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LIMNOLOGY OF LAKE RAINKHYONGKAIN OF BANGLADESH WITH A NEW RECORD OF *MARCHANTIA POLYMORPHA* L. VAR. *AQUATICA* NEES

MD ALMUJADDADE ALFASANE, MD SHARIF ULLAH AND MONIRUZZAMAN KHONDKER*

Department of Botany, University of Dhaka, Dhaka 1000, Bangladesh

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Abstract

In lake Rainkhyongkain, water temperature, pH, conductivity and total dissolved solids (TDS) were recorded 33.5°C, 7.39, 308 µS/cm and 49 mg/l, respectively. The mean values (n = 4) of dissolved oxygen content (DO), alkalinity, soluble reactive phosphorus (SRP), soluble reactive silicate (SRS) and NO_3-N were 7.93 ± 0.78 mg/l, 1.70 ± 0.12 meq/l, 17.25 ± 0.62 µg/l, 10.44 ± 0.72 mg/l and 34.00 ± 4.00 µg/l, respectively. The phytoplankton biomass as chlorophyll *a* (chl *a*) was found very low (4.93 ± 0.51 µg/l) with a phaeopigment concentration of 1.97 ± 0.51 µg/l. A total of 16 phytoplankton taxa were recorded of which *Cyclotella comensis* (V. Keissler) Lemm. was dominant followed by *Protoperidinium conicum* (Gran) Balech, *Coelosphaerium kuetzingianum* Näg., *Euglena* spp. and *Mallomonas paxillata* Bardley. For the first time in Bangladesh *Marchantia polymorpha* L. var. *aquatica* Nees was found to grow in masses in the shallow littoral of the lake. Among the dominant macrophytes of the littoral, *Nymphaea stellata* Willd., *Nymphoides indicum* (L.) O. Kuntze and *Monochoria hastata* (L.) Solms were common.

Introduction

Preliminary limnological information on two of the three natural lakes of Bangladesh, namely Lake Bogakain and Lake Ashura are now available (Khondker *et al*. 2010, Alfasane *et al*. 2010, 2012). The third lake, Lake Rainkhyongkain though investigated phycologically by Islam (1969) lacking limnological information. However, it has been regarded as a treasure of aquatic biodiversity (Husain 1967, Islam 1969). Thus, the present research work was undertaken to study the limnological features of the lake.

Materials and Methods

Geographically, Lake Rainkhyongkain is situated in the Bilaicchari Upazila, district Bandarban, Bangladesh in 22°01′10.74″ N and 92°32′36.68″ E and is bounded in the east by the Mizoram state of India and in part by the Chin State of Myanmar. Other features of the lake have been described in Husain (1967) and Islam (1969). The lake is more than one kilometer long and 200 - 300 m wide. It is situated at an altitude of 359 m above sea level (Roy, http://chakmaraj.com/about-chakma-raj/5articles/38-reingkhyongkine-lake-tour-chittagong-hill-tracts-22-28-dec-2011). The highest depth of the lake is known to be 82.30 m.

Surface water temperature (Traceable water proof digital thermometer, CONTROL Co., USA), pH (Griffin, UK), conductivity (HANNA Instruments HI 9033, 9044, Singapore) of the lake and TDS (HANNA Instruments HI 9033, 9044, Singapore) were measured *in situ* by using respective field meters. Phytoplankton sample was collected at a depth of 30 cm by dipping a plastic container. The sample was then poured in a one liter capacity plastic made screw capped bottle preoccupied with 1 ml Lugol's iodine solution for sedimentation. Four borosilicate BOD bottles (Pyrex, U.K.; 125 ml capacity) were filled in the site and fixed for dissolved oxygen (DO) determination by Winkler's method (Wetzel and Likens 2000). Another screw capped plastic made dark container of five liter capacity was also dipped to same depth and filled with lake water

*Author for correspondence: <mkhondker@yahoo.com>.

of pelagic region. This water sample was carried to the laboratory in a Cool Box and used for determining alkalinity, soluble reactive phosphorus (SRP), soluble reactive silica (SRS), nitrate-nitrogen, chl *a* and phaeopigment concentrations (Mackereth *et al*. 1978, Murphy and Riley 1962, Wetzel and Likens 2000, Müller and Wiedemann 1955, Marker *et al*. 1980). Littoral macrophytes were collected manually and kept in either one liter capacity wide mouthed screw capped plastic made specimen jars and/or in transparent polythene bags.

