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Algal study in the springs and streams from Shaqlawa district, Erbil Province, Iraq II- Zygnematales

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Abstract
Zygnematales an order of green algae in Shaqlawa District Erbil, Kurdistan Region, Iraq, has been studied in eighteen sites, distributed between twelve springs and six along the streams within Shaqlawa district from September2019 to August2020. A total of 116 species belonging to 9 genera were identified. The most dominant genera included ***Spirogyra*** and ***Cosmarium*** (31, 30) taxa respectively. Out of them, 30 species were recorded for the first time in Iraq. Newly found genera included one species each for ***Cylindrocystis, Debarya***, ***Hallasia*** and ***Staurastrum,*** nine species belonged *to* ***Mougeotia***, three species returned to ***Closterium,*** and fourteen genera were related to ***Cosmarium*** .Growth of Zygnemataceae and Desmids increased in the summer than during the winter season. A brief description as well as the measurement is given for each species.

Keywords: Algal, Springs, Streams, Erbil, Province, Zygnematales

دراسة الطحالب في العيون والجداول من قضاء شقلاوة ، محافظة أربيل/ العراق

Zygnematales-2

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الخلاصه
تمت الدراسة على رتبة زيكمينتالس وهي من الطحالب الخضراء في قضاء شقلاوة–أربيل، أقليم كردستان العراق في ثمانية عشر موقعًا موزعة على اثني عشر ينبوعًا وستة على طول مجري القناة من سبتمبر 2019 إلى أغسطس 2020. تم تشخيص ما مجموعه 116 نوعًا تنتمي إلى 9 أجناس. من الأجناس السائدة تشمل سبيروجيرا وكوسماريم (30و31) نوع لكل واحد منهم على التوالي .خارج من ذلك ، تم تسجيل 30 نوعا لأول مرة في العراق . الاجناس المشخصة حديثا تشمل نوع واحد لكل جنس وهي كالاتي سيلندروسستس ، ديباريا ، هلاسيا ، وستاروسترم . تسعة انواع تعود الى جنس موكوشيا ، ثلاثة انواع تعود الى جنس كلوستريوم ، وأربعةعشر نوعا تعود لجنس كوسماريم . زاد نو زيكمينتاليس وديسمدس في الصيف عن الشتاء . تم تقديم وصف بالاضافة الى قياسات لكل نوع .

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1. Introduction

Algae are an active group of aquatic organisms, the researchers depended on for monitoring and evaluating quality of water[1]. It is very important for any physio-chemical changes in freshwater [2]. Green algae are considered an important plant that forms starch from photosynthesis and contains different bio-active compounds like antioxidant, protein, amino acids and lipids [3]. Zygnematales are varied by having a wall of cells comprising of a single unit, without any ornamentations or pores. The order includes nearly 1000 species and 20 genera distributed between two families: Zygnemataceae, comprising of thirteen filamentous genera, and Desmidiaceae with seven genera. An important characteristic of Zygnemataceae is a conjugation by amoeboid gametes [4], while Desmids are unicellular microorganisms belonging to Chlorophyceae, also found exclusively in freshwater. Their attractive shape becomes more obvious when examined under microscope light. This is due to its form. Also more than 6000 species have been found in the inland water in various parts of the world [5]. It is also considered as one of the most important group of algae in the trophic classification in the aquatic ecosystem, and is considered good bio-indicators for ecosystem stability [6].

To find out the negative effects of acidification, cultivation and eutrophication on the living of Zygnematales in recent years, some studies are being conducted in different parts of Iraq and Kurdistan Region (7-11). Besides these studies, presently work is also being done to exclusively identify Zygnematales that are found in Shaqlawa District, Erbil-Kurdistan Region, Iraq.

2. Materials and Methods

2.1. Description of studied sites

Aquban and Sarkand villages belong to Shaqlawa District which is about 32km north-east of Erbil city located North-East of Iraq, at 36° 42′ to 360 23′ N latitude and 44° 29′ to 44° 08′ E longitude. Climate of the area is characterized by a wide diurnal and annual range of temperatures, closely relating to Irano-Turanian. Shaqlawa is characterized by fertile soil and the existence of water resources like snow and rainfall. These are a source of winter precipitation, and geology as given by [12, 13]. Sites under study in Aquban, consist of five shallow to medium depth??? [1, 2, 3, 4 and 5] found within the mountain area, containing different types of trees. In Sarkand village, six sites [6, 7, 8, 9, 11-14] along the stream and seven springs [10, 12, 13, 15, 16, 17 and 18] follow from the mountain area down flow of the streams. All the studied sites are about 40 km long (Figure 1).

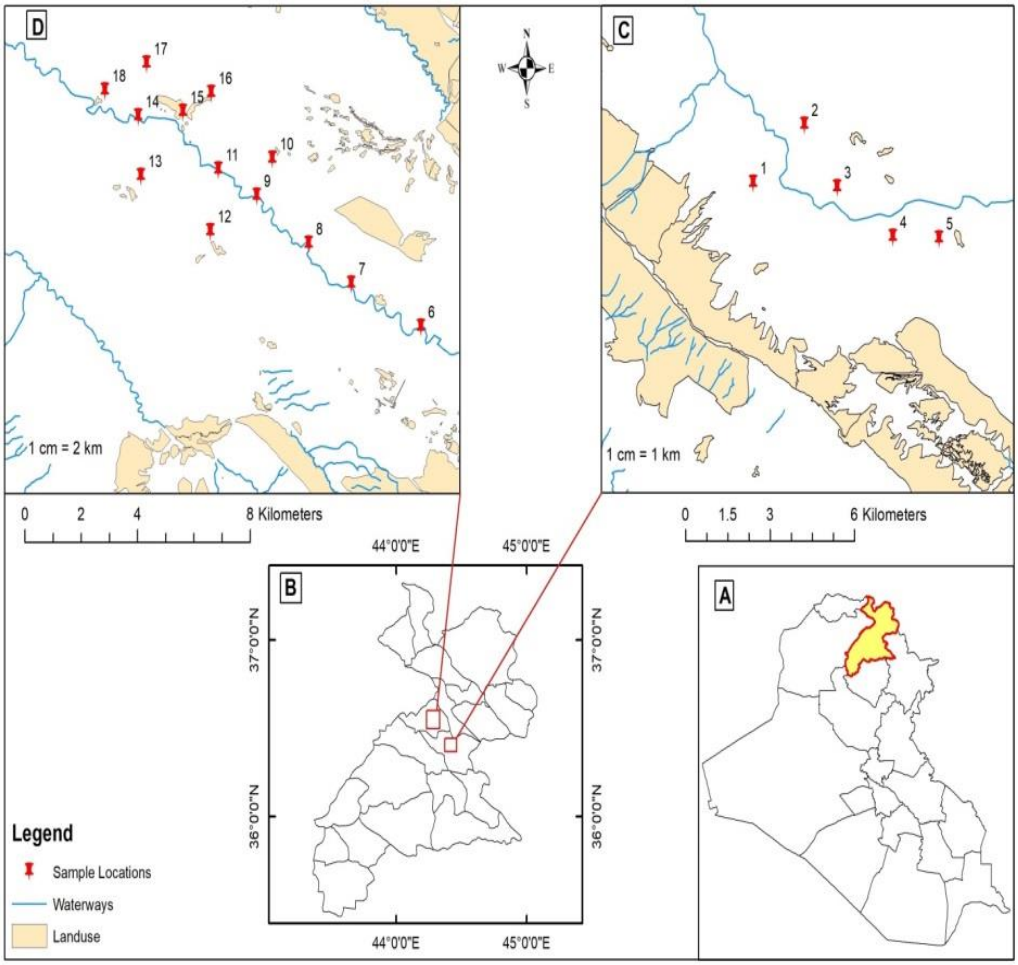


Figure 1 - shows: A- Map of Iraq and Erbil province shaded B- Map of Erbil governorate C- Aquban village D- Sarkand Khaylaneyan village

