Preliminary taxonomic survey of aquatic plants of Feni district was conducted between July 2016 and June 2017. Traditional taxonomic techniques and random meander methods were applied to record and collect aquatic plant species. A total of 56 aquatic plant species under 29 families were recorded from Feni district. Ecological habitats of aquatic plant species showed variations. Among them, 30% species prefer to grow near the edge of water, 20% as rooted submerged, 18% as rooted emergent, 16% as free floating, 12% as rooted floating and 4% surface creeper in the aquatic habitat. The uses of aquatic plants were showed that 27% species were used as fodder, 14% as medicinal, 11% as vegetable, 11% as edible fruits, 5% as duck weeds, 2% as artifacts and 30% as others purposes in the study area. Abundance of aquatic plant species in the habitat was showed variations. Among them 9% was found very abundant, 30% found common and 61% found rare in the study area. Based on the field observations and discussion with local people we were able to identify a good number of threats to aquatic plants and also pointed out some conservation measures for them. It was seemed that the species Achyranthes aquatic (thuash), Oenanthe javanica (painnaadani), and Chumanianthus dichotomus (patipata) were found to be limited in distribution outside Feni. These rare species need to be given priority for in situ and ex situ conservation.

Introduction

Plants living in water play multifarious roles including nutrient rotation, sediment stabilization, and the provision of foods and habitats for a variety of fishes and other animals (Chambers et al., 2008; O’Hare et al., 2017). Aquatics act as engineer species (Bouma et al., 2010; Bolpagni and Piotti, 2015) and their eradication cause drastic effect on trophic and functional status of the habitats with water bodies (Scheffer et al., 2003; Soana and Bartoli, 2014). Bangladesh supports a large number of aquatic plant species due to her geomorphological location and also the presence of good number of water bodies and flood plains. These aquatic plant species have the huge potentialities in the sector of ecology, environment and economics. Unfortunately less attention was paid on the aquatic angiosperms of Bangladesh except Khan and Halim (1987). For the management of aquatic flora data base is essential. Otherwise species will be lost before proper documentation in the scientific world. Plant taxonomic survey with aquatic plants has been started in Bengal regions. The most noteworthy works were done by Khan and Halim (1987), Alam et al. (2006), Seker et al. (2013), Mahmuda et al. (2017), Mukhopadhyay et al.(2017) and Alfasane et al. (2010, 2013, 2019a,b). But no works were found on the aquatic flora of Feni district except an ethnobotanical work (Uddin et al. 2014). Moreover, aquatic plants and their habitats are very fragile because of so many factors including dams and diversion, modern agriculture, irrigation, pollutants and also biological invasion. If research steps are not taken timely, species are going to extinct very rapidly before scientific documentation. That is why in the present study an attempt has been made to achieve the following objectives: to conduct the taxonomic survey of aquatic plants with all relevant data and also to find threats and to suggest some conservation measures for the aquatic plants of Feni district.

Abstract

Preliminary taxonomic survey of aquatic plants of Feni district. Ecological habitats of aquatic plant species showed variations. Among them, 30% species prefer to grow near the edge of water, 20% as rooted submerged, 18% as rooted emergent, 16% as free floating, 12% as rooted floating and 4% surface creeper in the aquatic habitat. The uses of aquatic plants were showed that 27% species were used as fodder, 14% as medicinal, 11% as vegetable, 11% as edible fruits, 5% as duck weeds, 2% as artifacts and 30% as others purposes in the study area. Abundance of aquatic plant species in the habitat was showed variations. Among them 9% was found very abundant, 30% found common and 61% found rare in the study area. Based on the field observations and discussion with local people we were able to identify a good number of threats to aquatic plants and also pointed out some conservation measures for them. It was seemed that the species Achyranthes aquatic (thuash), Oenanthe javanica (painnaadani), and Chumanianthus dichotomus (patipata) were found to be limited in distribution outside Feni. These rare species need to be given priority for in situ and ex situ conservation.
Materials and Methods

