

Descriptive Study of Some Epiphytic Algae Growing on *Hydrilla verticillata* (L.f) Royle (Hydrocharitaceae) found in the Shallow Freshwater Lake Laguna de Bay (Philippines)

Eldrin DLR. Arguelles

Philippine National Collection of Microorganisms, National Institute of Molecular Biology and Biotechnology (BIOTECH), University of the Philippine Los Baños, Laguna, Philippines.

e-mail: edarguelles@up.edu.ph

ARTICLE INFO

Article History:

Received: March 3, 2019
Accepted: March 22, 2019
Online: March 30, 2019

Keywords:

Cyanobacteria
Hydrilla verticillata
Epiphyte
Macrophytes
Microalgae
Laguna de Bay

ABSTRACT

Most of the phycological studies in the Philippines mainly focused on seasonal variations of phytoplankton in different lentic and lotic systems, with a little concern on epiphytic algal and cyanobacterial communities associated to aquatic macrophytes. In this study, the species composition and distribution of epiphytic algae living on the submerged plant tissues of aquatic macrophyte *Hydrilla verticillata* (L.f) Royle found at the largest freshwater shallow lake “Laguna de Bay” in the Philippines was studied, and documented with a detailed description for each species. A total of 15 algal species belonging to 12 genera of three algal phyla were observed including, 7 Cyanophyceae, 3 Bacillariophyceae, 3 Trebouxiophyceae, and 2 Chlorophyceae. Of these taxa, the occurrence of a rare microalga *Franceia amphitricha* (Lagerheim) Hegewald is reported for the first time in the Philippines. These taxonomic records will add to the pool of data useful for understanding the epiphytic algal flora composition of aquatic macrophytes found in Philippine freshwater bodies.

INTRODUCTION

Water thyme (*Hydrilla verticillata* L. f. Royle) is a non-native, fast-growing, submerged aquatic macrophyte found in Laguna de Bay. This monoecious aquatic plant is characterized by having bright green leaves with sharply toothed margins existing in whorls of 3-10 along the stem (Chaturangani, *et al.*, 2016). It is known for its rapid and dense growth reducing plant diversity to a single species. Dense growth of water thyme in the aquatic ecosystem causes increase in daily swings in dissolved oxygen and pH, which influences habitat quality. Underneath a dense growth of water thyme in an aquatic ecosystem, oxygen levels can drop so low during night that fish could not survive at a long time. Same effects on acidity and oxygen can lead to rise in the level of release of nutrients from sediments. This drastic increase can induce phytoplankton blooms, which is an indicative symptom of a polluted lake.

For several years the epiphytic algal flora associated with submerged aquatic macrophytes has been regarded largely as a curiosity and ignored as being quantitatively negligible (Wetzel, 1996). However, studies showed that the

microalgae and cyanobacteria associated with aquatic macrophytes primarily served as a source of food to small fish and invertebrates in the littoral zone. In addition, intricate co-existence of various algal periphyton on aquatic macrophytes also create remarkable conditions for breeding ground of several aquatic animals (Manna, *et al.*, 2017). These algal epiphyte community plays an important function in aquatic ecosystem by maintaining nutrient cycling, energy base for food web and as bioindicators.

In the Philippines, taxonomy, diversity and ecological studies of epiphytic microalgae and cyanobacteria in different aquatic macrophytes found in inland waters remain poorly understood. This paper will serve as a preliminary study on the taxonomic account of epiphytic algae inhabiting the aquatic macrophyte, water thyme (*Hydrilla verticillata* L. f. Royle) found in Laguna de Bay contributing important information on the algal biodiversity as part of the living resources of the Philippines.

MATERIALS AND METHODS

Study Site

Laguna de bay is one of the important shallow lakes in the Philippines. It lies at 14° 10' - 14° 35' N, 121° - 121°30' E, specifically in the Luzon island. This lake has a surface area of 900 km² with an average depth of 2.5 m and a water volume of 2.25 km³. Currently, the principal use of this lake is for fishery, both open water fishing and aquaculture. It is known to be a receptacle for floodwaters coming from Metropolitan Manila, and is considered a sink of treated and untreated liquid wastes (Santos-Borja & Nepomuceno, 2003).

Sampling of Epiphytic Algae

Samples of epiphyte-dominated water thyme (*Hydrilla verticillata* L.f. Royle) were collected from the littoral zone of Laguna de Bay. The plant parts were put into polyethylene bags filled water-lake for laboratory examination. The epiphytic microalgae and cyanobacteria attached on the macrophyte was separated by scraping the attached algae on stem and leaves of the plant and manual shaking for 30 minutes (Zimba & Hopson, 1997; Arguelles, *et al.*, 2014). A total of 15 aquatic macrophyte samples were analyzed throughout the study period. Immediately after collection, these samples were washed with sterile distilled water, scraped and were fixed with 4% formaldehyde. The collected scraped epiphyte sample were thoroughly mixed and a portion of 50 mL was kept for diatom analysis. Scraped sample for analysis of diatom flora was digested following the protocol of Utermöhl, 1958 and Tunca, *et al.*, 2014. An aliquot of cleaned diatom were air dried onto coverslips and mounted. The remaining water sample was transferred into a sterile graduated cylinder and allowed to settle for 24 hours. At the end of the settling period, 45 mL of water was removed and the remaining 5 mL of water was placed into a sterile glass vial for microscopic observation (Utermöhl, 1958; Tunca, *et al.*, 2014).

