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Original research article

Epixylic Algae in Periphyton Mats from Surfaces of Submerged Wood and Bamboo Poles of Fish Pens Found in Laguna de Bay (Philippines)

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ABSTRACT

Epixylic algae play an important role in nutrient cycling, food web interactions, and primary productivity in aquatic ecosystems. However, limited studies are available on the diversity of epixylic algae in periphyton mats occurring on the surface of submerged wooden posts and bamboo poles of fish pens in temperate lakes. A preliminary survey on the species composition of epixylic algae occurring on submerged wooden posts and bamboo poles found in Laguna de Bay (Philippines) was performed. In total, 18 algal taxa were taxonomically described: 5 Bacillariophyceae, 4 Cyanophyceae, 4 Chlorophyceae, 2 Euglenophyceae, and one each of Mediophyceae, Zygnematophyceae, and Coscinodiscophyceae. Of these taxa, the occurrence of a rare desmid, *Pleurotaenium trabecula* Nägeli, is reported for the first time in the Philippines. The diversity of epixylic algae in periphyton mats is higher on submerged bamboo poles compared to wooden posts, with 4 species (*Pleurotaenium trabecula, Trachelomonas armata, Cryptoglena skujae,* and *Westella botryoides*) not observed in wooden post mats. Generally, conditions such as a nutrient-rich (high phosphate and nitrate concentration) environment, optimum temperature, and high light intensity were found to be favorable for the existence of algal periphyton in these substrata. This study provides a quick assessment and identifies some of the dominant epixylic algal taxa in periphyton mats and creates baseline information for further molecular taxonomic and ecological studies.

Keywords: Epixylic algae; Diversity; Lake; Periphyton mats; Taxonomy; Water quality

1. Introduction

Submerged wood surface is considered an ideal habitat for microalgae and cyanobacteria (epixylic algae) by virtue of providing several attachment sites associated with rough and smooth

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microareas, that are often exposed to hydrodynamisms [1-3]. This habitat not only serves as a substrate for invertebrates (for resting, pupating, and emergence of different insects) and periphyton, but also serves as a direct source of food for other heterotrophic aquatic organisms [4]. Epixylic algae plays an important role in nutrient cycling, food web interactions, and primary productivity in aquatic ecosystems, making them an ideal organism for water quality monitoring. These organisms are considered sessile and thus cannot avoid pollutants by migration; thus, species composition of periphytic algae on wood surfaces may shed light on the past environmental conditions of the particular aquatic ecosystem from which they came. However, the diversity of epixylic algae found living on submerged surfaces of wood in the littoral zone of freshwater ecosystems have received little attention. To date, few studies have considered potential interaction between wood and epixylic algae in aquatic ecosystems [2-3, 5]. The majority of the studies on the composition and community structure of algal periphyton have concentrated on rocks [2, 6] or aquatic plants, such as submerged aquatic macrophytes [7-8, 10-12].

Studies on primary ecological productivity in bodies of water (such as lakes and oceans) focus more on analyzing the community structure of phytoplankton and pay little attention to the likely contributions of littoral zone algal periphyton. Despite the small surface area occupied by this group of algae in the littoral zone, productivity rates of algal periphyton in an aquatic environment can be greater than those observed from phytoplankton [13-14]. The existence of submerged wood surfaces as periphyton substrate has a strong effect on the overall productivity and features of the aquatic ecosystem. A recent study observed a positive correlation between the abundance of algal periphyton on such substrates, and fertilization of a lake, implying direct competition for nutrients between phytoplankton and algae [15]. In addition, earlier studies on the correlation between habitat and productive capacity of algal periphyton and macroinvertebrates found in three Ontario lakes reported a greater total productive capacity on the wood surfaces than on the lakes' sediment [16]. Furthermore, wood surfaces that are extremely decayed hold greater algal periphyton biomass as well as invertebrate diversity when compared to fresh wood substrate. These findings highlight the importance of epixylic algae in the overall productivity of lakes, contributing to the growing understanding of the ecological characteristics and biological interactions in an aquatic ecosystem.