2.2. Collection, preservation and identification of algae

With the help of nets used for phytoplankton, all different types of algal samples were collected by squeezing the leaves, stems and roots of macrophytes. To identify other types of algae, samples were also collected from the rocks[14]. Samples were then preserved by using 1ml of Lugal's iodine solution in airtight polylab vial, sealed and labeled, and then brought to the laboratory. Desmids and other algae concentrated by sedimentation were examined under microscope [14-19].

3. Results and discussions

This study was conducted on a monthly basis over a period of twelve months, from October 2019 to August 2020. The collected data on water temperature, pH, EC and salinity for each sample sites have been represented in Table 1.Analysis of 216 algal samples found 30 new records of which twelve belonged to Zygnemataceae (Cylindrocystis, Debarya, Hallasia, Mougeotia), and eighteen returned to Desmidiaceae (Closterium, Cosmarium, Staurastrum).These attributed to seven genera, two families, one order and one class [20, 21] (Table 2). In this study, Cosmarium is considered a dominant one. According to all of her studies, new record adds a list of Flora of Iraq followed by Mougeotia and Closterium. In the last, one species for each of the following genera Cylindrocystis, Debarya, Hallasia and Staurastrum (Table 3). Zygnemataceae and Desmidiaceae increased in the warm season than in the wet season [22].High temperature, bright sunlight, high transparency and rapid tropholytic activities could render a decrease in water level, thus bringing the deep nutrient-rich areas into the fold of tropholytic zone. It could result in the increase of Chlorophyceae

biomass during dry summer season [6, 22]. Similar conclusion was also observed by recent work which found out that the level increases during dry season and decreases during the wet season. Lower dominance found through wet season could be related to the further dilution of essential growth nutrients in the studied area. The reason for recording Zygnemataceae and Desmidiaceae algae in different sites over various months through the year can be related to the ability of some algae to acclimation or adaptation and tolerance against the stress of changes in the environmental factors, and a change in water temperature, pH, EC and other ecological factors. The results of this work were in agreement with a study done by [23] that emphasis algae produce specialized spores, defensive or tolerant, various chemical substances that protect them from desiccation and death, high irradiation and UV light. ***Mougeotia*** under study were seen to flourish during the extreme summer temperatures by giving shelter to other microalgae. Desmid algae in this study decreased during rainy season and were found to be the lowest in number. This was confirmed with the study of [24]. The low density of Desmids during wet or rainy season causes increased clay, sand and silt level that enters the inland water which increases turbidity, reduced sunlight penetration, badly affecting its photosynthesis [24]. It was found out during a recent study; neutral to alkaline pH reduced turbidity and promoted the increase of desmids. Water monitoring is necessary to know the status of water resources in Shaqlawa district. It suggests a possibility of prediction for desmid variability patterns by some water quality parameters.

Table 1-Some water properties found in the studied sites

Site	Place of Collection name	Habitat type	Water Temperature °C	pH	EC µs.cm^{-1}	Salinity ppt
1	**Sard**	**Spring**	**14.942**	**7.233**	**988.111**	**0.065**
2	**Piawan**	**Spring**	**15.439**	**7.249**	**1124.778**	**0.056**
3	**Zhnan**	**Spring**	**15.700**	**7.367**	**830.111**	**0.058**
4	**Darmanawa**	**Spring**	**14.108**	**7.479**	**1611.667**	**0.052**
5	**Mink Spring**	**Spring**	**14.039**	**7.764**	**627.472**	**0.059**
6	**Along River**	**River 1**	**16.211**	**7.844**	**786.250**	**0.072**
7	**Along River**	**River 2**	**17.517**	**7.875**	**785.222**	**0.071**
8	**Along River**	**River 3**	**17.381**	**7.894**	**782.972**	**0.076**
9	**Along River**	**River 4**	**17.272**	**7.992**	**764.056**	**0.078**
10	**Prenga**	**Spring**	**18.231**	**7.401**	**810.639**	**0.059**
11	**Along River**	**River5**	**17.397**	**7.823**	**841.778**	**0.077**
12	**Nawkand**	**Spring**	**17.917**	**7.235**	**1392.583**	**0.110**
13	**Benwan**	**Spring**	**18.475**	**7.309**	**1419.139**	**0.085**
14	**Along River**	**River6**	**17.542**	**7.816**	**911.167**	**0.080**
15	**Sarkand**	**Spring**	**18.033**	**7.330**	**924.972**	**0.059**
16	**Benwan**	**Spring**	**18.169**	**7.372**	**975.639**	**0.055**
17	**Azarian**	**Spring**	**16.108**	**7.297**	**2092.306**	**0.155**
18	**Razga**	**Spring**	**16.628**	**7.817**	**989.222**	**0.084**

Table 2-List of new records of Zygnematales in the studied sites

Division: **Chlorophyta**	**Closterium** Nitzsch ex Ralfs 1848
Class: **Chlorophyceae**	***Cl. idiosporum*** West et G.S.West 1900
Order: Zygnematales	***Cl. jenneri*** Ralfs 1848
Family : Zygnemataceae	***Closterium* praelongum var *brevius*** Brebisson1856
DebaryaWittrock1872	***Cosmarium*** Corda ex Ralfs 1848
D. jogensisIyengab1944	***C. abbreviatum* var. *planctonicum*** W & G. S. West 1906
Mougeotia C.Agardh 1824	***C. amoenum*** Brebisson in Ralfs 1848
M.america Transeau 1918	***C. anceps* var. *crispulua***(Nordst) Krieger and Gerloff 1858
M. calcarea(Cleve) Wittrock 1872	***C. angulosum* var. *concinnum*** West and G.S. West 1867
M. floridana Transeau 1934	***C. binum*** Nordst 1889
M. globulispora Jao 1935	***C .contractum* var. *rotundatum*** O.Borge 1878
M .laetevirens (A.Braun) Wittrock 1972	***C. cucurbita*** Breb 1844
M. paludosa G.S.West 1899	***C. depressum* var. *planctonicum*** Reverdin 1919
M. pawkuskae Taft 1934	***C. impressulum***Elfving1881
***M. tumidula* var. *palmerstoniana* S**.Skinner and Entwisle 2004	***C. moniliformis* Forma. *Panduriformis***Heimer1891
M.varians (Wittrock) Czurda 1932	***C. punctulatum* var. *subpunctulatum***(Nordstedt) Borgesen 1894
Cylindrocystis Meneghinii ex de Bary1858	***C. sphagnicolum*** West &G.S.West 1808
C. brebissonii Meneghinii ex de Bary1858	***C. sportella*** Brebisson 1849
Hallasia Rosenvinge 1924	C. ***turpinii* var. *podolicum*** Gutwinski 1890
H .reticulata Rosenvinge ex Curzda1924	***Staurastrum*** (Meyen) Ralfs 1848
Family: Desmidiaceae	***S. alternans*** Brebisson in Ralfs 1848