Micrometry, Photomicrography, and Identification

Morphotaxonomic description and identification of the epiphytic algae was done up to the species level possible using an Olympus CX31 binocular research microscope equipped with Infinity X digital camera. The algal species documented in this study were identified using the monographs and standard works of literature as follows: (Desikachary, 1959; Velasquez, 1962; Presscott, 1962; Round, 1990; Komárek and Anagnostidis, 2005; McGregor, 2007; Whitton, 2011; and John, 2011). Current accepted taxonomic names of each of the alga were presented in the paper which is based on Guiry & Guiry (2018).

RESULTS

A total of 15 epiphytic microalgae and cyanobacteria (belonging to Cyanophyceae, Chlorophyceae, Trebouxiophyceae, and Bacillariophyceae) were identified. The specimen were described and photographed for the first time in the studied area in order to understand the diversity of epiphytic algae of water thyme found in Laguna de Bay (Philippines). Taxonomy based on the morphology of each of the isolates is presented together with a concise description of the place of collection and habitat of their existence. Current names were used based on Guiry & Guiry (2018).

Cyanobacteria

Class Cyanophyceae

Order: Chroococcales

Family: Chroococcaceae

Genus: *Chroococcus* Nägeli

***Chroococcus minutus* (Kützing) Nägeli**

Pl. I Fig. 1

Basionym: *Protococcus minutus* Kützing

Whitton, 2011, Phylum Cyanobacteria (Cyanophyta) In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 54, pl. 11F; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 31; Desikachary, 1959, Cyanophyta, 104-105, pl. 24, g.4 and pl. 26, g. 4 and 15.

Colony are small, usually occurring as single or in groups of 2-4 cells; colonies enclosed in an amorphous, colorless, homogenous mucilage diffuent at the margin; 5.0-7.0 μm in diameter with sheath. Cells are spherical or hemispherical in shape, 3.0-7.0 μm in diameter, blue-green in color.

Found occurring as a slimy, blue-green crust attached on leaves and stems of water thyme associated with other cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

***Chroococcus minor* (Kützing) Nägeli**

Pl. I Fig. 2

Basionym: *Protococcus minor* Kützing

Bose, *et al.*, Phytomorphology. 79, Fig. 1d, 2016; Das and Adhikary, 2014, Freshwater algae of eastern India, p. 44, pl.1, Fig. 34; Samad and Adhikary, Algae, 23(2): 91, pl. 1 Fig. 21-23, 2008; Desikachary, 1959, Cyanophyta, p. 105, pl. 26, Fig. 4 and 15.

Colonies are microscopic and gelatinous usually occurring in groups of 2-4 cells; Cells are spherical, hemispherical or sometimes ellipsoidal, 3.0-5.0 μm in diameter; gelatinous lamellated sheath is colorless, thin and slightly visible.

Found occurring as a slimy, bluish green crust attached on the stem and leaves of water thyme associated with other filamentous cyanobacteria and green microalgae.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

***Chroococcus turgidus* (Kützing) Nägeli**

Pl. I Fig. 3

Basionym: *Protococcus turgidus* Kützing

Bose, *et al.*, Phytomorphology. 79, Fig. 1e, 2016; Whitton, 2011, Phylum Cyanophyta. In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 54, pl. 6A and 11A,B; Desikachary, 1959, Cyanophyta p. 101, pl. 26, Fig. 6.

Colonies are microscopic usually occurring in groups of 2-4 cells with the gelatinous sheath forming the border of the colony. Cells spherical, subspherical to ellipsoidal (7.0-8.5 μm in diameter), olive green in color, with colourless gelatinous sheath 14.0-35.0 μm in diameter.

Found occurring as a blue-green crust attached on the stem and leaves of water thyme associated with other green microalgae and diatoms.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Order: Chroococcales

Family: Aphanothecaceae

Genus: *Aphanothece* C. Nägeli

***Aphanothece stagnina* Sprengel (A. Braun)**

Pl. I Fig. 4

Basionym: *Coccochloris stagnina* Sprengel

Gaysina, *et al.*, *Crytogamie, Algologie*, 39(2): 16, Fig. 16, 2018; Whitton, 2011, *Phylum Cyanophyta*. In: *The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae*, 46, pl. 9G.