In the Philippines, the taxonomy and diversity of epixylic algae in running waters and shallow lakes remains poorly understood. Previously, the taxonomy and abundance of algal periphyton associated to rocks and aquatic macrophytes in Laguna de Bay were studied [7, 9, 10-11, 12, 36], but not much is documented about the taxonomic composition of epixylic algae on surfaces of submerged wood and bamboo poles present in the littoral zone of Laguna de bay. The goal of this investigation is to give an overview of the habitat characteristics and species composition of algal periphyton found on submerged wood and bamboo poles from selected sites along Laguna de Bay.

2. Materials and Methods

2.1 Sampling of epixylic algae

A single preliminary collection of periphytic samples from fish pens found in Laguna de Bay was made on 15 April 2019. Eight periphytic samples (four samples from each site) were collected from either submerged wooden posts or bamboo poles from two sampling sites: Calamba (Lat. 14° 12' 26.7696" N; Long. 121° 11' 30.8364' E) and Los Baños (Lat. 14° 11' 33.522" N; Long. 121° 13' 57.1656' E), situated in the littoral zone of the South Bay area of Laguna de Bay. Sampling was done on four fish pens at each site, two cages made of wooden posts and two of bamboo poles. The distance between each wooden post or bamboo pole in the fish pens was approximately 10.0-15.0 m. Firmly attached associated epixylic algae from the wooden posts and bamboo poles were scraped with a fine brush and/or scalpel approximately 10 cm below the water level. An area of 25 cm^2 was scraped and placed in a sterile conical specimen tube (Tarson) of 25 X 50 mm size and further analyzed in the laboratory *in vivo*. Microscopic observation was done using a binocular research microscope (Olympus CX31) provided with an Infinity X digital camera [17].

2.2 Morphotaxonomic enumeration and identification

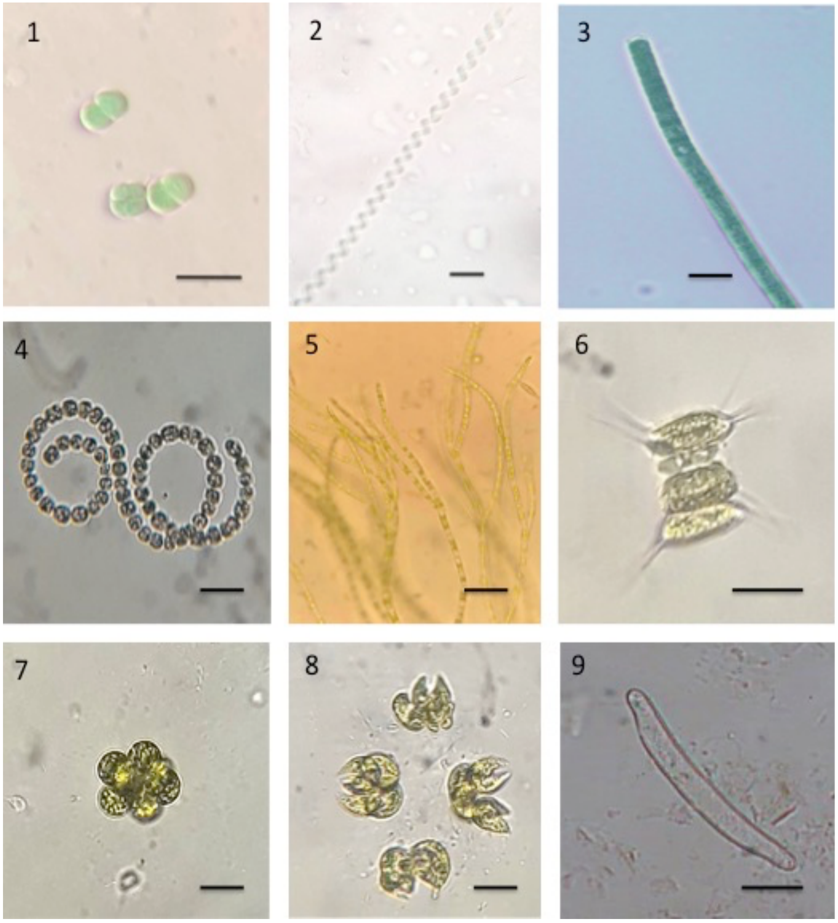
Identification and classification based on morphotaxonomic characteristics such as shape and size of cells (both vegetative and specialized cells such as akinetes and heterocytes), characteristics of the filaments, constrictions at the crosswall, width and length of intercalary cells; appearance and color of the sheath; characteristics and features of filaments and trichomes; and finally the presence or absence of specialized cells were noted for each epixylic algal taxa [17-18]. The taxonomic classification systems from different standard algal monographs [19-24] were used. Taxonomic identification down to the species level was done using all accessible information.

