

Morphotaxonomy and Diversity of Terrestrial Microalgae and Cyanobacteria in Biological Crusts of Soil from Paddy Fields of Los Baños, Laguna (Philippines)

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| | ABSTRACT |
|---|---|
| KEY WORDS : algae diversity new record taxonomy rice fields soil habitat | <p>Floristic and taxonomic study on the basis of morphological and cytological characteristics of terrestrial algae found in biological crusts of soil from paddy fields of Los Baños, Laguna showed the occurrence of 14 taxa (3 unicellular, 2 colonial, 7 non-heterocytous filamentous and 2 heterocytous filamentous) belonging to the class Cyanophyceae, Chlorophyceae, Klebsormidiophyceae and Trebouxiophyceae. The collection reported in this study represents 9 orders, 10 families, 13 genera and 14 species based on recent combined taxonomical approach. Of these taxa, the occurrence of a rare green alga <i>Chlorolobion braunii</i> (Nägeli) Komárek is reported for the first time in the Philippines. Three species are also reported here based on current taxonomic nomenclature and these are <i>Planktothrix agardhii</i> (Gomont) Anagnostidis & Komárek, <i>Kamptonema chlorinum</i> (Kützing ex Gomont) Strunecký, Komárek & J.Smarda and <i>Tetrademus dimorphus</i> (Turpin) M.J. Wynne. These taxonomic records are considered important information in enriching the knowledge about the diversity and habitat distribution of cyanobacteria and microalgae in the Philippines.</p> |

INTRODUCTION

Knowledge on the diversity and distribution of terrestrial microalgae and cyanobacteria in biological crusts on soils still falls behind those of marine and freshwater environments. The terrestrial environment, which contains a vast array of soil microalgae and cyanobacteria with unique biological properties, is one of the less studied biological resources. Biological crusts are normally formed by association of several microorganisms, e.g., algae, cyanobacteria, fungi, lichens and sometimes non-vascular plants, which are closely associated with the soil substratum (e.g. paddy fields) forming flat, amorphous structures (Belnap, et al., 2001; Pattanaik and Adhikary, 2005; Sethi, et al., 2012). Paddy fields are regarded as invaluable environments for diverse kinds of microalgae and cyanobacteria and are considered highly disturbed environments exposed to various physico-chemical activities. Algal species of such soils may be considered unique and can be used as indicators of specific wetland soil characteristics (Johansen, 1993; Irisarri, et al., 2001).

The high diversity of cyanobacteria and microalgae, combined with their unfavorable environments, in which these organisms live, makes them key subjects for the discovery of new algal species candidates in bioactive compound screening projects. In soil crusts of paddy fields, the activity of these algae results in the stabilization of the soil surfaces, decreasing the incidence of erosion and keeping moisture thus providing suitable habitat for growth of rice (Johansen, 1993). Several studies have analyzed the diversity of terrestrial algae on biological soil crusts of paddy fields in different parts of the world (Roger and Reynaud, 1982; Irissari, et al., 2001; Naz, et al., 2004; Pereira, et al., 2005). Although knowledge of terrestrial algal flora has accumulated in other countries, there are few published articles about the composition of cyanobacteria and microalgae in biological soil crusts of paddy fields in the Philippines (Pantastico and Suayan, 1973; Martinez-Goss, et al., 2014). Hence, the present study was carried out to isolate and morpho-taxonomically identify terrestrial microalgae and cyanobacteria associated with biological crusts of soil from paddy fields of Los Baños, Laguna, Philippines.

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MATERIALS AND METHODS

Sampling, Isolation and Identification of Terrestrial Microalgae and Cyanobacteria.

Several biological crust samples of visually noticeable algal growth on both submerged and exposed rocks and soils from three sampling sites (Table 1) were collected simultaneously for algal taxonomic studies. Six crust samples were collected from each of the sampling sites including rock and soil surfaces found within the vicinity of the different paddy fields. Sample collection was done by gently scraping rock and soil surfaces with a sterile blade and needle. The collected materials were placed in sterile screw cap tubes (Samad and Adhikary, 2008; Arguelles, 2016). Each sample was aseptically transferred into BG 11 medium with or without combined nitrogen and to plates containing solid medium (1.5% w/v agar) and stored at 25 ± 1°C beneath fluorescent light (148-230 lux) for 20 d following the method described by Arguelles, et al. (2014) and Samad and Adhikary (2008). Photomicrographs of the algal isolates appearing in the culture medium were taken using an Olympus CX31 binocular research microscope equipped with Infinity X digital camera. The morphological characteristics such as attributes of the filaments, the size and shape of vegetative cells as well as specialized cells (heterocytes and akinetes), length and width of intercalary cells, absence or presence of constriction at the cross wall and at the sheath; color and appearance of the sheath; nature of trichomes and filaments; and absence or presence of heterocytes and akinete were taken into examination during the identification and classification of each algal taxa. The taxonomic system described by Tilden (1910), Desikachary (1959), Prescott (1962), Anagnostidis and Komárek, (1990), and Whitton (2002) were used. Morphotaxonomic identification was done up to the species level possible using all available information. In the current taxonomic study, the orthographs ‘heterocytes’ and ‘hormogonia’ instead of ‘heterocysts’ and ‘hormogones’ respectively, were applied, as proposed by the International Association for Cyanophyte Research (IAC) (Mollenhauer, et al. 1994).

