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A NOTE ON THE FRESHWATER ALGAE OF GUNUNG STONG, KELANTAN, MALAYSIA

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Abstrak: Satu kajian tentang alga telah diadakan dalam satu ekspedisi saintifik yang dijalankan di kawasan Gunung Stong, Jeli, Kelantan pada 23–29 Mei 2003. Sepanjang tempoh kajian, sebanyak 25 spesies alga telah direkodkan daripada pelbagai tempat pada trek yang berlainan. Keputusan menunjukkan kumpulan alga yang paling banyak terdiri daripada kelas Bacillariophyceae (16 spesies) diikuti oleh Chlorophyceae (4 spesies), Cyanophyceae (3 spesies) dan Rhodophyceae (1 spesies). Keputusan kajian ini akan memberi satu gambaran tentang keunikan ekologi kawasan kajian, kerana kajian terperinci belum pernah dijalankan di sini lagi. Hasil kajian juga mungkin berharga dalam mengemukakan cadangan kawasan ini sebagai satu kawasan simpan.

Abstract: An algal study was conducted during a scientific expedition in Gunung Stong, Jeli, Kelantan from 23 to 29 May 2003. From the study conducted, a total of 25 species were recorded from various sampling sites at different tracks. The most represented class was the Bacillariophyceae (16 species) followed by the Chlorophyceae (4 species), Cyanophyceaea (3 species) and Rhodophyceae (1 species). Results of this work will enable us to assess the ecological uniqueness of this location, which has not been studied before. The findings could be a valuable tool in assessing conservation requirements of the area.

INTRODUCTION

Freshwater algae are well-represented in Malaysia by all nine major classes; Chlorophyceae, Rhodophyceae, Charophyceae, Xanthophyceae, Euglenophyceae, Bacillariophyceae, Cryptophyceae and Dinophyceae (Anton 1991). Morphologically, algae are cellular plants growing as single cell or aggregation of cells and even forming complex parenchymatous thalli (Round 1965). They are the major and primary organic producers occurring in the form of microscopic phytoplankton and living free-floating or attached to various substrates. Like other plants, they use the energy of sunlight to convert carbon dioxide and water into sugar and oxygen. Thus, besides forming the basic food source for the aquatic food chains, they also form the oxygen necessary for the metabolism of the consumer organisms (Round 1965).

First record of a study of the freshwater algae in Malaysia was the taxonomic identification of diatom from the Federated Malay States (and Siam) (Patrick 1936). The diatom were obtained from tadpole intestines collected mainly from Perak and Kedah. In this early study, 185 forms were identified out of which 65 were only recorded from Perak (Anton 1991). Subsequent studies included work on desmids (Prowse 1957), Euglenophyta (Prowse 1958) and the dinoflagellate of the Chrysophyta (Prowse 1960). These are among the earliest algological studies that were recorded in Malaysia.

Apart from taxonomic studies of individual species or group, very few studies have been carried out to determine the distribution and the ecological tolerance of algae in various freshwater bodies. Until recently, studies related to water quality have mostly been orientated towards physical and chemical parameters while biological aspects have been given little attention (Khan 1990).

One of the earlier algal studies conducted in relation to water pollution was carried out by Ho (1976) who studied the periphyton production in human disturbed Renggam Stream, Selangor. Khan (1985, 1990, 1991) studied the periphyton community, especially diatom, and its relation to water quality in Sungai Linggi basin. Anton *et al.* (1998) found that the primary productivity of the Maliau River systems is contributed mainly by the periphytic algae on stony substrates. Wan Maznah and Mansor (2002) quantify the relationship between the algal distribution and composition with water quality in Sungai Pinang basin, Pulau Pinang using the structure and species composition of periphytic algae colonized on artificial substrates (glass slides).

So far, there are no record of any algal study that has been conducted in Gunung Stong. It is considered that work on algae at this particular area has not been done widely, and details on the species composition and distribution are still lacking. Thus, the main objective of this work was to survey the microalgal flora inhabiting the freshwater habitat of Gunung Stong. Results of this work will enable us to assess the ecological uniqueness of this location, which has not been studied widely. The findings could be a valuable tool in assessing conservation requirements of the area.

