Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN (E): 2320-3862
ISSN (P): 2394-0530
www.plantsjournal.com
JMPS 2022; 10(3): 46-51

Received: 09-03-2022
Accepted: 22-04-2022

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Exploration of pteridophytic flora of rajshahi district, Bangladesh with special References to their medicinal potential and distribution

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DOI: https://doi.org/10.22271/plants.2022.v10.i3a.1424

Abstract
In Bangladesh the Pteridophytes are common member of flora of the country. Their presence has been recorded in almost all climatic zones and habitats. The present study was carried out from January 2011 to June 2011 in a small area of Bangladesh and a total of 20 species under 17 genera of the 14 families were collected and identified. All plant specimens were deposited in the Herbarium, Department of Botany, University of Rajshahi, Bangladesh. According to their habitat, the pteridophytes of Rajshahi have been categorized as aquatic, terrestrial, epiphytic and lithophytes. It was found that the pteridophytes of Rajshahi are not only medicinally important, but also they are good bioaccumulator of heavy metals and can be used as beautification and decorative purposes. Out of twenty pteridophytic species, twelve species are well established medicinally important pteridophyte and another one is a well known green manure. Among the medicinally important pteridophytes found in Rajshahi, six species have antibacterial, antiviral and antifungal activities; five species have anti oxidant activities; four species have anticancer activities and one species is diuretic, antidiabetic and used against snake bite. Four pteridophytes found in this area are good bioaccumulator of heavy metals and another six species of pteridophytes are used as ornamental plant. Most of them are common in eastern and north eastern India.

Keywords: Pteridophyte, Bangladesh, medicinal potential, distribution

Introduction
Pteridophyta are the most primitive vascular land plants. They appeared in the Silurian period as a tiny creature and in the Devonian period they became one of the major constituent of the land flora. In the Carboniferous, pteriphytes became the dominant plant group of the earth. Today, they comprise a group of about 12000 plant species which are widely distributed throughout the world [1, 2] however; the estimation may reach up to 15000 as the plant group is poorly studied and new species are still being found in unexplored tropical areas [3].
In Bangladesh, the Pteridophytes have been found to grow in almost all over the country under different habitats and different climatic conditions. According to the recent studies 196 pteridophytic taxa are available in Bangladesh [4]. It is expected that some of these plants may have the potential to possess either medicinal or food values as well as both. Exploration of medicinal and food values of pteridophytes was initiated for the first time in Bangladesh by Uddin and Pasha (1998) [5]. They reported 40 medicinal ferns and fern-allies available in Bangladesh. Uddin and Pasha (2012) [6], working in Rangamati district, found 41 pteridophyte species belonging to 26 genera under 13 families. The most important work in Bangladesh on ethno- botanical use of pteridophytes from the Chittagong Hill Tracts was conducted by Uddin *et al.* (2008) [7], where a total of 40 pteridophytic species were recorded with ethnic importance. The importance of studying local Pteridophytic diversity has been realized and carried out in Bangladesh by Khan *et al.*, (2001) [8], Mirza *et al.*, 2000 [9], Smitin and Larsen, (1989) [10], Ghosh *et al.*, (2004) [11] and Pasha (1985) [12].
However, similar work was extensively carried out in India by several workers in the adjoining areas. Mehra & Bir (1964) [13] studied the Pteridophytic flora of Darjeeling and Sikkim Himalaya, Baishya and Rao (1982) [14] worked on fern and fern-allies of Meghalaya, Jamir & Rao (1988) [15] worked on the ferns of Nagaland and Khullar (1994) (16) worked on ferns of Western Himalaya. Maity & Chauhan (2002) [17]; Maity & Maity (2007, 2009, 2011) [18, 19, 20] extensively explore the ferns and fern allies of Kanchenjunga Biosphere Reserve, Sikkim, India. According to Dixit (1984) [21], India has a rich Pteridophytic flora with about 1000 species under 191 genera spread over 67 families.