Colonies are gelatinous and spherical with 5.0-20.0 μm diameter; gelatinous mucilage is characterized by having a firm outer margin. Cells are oval to cylindrical with rounded ends, blue-green in color, 4.5-8.0 μm long, and 4.6-5.2 μm wide.

Found occurring as a slimy, blue-green conspicuous masses attached on the stem and leaves of water thyme associated with other filamentous cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Order: Synechococcales

Family: Leptolyngbyaceae

Genus: *Leptolyngbya* K. Anagnostidis & J. Komárek

***Leptolyngbya lagerheimii* (Gomont ex Gomont) Anagnostidis & Komárek**

Pl. I Fig. 5

Basionym: *Lyngbya lagerheimii* Gomont ex Gomont

Desikachary, 1959, *Cyanophyta*, 290, pl. 48, Fig. 6 and pl. 53, Fig. 2; Prescott, 1962, *Algae of the Western Great Lakes Area*, 501, pl. 112, Fig. 5,6; Whitton, 2011, *Phylum Cyanophyta*. In: *The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae*, 91, pl. 11D, M; Arguelles, *Philippine Journal of Systematic Biology*, 11(2): 29, pl. I. Fig. 5, 2017.

Trichomes are straight and usually occurring in clumps and slightly curled up. Cells are blue green in color, 1.0-2.0 μm long and 1.0-1.5 μm wide, septa not granulated; cellular protoplasm not granular, posterior and anterior end cells are rounded; filaments without calyptra; sheaths 1.5-2.0 μm wide, colorless and firm.

Found occurring as a bluish green crust attached to submerged leaves and stem of water thyme associated with other filamentous cyanobacteria and green microalgae.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

***Leptolyngbya foveolarum* (Gomont) Anagnostidis & Komárek**

Pl. II Fig. 1

Basionym: *Phormidium foveolarum* Montagne ex Gomont

Park, 2012. *Algal Flora of Korea: Cyanophyta: Cyanophyceae: Chroococcales, Oscillatoriales*, 5(2): 44, Fig. 16A; Whitton, 2011, *Phylum Cyanophyta*. In: *The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae*, 103, pl. 22E.

Trichomes are flexous and usually straight or slightly curled up with distinctly

constricted crosswalls and not attenuated. Cells blue green in color; 2.0 μm long and 1.0-2.5 μm wide, protoplasm not granulated, septa not granulated, apical cells are rounded without calyptra; posterior end cells rounded; sheaths 1.0-2.0 μm wide, firm and colorless.

Found occurring as a bluish green crust attached to submerged stem and leaves of water thyme associated with other filamentous cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Oscillatoria* Vaucher ex Gomont

***Oscillatoria tenuis* C. Agardh ex Gomont**

Pl. II Fig. 2

Arguelles, Tropical Life Sciences Research, 30(1): 4, pl. I. Fig. 2, 2019; Whitton, 2011, Phylum Cyanobacteria (Cyanophyta). In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 101, Pl. 20K; Pantastico, 1977, Taxonomy of the Freshwater Algae of Laguna de Bay and Vicinity, 54, pl. IV, Fig 11; Prescott, 1962, Algae of the Western Great Lakes Area, 491, pl. 110, Fig. 8, 9, 14; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 66; Velasquez, Philippine Journal of Science, 91(3): 289, pl. 1. Fig. 20, 1962; Desikachary, 1959, Cyanophyta, p. 222, pl. 42, Fig. 15.

Cells blue-green in color, 1.0-2.5 μm long and 2.0-4.0 μm wide, protoplasm is finely granular. Anterior end cells are rounded, slightly attenuated, without calyptra; heterocytes and akinetes are absent. Posterior end cell is more or less hemispherical. Trichomes are scattered, straight or sometimes slightly bend in the apical end cells, 4.5-6.0 μm broad.

Found occurring as a bluish-green crust on leaves and stems of water thyme submerged in water associated with other cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Chlorophyta

Class: Trebouxiophyceae

Order: Chlorellales

Family: Chlorellaceae

Genus: *Chlorella* Beyerinck [Beijerinck]

***Chlorella vulgaris* Beyerinck [Beijerinck]**

Pl. II Fig. 3

Basionym: *Chlorella pyrenoidosa* var. *duplex* (Kützing)

Arguelles, Philippine Journal of Systematic Biology, 11(2): 31, pl. II. Fig. 4, 2017; John, 2011, Phylum Chlorophyta (Green Algae). In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 476, pl. 103I; Zafaralla, 1998, Microalgae of Taal Lake, 36, pl. 7j; Ortega-Calvo, et al., Nova Hedwigia. 57: 246, pl. 2, Fig. 16 and 17, 1993; Prescott, 1962, Algae of the Western Great Lakes Area, 237, pl. 53, Fig. 13.