Feni is a south-eastern district of Bangladesh and lies between 22°44' and 23°17'N and between 91°15' and 91°35'E. The total area of the district is about 990.36 sq. km. The district is bounded on the north by Cumilla district and Tripura (India), on the east by Tripura (India), on the south by Chittagong district and on the west by Noakhali district. The district consists of 6 upazilas including Chhagalnaiya, Daganbhuiyan, Feni Sadar, Parshuram, Phulagzi and Sonagazi. The Feni, Selonia, Kohua and Muhuri are the main rivers of this district. There is huge number of manmade ponds present in the district. Maximum areas of Feni are flooded by four main rivers during monsoon. Sea water cannot reach to the cultivated land because of Muhuri dam. The area enjoys tropical climate with high rainfall and flush flood during monsoon period. The dry period the area has gone under boro cultivation using water from Muhuri project, a dam made in the estuary of Feni and Muhuri rivers. The vegetation type is similar to the vegetation of the lower Gangetic plain and other districts in the southern region of the country (Ishaq, 1977).

A number of field works for aquatic plants survey (Hyland, 1972; Alexiades, 1996) were conducted in different seasons of the year between 2016 and 2017. The survey areas were included seasonal and permanent water bodies, flood plains, rivers, ponds, and streams. Special efforts were given to find the species of conservation concern including threatened, endemic and rare. Maximum identifications were done at the field site and in case of confusion in identity, fertile plant specimens were collected and processed using standard herbarium techniques (Hyland, 1972). The Identification and updated nomenclature of the species were confirmed with standard literature (Uddin and Hassan, 2004; Siddiqui et al., 2007; Ahmed et al., 2008a,b; 2009a,b,c,d). Threatened categories of plants were recognized following Khan et al. (2001). Some noxious exotic plant species were also determined comparing with the reports of Hossain and Pasha (2004). Families were determined according to Cronquist (1981). Voucher specimens were deposited at Dhaka University Salar Khan Herbarium (DUSH).

Results and Discussion

A total of 56 aquatic plant species under 29 families were recorded from Feni district. Among the six aquatic plant families, Poaceae is the most common followed by Nymphaeaceae, Pontederiaceae, Hydrocharitaceae, and Najadaceae (Fig. 1). For each species, scientific name, bangle name, family, habitat, status, and uses wherever available are provided (Table 1). Habitats of aquatic plant species were showed variations. Among them, 30% species prefer to grow near the edge of water, 20% as rooted submerged, 18% as rooted emergent, 16% as free floating, 12% as rooted floating and 4% surface creeper in the aquatic habitats (Fig. 2).

![Fig. 1. Six common families of aquatic plants.](image1)

![Fig. 2. Habitat diversity of aquatic plants.](image2)
Table 1. Recorded list of aquatic plant species in Feni district.