2.3 Determination of water quality parameters

Water quality parameters were taken at 10:00-13:00 h on each sampling day. Parameters such as water temperature, pH, and dissolved oxygen were measured using Xplorer GLX (PASCO). The instrument probe was immersed at least two inches below the water surface. All measured values were expressed as mg/L for dissolved oxygen and degrees Celsius for temperature. Additionally, water samples were tested for orthophosphate and nitrate-nitrogen using Phospho Ver amino acid reagent powder pillows and NitraVer 5 nitrate reagent powder pillows, respectively. The treated water samples were analyzed using a Hach DR/2010 portable spectrophotometer [27].

3. Results and Discussion

Wooden posts, bamboo poles, soft organic sediments, and rocks are the dominant benthic substrata present in the selected sampling areas around Laguna de Bay. The wooden posts and bamboo poles of fish pens found in the lake peripheries are present in the middle of the edge of the lake and at 1.0-3.0 m below water. Assemblages of epixylic algae on these substrates formed mucilaginous matrices (5-10 mm thick) consisting of diatoms (centric and pennate types), single-celled photosynthetic euglenophytes, colonial chlorophytes, as well as colonial and filamentous type cyanobacteria. A total of 18 microalgal species were taxonomically identified from the samples scraped from wooden posts and bamboo poles, of which 5 species (5 genera) are classified as Bacillariophyceae, 4 species (4 genera) belong to Chlorophyceae, 4 species (4 genera) to Cyanophyceae, 2 species (2 genera) to Euglenophyceae 2 species (2 genera) to Euglenophyceae, and 1 species (1 genera) each for Mediophyceae, Zygnematophyceae, and Coscinodiscophyceae. The predominant group of algae was Bacillariophyceae (27.78%), followed by Chlorophyceae (22.22%) and Cyanophyceae (22.22%), Euglenophyceae (11.11%), Mediophyceae (5.56%), Zygnematophyceae (5.56%), and finally Coscinodiscophyceae (5.56%). Morphological characterization of each algal isolates together with the current taxonomic names based on Algaebase [26] is presented in the study.



Figs. 1-9. Plate I. Photomicrographs of (1) *Chroococcus minutus* (Kützing) Nägeli, (2) *Spirulina major* Kützing ex Gomont, (3) *Oscillatoria proboscidea* Gomont, (4) *Anabaenopsis arnoldii* Aptekar, (5) *Stigeoclonium tenue* (C. Agardh) Kützing, (6) *Scenedesmus quadricauda* (Turpin) Brébisson. (7) *Westella botryoides* (West) De Wildeman, (8) *Kirchneriella lunaris* (Kirchner) Möbius, (9) *Eunotia pectinalis* (Kützing) Rabenhorst. All scale bars = 10 µm.

PHYLUM CYANOBACTERIA
Class: Cyanophyceae
Order: Chroococcales
Family: Chroococcaceae

Chroococcus minutus **(Kützing) Nägeli Pl. I, Fig. 1**

Colony usually spherical or sub-spherical, of 2-4 cells, occurring in solitary or in groups, 4.5- 10.5 µm in diameter, but commonly 5.5-8.5 µm in diameter; enclosed by a colorless gelatinous sheath, 0.5-1.0 µm thick; cells blue- green in color, spherical sometimes obovoid or ovoid, homogenous protoplasm, 2.5 - 6.5 µm diameter.