Cells are solitary and spherical rarely occurring in groups; characterized by having a smooth and thin cell wall; chloroplast is single and is cup-shaped with a single pyrenoid; cells are 1.5-3.0 μm in diameter; asexual reproduction is by the formation of 2 or 4 autospores, liberated by rupture of the mother cell wall.

Found occurring as a greenish crust on submerged leaves of water thyme associated with other filamentous cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Family: Chlorococcaceae

Genus: *Chlorococcum* Meneghini

***Chlorococcum infusionum* (Schrank) Meneghini**

Pl. II Fig. 4

Synonym: *Chlorococcum humicola* (Nägeli) Rabenhorst 1868

Basionym: *Cystococcus humicola* Nägeli

Arguelles, Philippine Journal of Systematic Biology, 11(2): 30, pl. I. Fig. 9, 2017; John, 2011, Phylum Chlorophyta (Green Algae). In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 414, pl. 103L; Samad and Adhikary, Algae, 23(2): 91, pl. 1 Fig. 1., 2008; Zafaralla, Microalgae of Taal Lake, 33, pl. 8e.f, 1998; Pantastico, 1977, Taxonomy of the Freshwater Algae of Laguna de Bay and Vicinity, 76, pl. VII, Fig 1; Prescott, 1962, Algae of the Western Great Lakes Area, 280, pl. 45, Fig. 1.

Cells solitary or in groups of irregular form; spheroidal to ellipsoidal in shape and greenish in color; uni- or multinucleate, chloroplast is parietal more or less covering the entire cells with one or more pyrenoids; cells 9-14 µm in diameter.

Found occurring as a greenish crust on submerged stem and leaves of water thyme associated with other filamentous cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Family: Oocystaceae

Genus: *Franceia* Lemmermann

***Franceia amphitricha* (Lagerheim) Hegewald**

Pl. II Fig. 5

Basionym: *Oocystis ciliata* var. *amphitrichia* Lagerheim

John, 2011, Phylum Chlorophyta (Green Algae). In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 483, pl. 120D.

Single-celled or sometimes forming 2- or 4-celled colonies confined within a mucilaginous envelope. Cells are greenish in color, oval to broadly ovoid, 3.5-9.5 µm wide, and 7.0-11.5 µm long. Several spines (8 or more in number), 11.0-18.0 µm long, irregularly distributed all over the cell, thick and straight. Chloroplasts laminate, parietal, 2-4 per cell each with a pyrenoid.

Found occurring as a greenish crust on submerged stem and leaves of pink lotus associated with other filamentous cyanobacteria.

A new record for the Philippines.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Order: Sphaeropleales

Family: Scenedesmaceae

Genus: *Scenedesmus* Meyen

***Scenedesmus quadricauda* (Turpin) Brébisson**

Pl. III Fig. 1

Basionym: *Achnanthes quadricauda* Turpin

Arguelles, Philippine Journal of Systematic Biology, 11(2): 30, pl. II. Fig. 1, 2017; Arguelles, IAMURE International Journal of Ecology and Conservation, 17:32, pl. I. Fig. 8, 2016; Zafaralla, Microalgae of Taal Lake, 39, pl. 9g.j, 1988; Pantastico, 1977, Taxonomy of the Freshwater Algae of Laguna de Bay and Vicinity, 119, pl. IX, Fig 8; Prescott, 1962, Algae of the Western Great Lakes Area, 280, pl. 64, Fig. 2.

Coenobia are flat and straight with cells in one row, 2- or sometimes 4-celled, joined laterally and linearly arranged to each other. Cells are elongate or cylindrical in shape with apices rounded, 3.0-6.0 µm long and 1.5-2.0 µm wide, with solitary pyrenoid; inner cells of the linearly arranged coenobia are without spines and

terminal cells with two straight to slightly curved spiny projections with smooth cell wall.

Found occurring as a greenish crust on submerged leaves and stems of water thyme associated with other filamentous cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Class: Chlorophyceae

Order: Chlamydomonadales

Family: Volvocaceae

Genus: *Eudorina* Ehrenberg

***Eudorina elegans* Ehrenberg**

Pl. III Fig. 2

Dembowska, Acta Societatis Botanicorum Poloniae, 82(4): 261, Fig 2, 2013; John, 2011, Phylum Chlorophyta (Green Algae). In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 398, pl. 102G; Menezes & Bicudo, Hoehnea, 35(3): 454, Fig. 89-94, 2008.

Colonies cylindrical, or nearly spherical; composed of (8), 16, 32, or 64 cells inserted in the perimeter of a common gelatinous matrix; Cells 5.0-7.0 μm diameter, spherical, surrounded by a mucilaginous sheath. Cells separated from each other by spaces; cells spherical, with 2 equal-length apical flagella. Chloroplast cup-shaped, smooth, more than half of cell, pyrenoids 1-4 in number, spherical and basal. Stigma is globose and decreasing in size towards the posterior cells. Flagella homodynamic, 1.5-2 times the cell length. Cellular division is not synchronous.