MATERIALS AND METHODS

An algae study was conducted during a scientific expedition in Gunung Stong, Jeli, Kelantan which was held from 23 to 29 May 2003. Gunung Stong is located in the Rejmen Kuala Balah, West Kelantan. The main road connecting to this area is the Dabong-Jeli Highway. Gunung Stong is situated 103 km from Tanah Merah, 48 km from Jeli and 105 km from Kota Bharu. The expedition was focused totally on the 21,950 ha land at the heart of Gunung Stong. This study site covers compartment 17, 18, 19, 20 and 40 of the area. The study area was divided into four main tracks (Stong 1, 2, 3 and 4). However, during the expedition, sampling was done only on track Stong 1, 2 and 4, which covers nine sampling stations. This is because there were only two main streams flowing along the three chosen tracks. No sampling was done on track Stong 3 as this track consists of low land area without any water source. Detailed descriptions on all the sampling sites are given in the table below.

Site Description

Track	Description
Stong 1	Situated along the riverside area. The track is divided into three main stations; lower, middle and upper part of the up-hill track. Station 1 covers the upper part of the waterfall and stone area. Thus, the water velocity here is high. The area was fully exposed to maximum sunlight due to low vegetation. Station 2 consists of a man-made pond where the water here is stagnant. The area was fully canopied and this contributed to its high turbidity from the debris of leaves and litter. Station 3 is near the camp site area. There are boulders and various sizes of pebbles. The water is clear and the velocity is high. The area is partially canopied and it is the lowest part of the waterfall.
Stong 2	This track covers the same river as track Stong 1 but it is on the other side of the river that leads to different sampling stations. There are three different stations starting from the upper part of the river. Station 1 covers the waterfall and stone area with fast water flow. This area is similar to Station 1 on track Stong 1. The area is directly exposed to sunlight. Station 2 covers the upper part of the waterfall and stone area. It is also directly exposed to sunlight with low vegetation. The water at the sampling area was fast flowing. The last station covers the pool-like area after the waterfall. The water flow was slower compared to the other two stations. The area was partially canopied with only a few portion of the area is exposed to direct sunlight. The water is clear with low turbidity.
Stong 4	This track is the furthest track of all the three tracks. It is also divided into three different stations; station 1, 2 and 3. Station 1 covers the river and stone area. The water was fast flowing and the area was highly exposed to direct sunlight. Station 2 covers the middle part of the stream. Debris of leaves and litter add to the water turbidity. The area was fully canopied. The water at the area was fast flowing. Station 3 was at the Rafflesia area. The water turbidity was high due to debris from leaves. The area was fully canopied and the water flow was low.

Algal Collection

The algal samples were collected from a diverse range of habitats. These samples were taken from the river, stone surfaces and sediments in each station. Planktonic and flagellate algae were collected using plankton net (63 μm mesh size). Vertical hauls of the net were used to concentrate the plankton. The samples collected were then put into 500 ml polyethylene bottles and preserved with Lugol's iodine.

Epilithic algae (algae living on rocks) was sampled quantitatively by placing 3 × 3 cm^2 quadrates on stones, which were submerged in the river. The area within the quadrates was brushed and the algae on it will be rinsed into a bottle containing sufficient filtered river water. As for the epipelic algae (algae living on sediments), samples of sediments deposited in the river were taken, and filtered river water was used to rinse off the algae attached on the sediments. The water was then collected into bottles for further analysis.

All samples were examined using Phaco and Camera Olympus Microscope BH2 using 10x eye piece, and 20x, 40x and 100x field objectives lenses depending on the suitability and size of the specimen. Subsamples for microscopic examination of diatom were prepared by boiling in concentrated nitric acid and potassium permanganate (St. Clair and Rushforth 1976; Wan Maznah and Mansor 1999). The algae were identified as far as possible down to the species level with the help of taxonomic keys, drawings and description given in Chapman and Chapman (1973), Patrick and Reimer (1966), Prescott (1978), Belcher and Swale (1979), Ho (1979), Lee (1980), Pentecost (1984), Dexiang *et al.* (1985), Shamsudin (1991), Bukhtiyarova and Round (1996) and Salleh (1996).