RESULTS AND DISCUSSION

Fourteen algal isolates were obtained from biological crust samples collected from three paddy field sampling sites in the UPLB Campus and Los Baños, Laguna, Philippines. Of these isolates, eight taxa belong to cyanobacteria, five to Chlorophyta, and one to Charophyta. Morpho-taxonomic characterization of each of the isolates is presented together with a short description of the place of collection and habitat. Current names were used based on Guiry & Guiry (2017).

Presented below is a dichotomous key for the identification of the different cyanobacterial and microalgal isolates included in this survey.

Morpho-taxonomic Description of the Isolates

Cyanobacteria

Class: Cyanophyceae
 Order: Oscillatoriales
 Family: Microcoleaceae

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

1. *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek Pl. I Fig. 1

Basionym: *Oscillatoria agardhii* Gomont

Stoyanov, et al., Journal of BioSciences Biotechnology, 5(1), 25, Fig. 2.17, 2016; Starmach, Polish Polar Research, 16: 125, Fig. 3.20, 1995; = *Oscillatoria agardhii* Gomont, Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 56; Prescott, 1962, Algae of the Western Great Lakes Area, 484, pl. 108, Fig. 15 and 16.

Trichomes are straight and solitary, free floating, isopolar (both poles with the same morphology); slightly constricted at the crosswalls; apical cells not attenuated, not capitated and without calyptra; cells blue-green in color, 1-2 µm long

Table 1. List of the collection sites showing the coordinates determined by GPS.

| Sampling Site No. | Place of Collection | Global Positioning System (GPS) Location | |
|-------------------|--|--|-------------------|
| | | Latitude | Longitude |
| 1 | University of the Philippine Los Baños (UPLB) Science Park, College, Laguna, Philippines | 14° 9' 11.84" N | 121° 15' 33.62" E |
| 2 | Barangay Maahas, Los Baños, Laguna, Philippines | 14° 10' 33.73" N | 121° 15' 41.75" E |
| 3 | Philippine Rice Research Institute (PhilRice), UPLB Substation, College, Laguna, Philippines | 14° 9' 40.66" N | 121° 14' 48.03" E |

Dichotomous Key

1. Cells without membrane-bound organelles 2
 1. Cells with membrane-bound organelles..... 9
2. Heterocytes and akinete present 3
 2. Heterocytes and akinete absent 4
3. Filamentous without true branching..... *Nostoc commune*
 3. Filamentous exhibiting true branching..... *Hapalosiphon welwitschii*
4. Trichomes without a sheath..... 5
 4. Trichomes with a sheath 8
5. Trichomes broad, 7-11 µm diameter..... *Oscillatoria proboscidea*
 5. Trichomes narrower, 1-5 µm diameter..... 6
6. Trichomes slightly yellowish green in color..... *Kamptonema chlorinum*
 6. Trichomes blue green in color..... 7
7. Trichomes are slightly constricted at the crosswall *Planktothrix agardhii*
 7. Trichomes are distinctly constricted at the crosswall *Phormidium minnesotense*
8. Trichomes (2 µm broad) are slightly curled up *Leptolyngbya lagerheimii*
 8. Trichomes (2 µm broad) are straight..... *Leptolyngbya tenuis*
9. Unicellular or colonial, reproduction by autospores, zoospores or isogametes 10
 9. Filamentous, reproduction by fragmentation and formation
 of zoospores..... *Klebsormidium flaccidum*
10. Unicellular, solitary or in clump..... 11
 10. Colonial with 2-4 cells attached side by side..... 13
11. Cells cylindrical, acute at the ends (spindle-shaped)
 somewhat obtuse apices..... *Chlorolobion braunii*
 11. Cells spherical or ellipsoidal..... 12
12. Cells spherical, size highly variable (12-15 µm in diameter)..... *Chlorococcum infusionum*
 12. Cells spherical or ellipsoidal (1-3 µm in diameter)..... *Chlorella vulgaris*
13. Terminal cells oblong and not curved..... *Scenedesmus quadricauda*
 13. Terminal cells crescent-shaped and curved *Tetradesmus dimorphus*

and 1 µm wide; crosswalls not granulated, end cells rounded.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddle in rice paddies), E.DLR. Arguelles *s.n.* The specimen is similar in cell dimensions to that reported by Prescott (1962) and smaller to that observed by Starmach (1995). Found as a blackish crust on moist soil surface associated with other filamentous cyanobacteria.

