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Research Article

Twenty new Records of Algae in some Springs around Safeen Mountain Area

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Abstract: This study was carried out in 2015-2016 within Erbil governorate. A total of 151 algal species were identified from 8 divisions, 9 classes, 24 orders, 37 families and 72 genera. The majority of species were belonged to Chlorophyta with 68 species (45.033%), followed by Cyanophyta with 46 species (30.463%), Euglenophyta with 18 species (11.92%), Chrysophyta with 12 species (7.947%), Charophyta with 3 species occupied (1.987%), Rhodophyta with 2 species (1.32%) and each of Cryptophyta and Pyrrophyta with one species occupied (0.662%). Among them, 20 species and 6 genera are new records to Iraqi flora viz.: *Komvophoron constrictum*, *Nephrocytium agardhianum*, *Lepocinclis fusiformis*, *Petalomonas* sp., *Heteronema acus*, *Peranema trichophorum* and *Chilomonas paramecium* were recorded as new to the Iraqi algal flora.

Keywords: Species, Non-diatom algae, Phytoplanktonic and Tychoplanktonic algae, Epilithic, Epipelic.

1. Introduction

Algae are an important component of aquatic ecosystems like springs, streams, rivers, ponds, and lakes because they reflect the health of their environment through their distribution, abundance, and productivity (Stevenson *et al.*, 1996). Algae are the simplest but ancient photosynthetic plants, play an important role in ecology and molecular phylogeny. They stand at the lowest step in the evolution of life and have enormous economic implications. Recently, algae are using widely as an alternative source for human foods, plant fertilizers, and biodiesels and for antibiotics. Their importance is also increasing as tools for researchers in nanotechnology, space biology, genetics and other fields of applied sciences (Shrestha *et al.*, 2013).

Iraqi algologists have spent great efforts on algal identification and distribution (Kolbe and Krieger, 1942; AL-Barzingy, 1995; Goran, 2006; Aziz, 1997; Aziz and Maulood, 1999 and 2002; Bapeer, 2004; Aziz *et al.*, 2014; Sdiq, 2015; Aziz and Rasoul, 2016). Finally, in the checklist of algal flora of Kurdistan reviewed by Aziz (2011) and by Muhammed (2016). But a complete list of algal identification, in general, is not yet completed (Al-Mahdawi and Ali, 2014). Therefore, this study was carried out to know the composition of non-diatom algal communities in spring around Safeen mountain area and to further contribution the algal flora of Iraq and Iraqi Kurdistan region.

2. Materials and methods

2.1 Site description

Safeen mountain belong to Shaqlawa district is about 32 km northeast of Erbil city which situated in northeast of Iraq (Iraqi Kurdistan region), extended from latitude 36° 42′ to 360 23′ N and longitude 44° 29′ to 44° 08′ E. The climate, soil, geology, geography and springs of the Erbil, Kurdistan and the study area are previously reported in detail (Guest, 1966; Aziz 1997; Abdulwahid, 2008; Rasoul, 2013 and Hama *et al.*, 2014).

2.2 Algal Collection

Phytoplanktonic and Tychoplanktonic algae including epilithic, epipelic and epiphytic in studied spring waters were collected as previously suggested and applied (Smith, 1959; Desikachary, 1959; Prescott, 1968; 1970 and 1975; Bold and Wynne (1985); Aziz, 1997; Wehr and Sheath, 2003; Komarek and Anagnostidis, 2005; Aziz, 2006 and 2008 and John *et al.*, 2011 and Rasuol, 2013).

2.3 Algal preservation

Samples of non-diatom algae, which collected in vials in each station were preserved in Lugol's solution

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prepared as described by Bony (1975), added 0.7ml of solution to 100ml of sample and formalin solution (4-10%) was used for algal preservation by adding 3-4 drops to 100ml of sample (Prescott, 1968; Ibrahim, 1980; Aziz, 1997 and Rasoul, 2013).