Class: Cyanophyceae
Order: Spirulinales
Family: Spirulinaceae

Spirulina major **Kützing ex Gomont Pl. I, Fig. 2**

Trichomes, solitary, blue-green, 1.0-3.0 µm wide, regularly twisted trichome, ends not attenuated, regularly spiral or coiled, distance between coils 0.5-1.0 µm. Vegetative cells 1.0-4.0 µm in length and bright blue- green in color, protoplasm is homogenous; terminal cells rounded.

Class: Cyanophyceae
Order: Oscillatoriales
Family: Oscillatoriaceae
***Oscillatoria proboscidea* Gomont Pl. I, Fig. 3**

Trichomes (24.0-42.0 µm broad) solitary, straight and crosswalls are constricted. Filaments are straight, attenuated and without calyptra; blue-green in color, 8.00-11.0 µm in length and 2.0-3.0 µm in width, rough (granulated) protoplasm; rounded apical cells.

Class Cyanophyceae
Order: Nostocales
Family: Aphanizomenonaceae
***Anabaenopsis arnoldii* Aptekar Pl. I, Fig. 4**

Trichomes circular, solitary or clustered in small colonies (up to 200 µm in diameter), irregular screw-like coils, in 1.0-9.0 coils; coils 28.0 - 49.0 µm wide, 6.0-28.0 µm high, crosswalls are constricted with colorless and diffluent mucilaginous envelopes. Cells (5.0-10.0 µm in length and 3.0-4.5 µm in width) spherical or widely barrel-shaped, grey-blue to yellow-green, usually with aerotopes, heterocytes spherical, rarely widely oval, 4.0-9.0 x 4.5-8.5 µm. Akinetes (15.0 x 8.0 µm) are usually solitary or sometimes in pairs, elliptical.

PHYLUM: CHLOROPHYTA
Class: Chlorophyceae
Order: Chaetophorales
Family: Chaetophoraceae
***Stigeoclonium tenue* (C. Agardh) Kützing Pl. I, Fig. 5**

Filamentous elongate, slender thallus, branched by alternating origin, cells are cylindrical to quadrate with slight constriction at the crosswalls, 7.5-8.5 µm in diameter, end cell not sharply tapering off, blunt to round end cells, chloroplast is at the center of the cell round to flat disk in shape.

Class: Chlorophyceae
Order: Sphaeropleales
Family: Scenedesmaceae
***Scenedesmus quadricauda* (Turpin) Brébisson Pl. I, Fig. 6**

Usually occurring in a group of 2, 4, or 6 cells attached to each other linearly forming a colony; cells spherical or oblong in shape, 2.0-5.0 µm in length and 6.0-8.0 µm in width; cells occur in parallel; inner cells along the linear colony are without spines while the terminal cells are usually with two straight or curved spiny projections.

Class: Chlorophyceae
Order: Sphaeropleales
Family: Scenedesmaceae
***Westella botryoides* (West) De Wildeman Pl. I, Fig. 7**

Colonies occurring usually in 4-6 celled coenobia (9.0-14.0 µm in diameter). Cells are smooth and spherical (4.0-9.0 µm in diameter) creating irregular colonies (60.0-100.0 µm in diameter). Cells have parietal chloroplasts with a single pyrenoid.

Class: Chlorophyceae
Order: Sphaeropleales
Family: Selenastraceae
***Kirchneriella lunaris* (Kirchner) Möbius Pl. I, Fig. 8**

Colonies are spherical to ovoid, consisting of 4-64 crescent-shaped, curved, cylindrical cells. The chloroplast is parietal with 1-4 pyrenoids. Cells uninucleated, cylindrical, lunate, 3.0-3.5 x 1.0-7.0 µm, with smooth cell walls.

PHYLUM: BACILLARIOPHYTA
Class: Bacillariophyceae
Order: Eunotiales
Family: Eunotiaceae
***Eunotia pectinalis* (Kützing) Rabenhorst Pl. I, Fig. 9**

Valves are dorsiventral and are symmetrical to the transapical axis. Valve length is 24.0-45.0 µm, width of 7.0-9.0 µm. Striae are 3.0-9.0 in 10 µm. The ventral margin of the cell is concave while the dorsal margin is convex in shape. Anterior and posterior ends are broadly rounded.

