856, 13686 and 11434 constituent species respectively. In the present study, however, Poaceae and Asteraceae can be regarded as the largest families with 18 and 14 species respectively followed by Cyperaceae (9 spp.), Araceae-Amaranthaceae-Polygonaceae (5 species each), Hydrocaritaceae (4 spp.) and others.

Habitat preference of the recorded species indicating the predominance of amphibious and damp soil-dwelling species (36.45 % and 33.64 % respectively) over others corresponds to the report obtained by previous workers (1, 10).

Conclusion

Insufficient and uncomprehensive study on wetland vegetation is one of the major hurdles in the preparation of an organized flora of the wetland in a region. Authors feel more intensive studies concerning different aspects including taxonomy and ecology of the wetland to

Fig. 4. Species found in Kapla beel of Barpeta district (Assam) **A**. *Centella asiatica*; **B**. *Acmella paniculata*; **C**. *Ageratum conyzoides*; **D.** *Amaranthus spinosus*; **E.** *Blumea lacera*; **F.** *Chrysopogon aciculatus*; **G.** *Commelina longifolia*; **H**. *Cynodon dactylon*; **I**. *Cyperus compressus*; **J.** *Scoparia dulcis*; **K.** *Grangea maderaspatana*; **L.** *Hydrocotyle sibthorpioides*; **M.** *Youngia japonica*; **N.** *Oxalis corniculata*; **O.** *Persicaria hydropiperoides.*

understand and conserve the biodiversity of the wetland and to undertake any policy regarding the conservation of the wetland biodiversity. The present work is thought to be a breakthrough in adopting any conservation strategies in the Kapla beel wetland area of the Barpeta district of Assam.

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Authors contributions

DKB contributed towards conception and design of study, acquisition of data and critical revision of the manuscript. Final editing of the manuscript, analysis and interpretation of data, drafting the manuscript including the preparation of tables and graphs was done by EA.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to be declared.

Ethical issues: None.

Supplementary data

Supplementary Table. Enumeration of angiospermic plants as per APG-IV (2016).

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