Table 3-New records with its percentages in the sites during the studied period

	Name of Algal genus	Species	%	New Recorded species	%
	Division: Chlorophyta				
	Class: Chlorophyceae				
	Order: Zygnematales				
	Family Zygnematacea				
1	***Debarya*** Wittrock 1872	**1**	**0.9**	**1**	**3.3**
2	***Mougeotia*** C.Agardh 1824	**23**	**19.8**	**9**	**30**
3	***Spirogyra*** Link 1820	**31**	**26.7**	**0**	**0**
4	***Zygnema*** C.Agardh 1824	**12**	**10.4**	**0**	**0**
5	***Cylindrocystis*** Meneghinii ex de Bary1858	**1**	**0.9**	**1**	**3.3**
6	***Hallasia*** Rosenvinge 1924	**1**	**0.9**	**1**	**3.3**
	Family: Desmidiaceae				
7	***Closterium*** Nitzsch ex Ralfs 1848	**16**	**13.7**	**3**	**10**
8	***Cosmarium*** Corda ex Ralfs 1848	**30**	**25.8**	**14**	**46.8**
9	***Staurastrum*** (Meyen) Ralfs 1848	**1**	**0.9**	**1**	**3.3**
	Total	**116**	**100**	**30**	**100**

Description of the new records:

Cylindrocystis brebissoni (Meneghini ex Ralfs) de Bary 1858 (Pl.1, Figure 1)

Cells are cylindrical and rounded apices while chloroplasts are star in shape with center pyrenoids appearing between them, 16-20µm in width and 35-110µm in length. Recorded in Razga spring March2020 (Water temp16˚C, pH 8.02,EC 1980µs/cm) (P609, Pl152, E-F)[16].

Hallasia reticulata (Hallas) Rosenvinge ex Curzda1924 (Pl.1, Figure 2)
Vegetative cells have a plane end with two stellate chloroplasts in every cell. Central pyrenoid is found between them, and is 18-22µm wide, 55-145µm long. Identified in the Mink spring during October2019 (Water temp20˚C, pH 7.88, EC623µs/cm) (P294, Pl.1, Figure 7 A-K) [25].
Debarya jogensis Iyengab1944 (Pl.1, Figure 3)
Vegetative cell 7-9µm in width and 90-98 in length with 5-10 pyrenoids in a row. Recorded in the Chemma spring during July2020 (Water temp 21.7˚C, pH 7.2, EC 1363 µs/cm) (P111 and 112, Figure A-F) [17].
Mougeotia americana Transeau 1918 (Pl.1, Figure 4)
Vegetative cell 2-5µm width, 40-120µm length. Zygospores shape is quadrate with a smooth wall, 12-24µm wide and 18-32 µm long. Identified in the Azarian spring in May2020 (Water temp 20˚C ,pH 6.96, 2108µs/cm)(P 159, Figure 86) [17].

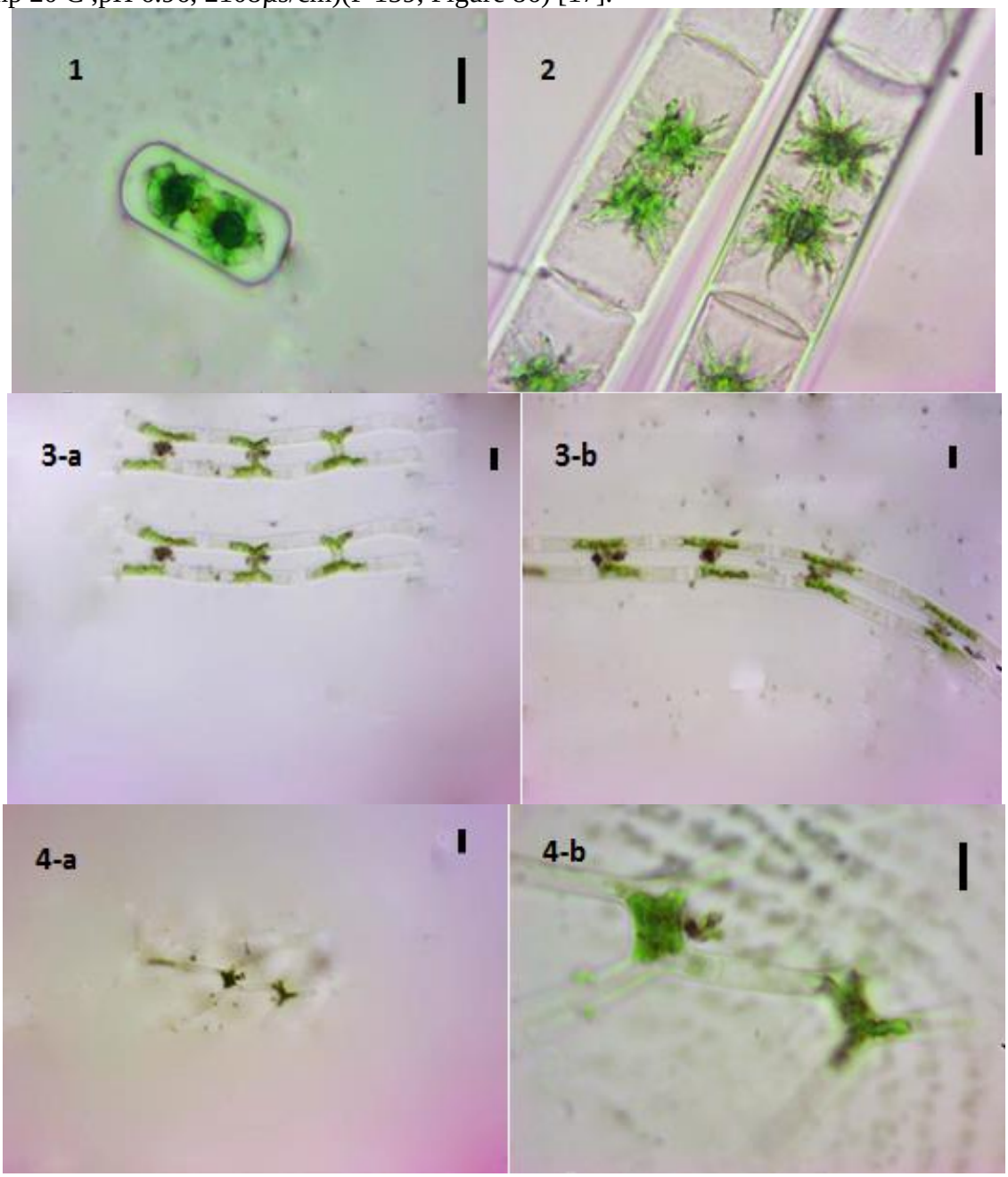
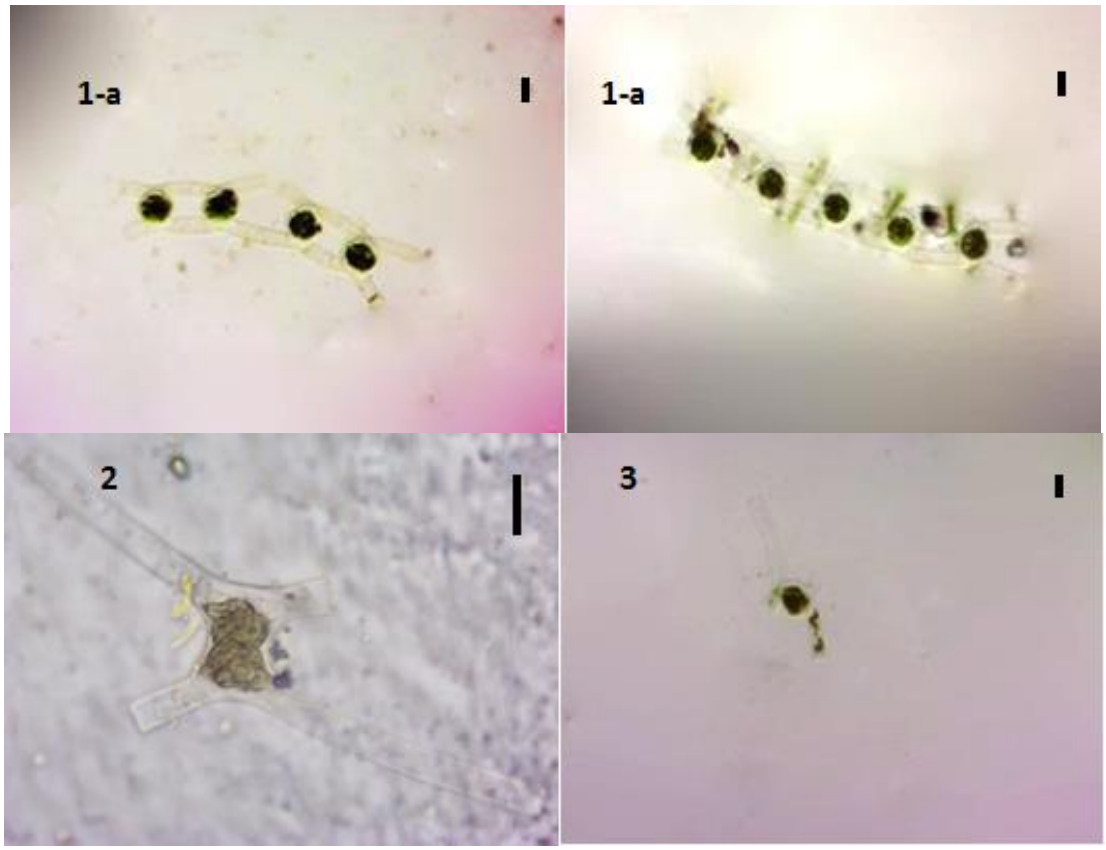