Genus: *Oscillatoria* Vaucher ex Gomont

1. *Oscillatoria proboscidea* Gomont

Pl. I Fig. 2

Kesarwani, et al., Phytos, 45 (1), 26, pl. 3, Fig. 21 and Fig. 36, 2015; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 64; Velasquez, Philippine Journal of Science, 91(3): 287, pl. 1. Fig. 15, 1962; Desikachary, 1959, Cyanophyta, p. 211, pl. 38, fig.9.

Trichomes are scattered and solitary, more or less straight, slightly constricted at crosswalls. Trichomes of the species are 7-11 µm broad, cells 1/6 to 1/3 as long as broad, 2-4 µm long. Cells attenuated and not capitated without calyptra; cells dull green to blue-green in color, protoplasm granular; crosswalls are granulated, end cells rounded.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddles in soil with decaying leaves) E.DLR. Arguelles *s.n.* This specimen is different to that observed in India by Kesarwani et al. (2015) by having cells that are heavily granulated at the crosswalls of a filament. Found occurring as bluish green crust on soil surface associated with other filamentous cyanobacteria.

Genus: *Phormidium* Kützing ex Gomont

1. *Phormidium minnesotense* (Tilden) Drouet

Pl. I Fig. 3

Basionym: *Oscillatoria minnesotensis* Tilden

Lashari, et al., Research Journal of Fisheries and Hydrobiology, 4(2): 79, pl. 2. Fig. 20, 2009; Velasquez, Philippine Journal of Science, 91(3): 302, pl. 2. Fig. 42, 1962; = *Oscillatoria minnesotensis*, Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 62; Desikachary, 1959, Cyanophyta, 225, pl. 40, fig.19.

Trichomes are scattered and straight, 2-3 µm broad; distinctly constricted at the cross walls, apex of the trichome straight, or slightly bent not attenuated and capitate; septa is distinct; cells blue green in color, 2 µm long and 1 µm wide; cell contents homogenous and not granulated; apical cells are

rounded and without calyptra.

Specimen: LUZON, Laguna, Los Baños (University of the Philippines Los Baños, UPLB Science Park, water irrigation area), E.DLR. Arguelles *s.n.* This specimen is similar to that observed in lakes and ponds of Sindh in Pakistan by Lashari et al., (2009) by having trichomes that are not attenuated. Found occurring as a bluish green crust on small stones on moist soil surface associated with other green microalgae.

Family: Microcoleaceae

Genus: *Kamptonema* Strunecký, Komárek & Smarda

***Kamptonema chlorinum* (Kützing ex Gomont) Strunecký, Komárek & Smarda**

Pl. I Fig. 4

Basionym: *Oscillatoria chlorina* Kützing ex Gomont

=*Oscillatoria chlorina* Kützing ex Gomont, Alam, et al., American International Journal of Biology, (2), 2, 15, pl. 1. Fig. 16, 2014; Naz, Masud-ul-Hasan, and Shameel, Pakistan Journal of Botany, 36(3): 503, Fig. 11, 2004; Zafaralla, 1998, Microalgae of Taal Lake, 19, pl. 5d; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 58; Pantastico, 1977, Taxonomy of the Freshwater Algae of Laguna de Bay and Vicinity, 53, pl. IV, Fig 5; Velasquez, Philippine Journal of Science, 91(3): 300, pl. 2. Fig. 40, 1962; Desikachary, 1959, Cyanophyta, 215, pl. 40, fig.4; Tilden, 1910, The Myxophyceae of North America and Adjacent Regions, 75, pl. 4, Fig. 22.

Trichomes very thin and yellowish green; filaments are straight or curved, not constricted or slightly constricted at the cross-walls; 3-4 µm broad, sometimes up to 6-7 µm broad, gas-vacuoles absent; cells somewhat longer or shorter than broad, 3.7- 8 µm long, cross-walls not granulated; calyptra absent.

Specimen: LUZON, Laguna, Los Baños (University of the Philippines Los Baños, UPLB Science Park, rice paddies), E.DLR. Arguelles *s.n.* This specimen resembles that of Pantastico (1977) which was collected in Laguna de Bay but is smaller in dimension. It is more similar to the one observed by Zafaralla (1998) in Taal Lake of Batangas, Philippines. Found occurring as yellowish green to bluish green mat on soil surface associated with other filamentous cyanobacteria and green microalgae.

Order: Synechococcales

Family: Leptolyngbyaceae

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

1. *Leptolyngbya lagerheimii* (Gomont ex Gomont)

Anagnostidis & Komárek

Pl. I Fig. 5

Basionym: *Lyngbya lagerheimii* Gomont ex Gomont

Whitton, 2002, Phylum Cyanophyta. In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 68, pl. 10D,M;
= *Lyngbya lagerheimii* Gomont ex Gomont, Desikachary, 1959, Cyanophyta, 290, pl. 48, fig. 6 and pl. 53, Fig. 2.