Found occurring as a brownish crust on stem and leaves of water thyme associated with other microalgae and cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen

Bacillariophyta

Class: Bacillariophyceae

Order: Naviculales

Family: Diploneidaceae

Genus: *Diploneis* Ehrenberg ex Cleve

***Diploneis elliptica* (Kützing) Cleve**

Pl. III Fig. 3

Basionym: *Navicula elliptica* Kützing

Leira, *et al.*, Anales del Jardín Botánico de Madrid, 74 (2): 10, Fig. 5n, 2017; Kolayli & Şahin, Turkish Journal of Fisheries and Aquatic Sciences, 7: 173, Fig. 2c, 2007.

Cell is longer than wide, 20.0 – 53.5 μm long and 8.0-9.50 μm wide. Valves are elliptic characterized by having a curved margin and rounded apices. The central area is wide and round. Axial area is narrow-lanceolate, gradually widening from the apices to the central area of the cell. Striae are observed to radiate at mid-valve, becoming strongly radiate towards the apices. Striae are uniseriate which is characterized by having complex and round areolae.

Found occurring as a brownish crust on stem and leaves of water thyme associated with other microalgae and cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Order: Aulacoseirales

Family: Aulacoseiracea

Genus: *Aulacoseira* Thwaites***Aulacoseira granulata* var. *angustissima* (Otto Müller) Simonsen Pl.III Fig. 4**

Basionym: *Melosira granulata* var. *angustissima* (Otto Müller)

Cavalcante et al., *Acta Botanica Brasilica*, 27(2): 246, Fig. 11G-I, 2013; Joh, 2010, *Chrysophyta: Bacillariophyceae: Centrales. Freshwater diatoms I*, 39, Figs. 21A-G.

Frustules are cylindrical forming colonies. Valves are longer than wide, 2.5–4.0 µm in diameter and a mantle height of 7.0-18.0 µm. The mantle height to valve diameter ratio is more than 3 (high mantle). Spines are located at the end of each perivalvar mantle costa.

Found occurring as a brownish crust on stem and leaves of water thyme associated with other cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Mayondon, Station 1), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

Class: Mediophyceae

Order: Stephanodiscales

Family: Stephanodiscaceae

Genus: *Cyclotella* (Kützing) Brébisson***Cyclotella meneghiniana* Kützing****Pl. III Fig. 5**

Costa, *et al.*, *Hoehnea*, 44(4): 566, Fig. 8-9, 2017; Leira, *et al.*, *Anales del Jardín Botánico de Madrid*, 74 (2): 7, Fig. 2e, 2017; Marra et al., *Biota Neotropica*, 16(4): 8, Fig. 2, 2016; Cavalcante *et al.*, *Acta Botanica Brasilica*, 27(2): 243, Fig. 8A-O, 2013; Akbulut, *Turkish Journal of Botany*, 27: 297, Fig. 7, 12-14, 2003.

Valves small, circular with a narrow mantle; central area is flat and smooth covering 1/3 of the valve surface and are striated by grooves that is radially disposed. Diameter 9.0-17.0 µm, perivalvar axis: 6.5-9.5 µm; striae 7.0-9.0 in 10 µm.

Found occurring as a brownish crust on submerged stem and leaves of water thyme associated with other filamentous fungi and cyanobacteria.

Specimen: LUZON, Laguna, Los Baños (Bayan, Station 2), E.DLR. Arguelles *s.n.* Photograph prepared from the mounted specimen.

DISCUSSION

This study examined the species composition of algal epiphytes observed on *Hydrilla verticillata* L.f. Royle found on the littoral zone of Laguna de Bay (Philippines). In total, 15 epiphytic algal taxa were identified: 7 Cyanophyceae, 3 Bacillariophyceae 3 Trebouxiophyceae, and 2 Chlorophyceae, all of which are characterized by wide geographic distributions. This study recorded for the first time in the Philippines the occurrence of *Franceia amphitricha* (Lagerheim) Hegewald first reported in submerged stem and leaves of *Hydrilla verticillata* found in Laguna de Bay. The diversity and species composition of epiphyton community of *Hydrilla verticillata* is similar in comparison with other aquatic macrophytes found in shallow water bodies in several countries (Effiong & Inyang, 2015; Inyang *et al.*, 2015; Toporowska *et al.*, 2008, Dunn *et al.*, 2008; and Sultana *et al.*, 2004). The abundance of aquatic macrophyte such as *Hydrilla verticillata* by the lake side as well as water surface maybe an indication of the eutrophic condition of Laguna de bay. With the nutrient waste, which drains into the lake, it could be expected that the phytoplanktons and algal epiphytes (including microalgae and cyanobacteria in aquatic macrophytes) present in the lake would possess pollution tolerance (eg. heavy

metal-resistance) and thus could be used as biological indicator species (Effiong & Inyang, 2015).