2.4 Identification of Algae

Flagellated forms of phytoplankton and epipelic algae were identified before fixation as soon as possible to avoid the loss of taxonomic characters. Non-diatom algae were using the references of Smith (1950), Desikachary (1959), Prescott (1968, 1970 and 1975), Bold and Wynne (1985), Komarek and Anagnostidis (2005), Wehr and Sheath (2003), and John *et al*., (2011). The classification of algal taxa was done according to Bold and Wynne (1985). The new records were reported, according to the last checklist of Aziz, 2011; Maulood *et al*., 2013; Aziz, *et al*., 2014 and Aziz and Rasoul, 2016).

3. Results and Discussion

In the present study a total of 151 taxa identified, among them 16 genera with 46 species belonged to Cyanophyta, 35 genera with 68 species belonged to Chlorophyta, 2 genera with 3 species belonged to Charophyta, 8 genera with 18 species belonged to Euglenophyta, 7 genera with 12 species belonged to Chrysophyta, 2 genera with two species belonged to Rhodophyta, and each of Pyrrophyta and Cryptophyta with 1 genera and 1 species.

The majority of the identified species were noted at site 6 with 45 species, most likely due to low discharge of the spring (Ibrahim, 1981 and Abdul Jabar, 1981) Also, the statement is supported by the findings Aziz (1997), while site 9 had the lowest number of species, most likely due to less available area, poor water quality, high turbidity in comparison to the other 9 sites, relatively fewer numbers of species are found in polluted water than clear water (Shekha, 2009).

In the present study, the maximum species number belonged to phytoplanktonic algal flora (97 species), then epilithic (60 species), and the specified number of epipelic algal community came after epilithic algal community (57 species), also Rasuol (2013) reported that the maximum species number belonged to Phytoplanktonic community, more than those belonging to epipelic algal flora. Meanwhile, Aziz (1997); Aziz (2006 and 2008) reported that the species number belonged to epilithic algal community was more than those belonging to planktonic or epipelic communities in Rwandiz river (Ganjo and Aziz, 1999).

Cyanophyta are the second and subdominant group represented by 46 species belonged to 16 genera with the percentage of 30.463 of the total number of recorded algal taxa. Generally, Cyanophyta were found in almost all sites, Cyanophyta are successful in a wide range of environments because they have a versatile metabolism (Hamadamen, 2015). Members of Oscillatoriales were the most commonly encountered Cyanophyta, and the most abundant genus were *Oscillatoria* and *Phormidium*. The same situation was observed by Aziz (1997), Bilbas (2004), Zewayee (2011) and Aziz *et al*., 2014. The species of *Chroococcus*, *Merismopedia, Lyngbya, Oscillatoria*, and *Phormidium* were very common in planktonic, epilithic and epipelic communities (Abdulwahid, 2008; Aziz and Abdulwahid, 2012).

Chlorophyta were found to be dominating represented by 35 genera and 68 species consisting of 45.033% of the total algal community. The high abundance of Chlorophyta indicates more productive water (Boyd and Tucker, 1998; Rasoul, 2013; Aziz and Rasoul, 2016).

Species of *Oedogonium* observed at the site (2, 3, 6, 8 and 9) which characterized by high alkalinity, generally, these species grow better in alkaline systems Stevenson *et al.*, (1996). *Cladophora* is a typical species in hard water (Prescott, 1970), it is found in epilithic community; *Cladophora glomerata* widespread especially in mesotrophic alkaline waters (Bapeer, 2004). While species of *Gloeocystis*, *Aphanochate*, *Chaetophora, Protoderma,* and *Leptosira* were usually found as epiphytic on other filamentous algae or plant leaves, this comes in accordance with (Abdulwahid, 2008), it is found in almost all studies. Among the Chlorophyta the species of *Spirogyra* was the second dominant species after *Cosmarium* sites, *Spirogyra* is ubiquitous in freshwater ecosystems on nearly every continent, and often forms large mats on the surface of stagnant pools or slow-moving water (Hinton and Maulood, 1980; Drummond, 2005; Zewayee, 2011).

Chara sp. was found in most of the sites, on muddy, or sandy, or sediment in freshwater ecosystems, Charophytes are the only macroalgae known to have rhizoids that are capable of limiting nutrients uptake from the sediments, a feature that allies them closely with terrestrial bryophytes (Stevenson *et al.*, 1996). Also, *Chara* sp. recorded in spring water resources elsewhere by some former researcher, Aziz (1997); Bilbas (2004); Abdulwahid, (2008).