Trichomes clumped and slightly curled up. Filaments are blue green in color, 2 µm long and 2-3 µm wide, protoplasm not granular, septa not granulated, apical cells rounded without calyptra; end cells rounded; sheaths 2 µm wide, colorless and strong.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddle in rice paddies), E.DLR. Arguelles *s.n.* The specimen is similar to that observed by Whitton (2002) by having trichomes that are slightly curled up without a calyptra. Found occurring as a bluish green crust on submerged rock surface associated with other cyanobacteria.

2. *Leptolyngbya tenuis* (Gomont) Anagnostidis & Komárek
Pl. I Fig. 6

Basionym: *Phormidium tenue* Gomont

Saha et al., Indian Journal of Microbiology, 47: 224, Fig. 16, 2007; = *Phormidium tenue* Gomont, Ortega-Calvo, et al., Nova Hedwigia. 57: 247, pl. 1, Fig. 7, 1993; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 71; Velasquez, Philippine Journal of Science, 91(3): 302, pl. 2. Fig. 44, 1962.

Trichomes expanded and thin; filaments straight or slightly bent, 1-2 µm broad, slightly constricted at the crosswalls; cells blue-green in color, 2 µm long and 4 µm wide, protoplasm not granular, septa not granulated, end cells rounded; calyptra absent.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddle in rice paddies), E.DLR. Arguelles *s.n.* The specimen dimensions as well as cellular characteristics (cells with non-granulated protoplasm and septa) are similar to that observed by Ortega-Calvo et al. (1993) in the cathedral walls of Salamanca and Toledo in Spain. Found occurring as a bluish green crust on soil associated with other cyanobacteria and

green microalgae.

Order: Nostocales

Family: Hapalosiphonaceae

Genus: *Hapalosiphon* Nägeli ex É. Bornet & C. Flahault

1. *Hapalosiphon welwitschii* West & G.S. West **Pl. I Fig. 7**

Arguelles, IAMURE International Journal of Ecology and Conservation, 17:30, pl. I. Fig. 5, 2016; Saha, et al., Indian Journal of Microbiology, 47: 219, Fig. 29, 2007; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 39; Desikachary, 1959, Cyanophyta, 588, pl. 137, Fig. 5.

Uniserial, irregularly arcuate trichomes having true branches, 4-5 µm broad, straight, slightly constricted at the crosswalls, apex is not attenuated and capitated; cells blue-green in color and are cylindrical, 2 µm long and 4 µm wide, protoplasm not granular, septa not granulated, end cells rounded; sheaths thin and colorless; lateral branches short, with similar dimensions as the main filament.

Specimen: LUZON, Laguna, Los Baños (Philippine Rice Research Institute (PhilRice) substation, paddy field), E.DLR. Arguelles *s.n.* The specimen is similar to that observed by Arguelles (2016) on a cement wall of a building found in Los Baños, Laguna (Philippines) by having short lateral branches that are not granulated. Found occurring as a bluish green crust on moist soil slightly submerged in water associated with other cyanobacteria.

Order: Nostocales

Family: Nostocaceae

Genus: *Nostoc* Vaucher ex Bornet & Flahault

1. *Nostoc commune* Vaucher ex Bornet & Flahault
Pl. I Fig. 8

Martinez-Goss, et al., The Philippine Scientist, 51: 78, pl. III, Fig. 5, 2014; Martinez, 1984, A Checklist of Blue-Green Algae of the Philippines, 52; Velasquez, Philippine Journal of Science, 91(3): 342, pl. 8. Fig. 105, 1962; Desikachary, 1959, Cyanophyta, 387, pl. 68, Fig. 3.

Thallus is solid, jelly-like, initially globose, later flattened, undulated and leathery, blue-green, olive green or brown in color; filaments are free-floating and aggregate at maturity in a mass, macroscopically or microscopically; cells are blue-

green, short barrel-shaped or nearly spherical; trichomes constricted at the crosswalls, 4-5 μm broad, not attenuated at the ends; cells 6 μm long, mostly shorter than broad; heterocytes nearly spherical, about 7 μm broad.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddle in rice paddies), E.DLR. Arguelles *s.n.* The trichome is highly constricted and its dimensions are similar to that observed by Martinez-Goss, et al., (2014) in soil from hilly places of Batac City, Ilocos Norte, Philippines. Found occurring as jelly-like and flattened macrocolony on slightly submerged soil surface associated with other cyanobacteria.

Chlorophyta

Class: Chlorophyceae
Order: Chlamydomonadales
Family: Chlorococcaceae

Genus: *Chlorococcum* Meneghini

1. *Chlorococcum infusionum* (Schrank) Meneghini

Pl. I Fig. 9

Synonym: *Chlorococcum humicola* (Nägeli) Rabenhorst
Basionym: *Cystococcus humicola* Nägeli; *Lepra infusionum* Schrank

Arguelles, IAMURE International Journal of Ecology and Conservation, 17: 32, pl. I. Fig. 7, 2016; Samad and Adhikary, Algae, 23(2): 91, pl. 1 Fig. 1., 2008; = *Chlorococcum humicola* (Nägeli) Rabenhorst, 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.