Although, politically divided from India, the pteridophytic flora of Rajshahi District, Bangaldesh is an extension of pteridophytic flora of both Eastern and North Eastern India. The plants of Rajshahi district exhibit diverse habitats, such as wetland, scrub jungles, uncultivated lands etc. which support luxuriant formation of different plants and play a vital role in the local economy, environment and primary healthcare system.

Thus the aim of the present study is to identify, describe and document the economic uses, medicinal potential as well as distribution of pteridophytic flora of Rajshahi District, Bangaldesh with special reference to the pteridophytic flora of both Eastern and North Eastern India which is yet to be done.

Materials and Methods

Study area: Rajshahi district is situated in the north-western Bangladesh and it is a part of Rajshahi division. This district is bounded by river Padma to the south, Chapai Nawabganj district to the west, Naogaon district to the north and Natore district to the east.

Methodology: A series systematic survey was carried out in the study area from January 2011 to June 2011 to determine the exact location of the plant species and to study the morphology and reproductive stage at field condition. The species were collected at mature stages and herbarium specimens were prepared following standard method. Different types of plant species were collected from different habitats in fertile stage. All plant specimens were deposited in the Herbarium, Department of Botany, University of Rajshahi, Bangladesh. The collected specimens were identified with the help of taxonomic literature. A total of 20 species under 17 genera of the 14 families were collected and identified.

Result

The present study was carried out in a small area of Bangladesh and a total of 20 species under 17 genera of the 14 families were collected and identified. According to their habitat, the pteridophytes of Rajshahi have been categorized as aquatic (*Azolla* sp., *Marsilea* sp., and *Salvinia* sp.), terrestrial (*Selaginella sp*., *Adiantum sp*., *Ceratopteris sp*., *Thelypteris sp*., *Ampelopteris sp*., *Dryopteris sp*. *Microlepia sp*., *Pteris* sp. *Equisetum sp*., D*iplazium*sp., *Lygodium sp.*), epiphytic (*Pyrrosia sp*., *Drynaria sp*.) and lithophytes (*Nephrolepis sp.*).

The plant materials collected from the study area using the identification methods was accumulated and described in Table 1` & 2. Table 1 deal with their taxonomy and uses, while Table 2 exclusively deals with their distribution.

Discussion

In India, the medicinal properties of pteridophytes were first described by Shusruta (6th century BC) and Charaka (4st century BC) in their 'Samhita Text' in traditional Indian medicine system [22]. This plant group was also used in unani system of medicine [23] as well as traditional Chinese system of medicine [24]. The uses of pteridophytes in ethnomedicine system in various parts of the globe are also widely documented [25, 26, 27, 28, 29, 30, 31]. Interestingly, medicinal properties of *Dryopteris filix-mas* were first documented by Theophrustus (4st century BC) and it is known for its antioxidant activities [22]. Thus, pteridophytes have several beneficial uses and exploited by human from ancient time.

According to Siddiqui *et al.* (2007) [4], there are 196 pteridophytic species present in Bangladesh. On the basis of the above data, it can be postulated that our study area possesses a moderate floristic richness. In an earlier work, Uddin and Pasha (1998) [5] estimated that about 40 medicinally important pteridophyte are present in Bangladesh. Later on, Uddin *et al*. (2008) [7] working on ethnomedicine in Chitagong hill area found almost similar number of medicinally important pteridophytes. Uddin and Hasan (2012) [6] carried out a study on pteridophyte in Rangamati district of Bangladesh and documented 41 species belonging to 26 genera under 13 families. Thus the actual population may be much higher and need serious attention from researchers.