| Scientific name | Local name | Family | Habitat | Uses | Abundance |
|-----------------|------------|--------|---------|------|-----------|
| Agrimonia aquatic (R.Br.) Moq. | Thuash | Amaranthaceae | Free floating | Medicinal | + |
| Actinoscirpus grossus (L.f.) Goeth. & D.A. Simpson | Motmotigash | Cyperaceae | Near edge of water | Fodder | ++ |
| Alpinia conchigera Griff. | Taragota | Zingiberaceae | Near edge of water | Medicinal | + |
| Alternanthera philoxeroides (Mart.) Griseb. | Helenecha | Asteraceae | Near edge of water | Vegetable | ++ |
| Alternanthera sessilis (L.) R. Br. ex Roem. & Schult | Haincha | Amaranthaceae | Near edge of water | Medicinal | ++ |
| Ammania gracilis Guill and Perr. | - | Lythraceae | Rooted submerged | - | + |
| Ammania pedicellata (Hiern) S.A.Graham & Gandhi | - | Lythraceae | Rooted submerged | - | + |
| Aponogoton natans (L.) Engl. & Krause | Gechu | Aponogotonaceae | Rooted submerged | - | + |
| Aeschynomena indica L. | Shola | Fabaceae | Rooted emergent | Fodder | + |
| Azolla pinnata R. Br. | Katipana | Azollaceae | Free floating | Duck weed | +++ |
| Ceratophyllum submersum L. | Katajhanji | Ceratophyllaceae | Rooted submerged | Fodder | + |
| Chamomullanthus dichotomus (Roxb.) Gagnep. | Patipata | Marantaceae | Near edge of water | Artifact | ++ |
| Colocasia esculenta (L.) Schott | Panikachu | Araceae | Near edge of water | Vegetable | ++ |
| Cyperus articulates L. | - | Cyperaceae | Near edge of water | Fodder | ++ |
| Echinocloa colonum (L.) Link. | Shamagash | Poaceae | Near edge of water | Fodder | + |
| Echinocloa crusgali (L.) P. Beauv. | Hamagash | Poaceae | Near edge of water | Fodder | ++ |
| Eichhornia crassipes (Mart.) Solms. | Kachripana | Pontederiaceae | Free floating | Fodder | +++ |
| Eleocharis acutangula (Roxb.) Schult. | Chesra | Cyperaceae | Rooted emergent | - | + |
| Erythraea flucaens Lour. | Titidata | Asteraceae | Near edge of water | Medicinal | + |
| Hemarthria portensia Steud. | Chaillagash | Poaceae | Near edge of water | Fodder | ++ |
| Hydrilla verticillata (L.f.) Royle | Janji | Hydrocharitaceae | Rooted submerged | - | + |
| Hydroclea zeylanica (L.) Vahl | - | Hydrophylaceae | Near edge of water | - | ++ |
| Hygrophiola philomoides Nees | - | Acanthaceae | Near edge of water | Medicinal | + |
| Hygrophila portensa (L.) Nees | Dolgash | Poaceae | Free floating | Fodder | + |
| Ipomoea aquatica Forssk | Kolmi | Convolvulaceae | Emergent surface creeper | Vegetable | ++ |
| Ipomoea fistulosa Mart. ex Choisy | Dolkolmi | Convolvulaceae | Near edge of water | Medicinal | ++ |
| Ludwigia adscendens (L.) H. Har. | Molsi | Onagraceae | Emergent surface creeper | Medicinal | ++ |
| Leersia hexandra Sw. | Araligash | Poaceae | Rooted emergent | Fodder | ++ |
| Lemna minor L. | Khupipana | Lemnaceae | Rooted emergent | Duck weed | +++ |
| Limnocharis flava (L.) Buchen. In Bremen | - | Alismataceae | Free floating | - | + |
| Limnophila heterophila (Roxb.) Benthy. | - | Scrophulariaceae | Rooted submerged | - | + |
| Monochoria hastata (L.) Solms | Boronukha | Pontederiaceae | Rooted emergent | Vegetable | ++ |
| Monochoria vaginalis (Brum. F.) Presl | Nukha | Pontederiaceae | Rooted emergent | Vegetable | ++ |
| Najas gracillima A. Br. ex Mangus | - | Najadaceae | Rooted emergent | - | + |
| Najas graminea Del. | - | Najadaceae | Rooted submerged | - | + |
| Najas marina L. | - | Najadaceae | Rooted emergent | - | + |
| Nechamandra alternifolia (Roxb.) Thw. | - | Hydrocharitaceae | Rooted submerged | - | + |
| Nymphaeasouchali Brum. f. | Neel shapia | Nymphaeaceae | Rooted floating | Edible | + |
| Nymphaeas pubescens Wild. | Sadashapla | Nymphaeaceae | Rooted floating | Edible | + |
| Aquatic Plant Species | Common Name | Family       | Life Form           | Use  | Abundance |
|-----------------------|-------------|--------------|---------------------|------|-----------|
| Nymphaea rubra Roxb. ex Andr. | Lalshapla | Nymphaeaceae | Rooted floating     | Edible | +         |
| Nelumbo nucifera Gaertn. | Padma      | Nelumbonaceae | Rooted floating     | Edible | +         |
| Nymphoides hydrophylla (Lour.) O. Kunte | Toktoi       | Menyanthaceae | Rooted floating     | Fodder | +         |
| Nymphoides indica (L.) O. Kunte | Chadmala   | Menyanthaceae | Rooted floating     | Fodder | +         |
| Oenanthe javanica (Blume) DC. | Painnaadani | Apiaceae     | Near edge of water  | Vegetable | +         |
| Ottelia alismoides (L.) Pers. | Panikola   | Hydrocharitaceae | Rooted submerged  | Edible | ++        |
| Paspalum schorbulatum L. | -          | Poaceae      | Near edge of water  | Fodder | ++        |
| Persicaria hydropiper (L.) Spach | Bishkatali | Polygonaceae | Near edge of water  | Medicinal | +       |
| Phragmites karka Trin. | Nolkhagra  | Poaceae      | Rooted emergent     | Fodder | +         |
| Pistia stratiotes L. | Molapanar  | Araceae      | Free floating       | -     | +++       |
| Potamogeton pectinatus L. | Gechu      | Potamogetonaceae | Rooted submerged | -   | +         |
| Sagittaria guayanensis Kunth. | -          | Alismataceae | Rooted floating     | -     | +         |
| Schenoplectus articulatus (L.) Palla | Chesra    | Cyperaceae   | Rooted emergent     | -     | +         |
| Sesbania sesban (L.) Merr. | Fuligash  | Fabaceae     | Emergent            | Fodder | +         |
| Trapa bispinosa Roxb. | Shingra    | Trapaceae    | Free floating       | Edible | +         |
| Utricularia exoleata R. Br. | Zaji       | Lentibulariaceae | Rooted submerged | -   | +         |
| Wolffia arrhiza (L.) Horkel ex Wimmer | Khudipana | Lemnaceae   | Free floating       | Duck weed | +++ |