The qualitative analysis of phytoplankton was carried out with the help of Siddiqui *et al*. (2007a) and Ahmed *et al*. (2008, 2009) whilst, the macrophytes were identified after Khan and Halim (1987), Subramanyam (1962) and Fassett (1957). The liverwort specimen was identified following Siddiqui *et al*. (2007b) and Kürschner and Frey (2011). The phytoplankton population were quantified using a Hawksley microplankton counting chamber with improved Neubauer Rulling (Hawksley Ltd., Lancing, England) under a Nikon compound microscope (Japan) at a magnification of 400×.

Results and Discussion

At the time of sampling, the pelagic water looked slightly turbid but the water in the littoral, particularly at a depth where the sheet of *Marchantia* were submerged looked reddish. It is known that the color of the lake water always takes a course of changes from dark grey, reddish to creamish hue annually. For this reason and out of fear nobody drinks the water of the lake (Roy, 2011 http://chakmaraj.com/about-chakma-raj/5articles/38-reingkhyongkine-lake-tour-chittagong-hill-tracts-22-28-dec-2011). During the present visit the water temperature was recorded 33.5°C, pH 7.39, conductivity 308 µS/cm and TDS 49 mg/l. DO, alkalinity, SRP, SRS and NO_3-N were 7.93 ± 0.78 mg/l, 1.70 ± 0.12 meq/l, 17.25 ± 0.62 µg/l, 10.44 ± 0.72 mg/l and 34.00 ± 4.00 µg/l, respectively. In Lake Rainkhyongkain, conductivity, TDS, alkalinity, silicate and nitrate nitrogen concentration were found relatively higher compared to lake Bogakain (Khondker *et al*. 2010). Both the lakes are situated to an almost similar altitude but the catchment characteristics are rather different. Except one side, Lake Rainkhyongkain has a peaty shore which is absent in Lake Bogakain and due this reason the former lake contains high values of conductivity, TDS, alkalinity and silicate concentration. Because of this peaty nature of the shore of Lake Rainkhyongkain, *Marchantia polymorpha* L. var. *aquatica* Nees colonized. Husain *et al*. (1967) also reported similar nature of Lake Rainkhyongkain.

From the lake, a total of 16 phytoplankton species were recorded of which the most dominant algal Division was Chrysophyta where a total of six taxa were recorded (Table 1). The division Chlorphyta and Euglenophyta were represented by three taxa in each. Cyanophyta was represented by two taxa, whilst Pyrrhophyta and Cryptophyta were represented by one taxon in each (Table 1). In lake Bogakain a total of 40 phytoplankton taxa were reported and was found to be dominated by the members of the Division Chlorophyta. Silicate concentration (10.44 ± 0.72 mg/l) of Lake Rainkhyongkain might be a factor of phytoplankton dominance by chrysophytes. On the other hand, very poor silicate concentration (0.16 - 0.62 mg/l) was reported from Lake Bogakain (Khondker *et al*. 2010). Chl *a* concentration and phaeopigment concentration from the pelagic water were recorded 4.93 ± 0.51 and 1.97 ± 0.51 µg/l which is similar to the surface concentration of Lake Bogakain (Khondker *et al*. 2010).

In Lake Rainkhyongkain, the phytoplankton population was dominated by *Cyclotella comensis* followed by *Protoperidinium conicum*, *Coelosphaerium kuetzingianum*, *Euglena* spp. and *Mallomonas paxillata*. Of these, *Cy. comensis* was found common with lake Bogakain (Khondker *et al*. 2010). Islam (1969) reported only some submerged and attached algae from Lake Rainkhyongkain.

Table 1. Density of phytoplankton of the Lake Rainkhyongkain.

Division	Taxa	Density (± sd) $\times 10^6$/l
Cyanophyta	*Chroococcus dispersus* (V. Keissler) Lemm.	2.90 ± 5.85
	Coelosphaerium kuetzingianum Näg.	6.30 ± 5.32
Chlorophyta	*Crucigenia truncata* G.M. Smith	0.66 ± 2.30
	Scenedesmus quadricauda (Turp.) de Brébisson	0.99 ± 2.87
	Tetraedron trigonum (Nägeli) Hansgirg	0.33 ± 0.81
Euglenophyta	*Euglena* spp.	5.60 ± 9.60
	Lepocinclis salina Fritsch	0.33 ± 1.15
	Trachelomonas raciborskii Wolosz.	0.66 ± 2.00
Chrysophyta	*Cyclotella comensis* Grunow	33.50 ± 44.69
	Cymbella tumida (Breb. Ex Kütz) Van Heurek	00.33 ± 0.81
	Navicula placentula (Her.) Grun.	2.9 ± 2.87
	Nitzschia fruticosa Hust.	0.99 ± 0.82
	Synedra ulna (Nitzsch) Ehr.	0.33 ± 1.15
	Mallomonas paxillata Bardley	5.30 ± 7.58
Pyrrhophyta	*Protoperidinium conicum* (Gran) Balech	9.29 ± 15.52
Cryptophyta	*Cryptomonas reflexa* Skuja	2.60 ± 4.49

Fig. 1. Lake Rainkhyongkain and its littoral. (a). Lake overview; (b). Littoral macrophytes dominated by *Nymphoides indicum*.