Euglenophytes algae are cosmopolitan, inhabiting very wide range of water environments Kim *et al*., (1998). In this study, almost all of Euglenophyta species were found in epipelic communities may be due to rich in organic matter, while some species were found in both epipelic and planktonic communities (Kim, *et al*., 1998; Rasoul, 2013).

The freshwater red algae were found in the clean moderate water quality (Aziz, 2007). In the present study, only two species *Audouinella hermannii* (at sites 2, 4 and 7) and *Batrachospermum moniliforme* (site 7) were recorded. The same species were recorded Maulood and Hinton (1978a) in Sarchnar spring, Aziz (1997) in Harir and Sarta spring, Bilbas (2004) in Shekhi Balakian and Azadi springs and Zewayee (2011) and Aziz (2014) recorded unicellular red alga

Porphyridium purpureum in Gali-Ali Bag valley springs.

4. Descriptions of algal new records

***Komvophoron constrictum* Anagnostidis & Komárek, 1988 (Plate 1; Fig. 1)**
Trichomes solitary, straight or slightly bent, motile, deeply constricted at cross-walls, 3-7m wide, cells bright, blue-green, barrel-shaped, rounded ends, constricted at the middle. 2-5m, separated by hyaline cross-walls, (Komárek and Anagnostidis, 2005; Fig. 462, p. 333).

***Nephrocytium agardhianum* Naeg., 1849 (Plate 1; Fig. 2)**
Coenobia usually of 4 or 8 spirally or irregularly arranged cells, embedded within mucilage, often asymmetrical ovoid, 40-90μm in size, cells elongate, somewhat kidney-shaped and with rounded apices (John *et al*., 2011; pl. 108b, p. 491).

***Tetrastrum triangulare* (Chodat) Komárek, 1974 (Plate 1; Fig. 3)**
Coenobia about 7-15μm across, rhomboidal or more rarely quadrate in outline, cells 2-8μm in width, more or less triangular (John *et al*., 2011; pl. 110E, p. 438).

***Protoderma frequens* (Butcher) Printz, 1964 (Plate 1; Fig. 4)**
Thallus is circular, elongate or lobed, enclosed in a thin mucilaginous envelope, cells in a center are more or less angular, 4-5μm wide, irregularly grouped and often, cells toward margin 4-5μm wide, 6-9μm long. (John *et al*., 2011; pl. 133c, p. 543).

***Spirogyra articulata* Trans., (Plate 1; Fig. 5)**
Cells 24-28 × 300-600μm, with replicate end walls; chloroplast 1 with 3-8 turns. Zygospores unknown reproducing by ellipsoid aplanospores, 36-40 × 60-88μm; median spore wall yellow, smooth; sporangia cylindric, enlarged or slightly inflated, sometimes straight, often bowed or bent toward the middle. It is recorded at site 9 (Randhawa, 1959, Fig. 441, p. 388).