Note: + means rare, ++ means common, +++ means abundant.

The study was also recorded the uses of aquatic plant species for different purpose of daily life. Among them, 27% species were used by local people as fodder, 14% as medicinal, 11% as vegetable, 11% as edible fruits, 5% as duck weeds, 2% as artifacts and 30% as others purposes in the study area (Fig. 3). The abundance of different aquatic species in the habitats was not uniform. Our overall observations showed that 61% aquatic plant species in the study area were found to be rare, 30% species were common and 9% species were abundant (Fig. 4). The results of abundance status of aquatic plant species represented here were based on basically filed observations and discussion with local people in the study area.

**Aquatic plants used as medicines, vegetables and fruits**

In the present preliminary study, some very interesting local uses and distribution of aquatic plant species have been recorded. *Achyranthes aquatica* locally known as thuash, a free floating aquatic plant is growing on the surface of the ponds and stagnant water bodies. The distribution of this species is very restricted and found only in greater Noakhali district and some parts of
Chittagong, particularly in Mirsharai. Exploration is needed to find the species in other districts of Bangladesh. Stems are sold in the local market as vegetable. Local people used it to increase appetite. It has some medicinal properties to cure cough, flu and stomach disorder (Uddin et al., 2014). In case of constipation, the stem paste is very effective. We also assumed that the stem of such plant may reduce blood sugar of human body. Phytochemical and pharmacognosy research are essential to prove the medicinal properties of this plant species. We saw this plant during childhood in west Modhugram of Chhagalmaiya upazila. But it is very difficult to find it now in this area. The species can be propagated through stem cutting. As the species has commercial and medicinal values, conservation effort should be given to protect it from extinction.

_Oenanthe javanica_, locally called as painnaadani, is an aquatic herb growing near the edge of water. The shoot of this plant is sold in the local market as vegetable. Leaves juice is used to cure jaundice (Uddin et al., 2014). The status of the species is very rare in the study area. We found it in one location in nature and also saw in the market.

_Enhydra fluctuans_, locally called as Tititidata, is growing near the edge of water bodies. The species is also sold in the local market as vegetable. It has some medicinal properties. Local people used it to cure diabetes and as brain tonic (Uddin et al., 2014). Status of the species in nature is very rare. We found it in one location during our survey.

_Ludwigia adscendens_ locally known as Molsishak, is an aquatic species growing in the surface of water as creeper. The plant shows some visible adaptive feature (white spongy roots) during creeping on the water surface. People used it to cure dysentery and also used as vegetable.

_Lastia spinosa_ locally called it katbash/katakachu, is growing in the wet area of fallow lands. Population status of this species is very rare in the study area. Rhizome of the plant was used by the local people as to cure stomach pain (Uddin et al., 2014) and flowers are used as vegetable.