RESULTS

A total of 25 species were recorded and listed in the Table 1. The most represented class was the Bacillariophyceae (16 species) followed by the Chlorophyceae (4 species), Cyanophyceae (3 species) and Rhodophyceae (1 species). Bacillariophyceae are unicellular and colonial algae usually with numerous discoid plastids; pectinaceous cell wall, impregnated with silica, in two distinct halves (valves). All the species present are never flagellate. Chlorophyceae consists of green pigmented unicellular, colonial, filamentous, siphonaceous and thalliod algae, and contains one or more plastids with pyrenoids. Cyanophyceae are prokaryotic algae lacking typical membrane-bound nuclei and plastids (Reynolds 1984).

Table 1: Species recorded from the study area.

	Species detected/collected
1	**Bacillariopyceae (diatoms)**
	Achnanthes oblongella
	A. exigua
	Amphora bitumida
	Cocconeis sp.
	Cymbella gracilia
	C. naviculiformis
	Eunotia sp.
	Fragilaria pinnata
	Frustulia sp.
	Gomphonema sp.
	Navicula sp.
	Navicula radiosa
	Navicula rhynchocephala
	Pinnularia microstauron
	Surirella sp.
	Synedra ulna

(continue on next page)

Table 1 *(continued)*

	Species detected/collected
2	**Cyanophyceae (Blue-green algae)** *Anabaena* sp. *Bangia* sp. *Lyngbya* sp. *Oscillatoria agardhii* *Scytonema* sp.
3	**Chlorophyceae (Green algae)** *Ankistrodesmus* sp. *Mougeotia* sp. *Spirogyra* sp. *Zygnema* sp.

Taxonomical Notes on Some of the Common Species

Achnanthes exigua

Plate 1: *Achnanthes exigua.*

Frustules of this species is narrowly elliptic with smooth undulated margins in valve view. *A. exigua* is more rectangular or naviculate in girdle view. The valve of this species is rimless, just within the margin as seen in the valve view. This species also showed the absence of septa.

Distribution: As the species is known to be a benthic diatom, their occurrence is noted regularly in the sediment samples collected from each station.

Amphora bitumida

Plate 2: *Amphora bitumida.*

The frustules of *Amphora bitumida* are crescent-shaped in valve view but broadly elliptic with truncate poles in girdle view. The cell looks like two *Cymbellas* stuck together as the two valves are strongly arched and attached by their ventral margins. The raphe system of both valves appears on the same side. The reverse side of the frustules has no raphe but consists only remainder of the valve ornamentation.

Distribution: A. bitumida is a soil algae and often found on base rich loams. Being a soil algae, this species was commonly noted on the river sediments of the study area.

Fragilaria pinnata

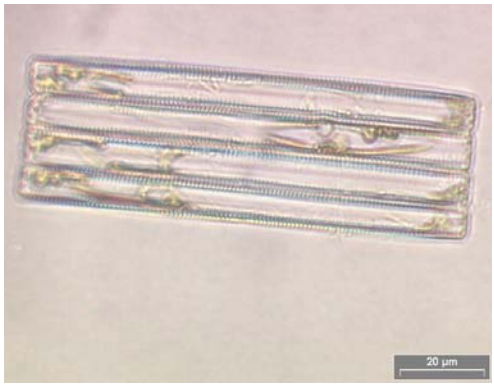

Plate 3: *Fragilaria pinnata.*

Frustules of this species are joined into ribbons by the valve faces. The valves of *F. pinnata* are fusiform. In unclean material, the valve of this species is sometimes centrally gibbous or with capitate ends in girdle view. *F. pinnata* displays fine and usually parallel striae.

Distribution: Species detected mostly from the sample scrapped from the stone and some were also detected in samples washed from the sediment. Although their presence were noted in various samples collected, this particular species does not show great abundance in the study area.