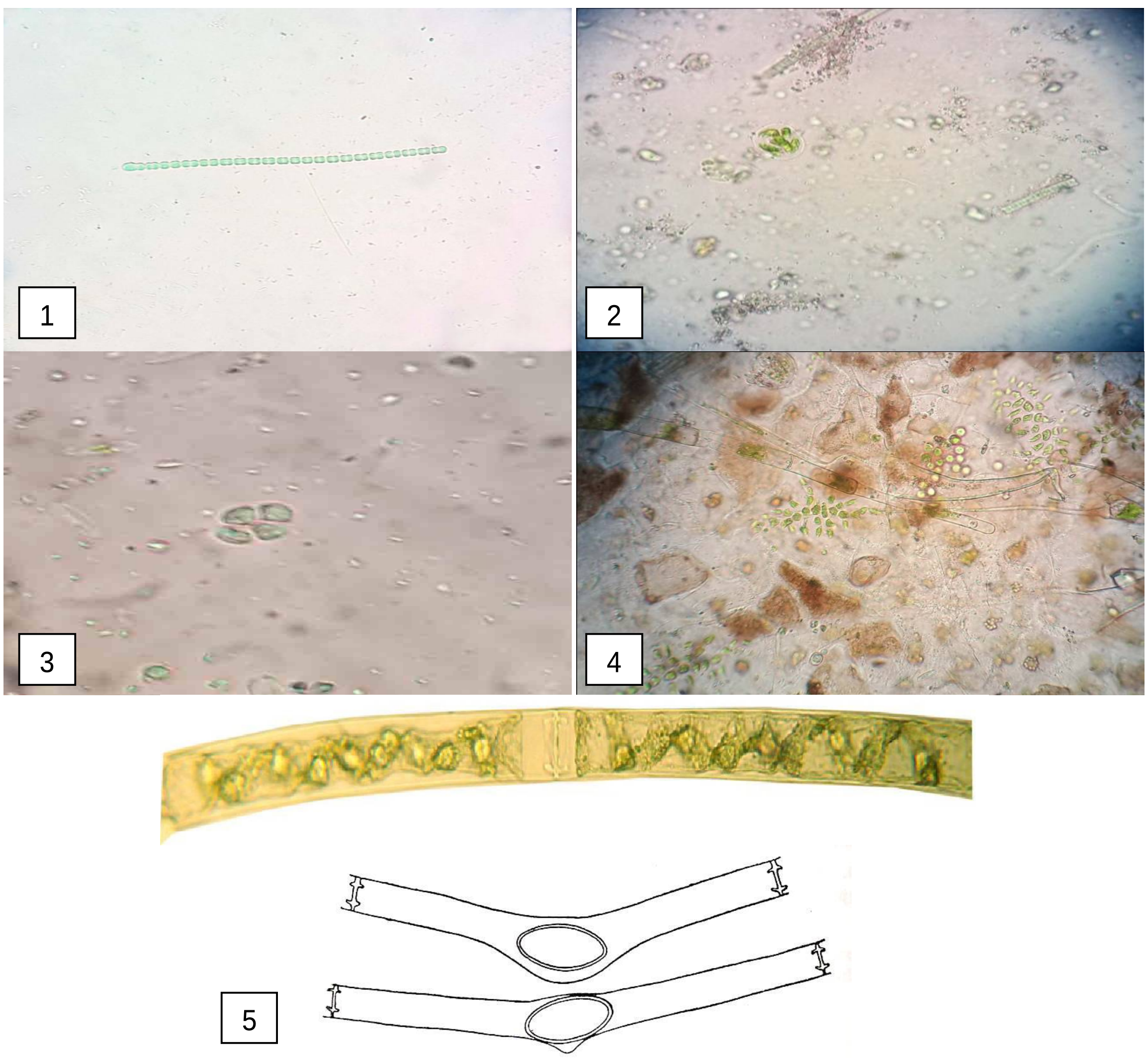

Plate (1): Fig. 1. *Komvophoron constrictum*, Fig. 2. *Nephrocytium agardhianum*, Fig. 3. *Tetrastrum triangulare*, Fig. 4. *Protoderma frequens*, Fig. 5. *Spirogyra articulate*. (40x).

Cosmarium pericymatium **Nordstedt, 1875 (Plate 2; Fig. 1)**
Cells 25-32µm wide, 40.8-50.8µm long, sinus shallow and widely open, semi-cells subcircular with some 13-16 undulations, walls thick, with distinct pores making pore channels at margins (John *et al.*, 2011; pl. 159h, p. 660).

Cosmarium sportella **Brébisson, 1849 (Plate 2; Fig. 2)**
Cells 33-46µm wide, 45-50µm long, sinus deep, narrow, linear, semi-cells truncate-pyramidate, basal angle rounded, upper margins very slightly retuse, upper angles obtuse, apex broad (John *et al*., 2011; pl. 163, p. 671).

