# Variety of Cell Size of *Cosmarium* spp. and *Euastrum* spp. (Desmidiaceae, Charophyte) from the Aquatic Environment around Palangka Raya, Central Kalimantan, Indonesia

***Chaidir Adam***

*Department of Biology Education, Faculty of Teacher Training and Education, University of Palangka Raya*

**email: chaidir.adam03@gmail.com*

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**ABSTRACT**

*Desmids (Desmidiaceae) is the family of green algae that characterized by cells that are shaped of two symmetrical semicells and it is estimated that there up to 12,000 species of Desmids. Cosmarium and Euastrum are two genera of Desmids that considered as the most representative taxa of this family. They are vary widely in size and shape of the cells. Based on the results of preliminary observations, in the aquatic enviroment around University of Palangka Raya is rich in microalgal diversity including Desmids. Cell size and shape are the most important points to be known to study the microalgae. This research is aimed to study the variety of cell size of Cosmarium spp. and Euastrum spp. from the aquatic environment around Palangka Raya. The results of this study show that the Cosmarium cells have the dimension of 17-80 μm long and 14-57 μm wide; Euastrum cells have the dimension of 24-89 μm long and 17-80 μm wide.*



## Introduction

Desmids (Desmidiaceae) is the family of green algae that characterized by cells that are shaped of two symmetrical semi-cells (Meesters & Coesel, 2007) and it is estimated that there up to 12,000 species of Desmids (Coesel & Krienitz, 2008). *Cosmarium* and *Euastrum* are two genera of Desmids that considered as the most representative taxa of this family. *Cosmarium* is one of the oldest genera of the family Desmidiaceae with approximately 1,026 species and *Euastrum* has 304 species and infraspecies which are accepted taxonomically (Guiry & Guiry, 2021). Based on the results of preliminary observations, in the aquatic enviroment around University of Palangka Raya is rich in microalgal diversity including Desmids. They are vary widely in size and shape of the cells. Cell size and shape are the most important points to be known to study the diversity of microalgae, because each microalgae species has its own distinctiveness in terms of the size and shape of its cells.

The study of the variety of cell size and shape of microalgae is necessary as there no official data to be used as a reference for further research and as a learning material for the courses related to biology, especially microalgae, at University of Palangka Raya. This research is aimed to study the variety of cell size of *Cosmarium* spp. and *Euastrum* spp. from the aquatic environment around Palangka Raya, Central Kalimantan, Indonesia.

## Materials and Methods

### Study Sites and Sample Collection

This research is a descriptive quantitative research with direct observation method. The samples were collected from the water canals around University of Palangka Raya, which was divided, into 3 sampling sites (figure 1). It was conducted between November 2020 and January 2021. Sample identification was carried out in the Laboratory of Biology Education Program.