_Alternanthera sessilis_ locally called it Haincha, is growing near the edge of water bodies. Local people used as vegetable and also used to cure gastric pain. Recent study proved that this species has comparatively better anti-oxygen properties than other less valued wild leafy vegetables (Shethi and Uddin, 2018).

_Alternanthera philoxeroides_ locally called as Helencha, is growing in the edge of water bodies. The species sold in the local market as vegetable. To cure constipation and stomach pain the plant is also used by the local people.

_Glymus oppositifolius_ locally called as Gimashak, a herbaceous plant growing in the wetlands when water was receded out during dry season. Whole plant is sold in the local market as vegetable. It has some medicinal properties. During chest pain cooked plant is used (Uddin et al., 2014).

_Nymphaea rubra_ also called as Lalshapla, an aquatic rooted floating herb is growing in water bodies. It has long petiole with large single flower showing above the water. This petiole is edible and sold in the market. Local people used it to remove constipation and also to reduce blood sugar. Fruits are also edible. In our survey in Feni Lalshapla was found in only one location that means the species is very rare in the natural habitat.

_Nymphaea pubescens_, called Sadashapla (designated as national flower), is an aquatic rooted free floating herb is growing in the deep water bodies of wetlands. In the local market the petiole is sold as vegetable. Fruits are also edible. People believed that the plant is useful for constipation and diabetes. The population status of this plant species is also rare. During our survey we recorded this species in only one location.

_Nelumbo nucifera_ also called Padma, is an aquatic rooted floating herb growing in water bodies. The flower of the species is very large and showy. The seeds of this species are very favorite to diabetic patients. We spotted this species in one location of Feni district. In the last visit
we saw the habitat of this species totally altered to urban land for erecting tower building. We assumed that this species is not present other areas of Feni district. Distribution record of this species should be checked before confirming the status in Feni district.

_Trapa bispinosa_ (Singra) is one of the rare aquatic plant species was recorded in the study area. The species was located in only two locations. The population number of this species is very low. Over-exploitation of fruits was one of the major causes to make it rare. Fruits are edible and sell it in the local market.

_Ottelia alismoides_ locally called it _panikola_ is one of the known edible fruits in aquatic ecosystem. This is very rare in the study area.

**Commercially potential plants**

Some ponds and beels of the study area supported profuse growth of duck weeds, particularly _Lemma minor, Wolffia arrhiza_ and _Azolla pinnata_. Local people harvested these plants and sell them in the market for poultry and fish feeds. Talking to local people we have learned that these plant species have huge market values. If these duck weeds can be cultivated in a planned way then there is a chance to get a lot of financial benefits from them. No investment required to cultivate these species. More over these species can be grown in the stagnant water bodies naturally.

Another interesting species is _Chumannianthus dichotomus_ locally known it as patipata, an aquatic emergent herb is growing in the edge of ponds and water bodies. The plant has high commercial values. Bangladesh forest department introduced it in the commercial plot of wet area of forest lands. Fine mat is making from the peel of the stem of this plant. Mats are used as bed cover, wall mat and handicraft materials. The plant is growing without care. Once planted, the plant can be sprouted from the base of the stem near the root system like bamboo population and continued to grow after generation to generation. Leaves juice are used by the local people to cure ear pain. As you all know that Sheetolpati is very famous in greater Sylhet region. The distribution of this plant is very restricted particularly in few districts.

One rare species growing near the water not listed as aquatic _Calamus guruva_ (Jalibet) is very interesting. This species has been used in different purpose of daily life including binding material. Population of this species was very rare in the study area and listed as threatened species of Bangladesh (Khan et al., 2001). The species was recorded in few locations only.

In our survey number species were also observed those can withstand with waterlogged condition. _Barringtonia acutangula_ (Hizol), _Crataeva nurvala_ (Barun), _Pongamia pinnata_ (Karoj), _Trewia nudiflora_ (Pidal), _Syzygium fruticossum_ (Bhutijam) and _Calamus guruva_ (Jalibet) are the best example of such species. These species are doing well near the water and even inside the water bodies. These species were not listed as aquatics.