Plate 1: 1. *Cylindrocystis brebissoni,* 2. *Hallasia reticulata,* 3. a-b *Debarya jogensis,* 4. a-b *Mougeotia americana* Scale bar: 10µm

Mougeotia calcarea (Cleve) Wittrock 1872 (Pl.2, Figure 1)
Cells in the early stages of reproduction are elongated and geniculate, 8-14µm wide and 40-280µm long. Zygospores are spherical and are formed within conjugation tube, 22-28µm wide and 25-50µm long. Found in the Chemma spring during July and August2020 (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 1363µs/cm and 1313µs/cm) (P580, Pl.144-A) [16].
Mougeotia floridana Transeau 1934 (Pl.2, Figure 2)
Vegetative cells are 14-20µm wide and 60-200µm long. Zygospores are triangulate-ovoid to globose in shape, 30-40µm wide and 36-50µm long, observed in Azarian spring in July and August2019 (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 1363µs/cm and 1313µs/cm) (P154, Figure 74 A-B) [17].
Mougeotia globulispora Jao 1935 (Pl.2, Figure 3)
Vegetative cell are 14-32µm in width and 80-220 µm in length. Chloroplast is with many pyrenoids in one row. Zygospore form varied between globose to sub-globose, 30-38µm in width and 30-40 µm in length. Found in Chemma spring during July and August2020 (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 1363µs/cm and 1313µs/cm) (P136, Fig 37) [17].
Mougeotia laetevirens (A.Braun)Wittrock 1972(Pl.2, Figure 4)
Cells 20-40µm in width, 60-350 in length are broad chloroplast and like ribbon with many pyrenoids scattered in. Zygospores have spherical form, 30-75µm wide and the wall is smooth. Found in Azarian and Chemma springs during August2019 (Water temp 20.0˚C,20.5˚C, pH 6.80 and 7.42, EC 1363µs/cm and 1313µs/cm) (P583, Pl 143D) [16].



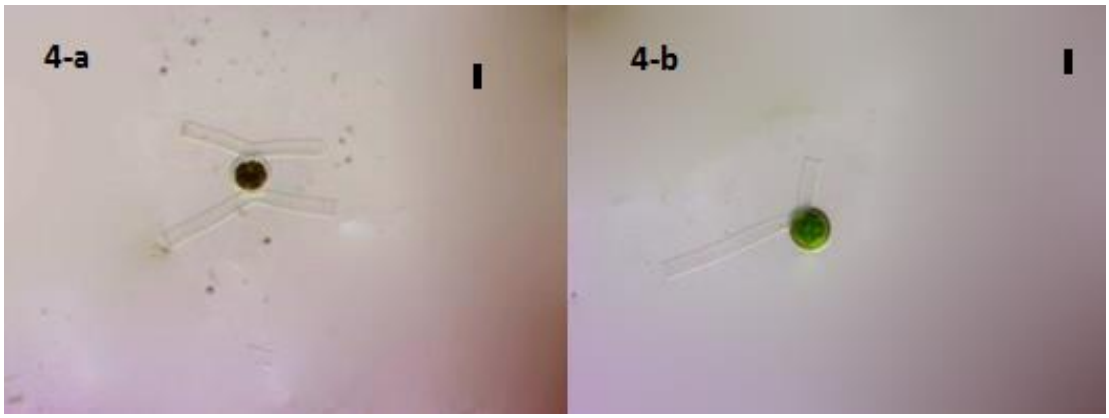


Plate 2: 1. a-b *Mougeotia calcarea,* 2. *Mougeotia floridana,* 3. *Mougeotia globulispora* 4. a-b *Mougeotia laetevirens* Scale bar: 20µm