The relationships between host aquatic macrophyte and attached algae are complex and also reflect dynamic seasonal changes of environmental parameters. Algal species composition and population are largely affected by factors such as changes in various environmental factors (such as light, temperature, water level, and the like) and seasonal changes as well as lifespan, abundance and morphology of the host aquatic macrophyte (*Hydrilla verticillata* L.f. Royle). Thus, seasonal dynamics and its affect on the diversity and population of epiphytic algae as well as effects of various environmental factors on growth and abundance of algal epiphytes should be investigated thoroughly in the future study. The taxonomic record of epiphytic algae obtained from this study provides basal knowledge of the taxonomy, distribution and diversity of epiphytic algae on macrophytes found in Laguna de Bay.

CONCLUSION

The present study reported a compilation of algal epiphytes associated with water thyme (*Hydrilla verticillata* L.f. Royle). One taxa identified in this study represent a new record for the Philippines, enriching the knowledge about the ecology of epiphytic algae associated with submerged aquatic macrophytes. This study emphasizes the importance of algal taxonomic studies in aquatic and terrestrial habitats in order to increase knowledge of the habitat distribution and biodiversity of microalgae and cyanobacteria in the Philippines.

ACKNOWLEDGMENT

The author is grateful to Mr. John O-Neil Geronimo for the preparation of the algal photomicrographs and to the National Institute of Molecular Biology and Biotechnology (BIOTECH) for financial and technical assistance through the course of the study.

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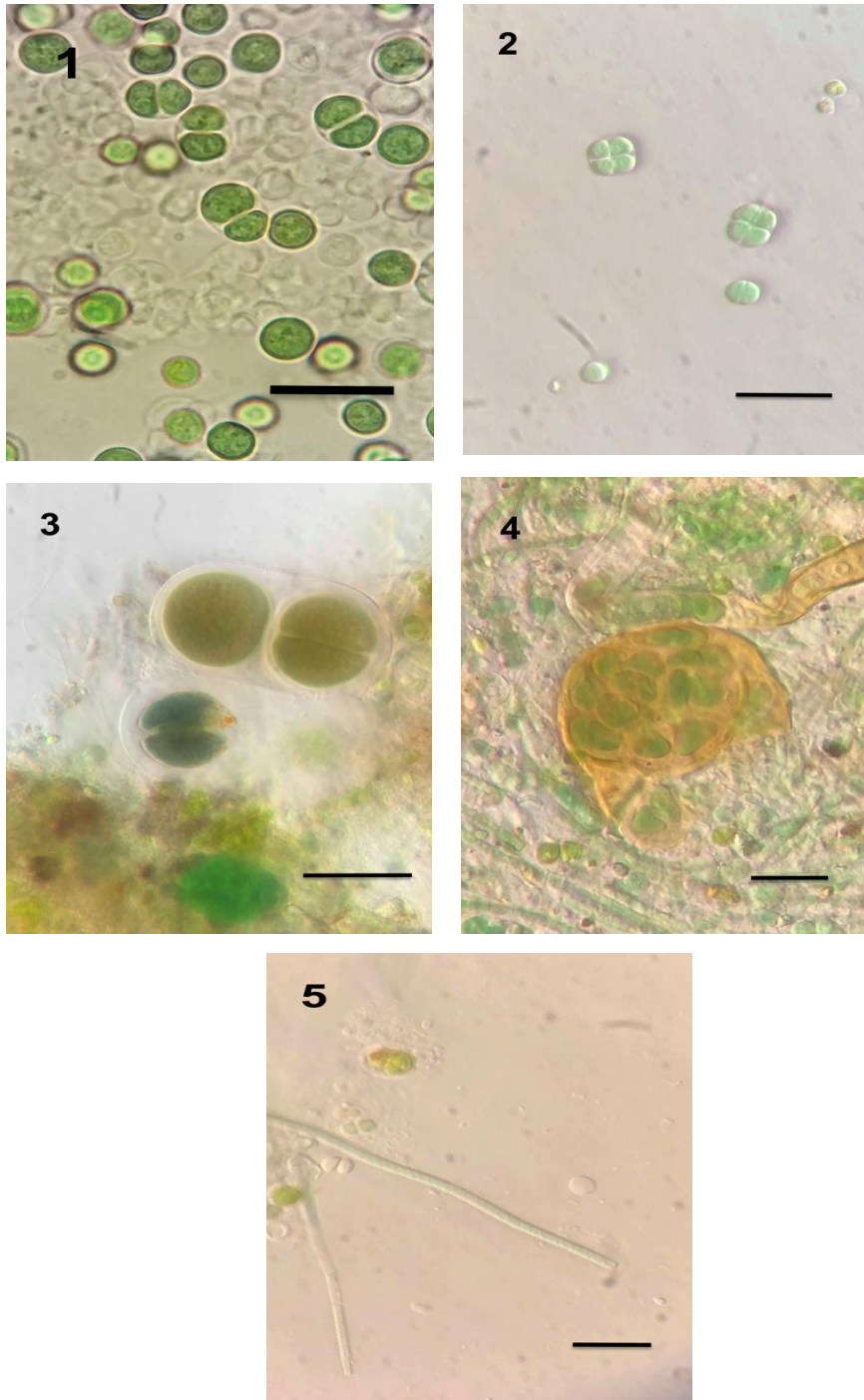