**Exotics in aquatic ecosystem**

Exotic and invasive species in aquatic ecosystem are great problem to native flora. They have some aggressive features. Using such features they always dominated on the native flora for their survival. Water hyacinth is the best example of invasive species in aquatic bodies of Feni district. This is fast growing aquatic plant quickly covered the surface area of the water bodies and inhibits the growth of light demanding submerged and free floating aquatic plant species. According to local people opinion and our observations revealed that the presence of water hyacinth may create huge problems for other aquatic species including _Nymphaea nouchali, Nymphaea rubra, Nymphaea pubescens, Ottelia alismoides, Hydrilla verticillata, Potamogeton pectinatus, Utricularia exoleata, Najas graminea, Nymphoides indicum_ and _Trapa bispinosa_. They also mentioned that water hyacinth has some positive uses including as fodder to domestic cows and...
buffalos but negative impacts are enormous. In order to maintain native aquatic plant species diversity, water hyacinth should be controlled. During our filed work a number exotic tree species were also observed near the water bodies. These are Samanea saman (Rain tree), Acacia auriculiformis (Akashmoni) and Eucalyptus camaldulensis (Euacalyptus). Local people informed that among the exotics rain tree creates more hazards to local aquatic flora. This species produces spreading canopy and provided shade on the water bodies. Rotten leaves of this tree in the water may also create problems to aquatic plants as well as fishes.

**Threats to aquatic flora**

Aquatic plants of Feni district are in vulnerable to extinction because of so many threats. During our exploration and observations in the study area, consultations were made with local people on this issue of threats. Finally a good number of factors were came out those were responsible to make aquatic plants vulnerable to extinction. Among the factors modern agriculture, irrigation, Muhuri dam, herbicide, pollutants from upstream, exotic plantations, wetland filling, biological invasion and lack of awareness are the noteworthy. Muhuri dam is one of the most important threat to the aquatic habitats and aquatic plant diversity and other aquatic animals in the study area as confirmed by our observations and local people opinion.

**Conservation measures**

Conservation is a both the matter of investment and insurance that is sustained in the fields of environment, forestry, agriculture and fisheries. It is multidisciplinary approach involved knowledge of many areas including botany, zoology, social sciences, economics and laws (Hunter, 1995). Here as plant taxonomist we tried to focus species composition of the study area, importance of such species, their present status and factors responsible for extinction. Based on our observations and discussion with local people, a number of suggestions were made for the conservation of aquatic plant species in Feni district. First, species those are very rare in the natural habitats need to be located with GIS techniques and try to determine their population status and identify the threats and to minimize that immediately. If the rare species will not be survived in nature that case ex situ measure should be taken for that species particularly Trapa bispinosa, Achyrantehs aquatica, Nymphaea pubescens, Nymphaea rubra, Nymphaea naouchali, Nelumbo nucifera, Aschynomene indica, Oenanthe javanica and Ottelia alismoides. Propagation and germination experiments initiative should be undertaken to understand their mode of multiplication in nature. Some small areas with full of aquatic plant species should be declared protected for the sources of mother seeds. In this case compensation is necessary for the local people those who own the lands. Awareness among the local people should be created for the importance of aquatic plants in our daily and social life. Herbicide should be banned in the cultivated land to burn weeds, a new threat added to the aquatic life. We should rethink about the benefits and losses of dams and diversion of water. The dam and diversion of water create huge problems to aquatic life in nature as local people informed us.

**Conclusions**

The present study in aquatic habitats of Feni district was first initiation. The record 56 aquatic plant species is the good indication of species richness. Further study in the district may enrich the list of aquatic plants. The finding of some interesting rare aquatic plants with their local uses made the demand for their conservation in the aquatic habitats. It was seemed that the species Achyrantehs aquatica (thuash), Oenanthe javanica (painnaadani), and Chmannianthus dichotomus (patipata) were found to be limited in distribution outside Feni. These rare species need to be given priority for the conservation either in natural habitats or at the ponds otherwise it will be lost from the nature before known to scientific world for the evaluation of their medicinal
properties. The presence of Muhuri dam (an irrigation project) is one of the strongest divers for the elimination of aquatic plant species from the nature. As the results of the present study are very preliminary, sound conclusion was not possible here. Further long term study is needed.

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