Navicula rhynchocephala

Plate 4: *Navicula rhynchocephala.*

There is a raphe in both valves. There maybe internal plate but not complete septa. The striae or rows of puncta are convergent toward the central.

Distribution: Navicula is the most abundance genus found in all the samples collected. *Navicula rhynchocephala* is the most abundance species detected through the microscopy observation. This species showed high occurrence in every samples collected at each station. Its occurrence was noted not only from the plankton samples but some are also detected in the epipelic and epilithic samples collected. The species occur in all kinds of aquatic habitats. It is the dominant species found at the study area.

Scytonema sp.

Plate 5: *Scytonema* sp.

This genus exhibits false branching, the branches arising either singly or in pairs where there has been a break in the trichome of the main axis. Sheaths are either close and thin or wide and lamellate; often yellow or brown.

Distribution: Scytonema sp. usually forms wooly mats and sometimes were also found free-floating or creeping along the substrate. Most of the Scytonema species are aerial or subaerial algae. Therefore, this algae was very common in samples scraped from wet rocks or soil.

Synedra ulna

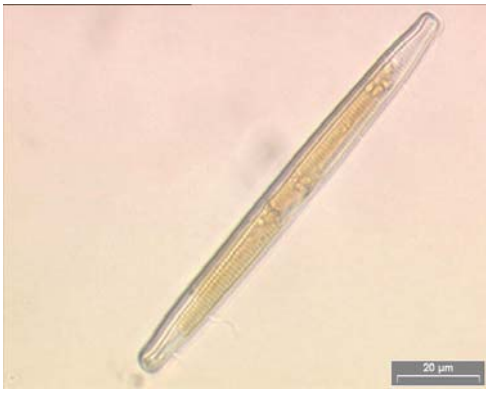

Plate 6: *Synedra ulna.*

Cells in irregular bundles or in two joined side-by-side, but not forming ribbons. Valves needle-shaped or fusiform are often capitate. Only two of the several common forms illustrated by *Synedra ulna* may be distinguished by its rostrate or wedge-shaped apices and the quadrate, unswollen central area.

Distribution: Synedra is an exclusive freshwater genus. This species were free-living and fond to be epiphytic within this benthic river communities.

Oscillatoria sp.

Plate 7: *Oscillatoria* sp.

Oscillatoria occurs both in water and on moist subareal substrates such as soil or dripping rocks. The trichomes are straight or bent, often of great length and either isolated or in dense bundles. Sheaths are absent and gliding motility in common in the benthic forms. Trichomes are olive, blue-green or brownish. Gas vacuoles are frequent in the planktonic form and the cells are disk-like.

Distribution: Oscillatoria sp. was detected to occur in a diverse range of conditions, in damp soil or on dripping rocks and within the river body. In water, they formed part of the benthic community, although there are some species which are planktonic. The occurrence of this species support the growth of some of the benthic diatom species that were found attached to their filaments.

DISCUSSION

The lotic environment of streams and rivers provide habitats which changes in depth, rate of flow, geology of the land surface and the stream bed along their length. Thus, multitude of habitats are available and most are colonized by algae. Streams may arise from springs or standing waters. In streams arising from springs, there is never a floating community of actively growing algae. However, in streams and rivers outflowing from standing waters, this phytoplanktonic community does exist (Round 1965). In the study conducted, the samples collected showed more of the epilithic and epipelic community rather than the phytoplanktonic community. Thus, by looking at the algal community structure, we can conclude that the river of Gunung Stong may have arise from spring instead of standing waters which compliment the findings by Round (1965).

The other explanation for the development of such community in the river may also be related to the rate of flow in the river sampled at each station. From the observation conducted, the water in the entire river (Sungai Stong and Sungai Semalian) showed a similar fast water movement. Thus, it is rather obvious that the phyhtoplanktonic community cannot be well detected in the sampling area. Indeed only in slow flowing rivers can a true floating phytoplankton community be developed. Flowing water would appear to afford highly characteristic habitats in which only species with high adaptability would be able to survive. Thus, only in rivers under conditions of reduced flow will a true phytoplanktonic community able to maintain itself by active reproduction of cells.