Keeping in the mind about the medicinal potential of this plant group, when we concentrate about our collection, we found there are two species of *Selaginella* (*S. ciliaris* and *S. vaginata*) present in our study area. This genus has some bioactive compounds which are potential antioxidant, antiviral, anticancer activity [22]. *S. ciliaris* have both antioxidant properties [22] as well as anticancer properties [32, 33, 34, 35, 36]. Another important species is *Pteris vittata*. It contains kaemferol monoglycoside, kaemferol diglycoside, quercetin monoglycoside and quercetin diglycoside [30, 37]. This fern have antioxidant potential [38]; anticancer activity [33, 35] and antimicrobial activity [30]. *M. quadrifolia* and *M. minuta* are two medicinally important plants found in this area. *M. quadrifolia* has antioxidant properties [39, 40] and used to treat human breast cancer, diabetes and snake bite. It is antiinflammatory, diuretic and has antimicrobial activity (40). *M. minuta* also contain anticancer activity [22]. *Diplazium esculentum* is an edible pteridophyte with strong antioxidant activities [38]. Similarly, *Lygodium flexuosum* have antiviral [25] and antiinflammatory properties, *Adiantum philippense* have the antihyperglycimic and analgesic activities [41]; *Ceratopteris thalictroides* have the potentials to cure cuts, wounds and inflammations and traditionally used for these purposes in Simlipal Biosphere Reserve, Odhisa, India [42]. *Ampelopteris prolifera* have antimicrobial active principles [22]. *Nephrolepis cordifolia* possess both wound healing [43] as well as antibacterial and antifungal properties [44].

So, out of twenty pteridophytic species found in Rajshahi, twelve species are well established medicinally important pteridophyte and another one is a well known green manure (*Azolla pinnata)*. Among the medicinally important pteridophytes found in Rajshahi, six species have antibacterial, antiviral and antifungal activities; five species have antioxidant activities; four species have anticancer activities and one species is diuretic, antidiabetic and used against snake bite.

Ethno-medicinal properties of pteridophyte were first documented by Theophrustus [22]. *P. vittata* [45], *L. flexuosum, C. thalictroides, D. esculentum, N. cordifolia, Microlepia speluncae, Pyrrosia lanceolata and M. minuta* are used by various ethno-medicine practitioners [46]. Alcoholic and chloroform extracts of *Thelypteris dentate, Thelypteris parasitica, Ampelopteris prolifera* and *Dryopteris filix-mas* have been used as an herbal medicine for their antibacterial properties [47, 41].

The cultivation of Pteridophytes species *viz. Azolla, Salvinia* and *Marsilea* in the paddy field has enhanced the agricultural productivity. Thus, Pteridophytes have an efficient trait of nitrogen fixation which directly or indirectly can be utilized as a biofertilizer.

It was found that the study area was devoid of any endemic species. All species are well distributed in eastern and north eastern India and even in Europe and other part of the globe.

Thus, from this point of view, it can be considered that the population is an extension of the flora of eastern and north eastern India.

The rapid industrialization and urbanization of the earth emits tons of suspended particulate matter, metals and metalloids in the ecosystem in every day and night. These pollutants have enormous toxic effect in living organisms at different biomagnifications level. The bioaccumulation is a wonderful and cost-effective technique to reduce the impact of these toxic chemicals. The plants particularly Pteridophytes are best known bioaccumulator of such suspended particulate matter, metals and metalloids from the ecosystem. *P. vittata, Salvinia molesta, N. cordifolia, Azolla sp* has been experimentally determined as a hyper-accumulator of carcinogenic heavy metals [48].

Some pteridophytes (*S. vaginata, S. ciliaris, N. cordifolia, L. flexuosum, A. philippense, C. falcatum*) with their attractive foliar are enormously used during the ceremonial events as beautifying and decorative assets for their aesthetic appeal.

Thus, the pteridophytes of Rajshahi are not only medicinally important, but also they are good bioaccumulator of heavy metals and used as beautifying and decorative purposes. A diagrammatic representation of economic potential of peridophytes found in Rajshahi district of Bangladesh is given in Fig 1.