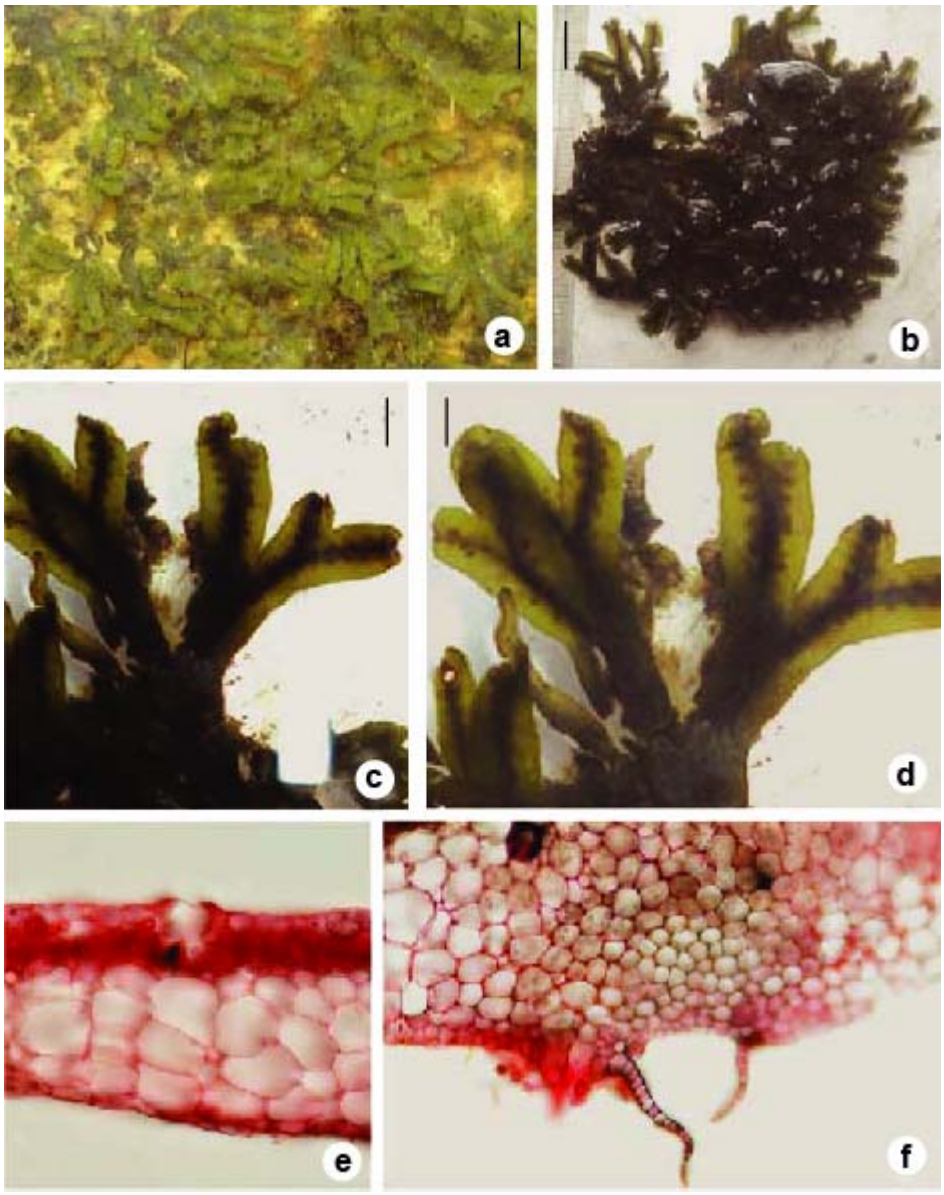

Fig. 2. *Marchantia polymorpha* var. *aquatica.* (a), Thalli under water; (b), Masses of fronds; (c), Ventral surface of the thallus; (d), Dorsal surface of the thallus; (e), T.S. of the thallus showing air pore × 200; (f), T.S of the thallus showing scales × 200 (safranine dyed) Scale = 2.0 cm.