Mougeotia paludosa G.S.West 1899(Pl.3 Figure 1)
Cells are 11-5-13.5µm in width, 70-185µm in length. One-third of cell length is occupied by chloroplast, found in many pyrenoids. Zygospores shapes change from ovoid to quadrangular,22-38µm wide, 42-49µm long and have a smooth wall. Found in Chemma spring during July and August2019 (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 1363µs/cm and 1313µs/cm) (P185,Pl.144I) [16].
Mougeotia *Pawhuska* Taft 1934(Pl.3, Figure 2)
Cells are 16-22µm in width, 90-170µm in length, 6-8 pyrenoids in a row are found in the chloroplast. Compressed Zygospores and globose form, 32-40µm wide, 22-32µm long (P 149, Figure 64) [17]. These were found in Chemma spring during July and August2019 [13] (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 63µs/cm and 1313µs/cm) (P149, Figure 64) [17].
Mougeotia tumidula* var. *palmerstoniana S.Skinner and Entwisle 2004 (Pl.3, Figure 3)
Cells have cylindrical form, and are 11-14µm in width. Chloroplast are irregularly distributed in the cell. Zygospores are rectangular in shape, 20-24µm wide, 20-30 long. Recorded in Mink spring during October2019 (Water temp 22.0˚C, pH 7.80,EC 623µs/cm) (P491, Figure 2-e) [26].
Mougetia varians (Wittrock) Czurda 1932(Pl.3, Figure 4)
Cells are 25-30µm in width. Pyrenoid is scattered in chloroplast. Zygospores have ovoid-cylindrical shape usually concave on the sides and ends. They are 42-60µm in width, 62-78 µm in length. Found in Chemma spring during July and August2019 (Water temp 20.0˚C,20.5˚C, pH 7.22 and 7.42, EC 1363µs/cm and 1313µs/cm) (P586,Pl145A) [16].

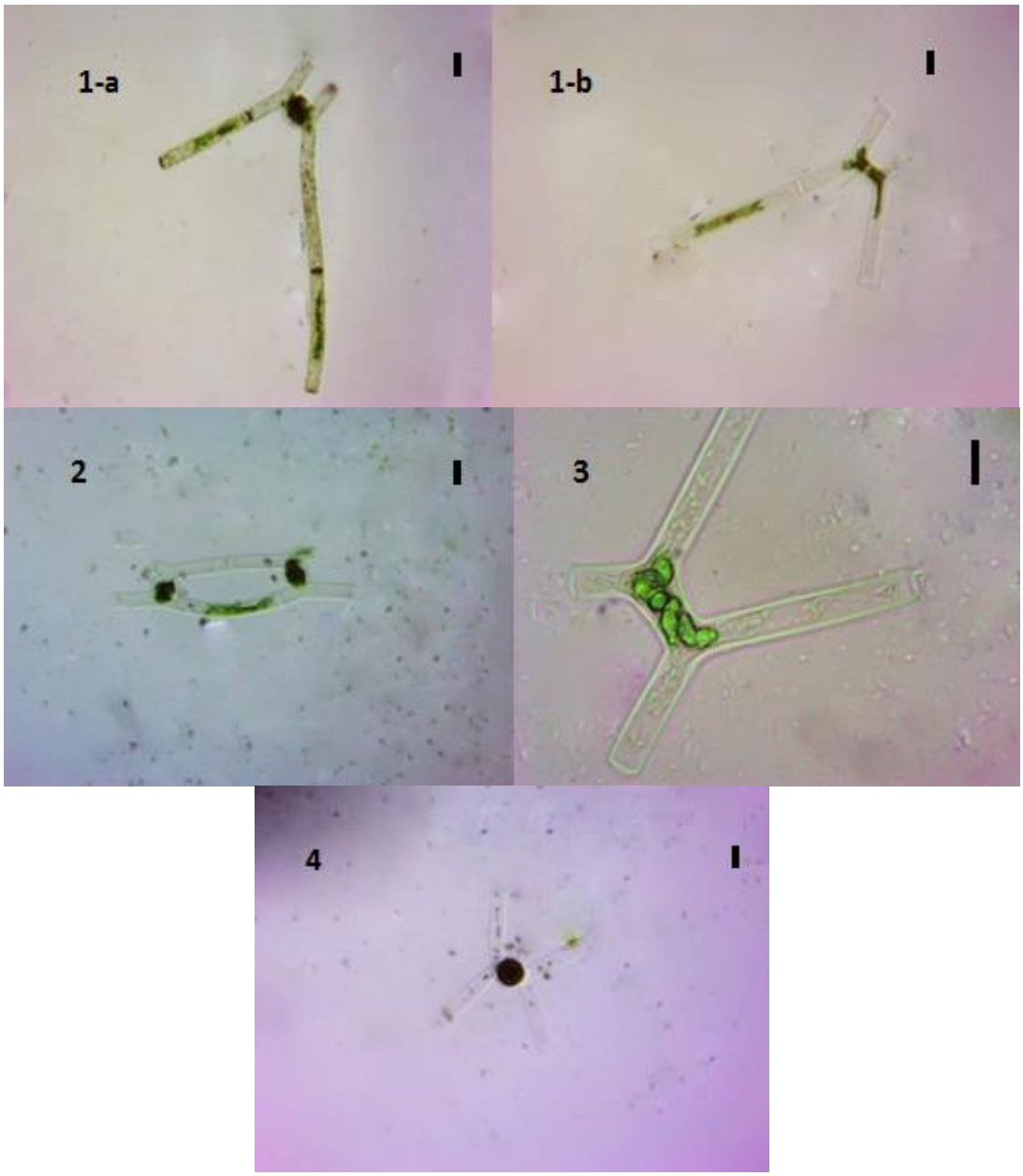


Plate 3: 1. a-b *Mougeotia paludosa,* 2. Mougeotia *pawkuskae,* 3. *Mougeotia tumidula* var. *palmerstoniana,* 4. *Mougetia varians*. Scale bar: 20µm

Closterium idiosporumWest et G.S.West 1900 (Pl.4, Figure 1)
Cell are spindle in form, 8-12µm wide, 150-250 long, and are either slightly curved or straight. These appeared attenuated far from mid region. Recorded in Chemma and Piawan springs (Water temp 20.5°C and 16.5°C,7.22 and 7.00, 1366 µs/cm and 1095 µs/cm) during June- July2020, along river (Site 7) during October2019 respectively (Water temp19.5°C, pH 7.70,833 µs/cm)(P625, Pl.153 G) [16].
Closterium jenneri Ralfs 1848 (Pl.4, Figure 2)
Cells are 8-20µm wide, 60-150µm in length, curved strongly especially in middle area. They are sometimes straight, attenuating toward apices. Recorded in Sard spring during August2020 (Water temp15.0°C, pH 7.03,EC980µs/cm) (P627, Pl 154L) [16].
Closterium* praelongum var *brevius Brebisson 1856 (Pl.4, Figure 3)

Cells are 12-22µ in width, 250-350µm in length, narrow and shorter than nominal variety. Recorded in Sard and Piawan springs during August2020 (Water temp 15˚C and16.0˚C, pH 7.03 and 6.95, EC 980µs/cm) (P 629, Pl 154F) [16].