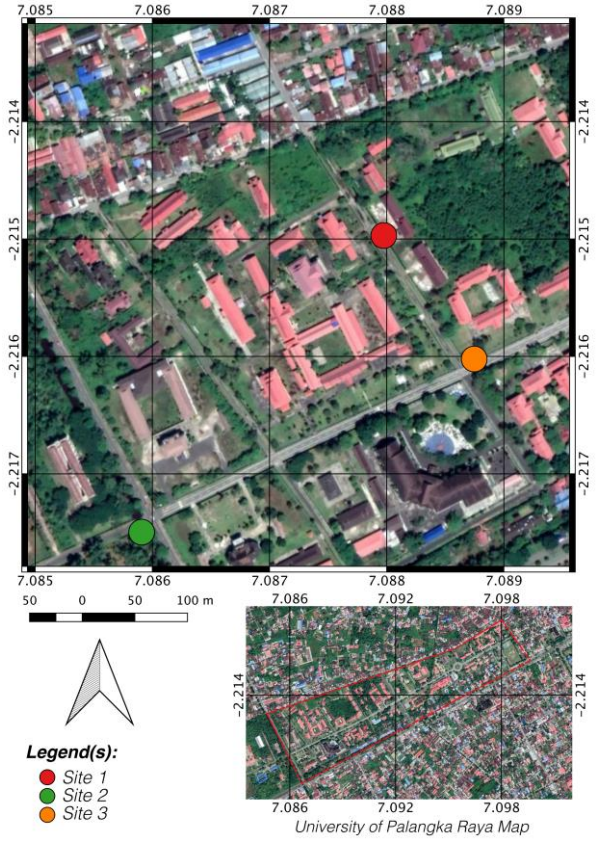


**Figure 1. Sampling Sites (Map Source: Google Satellite, QGis 2.18 for Mac)**

### Species Identification

The cell morphology was observed under the microscope at 400× (10× ocular and 40× objective) magnification using Olympus CX21 light microscope and photographed using 64-megapixel Redmi Note 9 Pro camera for further identification. The identification of *Cosmarium* and *Euastrum* species is based on the observed morphological characteristics using the following published works: (1) A Beginner's Guide to Freshwater Algae (Belcher & Swale, 1978); and (2) How to Know the Freshwater Algae (Prescott, 1970). At this stage the database from the algaebase.org site is also used as a reference for identification of microalgae species.

### Cell Size Measurement

The estimation of *Cosmarium* and *Euastrum* cell size (length and width) was done by calculating the ratio of the object to the diameter of field of view at certain magnification (Table 1). The simulation of the cell size measurement is shown in Figure 2 in details.

**Table 1. Diameter of Field of View (Armstrong, 2021)**

| Objective | Diameter of Field of View (mm) | Magnification (10× Ocular) |
|---|---|---|
| 4× | 4.0 | 40× |
| 10× | 2.0 | 100× |
| 40× | 0.4 | 400× |
| 100× | 0.2 | 1000× |

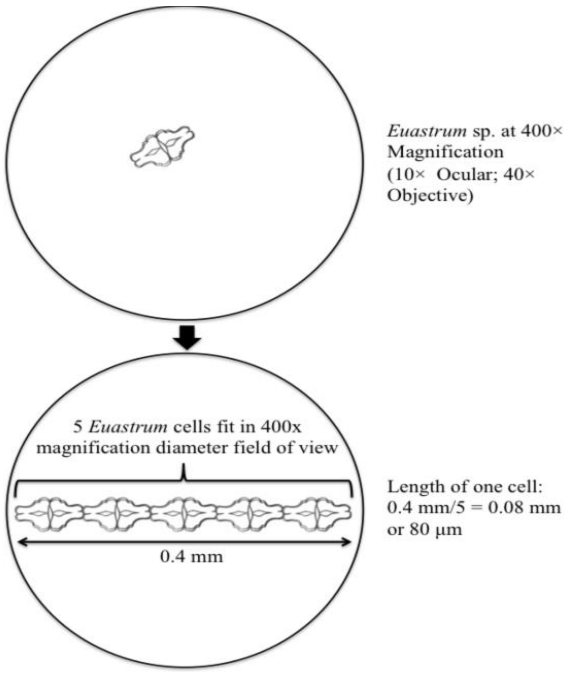


**Figure 2. The Simulation of the Cell Length Measurement: position the object horizontally to the diameter of the microscope field of view**

Based on Figure 2, position the object horizontally to the diameter of the microscope field of view to measure the cell width. The measured images of *Cosmarium* and *Euastrum* are then processed to add a

scale bar using ImageJ software version 1.53g (Rasband, 2020).

## Results and Discussion

### *Cosmarium* spp.

Morphologically, the *Cosmarium* cell is in the form of two symmetrical semi-cells which are divided by a narrowing in the area between the two semi-cells called isthmus. Semi-cells of *Cosmarium* have several forms of which are elliptical, spherical, hemi-spherical, angular, pyramidal or red bean-shaped (Belcher & Swale, 1978; Janse van Vuuren *et al*., 2006). The nucleus lies in the isthmus, appearing white between the two semi-cells (Osório *et al*., 2018; Prescott, 1970).

The number *Cosmarium* species found in this study were 6 (six) species, namely *Cosmarium botrytis*, *Cosmarium biretum*, *Cosmarium granatum*, *Cosmarium trilobulatum*, *Cosmarium* sp.1, and *Cosmarium* sp.2 (Figure 3).