Plate I. (1) *Chroococcus minutus* (Kützing) Nägeli, (2) *Chroococcus minor* (Kützing) Nägeli, (3) *Chroococcus turgidus* (Kützing) Nägeli, (4) *Aphanothece stagnina* Sprengel (A. Braun), (5) *Leptolyngbya lagerheimii* (Gomont ex Gomont) Anagnostidis & Komárek. All scale bars = 10 μ m.

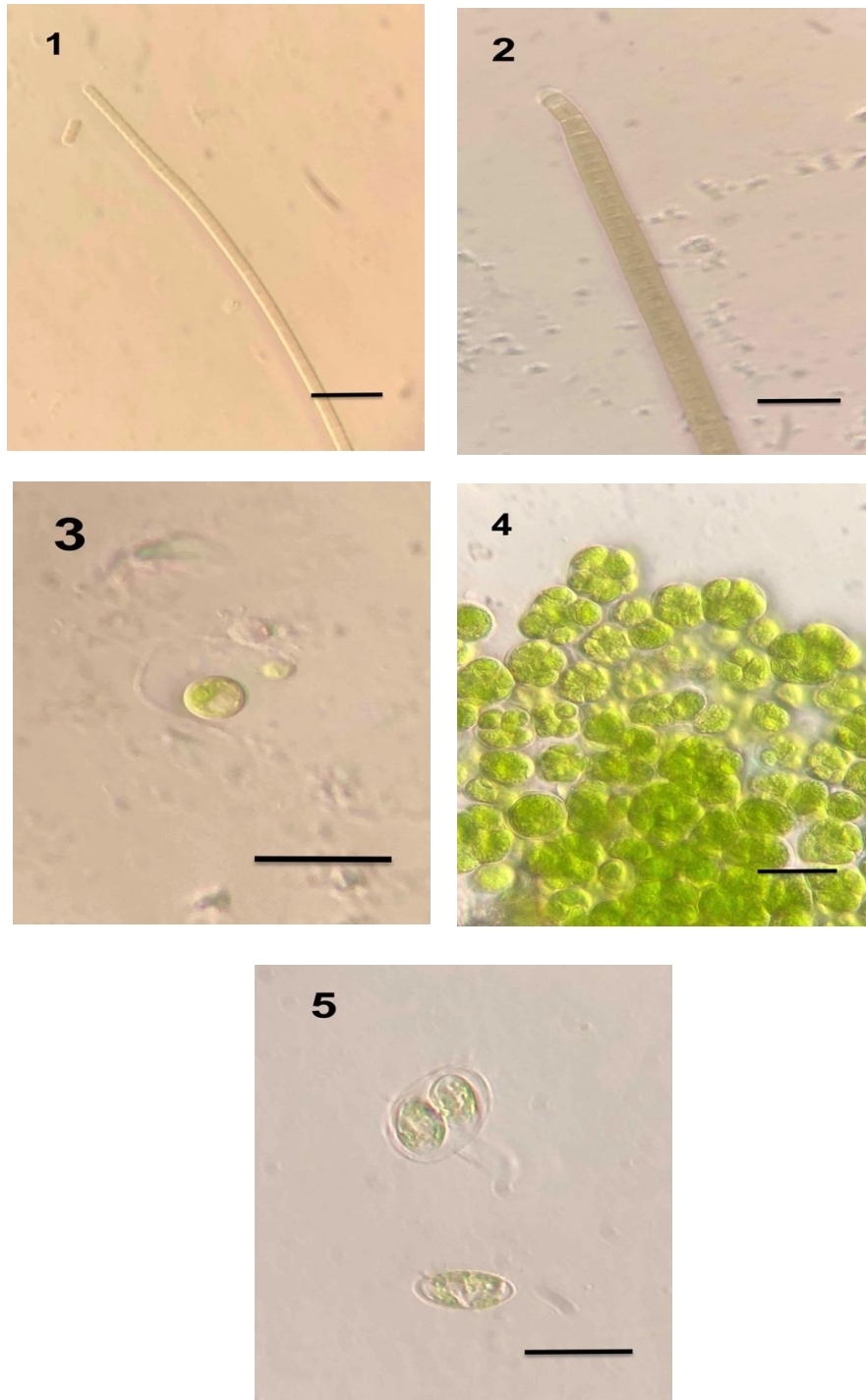


Plate II. (1) *Leptolyngbya foveolara* (Gomont) Anagnostidis & Komárek, (2) *Oscillatoria tenuis* C. Agardh ex Gomont, (3) *Chlorella vulgaris* Beyerinck [Beijerinck], (4) *Chlorococcum infusionum* (Skrank) Meneghini, (5) *Franceia amphitricha* (Lagerheim) Hegewald. All scale bars = 10 μ m.