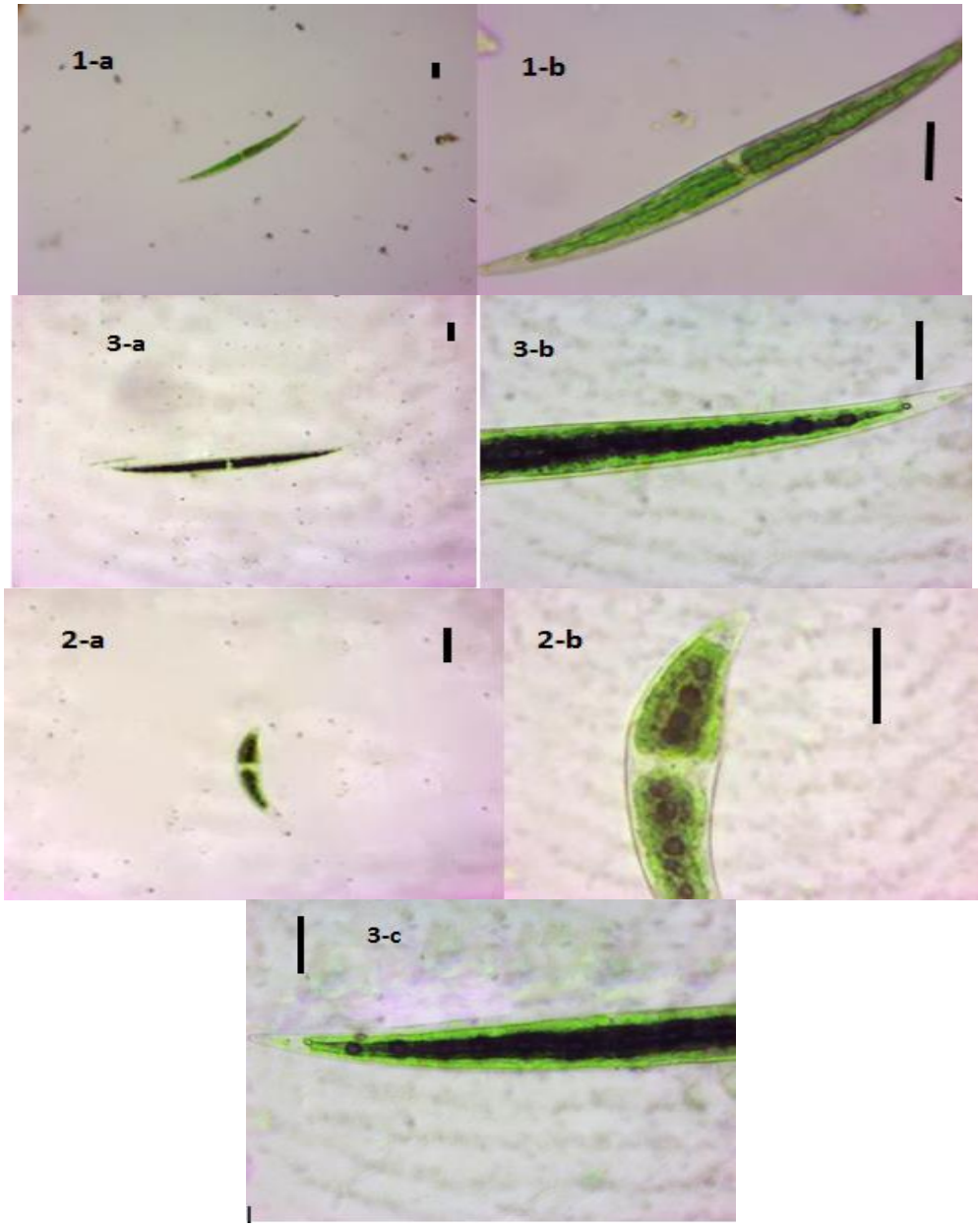
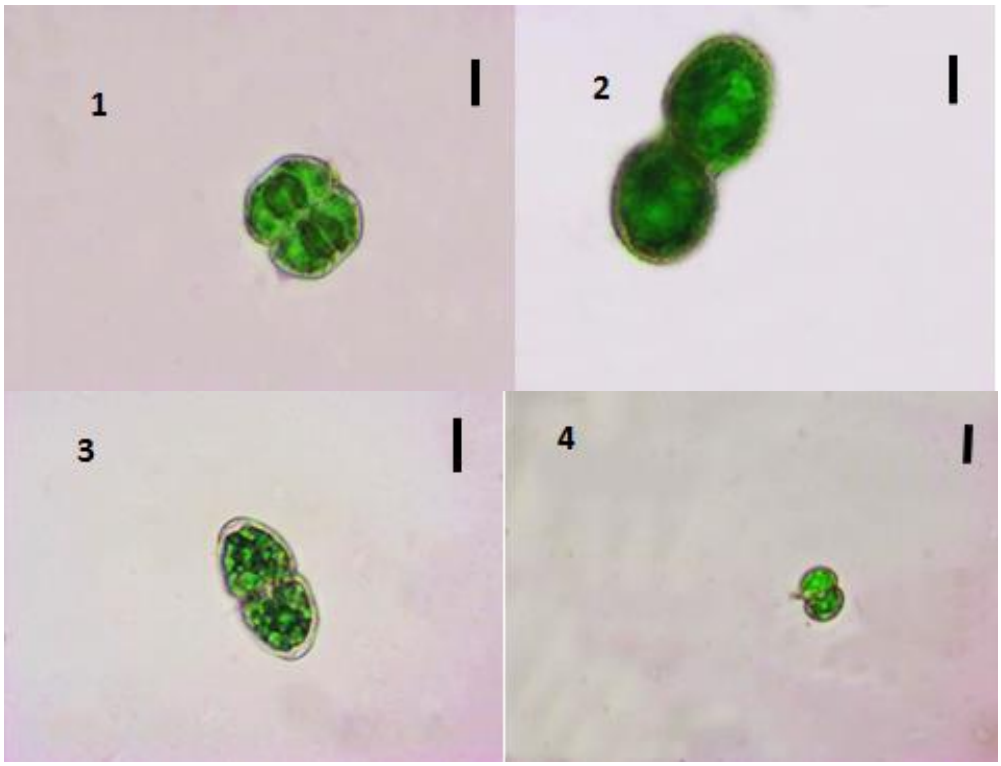


Plate 4: 1. a-b *Closterium idiosporum*, 2. a-b *Closterium jenneri*, 3. a-b *Closterium* praelongum var *brevius* Scale bar: 20µm

Cosmarium abbreviatum* var. *planctonicum W & G. S. West 1906 (Pl.5, Figure 1)
Various from nominal to narrow and semi cell oval, 21-30µm wide, 19-29 long, margins on lateral side are convex than straight. Found in Razga (Water temp 7.0˚C, pH7.93, EC957µs/cm) and Mink (Water temp 11.5˚C,pH 7.52,EC 575µs/cm) springs in November2019 (P.646,Pl.162N) [16].
Cosmarium amoenum Brebisson in Ralfs 1848 (Pl. 5, Figure 2)
Cells are 22-33µm in width, 40-59µm in length, semi-cell usually semicircular to semi-ellipsoidal, sometimes apices seen flattened, shallow sinus and slightly opened. Recorded along the stream (Site 11) during November2019 (Water temp12.5˚C, pH 8.02, EC 874µs/cm)(P.646,Pl.164J) [16].