Spherical cells, solitary, sometimes several cells are crowded together to form a cluster, light green to greenish in color; chloroplast nearly covering the entire cells; cells 12-15 μm in diameter.

Specimen: LUZON, Laguna, Los Baños (PhilRice, paddy field), E.DLR. Arguelles *s.n.* The specimen dimensions are similar to that of Pantastico (1977) collected from Laguna de Bay but greater than that observed by Zafaralla (1998) in Taal lake, Batangas, Philippines. Found occurring as a greenish crust on moist soil surface associated with other cyanobacteria.

Order: Sphaeropleales
Family: Scenedesmaceae

Genus: *Scenedesmus* Meyen

1. *Scenedesmus quadricauda* (Turpin) Brébisson Pl. II Fig. 1

Basionym: *Achnanthes quadricauda* Turpin

Arguelles, IAMURE International Journal of Ecology and Conservation, 17:32, pl. I. Fig. 8, 2016; Satpati, et al., Journal of Algal Biomass Utilization. 4 (1): 26, pl. 1, Fig. 4; pl. 5, Fig. 6, 2013; Ortega-Calvo, et al., Nova Hedwigia. 57: 247, pl. 3, Fig. 35, 1993; 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.

Colonies with two or four cells attached side by side, arranged linearly in coenobia; cells spherical or oblong, 3-4 μm long and 5-6 μm wide, with visible pyrenoid; cells parallel with setae; inner cells without spines and terminal poles with two spiny projections, which are straight or curved and with smooth cell wall.

Specimen: LUZON, Laguna, Los Baños (Maahas, puddle in rice paddies), E.DLR. Arguelles *s.n.* This specimen is similar in cell number (usually occurring in colonies with two cells attached side by side) and dimension to that observed by Arguelles (2016) in Los Baños, Laguna (Philippines) but smaller to that observed by Zafaralla (1988) in Taal Lake. Found occurring as a greenish crust on soil surface slightly submerged in water associated with other cyanobacteria.

Genus: *Tetradesmus* G.M. Smith

1. *Tetradesmus dimorphus* (Turpin) M.J. Wynne Pl. II Fig. 2

Synonym: *Scenedesmus dimorphus* (Turpin) Kützing
Basionym: *Achnanthes dimorpha* Turpin

Satpati, et al., Journal of Algal Biomass Utilization. 4 (1): 30, pl. 1, Fig. 5 and pl. 5, Fig. 7; 2013; = *Scenedesmus dimorphus* (Turpin) Kützing, Pantastico, 1977, Taxonomy of the Freshwater Algae of Laguna de Bay and Vicinity, 117, pl. IX, fig 6; Prescott, 1962, Algae

of the Western Great Lakes Area, 277, pl 63, Figs 8, 9.

Colonies composed of four to eight spindle-shaped cells aligned in a single or alternative chain; cells 13 µm long and 7 µm wide; inner vegetative cells with straight and sharp apices; terminal cells crescent-shaped and are strongly curved, with acute apices and a smooth cell wall.

Specimen: LUZON, Laguna, Los Baños (University of the Philippines Los Baños, UPLB Science Park, water irrigation area), E.DLR. Arguelles *s.n.* This specimen is similar in cell number (four to eight spindle-shaped cells) and dimension to the specimen observed by Satpati et. al., (2013) in Matla river of the Indian Sundarbans mangrove forest. Found occurring as a greenish to bluish green crust on submerged rock surfaces associated with other cyanobacteria.

Order: Sphaeropleales

Family: Selenastraceae

Genus: *Chlorolobion* Korshikov

1. *Chlorolobion braunii* (Nägeli) Komárek **Pl. II Fig. 3**

Synonyms: *Ankistrodesmus braunii* (Nägeli) Lemmermann; *Monoraphidium braunii* (Nägeli) Komárková-Legnerová
Basionym: *Rhaphidium braunii* Nägeli

John and Tsarenko, 2002, Order Chlorococcales. In: The Freshwater Algal Flora of the British Isles. An Identification Guide to Freshwater and Terrestrial Algae, 338, pl. 90c; Starmach, 1995. Polish Polar Research, 16: 144, Fig. 9:68.

Cells cylindrical, acute at the ends (spindle-shaped) somewhat obtuse apices, straight or rarely slightly asymmetrical, 12-16 µm long, 2-2.5 µm wide; free-living; solitary and sometimes found in groups; chloroplasts covering 2/3 of the inner surface and are centrally located with a pyrenoid; 2-8 autospores are being produced in each sporangium and are being released by rupture of the mother cells.