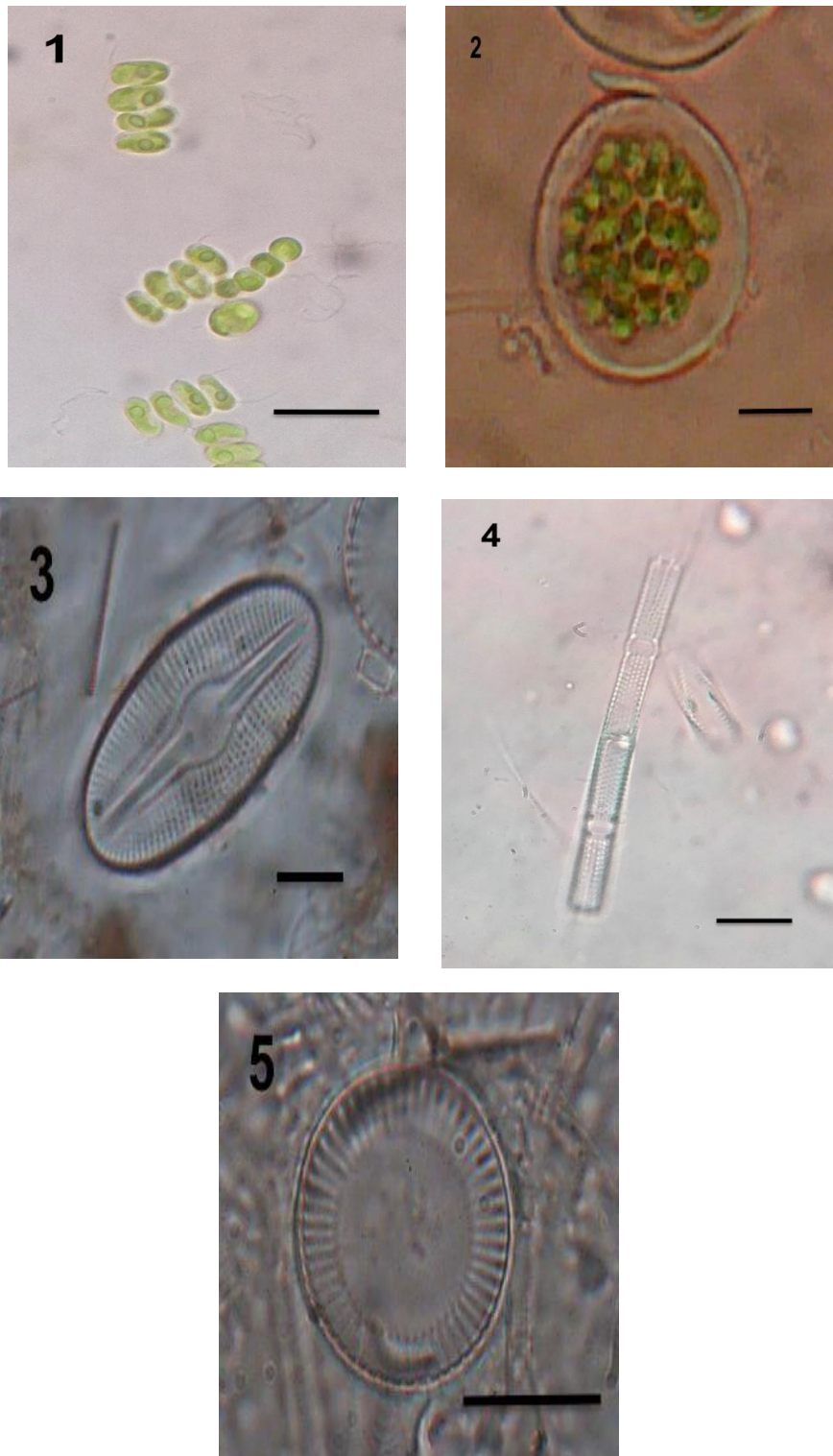


Plate III. (1) *Scenedesmus quadricauda* (Turpin) Brébisson, (2) *Eudorina elegans* Ehrenberg, (3) *Diploneis elliptica* (Kützing) Cleve, (4) *Aulacoseira granulata* var. *angustissima* (Otto Müller) Simonsen, (5) *Cyclotella meneghiniana* Kützing. All scale bars = 10 μ m.