Cosmarium anceps* var. *crispulua (Nordst) Krieger and Gerloff (Pl.5, Figure 3)
Generally smaller than the typical anceps, with the basal angles of the semi-cells obscurely sub-rectangular and the sides slightly undulate. Cells are 12.5-20µm in width, 22.5-38µm in length. Recorded in the Mink spring during October2019 (Water temp20°C , pH 7.88, EC 623µs/cm)(P 47, Pl. LXX, Figure 13) [15].
Cosmarium angulosum* var. *concinnum West and G.S. West 1867(Pl.5, Figure 4)
Cells are a little smaller than in size, upper angles of semi-cells obliquely truncate or retuse, 8-12µm wide, 10.5-13µm long. Recorded in Darmanawa spring during July2020, also along the river (site 7) during September 2019 (25.2°C, pH 7.83, EC 814µs/cm) (P.94, Pl.LXXIV, gigs 37,38) [15].
Cosmarium binum Nordst 1889(Pl.5, Figure 5)
Cells are 30-39µm in width, 41-90µm in length, depth sinus, closed linear, hemispherical semi-cell, roundly basal angles and convex on sides. Identified along the river (site 9) during November2019 (Water temp14.5°C,pH 7.92, EC 788µs/cm) (P.646,Pl.164E) [16].
Cosmarium contractum* var. *rotundatum O.Borge 1878(Pl.5, Figure 6)
Various from nominal variety that have circular semi-cell in outlet, 21-33µm in width and 31-52µm in length. Recorded in Darmanawa (Water temp18°C, pH7.70, EC 1110µs/cm) and Mink (Water temp17°C, pH 7.41,EC 644µs/cm) springs during July2020 (P.649,PI.160P) [16].
Cosmarium cucurbita Breb1844 (Pl.6, Figure 1)
Cells are small, almost cylindrical about twice as long as broad, slightly constricted, sinus a slight notch, semi-cells subquadrate, 15-24µm in width, 29-51µ in length. Recorded along river (Site 8) (Water temp 23°C , pH 7.94, EC 725µs/cm) during May2020 (P106, Pl.LXXIV, Figure 3) [15].
Cosmarium depressum* var. *planctonicum Reverdin1919 (Pl.6, Figure 2)
Smaller cell than nominal variety, 16-30µm in width and 18-28µm in length, gelatinous sheath with thread like surrounded by the cell. Found in Darmanawa spring during July 2020 (Water temp18°C , pH 7.70, EC 1110µs/cm) (P.652,Pl.160S) [16].



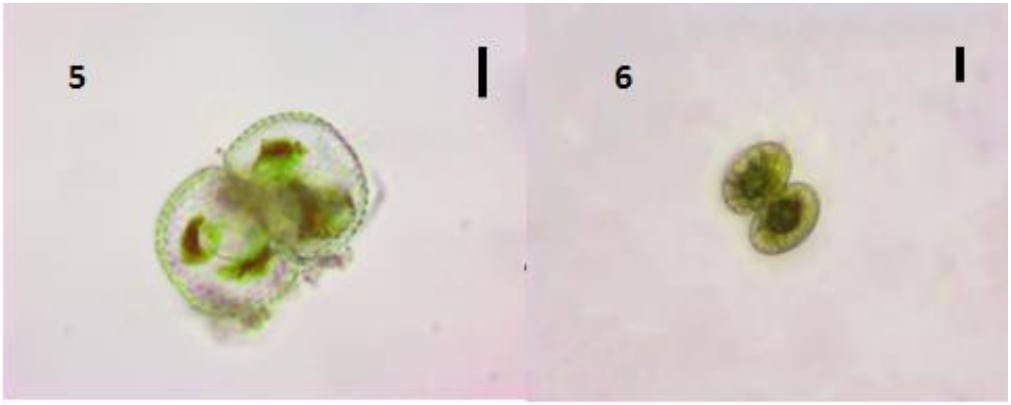


Plate5: 1. *Cosmarium abbreviatum* var. *planctonicum,* 2. *Cosmarium amoenum, 3. Cosmarium anceps* var. *crispulua,* 4. *Cosmarium angulosum* var. *concinnum*, 5. *Cosmarium binum, 6. Cosmarium contractum* var. *rotundatum* Scale bar: 10µm

Cosmarium impressulum Elfving 1881 (Pl.6, Figure 3)
Cells are 13-27µm in width, 18-37µm in length, deep sinus, semicircular to ellipsoidal semi-cells, all margins regularly undulate. Recorded in Chemma spring during July2020 (Water temp 21.7°C, pH 7.2, EC 1363 µs/cm) (P.654, Pl.162S) [16].
Cosmarium moniliformis panduriformis Heimer1891 (Pl.6, Figure 4)
Cells are 10-15µm in width and 17.5-25µm in length, smooth cell wall, with broader isthmus. Found in the Mink spring during in June2020 (Water temp 15°C, pH 7.82, EC 685µs/cm) (P.22, Pl.LXVII, Figure 4) [15].
Cosmarium punctulatum* var. *subpunctulatum (Nordstedt) Borgesen 1894 (Pl.6, Figure 5)
Cells are 22-37µm in width, 24-42µm in length. Semi-cells varies from normal variety, having central protuberance with granules. Recorded in Razga spring during September2019 and along the river (site 7) in May2020 (Water temp 23°C, pH 8.00, EC 704µs/cm) (P.663, Pl163S) [16].
Cosmarium sphagnicolum West & G.S. West 1808 (Pl.6, Figure 6)
Cells are 11-13.5µm in width and 10.5-12.5µm in length. Minute cells, broad to long, moderately constricted, short sinus and open. Identified in the Mink spring during November2019 (Water temp11.5°C, pH 7.53, EC574µs/cm) (P71, Pl LXXI, Figures. 11-14) [15].