Class: Bacillariophyceae
Order: Naviculales
Family: Diploneidaceae
***Diploneis elliptica* (Kützing) Cleve Pl. II, Fig. 1**

Valves are elliptic in shape with margins that are convex and rounded apices (length is 47.0-61.0 µm; width is 20.0-31.0 µm). The central area is round with an axial area that is narrow and lanceolate. Striae radiate from the mid-valve (10-12 striae in 10 µm). Raphe are straight and expand towards the proximal end.

Class: Bacillariophyceae
Order: Bacillariales
Family: Bacillariaceae
***Nitzschia palea* (Kützing) W. Smith Pl. II, Fig. 2**

Valves are lanceolate and straight with tapered and capitated apices. Distinct fibulae are observed with visible nodules at the central part of the cell. Striae (19.0-23.0 in 10 µm) are slightly visible. Valves are 20.0-49.0 µm in length and 4.0-9.0 µm in width, while the costae are 9.0-16.0 µm.

Class: Bacillariophyceae
Order: Rhopalodiales
Family: Rhophalodiaceae
***Rhopalodia gibba* (Ehrenberg) O. Müller Pl. II, Fig. 3**

Valves are bracket- shaped, with an expanded middle area, indented at the central nodule; apices are bent ventrally and slightly capitate, flatly trimmed. Length is 50.0-230.0 µm; frustule breadth is 15.0-25.0 µm, valve breadth is 6.0-10.0 µm. The raphe lies along the dorsal margin, merely recognizable in valve view. Costae are 4.0-9.0 in 10 µm. Areolae are in rows, 10.0-12.0 in 10 µm, and usually 2-4 rows between the costae.

Class*:* Bacillariophyceae
Order*:* Cymbellales
Family*:* Cymbellaceae
***Cymbella affinis* Kützing Pl. II, Fig. 4**

Cells are solitary and are naviculoid (length is 22.5-26.0 µm and width is 5.0-7.0 µm). Striae are 7.0-11.0 for every 10 µm. Valves are lanceolate in shape and with protracted apical ends. Cells have a small axial area with a linear-arched central area.

Class: Mediophyceae
Order: Stephanodiscales
Family: Stephanodiscaceae
***Cyclotella meneghiniana* Kützing Pl. II, Fig. 5**

Valves are small and circular with a tapered and narrow mantle; central area is smooth occupying 1/3 of the overall valve surface and are striated by radially disposed grooves. Diameter of the cell is 10.0-15.0 µm, pervalvar axis is 7.5-8.5 µm; striae 6.0-9.0 in 10 µm.

Class: Coscinodiscophyceae
Order: Aulacoseirales
Family: Aulacoseiraceae
***Aulacoseira granulata* (Ehrenberg) Simonsen Pl. II, Fig. 6**

Frustules are cells forming cylindrical colonies. Valves are usually longer than wide, 3.0-4.0 µm in diameter with a mantle height of 10.0-21.0 µm. The ratio of mantle height to valve diameter is usually more than 3:1. Spines are present at the end of each pervalvar mantle costa.

PHYLUM: CHAROPHYTA
Class: Zygnematophyceae
Order: Desmidiales
Family: Desmidiaceae
***Pleurotaenium trabecula* Nägeli Pl. II, Fig. 7**

Cells usually 380.0-570.0 µm in length and 38.0-44.0 µm in width. The apex of the cell is 27.0-36.0 µm wide while the isthmus is 29.0-36.0 µm wide. The lateral margins are parallel to each other with hyaline cell walls, somewhat tapered at the apex; constrictions at the median part of the cell are somewhat shallow; chloroplasts are parietal and ribbon-like in appearance; several pyrenoids within the protoplasm.

A new record for the for the philippines.