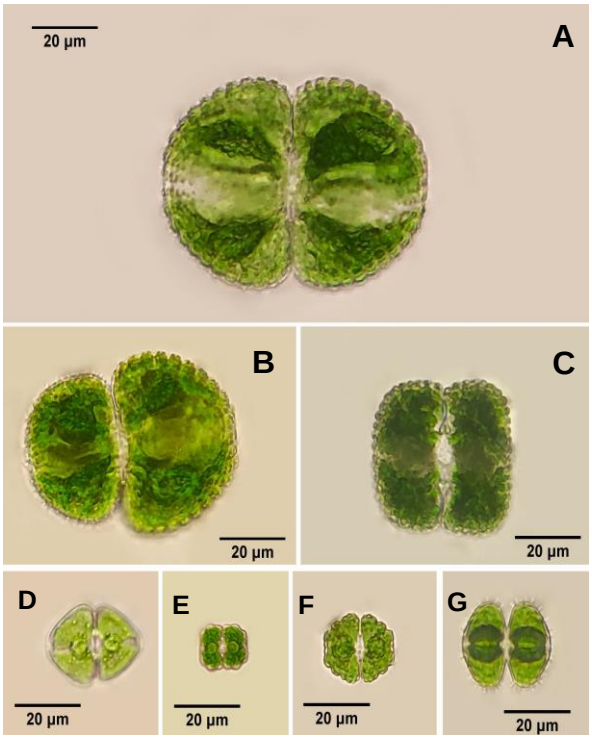


**Figure 3. *Cosmarium* Species found in this study: (A-B) *Cosmarium botrytis*; (C) *Cosmarium biretum*; (D) *Cosmarium granatum*; (E) *Cosmarium trilobulatum*; (F) *Cosmarium* sp.1; and (G) *Cosmarium* sp.2**

The results of the measurement of *Cosmarium* cell lengths and widths are presented in Table 2. The length of the cells measured in this study is the length of the two semi-cells from end to end.

**Table 2. The Cell Lengths and Widths of *Cosmarium* spp.**

| Species | Cell Length | | Cell Width | |
|---|---|---|---|---|
| | N | D/N (µm) | N | D/N (µm) |
| *Cosmarium botrytis* | 5 | 80 | 7 | 57 |
| *Cosmarium biretum* | 9 | 44 | 9.5 | 42 |
| *Cosmarium granatum* | 13.5 | 30 | 17 | 24 |
| *Cosmarium trilobulatum* | 23.5 | 17 | 28 | 14 |
| *Cosmarium* sp.1 | 17 | 24 | 19.5 | 21 |
| *Cosmarium* sp.2 | 14 | 29 | 14.5 | 28 |

**Notes:** **N (**Number of Objects fit in the Diameter of the Field of View); **D** (Diameter of Field of View at 400× Magnification: 0.4 mm)

Table 2 shows the range of *Cosmarium* spp. cell sizes according to cell length and width. The cell length ranges from 17-80 µm and the cell width ranges from 14-57 µm. The largest species of *Cosmarium* based on this study is *Cosmarium botrytis* with a length of 80 µm and a width of about 57 µm. The smallest species is *Cosmarium* sp.2 with a length of 17 µm and width of 14 µm. According to Belcher & Swale (1978) and Janse van Vuuren *et al*. (2006), the dimension *Cosmarium* cells are 10-200 µm long and 6-140 µm wide.

*Cosmarium botrytis*

*Cosmarium botrytis* is the largest *Cosmarium* species found in this study with 80 µm long and 57 µm wide. In this study, *Cosmarium* cells were also observed after binary fission with asymmetrical cell shapes with 67 µm long and 40-47 µm wide (Figure 4A).

The semi-cells are joined by a narrow isthmus at the cell equator (Bellinger & Sigee, 2010) and appear to be pyramidal in shape with rounded margins. The nucleus is clearly visible in the area between the two semi-cells (isthmus). (Sahin & Akar, 2019) said that the semi-cells of *C. botrytis* are ovate-pyramidal in shape with angles broadly rounded. The sinus appears deep and

linear straight towards the isthmus. *C. botrytis* is also noticed by the two pyrenoids that are clearly visible in each semi-cell (Figure 4B).

*Cosmarium botrytis* originally described in 1840 by Meneghini has the homotypic synonym *Euastrum botrytis* (Meneghini ex Ralfs) Nägeli 1849 and 3 (three) heterotypic synonyms that are *Heterocarpella botrytis* Bory 1825, *Didymidium botrytis* (Bory) Reinsch 1866, and *Ursinella botrytis* (Bory) Kuntze 1891. *Cosmarium botrytis* is the only scientific name of this species that is currently accepted taxonomically (Guiry & Guiry, 2021).