Conclusion

Though Rajshahi is rich in species diversity but a comprehensive floristic study of the area is still lacking. Presently this area is under severe threats mainly due to different ethnic activities. As a result of that, a number of economically important species/germplasm stocks have become endangered or threatened and perhaps extinct. So, it is essential to have a documentation of the plant resources for conservation and sustainable development. In our study, we found enormous possibilities of exploration of pteridophytic flora of this area. It deserves a serious attention from researchers in the field of ethno-botany, ethno-medicine and pharmacology for further studies.

Acknowledgement

The authors are grateful to the Faculty of Life and Earth Sciences, Rajshahi University, Rajshahi, Bangladesh for financial support to complete this research work.

Table 1. Pteridophytes of Rajshahi District of Bangladesh with their economic importance.

Sl No	Scientific Name	Family	Common name	Economic importance
1.	*Selaginella vaginata* Spring	Selaginellaceae	Spike moss	A popular plant for terrarium and hanging baskets. They are also used for landscape decoration.
2.	*Salvinia natans* (Linn.). All	Salviniaceae	Floating fern, Floating water moss	Bio-accumulator of many heavy metals, provide shelter to fishes and biomass used as green manure.
3.	*Azolla pinnata* R. Br	Azollaceae	Water velvet.	Used as a diuretic and also has antibacterial properties. Bio-accumulator of many heavy metals, and biomass used as green manure.
4.	*Marsilea minuta* L.	Marsileaceae	Marshy Fern	Fronds are cooked as vegetables. The decoction of the leaves along with ginger is used in cough, spastic condition of leg muscles and bronchitis, used as a sedative in insomnia, also has antibacterial activities (Uddin *et al*., 1998a).
5.	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Climbing Fern.	Used in making fish- catching baskets and decoration items in Mymensingh, Sylhet and Panchagarh districts in Bangladesh. The fronds are used as expectorant; roots are used in external application for rheumatism, scabies, eczema and wounds, also in carbuncles (Ghosh *et al*., 2004; Uddin *et al*., 1998b).
6.	*Pteris vittata* L	Pteridaceae	Chinese brake or ladder brake.	Bio-accumulator of arsenic. It has also shown anti-microbial activities.
7.	*Adiantum philippense* L. subsp. *philippense*	Adiantaceae	Maiden Hair Fern. Walking maidenhair fern or black maidenhair	Used as an indoor ornamental pot plant for its beautiful fronds. Rhizome is used to cure glandular swellings accompanied by fever. Juice of leaves is used in the treatment of dysentery, disease of blood, ulcers, erysipelas and burning sensation. It has also antibacterial properties (Uddin *et al*., 1998).
8.	*Ceratopteris thalictroides* (L.) Brongniart.	Pteridaceae subfamily Parkerioideae	Water sprite, Indian fern, water fern, oriental water fern, and water horn fern.	Fresh fronds are used in vegetable curry. It is ploughed in as a part of the green manure in rice fields in India (de Winter and Amoroso, 2003). The fronds are used as poultice in skin complaints and in Chaina as a tonic and styptic.
9.	*Thelypteris dentata* (Forssk.) E.P.St.John.	Thelypteridaceae	Downy Maiden Fern; Downy shield fern.	Juvenile fronds used as vegetable, however entire plant is used as fodder. It has been found to be an herbal medicine, as it has antibacterial properties from the alcoholic and chloroform extracts.
10.	*Thelypteris parasitica* (L.) Tardieu.	Thelypteridaceae	Not known.	Plant is used as fodder. It is taken as an anti-thelminthic (Burkill, 1995), with antifungal and antibacterial properties (Ma *et al*., 2010;Paul *et al*., 2011; Srivastava, 2009) as well as other medicinal uses (Fang *et al*., 2008; Hunyadi *et al*., 2014). Fronds are used medicinally to treat gout and rheumatism.
11.	*Ampelopteris prolifera* (Retz.) Copel.	Thelypteridaceae	Riverine scrambler; Oewer kloutervaring (Afr.)	Tender fronds are cooked as a vegetable. Plant possesses antibacterial properties. In Panchagarh and Sylhet districts of Bangladesh, it is given to pregnant women for nutrition.
12.	*Dryopteris filix-mas* (L.) Schott.	Dryopteridaceae	Male Fern.	The root stalks are anodyne, antibacterial, anti-inflammatory, antiviral, astringent, febrifuge, vermifuge and vulnerary. The root contains an oleoresin that paralyses tapeworms and other