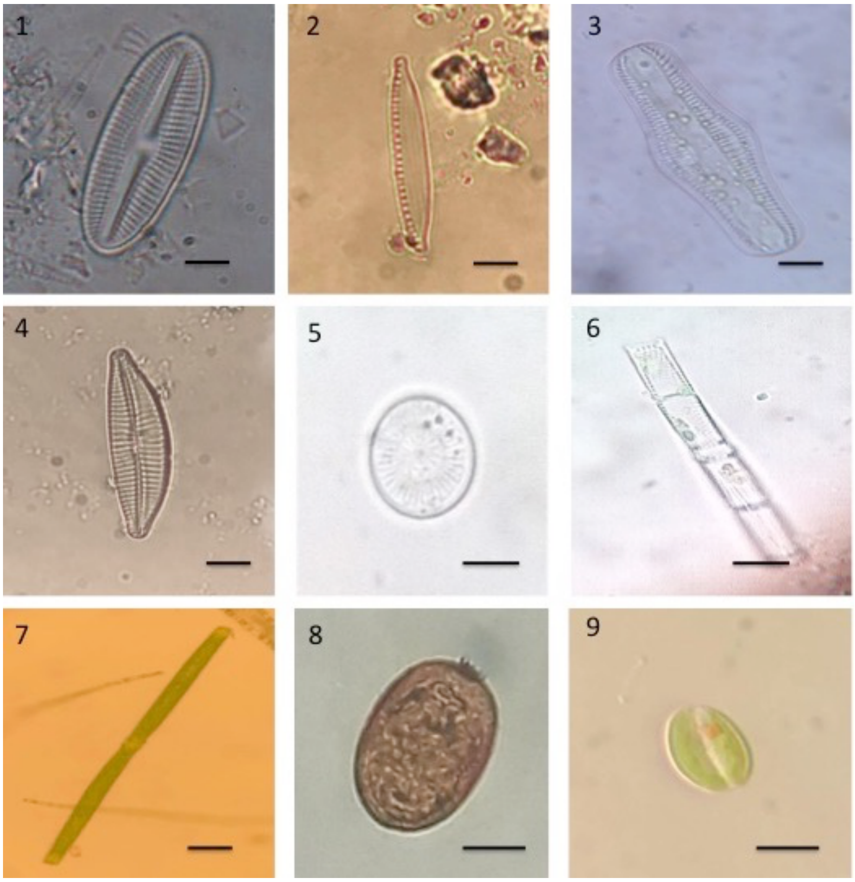


Plate II. Photomicrographs of (1) *Diploneis elliptica* (Kützing) Cleve, (2) *Nitzschia palea* (Kützing) W. Smith, (3) *Rhopalodia gibba* (Ehrenberg) O. Müller, (4) *Cymbella affinis* Kützing, (5) *Cyclotella meneghiniana* Kützing, (6) *Aulacoseira granulata* (Ehrenberg) Simonsen, (7) *Pleurotaenium trabecula* Nägeli, (8) *Trachelomonas armata* (Ehrenberg) F. Stein, (9) *Cryptoglena skujae* Marin & Melkonian. All scale bars = 10 µm.

Table 1. Limnological characteristics of the two sampling sites in Laguna de Bay.

Abiotic Characteristics	Sampling Sites	
	Calamba	Los Baños
Temperature (ºC)	27.5	28.0
Dissolved Oxygen (mg/L)	7.21	7.62
pH	7.03	7.31
Nitrate (mg/L)	5.32	4.13
Phosphate (mg/L)	0.29	0.20

Table 2. Distribution of epixylic algae from selected sampling sites in Laguna de bay.

Microalgal Species	Sampling Sites			
	Calamba		Los Baños	
	Bamboo Poles	Wooden Posts	Bamboo Poles	Wooden Posts
Cyanobacteria				
Chroococcus minutus (Kützing) Nägeli	+	+	+	+
Spirulina major Kützing ex Gomont	-	-	+	+
Oscillatoria proboscidea Gomont	+	+	+	+
Anabaenopsis arnoldii Aptekar	+	+	-	-
Chlorophyta				
Stigeoclonium tenue (C. Agardh) Kützing	+	+	-	-
Scenedesmus quadricauda (Turpin) Brébisson	+	+	+	+
Westella botryoides (West) De Wildeman	-	-	+	-
Kirchneriella lunaris (Kirchner) Möbius	+	+	-	-
Bacillariophyta				
Eunotia pectinalis (Kützing) Rabenhorst	+	+	-	-
Diploneis elliptica (Kützing) Cleve	+	+	+	+
Nitzschia palea (Kützing) W. Smith	+	+	+	+
Rhopalodia gibba (Ehrenberg) O. Müller	+	+	+	+
Cymbella affinis Kützing	+	+	-	-
Cyclotella meneghiniana Kützing	+	+	+	+
Aulacoseira granulata (Ehrenberg) Simonsen	+	+	+	+
Charophyta				
Pleurotaenium trabecula Nägeli	-	-	+	-
Euglenophyta				
Trachelomonas armata (Ehrenberg) F. Stein	+	-	-	-
Cryptoglena skujae Marin & Melkonian	+	-	-	-