The algae of rock surfaces are adapted to swiftly flowing water by being either encrusting or basally attached, but flexible and streaming in the current. Water flow may appear fast, however, there is a surface effect which greatly reduces the rate of flow in the region immediately above the rock surface. In this particular region, there is possibility to find attached unicellular, sporelings of filamentous forms or encrusting parenchymatous algae. Another interesting fact about this particular habitat is that the rapid movement of the water is expected to contribute to a constant high concentration of gases and nutrient in the water, which in this case would play an important role in supporting an abundant growth of algae. Four groups of algae frequently found in the epilithic flora are the Cyanophyceae, Chlorophyceae, Rhodophyceae and Bacillariophyceae (Round 1965).

Species that were detected in the observation done on the samples collected were mostly encrusting Bacillariophyceae, eg. *Achnanthes* sp., *Cocconeis* sp., *Cymbella* sp., *Flagilaria* sp., *Gomphonema* sp., *Navicula* sp. and *Synedra* sp. According to Round (1965), the *Achnanthes, Gomphonema* and, *Synedra* group are usually associated with acidic and, nutrient poor waters in rapidly flowing streams. This fact was proven true as most of the species detected in the samples collected were mostly from the group mentioned above and the place where the samples were collected fit the profile; fast flowing water. The Chlorophyceae detected from the samples were *Spirogyra* sp., *Zygnema* sp., *Mougeotia* sp. and *Ankistrodesmus* sp. There was a rich development of filamentous algal associations of species of *Spirogyra, Zygnema* and *Mougeotia*

in the samples collected from all the stations. All the species detected has the ability to thrive in fast flowing rivers.

Very little investigation has been done on this particular community in running waters. Epiphytic algae are found attached to larger algae; Bryophytes and Angiosperms. A great variety of algae may attach themselves; eg. *Oscillatoria* sp. and *Lyngbya* sp., *Synedra* sp., *Eunotia* sp., *Cymbella* sp., and *Gomphonema* sp. In the fast running water environments, these epiphytic algae contaminates the water and may sometimes appear as planktonic, epiphytic or even epipelic algae. Thus, it is important to note the existence of this community for identification purposes (Round 1965).

Along the length of rivers and streams, sediments are deposited varying from coarse sand to fine silts and rich organic deposits. The epipelic algae found was mainly dominated by diatoms, besides the presence of other blue green algae, coccoid green algae and Euglenoids. From the study conducted, the main component of algae collected from the sediment samples were species of *Fragilaria, Frustulia, Navicula, Amphora, Cymbella* and *Surirella*. All the species formed a dark brown coating on the sediment and were being removed after rinsing the sediment collected with filtered river water. The majority of the species collected were motile while there were a few species attached by mucilage to the sand particles. Some *Fragilaria* sp. lie free on the sediments in the form of chains and were non-motile. The sediment collected was also rich in contaminants from the epiphytic community (e.g. *Fragilaria, Synedra, Achnanthes, Cocconeis*). All these algae can be found together with the other epipelic algae while doing the observation under the microscope.

Bacillariophyceae was the most common group found in particularly every samples observed from all the stations. As reported by Pentecost (1984), diatoms are known to be the successful class inhabiting all kinds of habitats. Mann (1999) added that diatoms are the most rich species group of algae with tens of thousands of species. There are currently over 260 genera of living diatoms with over 100,000 species (Round *et al.* 1990).

River health can be assessed using diatoms (e.g. Prygiel & Coste 1999, in France; Harding & Kelly 1999, in UK; Stevenson & Pan 1999, in USA). Diatom assemblages in river and stream can be analysed by rigorous statistical techniques to establish their relationship to the environmental factors. The relative abundance of diatom species have been used as the most valuable characteristics of diatom assemblages for bioassessment of river health. Thus, accurate identification of taxa with information on geographical distribution is essential for the use of these diatoms as reliable indicators.

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