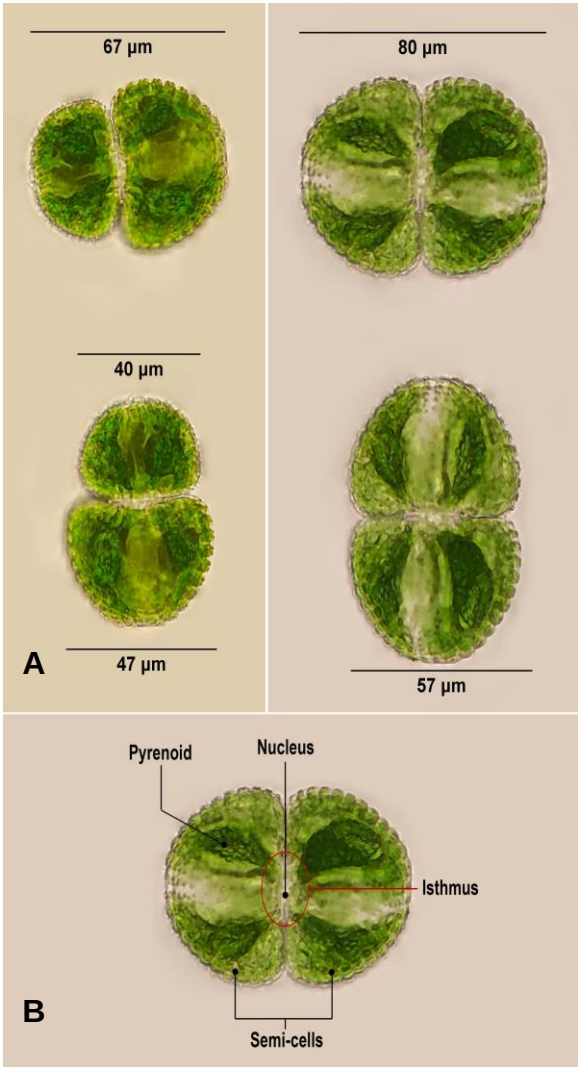


**Figure 4. *Cosmarium botrytis*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Cosmarium biretum*

*Cosmarium biretum* is the second largest *Cosmarium* species found in this study with 44 µm long and 42 µm wide (Figure 5). *Cosmarium biretum* has dark green color and the nucleus is clearly visible in the isthmus. Each semi-cell is shaped like a kidney and looks like two kidneys joined together with a closed sinus.

*Cosmarium biretum* Brebisson ex Ralfs 1848 is the only scientific name of this *Cosmarium* species that is accepted taxonomically, although there are 3 (three) synonyms of this species, namely *C. biretum* var. *triquetrum* Brébisson 1856, *C. quadrangulatum* Hantzsch 1860, and *C. biretum* var. *minus* Hansgirg 1888 (Guiry & Guiry, 2021).

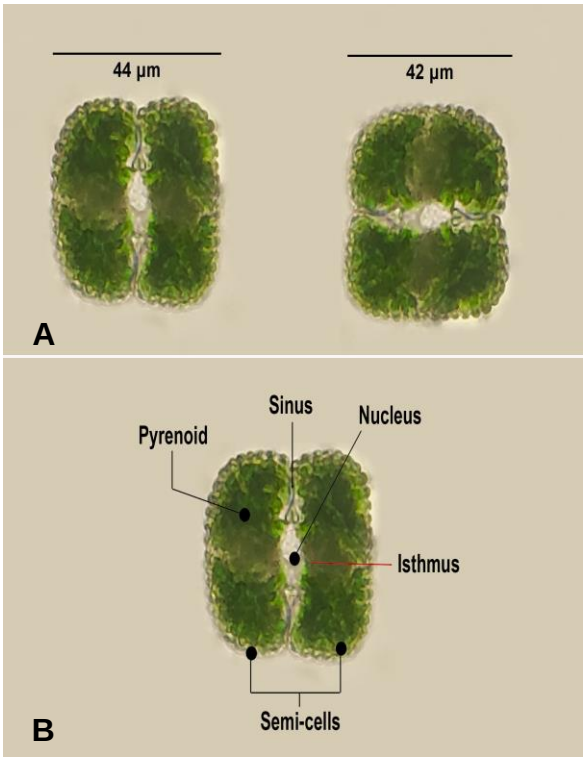


**Figure 5. *Cosmarium biretum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Cosmarium granatum*

*Cosmarium granatum* cell has 30 µm long and 24 µm wide (Figure 6). *Cosmarium granatum* cell is small, has green coloration, and the nucleus is clearly visible in the isthmus. Both semi-cells are pyramidal in shape with a rounded and truncate apex.