+: Present, -: Absent

PHYLUM EUGLENOPHYTA
Class: Euglenophyceae
Order: Euglenales
Family: Euglenaceae
***Trachelomonas armata* (Ehrenberg) F. Stein Pl. II, Fig. 8**

Lorica are broadly ovoid or spherical and smooth (26.0 x 23.0 μm in diameter), spines (4-6) are found at the posterior end of the euglenoid; anterior part with collar where a single emergent flagellum is present; parietal chloroplasts are found in the cell.

Class: Euglenophyceaea
Order: Euglenales
Family: Euglenaceae
***Cryptoglena skujae* Marin & Melkonian Pl. II, Fig. 9**

Cells are quite small (14.0- 20.0 μm long and 8.0- 13.0 μm wide), ovoid, rigid, coffee- bean- shaped; anterior and posterior ends of the cell are broadly rounded; a single flagellum emerges at the anterior end; pellicle is rigid (no metaboly); a longitudinal furrow extending along the length of the ventral surface of the cell; a small red eyespot (stigma) is found near the anterior end of the cell.

The diversity of algal periphyton assemblages in submerged surfaces of wood and bamboo poles is highly influenced by spatial and temporal variations in different ecological parameters. Based on the water quality parameters (Table 1), higher phosphate and nitrate levels were observed at Calamba sampling site as compared to the Los Baños site. Overabundance of these nutrients favors the growth and proliferation of epixylic algae on submerged wooden posts and bamboo poles in Calamba (Table 2). Also, high concentrations of these nutrients can cause eutrophication under high light intensity, resulting in blooms of phytoplankton and episodic occurrences of fish death in the lake. Human activities at the Calamba sampling site, such as the release of agricultural waste (pesticides, heavy metals, and fertilizers) as well as urban waste being dumped into lake water results in the increase of inorganic and organic matter in the ecosystem that affects the water quality as well as the composition and assemblage of algal periphyton [4]. The temperature, pH, and dissolved oxygen (DO) concentration of both sampling areas were observed to be within the limits set by the Department of Environment and Natural Resources (DENR Administrative Order (DAO) 2016-08) of the Philippines for "Class C" water quality guidelines in propagation and growth of fish and aquatic resources in fresh water: 25-31°C, 6.5-9.0 pH, 5 mg/L, respectively [35]. Generally, lake conditions such as nutrient abundance (high phosphate and nitrate concentrations), environment, optimum temperature, and high light intensity (during sunny weather conditions) were found to be favorable for the fast proliferation of algal periphyton on bamboo poles and wood surfaces.