The lake littoral was dominated by *Nymphaea stellata* Willd., *Nymphoides indicum* (L.) O. Kuntze and *Monochoria hastata* (L.) Solms (Fig. 1). The vast peaty shoreline was mostly dominated by *Colocasia* sp. and grasses. Sample of one liverwort species was collected from a depth of ~0.50 m near the shore of the Lake Rainkhyongkain. It was identified as *Marchantia polymorpha* L. var. *aquatica* Nees and hitherto is the first report of its kind in Bangladesh (Fig. 2).

In Bangladesh, so far two species of *Marchantia* L. have been reported from the terrestrial habitats. These are *M. nepalensis* L. and *M. palmatia* Nees (Siddique *et al*. 2007b). Among aquatic Hepaticae, eight hygrophilous species are reported of which *Marchantia aquatica* (subsp. *polymorpha*) was one of them (Hutchinson 1975). Most of these Hepaticae when grow under water remain sexually sterile and show morphological changes from the typical marshy and sub-aerial habitats. Though *M. aquatica* was believed to be distinct from *M. polymorpha* (Hutchinson 1975), presently it is considered as *M. polymorpha* (Kürschner and Frey 2011, Anonymous http://www.uniprot.org/taxonomy/3197). However, Matthews (1993) discussed that for common liverworts, the currently accepted scientific name is *Marchantia polymorpha* L. but having three varieties determined on the basis of ecological and morphological characteristics. These are *M. polymorpha* L. var. *polymorpha*, *M. polymorpha* L. var. *aquatica* Nees (growing submerged with erect or sub-erect thalli). The third one is *M. polymorpha* var. *alpestris* Nees (growing mostly in the alpine regions as dense compact masses). The morphological and ecological description of *M. polymorpha* var. *aquatica* as provided by Matthews (1993) fits well with the present specimen. Therefore, the present specimen has been identified as *Marchantia polymorpha* L. var. *aquatica* Nees.

Class Hepaticopsida, Order Marchantiales, Family Marchantiaceae

Genus Marchantia L.

Marchantia polymorpha L. var. **aquatica** Nees **(Fig. 2)**

(Hutchinson 1975, p. 46, Figs 19G-F; Matthews 1993)

Thallus light green, dichotomously branched, erect or sub-erect, 2.0 - 2.5 cm long, 0.5 - 0.8 cm broad differentiated into upper photosynthetic and lower storage region, prostrate, margin lobulate, ventral multicellular scales present, hyaline, mid rib dark, prominent, air pore and branched photosynthetic filaments are present in the upper photosynthetic region.

Notes: Since the thallus masses grew underwater, it was sexually sterile. From the genus *Marchantia*, *M. polymorpha* var. *aquatica* is the only taxon which grows under water and therefore, by considering the ecological, morphological and anatomical features the specimen has been identified.

Regarding the aquatic flora of the Lake Rainkhyongkain, Islam (1969) is the only known source. In his contribution, *Chara corallina* var. *corallina* (A. Br.) Wood was reported as submerged macro-algae while *Cladophora lehmanniana*?, *Lyngbya bergei* Smith, *L. majuscula* Harvey *ex* Gomont, *L. sordea* (Ganard) Gomont and *Scytonema tolypothrichoides* Kutz. were reported as attached form. In the present investigation occurrence of some larger macrophytes namely, *N. stellata*, *Nymphoides indicum* and *M. hastata* has been confirmed. Besides, floristic composition of pelagic phytoplankton has also been revealed. Husain (1967) characterized the lake as peaty and acidic but Islam (1969) by observing the indicator species, opined that it is alkaline and eutrophic drainage type. But none of them had any data on chemical water quality. In the present investigation, few water quality data has been furnished based on the collection of a single water sample. The pH recorded is little above neutrality (7.31) which does not support a peaty nature of water but the presence of submerged mats of *Marchantia polymorpha* var. *aquatica*, changing water color, relatively high conductivity and TDS and low SRP and chl *a* concentration supports a peaty nature of water. *M. polymorpha* var. *aquatica* colonizes in peaty water (Matthews 1993). Islam (1969) mentioned that at least one part of the shore of the lake is steep and devoid of littoral vegetation. In the present investigation a vast majority of the shoreline was seen to be covered by *Pteris* sp. and *Colocasia* sp. accompanied by some grasses. Lake Rainkhyongkain is a drainage lake (Islam 1969, Roy, 2011 http://chakmaraj.com/about-chakma-

raj/5articles/38-reingkhyongkine-lake-tour-chittagong-hill-tracts-22-28-dec-2011) but whether it is passing eutrophic or dystrophic stage is difficult to comment. However, the occurrence of *Marchantia polymorpha* var. *aquatica* population in the littoral, low concentrations of chl *a* and SRP and poor phytoplankton density suggests a peaty low productive nature of the lake.

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