A new record for the Philippines.

Specimen: LUZON, Laguna, Los Baños (University of the Philippines Los Baños, UPLB Science Park, rice paddies), E.DLR. Arguelles *s.n.* This specimen resembles that of Starmach (1995) but is smaller in dimension. It is more similar to the one observed by John and Tsarenko, (2002) in the British Isles. Found occurring as a greenish crust on soil surface associated with other filamentous cyanobacteria.

Class: Trebouxiophyceae

Order: Chlorellales

Family: Chlorellaceae

Genus: *Chlorella* Beyerinck [Beijerinck]

1. *Chlorella vulgaris* Beyerinck [Beijerinck] **Pl. II Fig. 4**

Synonym: *Chlorella pyrenoidosa* var. *duplex* (Kützing) West

Satpati, et al., Journal Algal Biomass Utilization, 4 (1): 30, pl. 1, Fig. 1 and pl. 5, Fig. 2, 2013; Sethi, et al., Phycos 42 (1): 3, Pl. 3, fig. 27, 2012; 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.

Spherical cells; thin cell wall; chloroplast is single, parietal and cup-shaped with only one pyrenoid occupying the basal zone of the cell; young cells either ellipsoidal or spherical, 1.5 x 2.5 µm or 3 µm in diameter; cell reproduction is by formation of 2 or 4 ellipsoidal or hemispherical autospores of the same size, set free by the rupture of mother cell wall.

Specimen: LUZON, Laguna, Los Baños (PhilRice, paddy field), E.DLR. Arguelles *s.n.* The specimen is similar to that observed by Sethi, et. al. (2012) in soil crusts from rice fields of Gazalbad, Surada, Ganjam, and Orissa in India by having cells that are spherical with single, parietal, cup-shaped chloroplasts. Found occurring as a greenish mat on soil surface associated with other filamentous cyanobacteria.

Charophyta

Class: Klebsormidiophyceae

Order: Klebsormidiales

Family: Klebsormidiaceae

Genus: *Klebsormidium* Silva, Mattox & Blackwell

1. *Klebsormidium flaccidum* (Kützing) Silva, Mattox & Blackwell **Pl. II Fig. 5**

Basionym: *Ulothrix flaccida* Kützing

Mikhailyuk, et al., Journal of Phycology. 755, fig. 2a-f, 2015; Flechtner, et al., Western North American Naturalist. 410, fig. 5, 2008; Ortega-Calvo, et al., Nova Hedwigia. 57: 246, pl. 3, fig. 32, 1993; = *Ulothrix flaccida* Kützing, Pantastico, 1977, Taxonomy of the Freshwater