				internal parasites and has been used as a worm expellant.
13.	*Pyrrosia lanceolata* (L.) Farw.	Polypodiaceae	Fern.	Decoction of young fond is used as medicine in treatment of sore throat.
14.	*Aglaomorpha quercifolia* (L.) Hovenkamp & S. Linds. (*Drynaria quercifolia* (L.) J. Sm.)	Polypodiaceae	Oak leaf fern or oak leaf basket fern	Rhizome is bitter and is used as antibacterial, anti-inflammatory, for treating constipation, diarrhea, ulcers and other inflammations. The decoction of plant is used in typhoid fever and fronds are useful in treating swellings (Dixit & Vohra, 1984; Warrier*et al.*, 1996).
15.	*Equisetum debile* Roxb.	Equisetaceae	Horsetail.	A popular plant for terrarium and hanging baskets and used for landscape decoration. *Equisetum debile* has been experimentally determined as a hyper-accumulator of carcinogenic heavy metal cadmium.
16.	*Selaginella ciliaris (*Retz.*)* Spring.	Selaginellaceae	Ciliated Spike Moss/ fringed spike moss	Used as an ornamental pot plant.
17.	*Marsilea quadrifolia* L.	Marsiliaceae	Four leaf clover; European water clover (USA); *sushni* (India)	Fresh leaves used as vegetable. The decoction of the leaves along with ginger it is used in cough, spastic condition of leg muscles and bronchitis and also as a sedative in insomnia.
18.	*Nephrolepis cordifolia* (L.) C. Presl.	Nephrolepidaceae	Fishbone fern, tuberous sword fern, tuber ladder fern, erect sword fern, narrow sword fern and ladder fern, and herringbone fern.	The plant is used as an indoor ornamental pot plant for its beautiful fronds. Cultivated in nurseries and garden.
19.	*Microlepia speluncae* (L.) Moore.	Dennstaedtiaceae	Limp leaf fern.	Young fronds used as vegetable.
20.	*Diplazium esculentum* (Retz.) Sw.	Athyriaceae	Edible fern	Young leaves are cooked as vegetables by the tribals of Uttar Pradesh (Singh *et al.*, 1989). Decoction prepared from rhizome and young leaves is used for haemoptysis and cough in Philippines (Manickam and Irudayaraj, 1992). Given to pregnant mother for nutrition.

Table 2. Enumeration of Pteridophytes of Rajshahi District of Bangladesh along with their distribution and habitat.