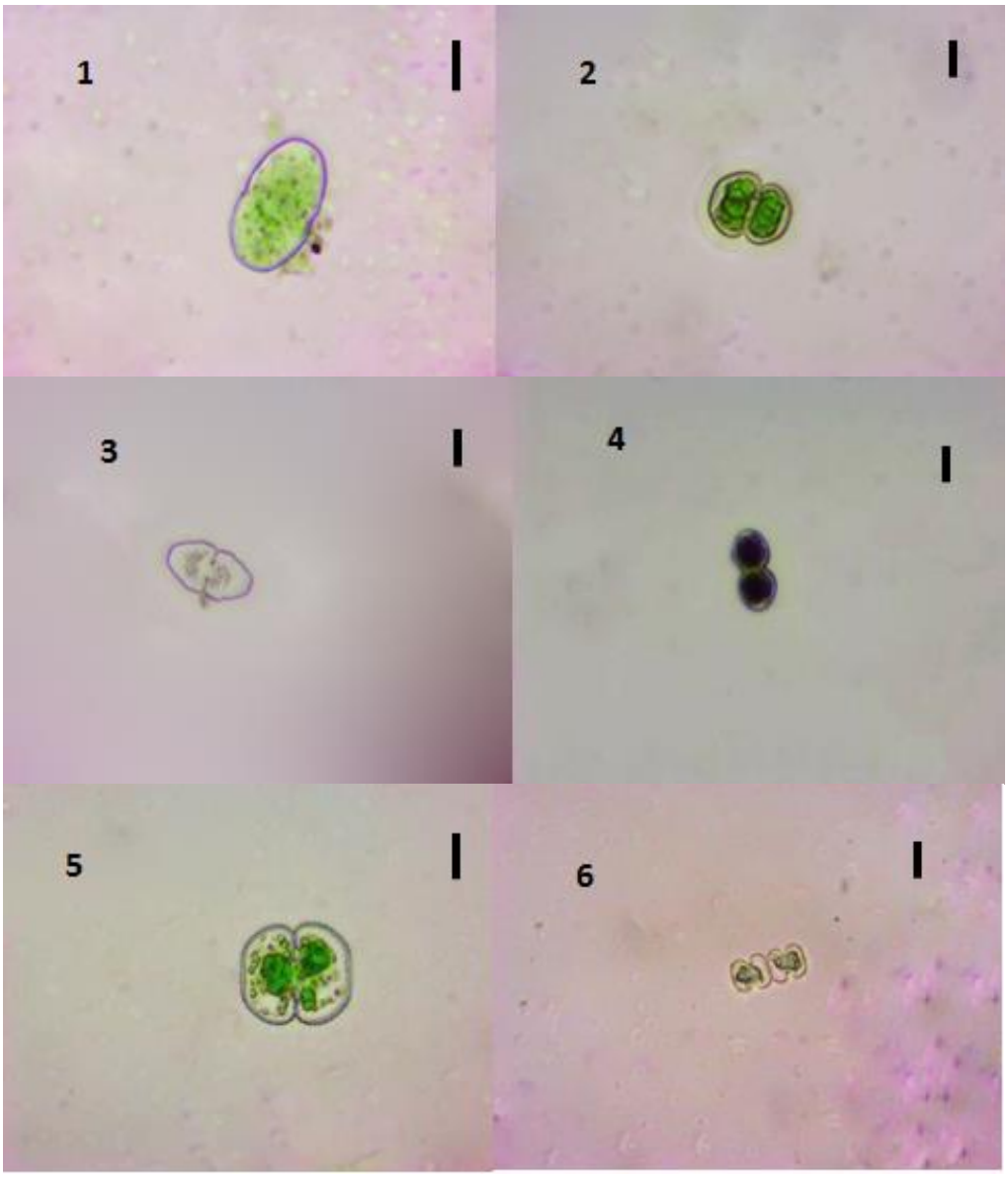


Plate 6: 1. *Cosmarium cucurbita,* 2. *Cosmarium depressum* var. *planctonicum, 3. Cosmarium impressulum, 4. Cosmarium moniliformis* var *panduriformis*, 5. *Cosmarium punctulatum* var. *subpunctulatum,* 6. *Cosmarium sphagnicolum* Scale bar: 10µm

Cosmarium sportella Brebisson 1849 (Pl.7, Figure 1)
Cells are 33-46µm in width, 45-50µm in length, deep sinus and narrow, linear, pyramidate truncate semi-cells. Recorded in Chemma (Water temp 22˚C, pH 7.42, EC 1323µs/cm) and Sarkand (Water temp 16˚C, 7.43,EC 921µs/cm) springs during May2020 and November2019 and along the river (site 6) during October2019 (P.671, Pl.163K) [16].
Cosmarium turpinii var. podolicum Gutwinski 1890 (Pl.7, Figure 2)
Cells are 40-83µm in width, 46-84µm in length. Smooth and granulate margins, size is variable, semi-cells emarginated crenation on both sides only below apex. Recorded in Razga spring during August2020 (Water temp 19˚C,pH 7.95, EC 1087µs/cm) , also along the river (site 11) (Water temp18.0˚C,pH 7.95, EC 874µs/cm) in November2019 (P.673,Pl.163L) [16].
Staurastrum alternans Brebisson in Ralfs (Pl.7, Figure 3)
Cells are 21-31µm in width, 22-45µm in length. Narrow semi-cell, oblong-elliptical, angles rounded, flat apex in middle or convex but slightly. One semi-cell angles alternate with others

found in site Azarian spring in November2019 (Water temp 10.0°C, pH 7.52, EC 2170µs/cm) (P702,Pl.172C) [16].

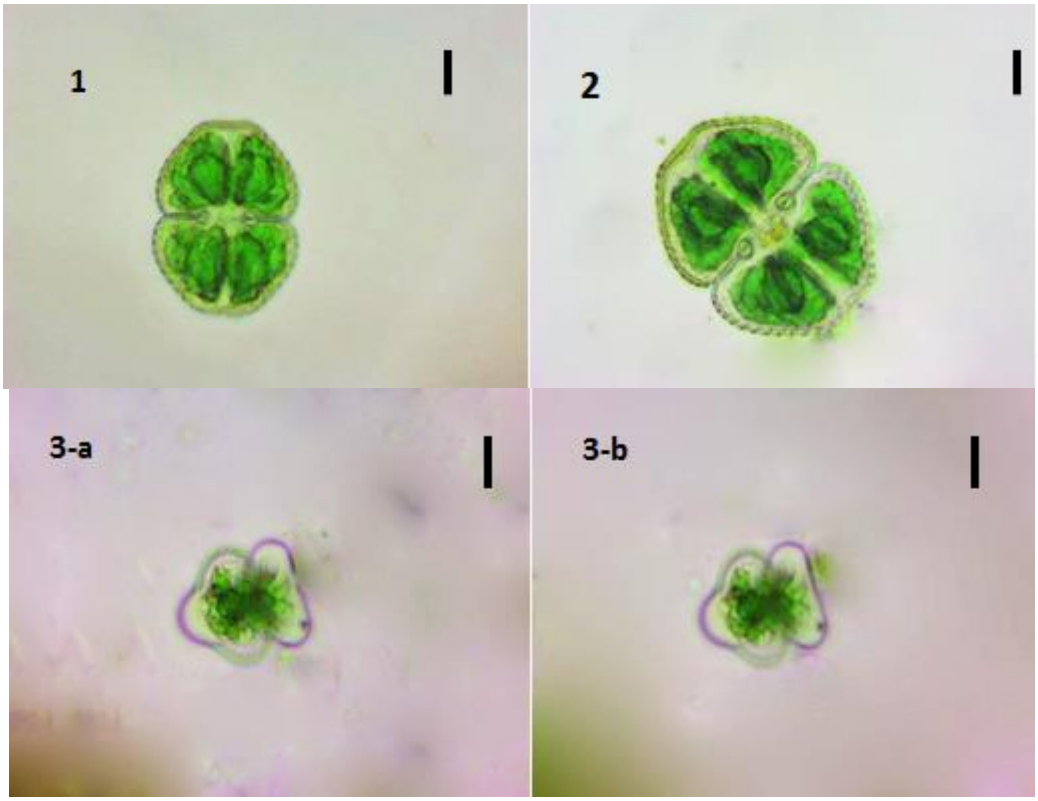


Plate 7: 1. *Cosmarium sportella,* 2. *Cosmarium turpinii* var. *podolicum,* 3. *Staurastrum alternans*
Scale bar: 10µm

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