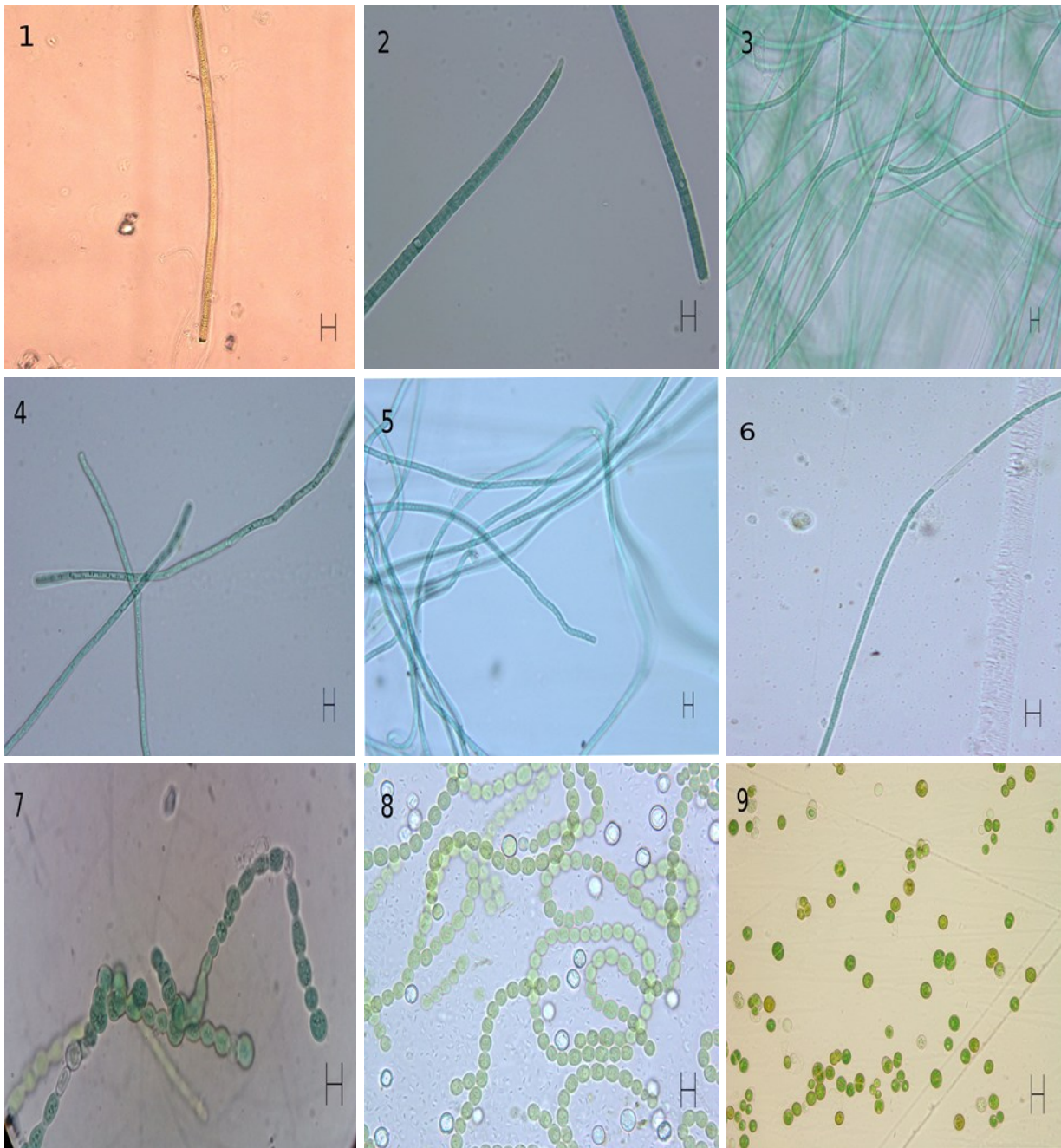


Plate I. (1) *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek, (2) *Oscillatoria proboscidea* Gomont, (3) *Phormidium minnesotense* (Tilden) Drouet, (4) *Kamptonema chlorinum* (Meneghini ex Gomont) Strunecký, Komárek & J.Smarda (5) *Leptolyngbya lagerheimii* (Gomont ex Gomont) Anagnostidis & Komárek, (6) *Leptolyngbya tenuis* (Gomont) Anagnostidis & Komárek, (7) *Hapalosiphon welwitschii* West & G.S.West, (8) *Nostoc commune* Vaucher ex Bornet & Flahault, (9) *Chlorococcum infusionum* (Schrank) Meneghini. All scale bars = 10 µm.