Staurastrum lapponicum **(Schm.) Gronb., 1926 (Plate 2; Fig. 3 & 4)**
Cells radiate 30-42µm wide, 29-42µm long, semi-elliptical, dorsal and ventral margins are curvature, angles broadly rounded apices convex, and walls with small granules. Vertical view triangular, with broadly rounded angles and concave sides, with 3-4 marginal rows of granules, scattered in center of apices (John *et al*., 2011; pl. 171d, p. 709).

Lepocinclis fusiformis **(Carter) Lemm., (Plate 2; Fig. 5)**
Cells 15-32.5µm wide, 15-42.5µm long, lemon shaped, widely oval, anterior end conically narrowing and concave at apex, posterior end narrowing to a short, conical tail-piece, pellicle with left-handed striae, colorless to yellow, chloroplasts minute and numerous. Recorded at sites 1, 7 and 10 (John *et al.*, 2011; pl. 50i, p. 198).

Astasia curvata **(G.A. Klebs), 1893 (Plate 2; Fig. 6)**
Cells solitary, colorless, osmotrophs, Cells 5-8µm wide, (32-)40-60µm long, spindle-shaped or cylindrical, slightly-flattened, ribbon-shaped, twisted several times, when strongly contracted whole cell curved and almost semi-circular, pellicle slightly spirally striated, flagellum shorter than the cell length (John *et al.*, 2011; pl. 59u,v, p. 230).