		Habitat	Eastern & N.E. India	Bangladesh	Myanmar	Bhutan	Malaya Peninsula	Australia & New Zeeland	Europe	China	Africa	North America
Sl No	**Scientific Name**											
1.	*Selaginella vaginata* Spring	T	+	+	+	+	+					
2.	*Salvinia natans* (Linn.).All	A	+	+	+	+	+		+	+	+	+
3.	*Azolla pinnata* R. Br	A	+	+	+		+	+	+		+	
4.	*Marsilea minuta* L.	A	+	+	+		+			+		+
5.	*Lygodium flexuosum* (L.) Sw.	T	+	+	+		+	+		+		
6.	*Pteris vittata* L	T	+	+	+		+					
7.	*Adiantum philippense* L. subsp. *philippense*	T	+	+	+		+					
8.	*Ceratopteris thalictroides* (L.) Brongniart.	T	+	+	+	+	+			+		
9.	*Thelypteris dentata* (Forssk.) E.P.St.John.	T	+	+								
10.	*Thelypteris parasitica* (L.) Tardieu.	T	+	+	+	+		+			+	
11.	*Ampelopteris prolifera* (Retz.) Copel.	T	+	+	+	+	+	+		+	+	
12.	*Dryopteris filix-mas* (L.) Schott.	T	+	+	+	+	+	+	+	+	+	+
13.	*Pyrrosia lanceolata* (L.) Farw.	E	+	+	+	+	+	+		+	+	
14.	*Drynaria quercifolia* (L.) J. Sm.	E	+	+	+	+	+	+				
15.	*Equisetum debile* Roxb.	T	+	+	+	+	+			+		
16.	*Selaginella ciliaris (*Retz.*)* Spring.	T	+	+	+			+		+		
17.	*Marsilea quadrifolia* L.	A	+	+	+		+	+	+	+		+
18.	*Nephrolepis cordifolia* (L.) C. Presl.	L	+	+	+		+	+			+	
19.	*Microlepia speluncae* (L.) Moore.	T	+	+	+		+	+				
20.	*Diplazium esculentum* (Retz.) Sw.	T	+	+	+			+		+		

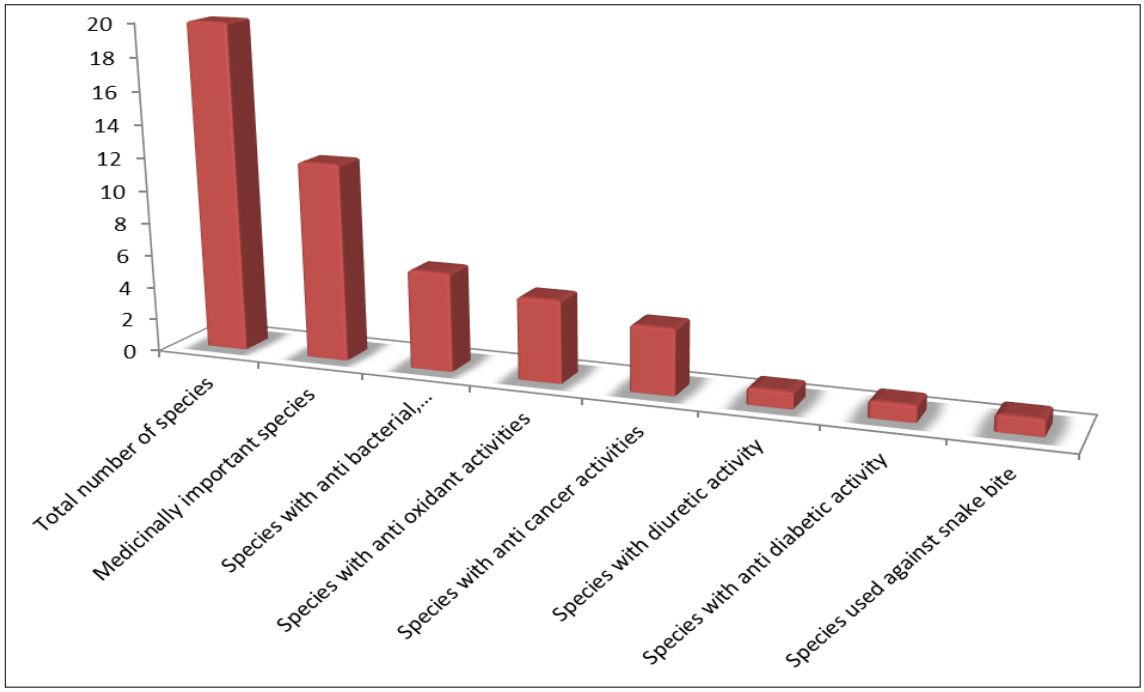

Fig 1: Diagrammatic representation of medicinal potential of peridophytes found in Rajshahi district of Bangladesh

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