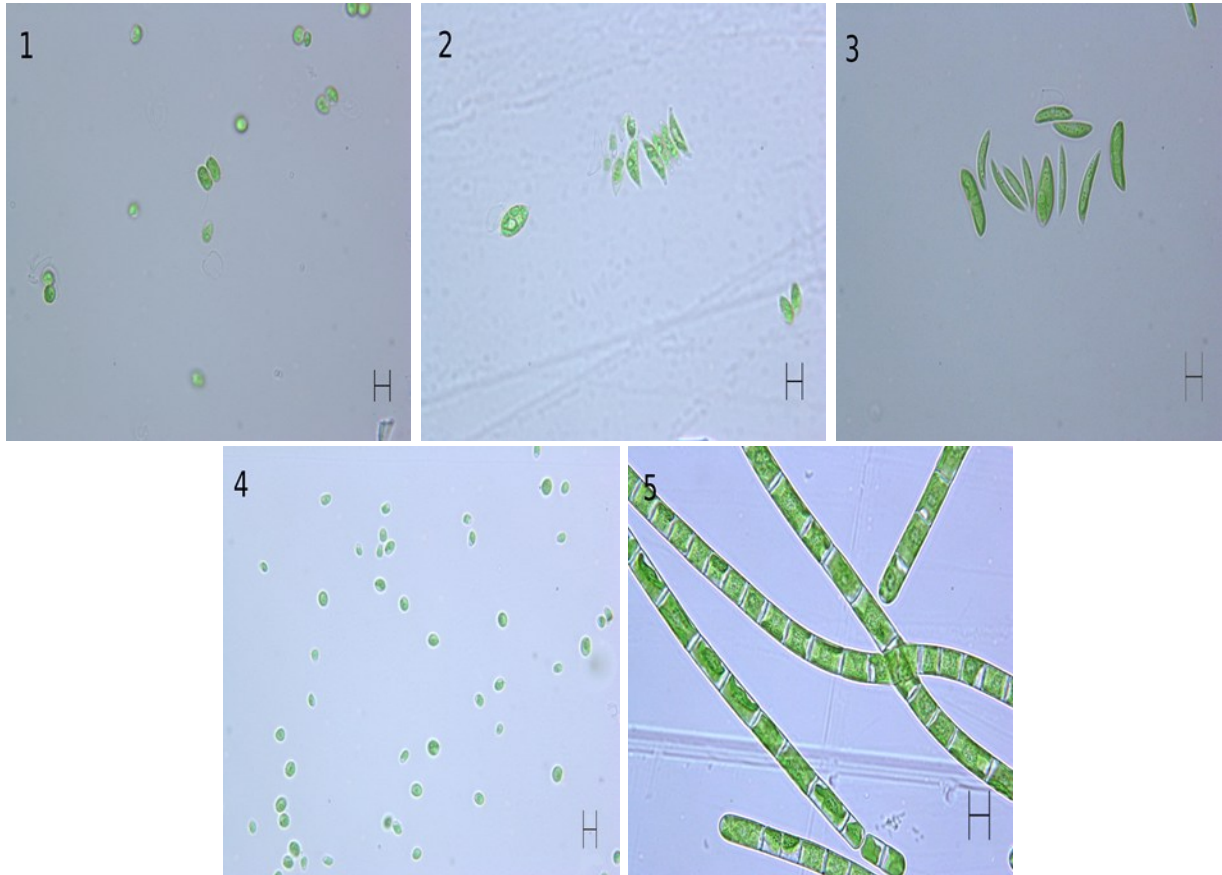


Plate II. (1) *Scenedesmus quadricauda* (Turpin) Brébisson, (2) *Tetradesmus dimorphus* (Turpin) M.J. Wynne, (3) *Chlorolobion braunii* (Nägeli) Komárek, (4) *Chlorella vulgaris* Beyerinck (Beijerinck), (5) *Klebsormidium flaccidum* (Kützing) P.C.Silva, K.R.Mattox & W.H.Blackwell . All scale bars = 10 μ m.

Algae of Laguna de Bay and Vicinity, 143, pl. XI, fig 1.

Filaments are usually long with tendency to divide and disintegrate into small fragments, not or slightly constricted; cells cylindrical or have rounded ends, 15 µm long and 7 µm wide; cell wall moderately thickened; parietal band-shaped chloroplasts occupying 1/2–2/3 of the cell inner surface and periphery, having smooth margins and one large pyrenoid. In liquid media, forming a surface hydrorepellent layer and submerged tufts; on agar, forming irregular and undulating colonies.

Specimen: LUZON, Laguna, Los Baños (University of the Philippines Los Baños, UPLB Science Park, rice paddies), E.DLR. Arguelles *s.n.* This specimen possesses filaments that are long and slightly constricted which is similar to the specimen observed by Pantastico (1977) in Laguna de bay and its vicinities. Found occurring as a greenish mat on rock surface associated with other filamentous cyanobacteria and green microalgae.

Diverse collection of microalgae and cyanobacteria on biological crusts from soils of paddy fields in Los Baños, Laguna Philippines were observed in the three sampling sites. A total of 14 species (3 unicellular, 2 colonial, 7 non-heterocytous filamentous and 2 heterocytous filamentous) were recorded and described in detail including their habitats and place of collection. The present collection represents 9 orders, 10 families, 13 genera and 14 species based on recent combined taxonomic systems (Anagnostidis & Komárek, 1990; Desikachary, 1959; Komárek & Anagnostidis, 1989; 1999). In the present study, there was a dominance of members of the Cyanobacteria (57%), followed by Chlorophyceae (29%), Klebsormidiophyceae (7%) and Trebouxiophyceae (7%). This study recorded for the first time in the Philippines the occurrence of *Chlorolobion braunii* (Nägeli) Komárek a rare green microalga first collected from the paddy fields of the UPLB Science Park. In addition, new names such as *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek, *Kamptonema chlorinum* (Kützing ex Gomont) Strunecký, Komárek & J. Smarda and *Tetrademus dimorphus* (Turpin) M.J. Wynne are used in this study in favor of their former names *Oscillatoria agardhii* Gomont, *Oscillatoria chlorina* Kützing ex Gomont and *Scenedesmus dimorphus* (Turpin) Kützing, respectively, as a result of current molecular and cytomorphological studies. The algal groups observed on biological crusts found in Los Baños, Laguna rice fields are similar to those in other paddy fields ecosystems found in other countries (Irissari, et al., 2001; Pereira, et al., 2005). The results of this study showed that cyanobacteria and microalgae colonize a wide spectrum of substrata under optimal growth and environmental conditions.

The distribution of heterocytous cyanobacterial forms in paddy fields contributes to a certain extent in increasing the nitrogen budget in soils, thus contributing to the management of soil fertility in support of sustainable agriculture. The utilization of molecular techniques in identifying these algal species gives a more precise taxonomic delimitation and allows a clearer understanding of the diversity of microalgae and cyanobacteria in biological soil crusts of paddy field habitats.

CONCLUSION

The present study documented a collection of microalgae and cyanobacteria in biological crusts found in paddy fields of Los Baños, Laguna. Systematic analysis of these genetic resources reported taxonomic records that are considered important basal information in enriching the knowledge about the diversity, ecology and habitat distribution of cyanobacteria and microalgae in the Philippines.

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