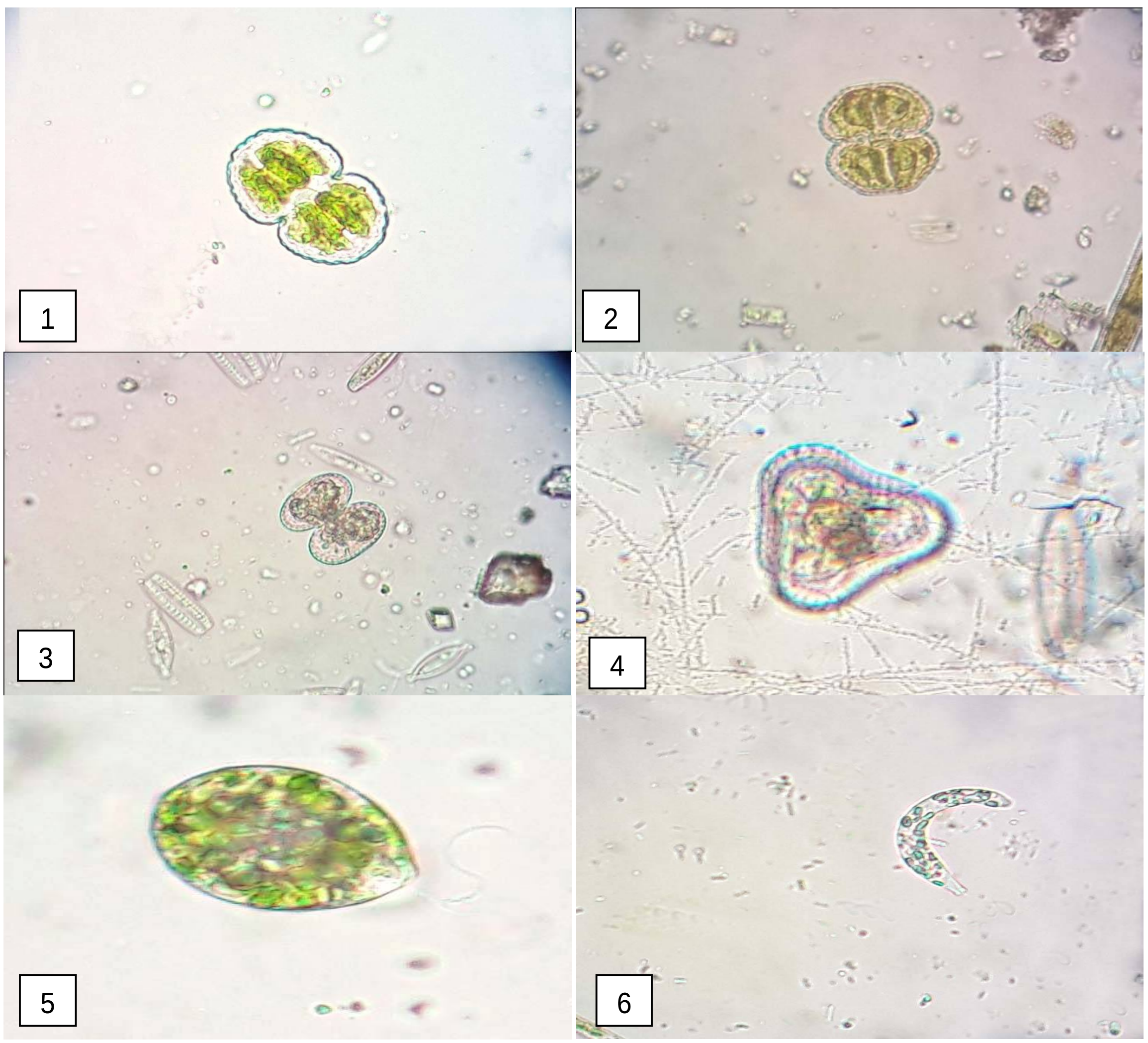

Plate (2): Fig. 1. *Cosmarium pericymatium*, Fig. 2. *Cosmarium sportella*, Figs. 3 & 4. *Staurastrum lapponicum*, Fig. 5. *Lepocinclis fusiformis*, Fig. 6. *Astasia curvata*, (40x).

Astasia klebsii **Lemmermann, 1910 (Plate 3; Fig. 1)**
Cells 10.5-15 (-20)µm wide, 42-55µm long, often twisted several times around longitudinal axis, when swimming the spiral twisting gradually disappears and cell becomes straight and club-shaped, anterior end widely protruded and truncate, euglenoid and creeping movements frequent flagellum about length of cell (John *et al*., 2011; pl. 58h, i, p. 229).

Anisonema acinus **Dujardin, 1841 (Plate 3; Fig. 2)**
Cells ellipsoid-ovate, flattened, 16-19 x 27-30µm, rigid, with one longitudinal furrow, anterior end rounded and slightly dented, posterior end widely rounded, flagella unequal, shorter as long as cell and longer 2-3 times cell length (John *et al*., 2011, p. 234).

Petalomonas **sp. F. Stein, 1859 (Plate 3; Fig. 3)**
Cells colorless, rigid, flattened, obovate, oval, elliptical or triangular, usually symmetric, sometimes with various extensions at posterior end, backside convex, ventral side flat, one flagellum (John *et al*., 2011, p. 236).

Heteronema acus **(Ehr.) F. Stein, 1878 (Plate 3; Fig. 4)**
Cells 7-10µm wide, 45-70 (-96)µm long, spindle-shaped, at the anterior end narrowed and obliquely truncate, strongly Euglenoid movement, gullet flask-shaped, pellicle smooth or striated (John *et al*., 2011, p. 238).

Peranema trichophorum **(Ehr.) F. Stein, 1859 (Plate 3; Fig. 5)**
Cells 10-16 (--25)µm wide, 31-78 (-80)µm long, euglenoid movement violent, longitudinally spindle-shaped or almost cylindrical, flattened anterior end narrowed, posterior end usually slightly narrowed and rounded at end in stationary cells, pellicle thick (John *et al*., 2011, p. 238).

Mischococcus confervicola **Nägeli, 1849 (Plate 3; Fig. 6)**
Plants attached, dichotomously branched, mucilaginous tube enclosing or bearing spherical cells at the dichotomies or ends, with cells single or in 2 or 4. Cells spherical 5-10µm in diameter, walls firm, chloroplasts 1 or 2 (John *et al*., 2011; pl. 86F, p. 329).