The species composition of epixylic algae in periphyton mats taken from submerged wooden posts and bamboo poles found in the littoral zone of Laguna de Bay was studied. In total, 18 epixylic algal taxa were described: 5 Bacillariophyceae, 4 Cyanophyceae, 4 Chlorophyceae, 2 Euglenophyceae, and 1 each of Mediophyceae, Zygnematophyceae, and Coscinodiscophyceae, all of which are characterized by wide geographic distributions. This survey recorded, for the first time in the Philippines, the occurrence of *Pleurotaenium trabecula* Nägeli, first reported in periphyton mats of submerged bamboo poles found in Laguna de Bay. The diversity of epixylic algae in periphyton mats as well as biofilm growth was higher on submerged bamboo poles than it was on wood posts, which is similar to the findings of previous studies [33-34]. The algal taxa (18 species) described in this survey were all observed to occur on bamboo poles with 4 species (*P. trabecula, T. armata, C. skujae,* and *W. botryoides*) not present on wooden posts (Table 2). Among the epixylic algal periphyton community, diatoms were the most dominant forms, followed by cyanobacteria and green microalgae. The biofilm and periphyton mats can serve as food for growing invertebrates, which in turn are consumed by fish, thus providing a significant contribution to primary production in the food web of Laguna de Bay [34]. The species composition of epixylic algal communities observed in this study is similar to other reported algal species in several countries [1, 25]. The high proportion of taxa resistant to desiccation (such as *Nitzschia palea*, and the chlorophyte *Scenedesmus quadricauda*) suggests that the studied algal community is well adapted to relatively predictable water fluctuations [1, 25]. In this study, the Calamba sampling site showed greater diversity of epixylic algae than was found at Los Baños, showing the dominance of Bacillariophyceae (*Cyclotella meneghiniana* and *Nitzschia palea*) together with chlorophyceae (*Scenedesmus quadricauda*), cyanobacteria (*Chroococcus minutus, Oscillatoria proboscidea*), and photosynthetic euglenoid (*Trachelomonas armata*) that are tolerant to extreme environments suggests the eutrophic state of the lake. This may be due to the high amount of wastewater being dumped into the lake in this area, which comes largely from industrial establishments and highly urbanized communities present near the sampling site. These algal taxa are considered good indicators of environmental changes and the ecological status of the lake due to its responsiveness to different sources of pollution. The current floristic survey provides baseline information necessary for deepening our understanding of the ecology and diversity of epixylic algae on surfaces of submerged wooden posts and bamboo poles in fish pens found in aquatic ecosystems in the Philippines.

Aside from the traditional morphotaxonomic (microscopic) methods done in this study, several molecular detection and identification techniques were developed as alternative tools to distinguish microalgal species. These methods can contribute to achieving a more stable and reliable taxonomic identification of the epixylic algal species observed in this study. Among recent molecular techniques, some are efficient for small-scale detection such as quantitative real-time polymerase chain reaction (qPCR), biosensors, and single-cell PCR. These methods have their own advantages and disadvantages. For instance, qPCR offers sensitive, rapid analysis and is a cost-effective technique for the quantification and detection of microalgae in both field samples and laboratory conditions [28-31]. On the other hand, single-cell PCR is an effective molecular tool for identification of uncultured microalgal cells (from environmental samples) but is inefficient in identifying picoplankton species. Other molecular techniques such as isothermal nucleic acid sequence-based amplification, terminal restriction length polymorphism, microarray, next generation sequencing (NGS) techniques, and loop-mediated isothermal amplification (LAMP) are more useful for high-throughput and large-scale detection of microalgae [28, 30, 32]. Isothermal DNA amplification techniques (e.g. Isothermal nucleic acid sequence-based amplification (NASBA) and LAMP) provide a major advantage over other techniques by being relatively simple, low cost, and robust making these methods useful for screening assays and large-scale detection, diversity analysis, and quantification of microalgae [28, 32]. The current study suggests the use of combined morphological and molecular methods for future floristic and taxonomic studies of epixylic algae in the Philippines. For now, the epixylic algal taxa reported in this study are adequately different and can be satisfactorily differentiated by means of morphological characteristics. This study provided a quick assessment and identifies some of the dominant epixylic algal taxa and creates baseline information for further molecular and phylogenetic studies.

4. Conclusion

The current taxonomic study reported a preliminary survey of the species composition of epixylic algal communities in periphyton mats obtained from submerged surfaces of wooden posts and bamboo poles in the littoral zone of Laguna de Bay. To our knowledge, one taxon (*Pleurotaenium trabecula* Nägeli) is reported and described for the first time occurring in the Philippines. The diversity of epixylic algae in periphyton mats is higher on submerged bamboo poles than on wooden posts with 4 species (*Pleurotaenium trabecula, Trachelomonas armata, Cryptoglena skujae,* and *Westella botryoides*) not observed on wooden posts. Generally, conditions such as a nutrient-rich environment (high phosphate and nitrate concentrations), optimum temperature, and high light intensity were found to be favorable for the existence of algal periphyton on bamboo poles and wood surfaces. This study provided a quick assessment and baseline information of the species composition and dominant epixylic algal taxa of periphyton mats associated with fish pens found in Laguna de Bay.

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