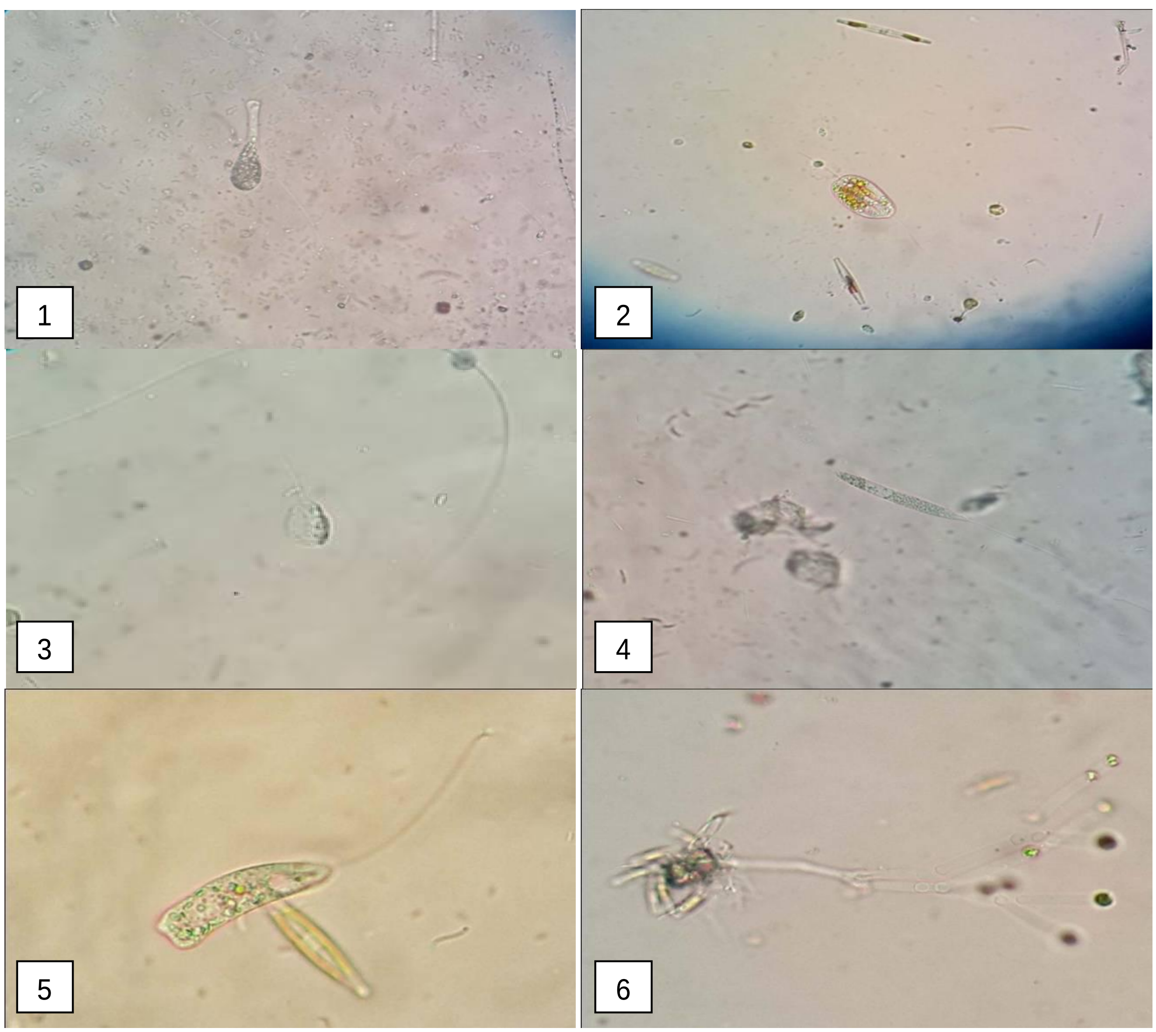

Plate (3): Fig. 1. *Astasia klebsii*, Fig. 2. *Anisonema acinus*, Fig. 3. *Petalomonas* sp., Fig. 4. *Heteronema acus*, Fig. 5. *Peranema trichophorum*, Fig. 6. *Mischococcus confervicola*. (40x).

***Ophiocytium arbusculum* (A. Braun) Rab., 1868 (Plate 4; Fig. 1)**

Cells epiphytic, colonial, consisting of an empty cylindrical mother cell wall; straight or curved, 3-8µm wide, up to 100µm long, attached at base by a short stalk and about whose apex similar branched daughter, cells are arched (John *et al*., 2011; pl. 88a, p. 330).

***Ophiocytium desertum* Printz (Plate 4; Fig. 2)**

Cells cylindrical, attached by a short, relatively stout stalk, and by a thick adhesive disk, epiphytic on filamentous algae, cells rounded at the anterior end, without a spine, 9-4µm wide, 30-60µm long (Prescott, 1970, P. 364).

***Vaucheria cruciata* (Vauch.) de Candolle (Plate 4; Fig. 3)**

Filaments 17-55µm wide, monoecious, antheridia 13-36 x 13-24µm, Oogonia 39-60 x 43-79µm, ovoid or spherical, borne on short stalks lateral to the antheridial stalk, erect or slightly inclined to one side, Oospore 43-56 x 49-77µm (John *et al*., 2011; pl. 91c, p. 338).

***Chilomonas paramaecium* Ehr., 1838 (Plate 4; Fig. 4)**

Cells 15-30µm long and 5-10µm wide, varied in shape from elongate-ellipsoid to ovate-cylindrical, rounded at anterior end and narrower at posterior end, flagella equal or subequal, from one half to length of cell, rarely considerably longer, contractile vacuole often present in anterior end (John *et al*., 2011; pl. 62a, p. 244).

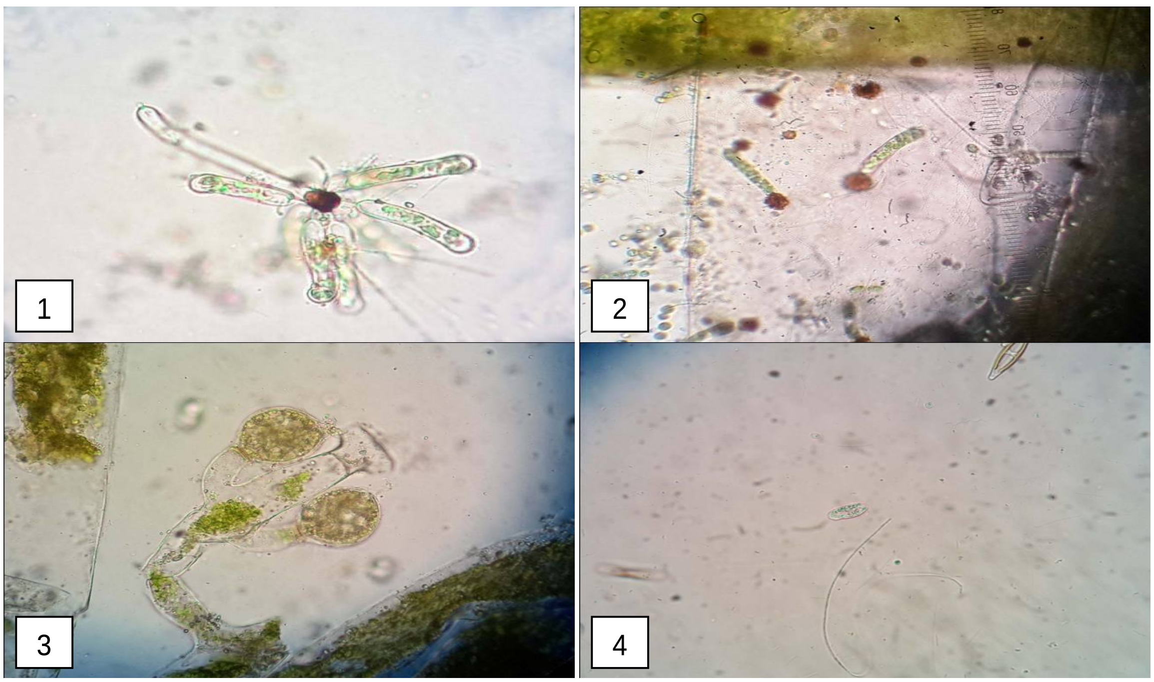

Plate (4): Fig. 1. *Ophiocytium arbusculum*, Fig. 2. *Ophiocytium desertum*, Fig. 3. *Vaucheria cruciata,* Fig. 4. *Chilomonas paramaecium*. (40x).

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