There is a slight notch at the center of the apex. The sinus between the two semi-cells is slightly closed. The pyrenoids appear to be spherical in shape and clearly visible in each semi-cell.

*C. granatum* Brébisson ex Ralfs 1848 is the scientific name of this *Cosmarium* species that is accepted taxonomically and has two heterotypic synonyms that are *Euastrum granatum* (Brébisson ex Ralfs) F. Gay and *C. granatum* f. *pentagonum* Raciborski 1892 (Guiry & Guiry, 2021).

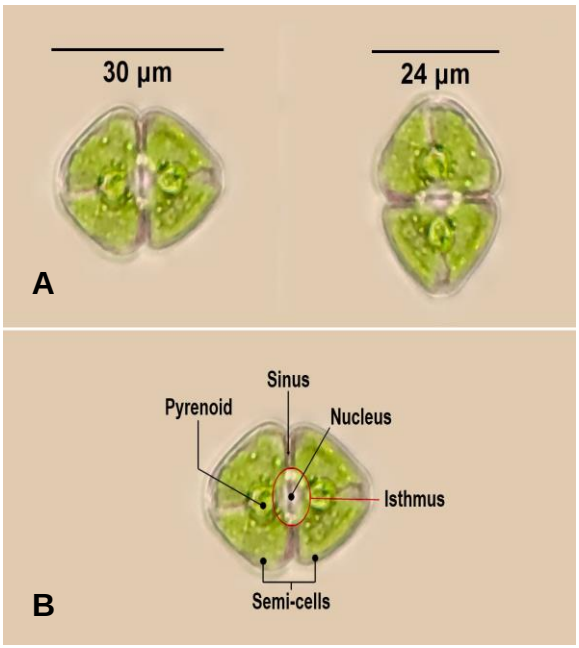


**Figure 6. *Cosmarium granatum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Cosmarium trilobulatum*

*Cosmarium trilobulatum* is the smallest *Cosmarium* species found in this study with 17 µm long and 14 µm wide (Figure 7). *Cosmarium trilobulatum* has two subtrapizoidal and 3-lobed semi-cells (Felisberto & Rodrigues, 2004). The apex of each semi-cell is wide and truncate, sometimes with a slight notch at the center region (Lee, 2015). The sinus between the two semi-cells is closed. The pyrenoids appear to be spherical in shape and clearly visible in each semi-cell.

*C. trilobulatum* originally described by Reinsch 1866 and published in his paper in 1867 and currently is accepted taxonomically (Guiry & Guiry, 2021).

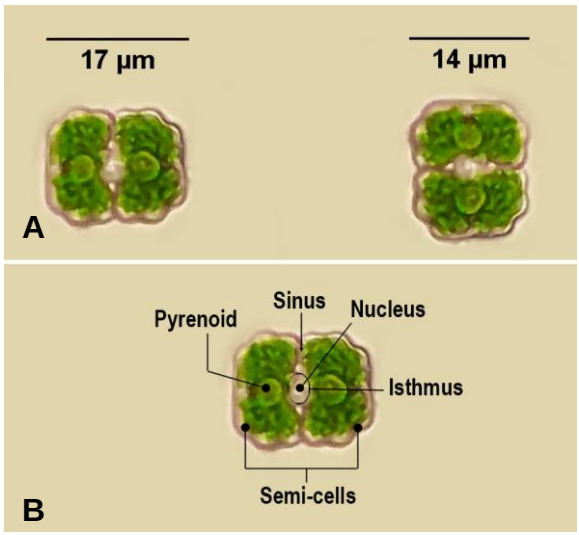


**Figure 7. *Cosmarium trilobulatum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Cosmarium* sp.1

*Cosmarium* sp.1 cell has 24 µm long and 21 µm wide (Figure 8). The semi-cells appear to be pyramidal in shape with wide and truncate apex. Pyrenoids are spherical and have a color that appears to almost blend with the cell's color.

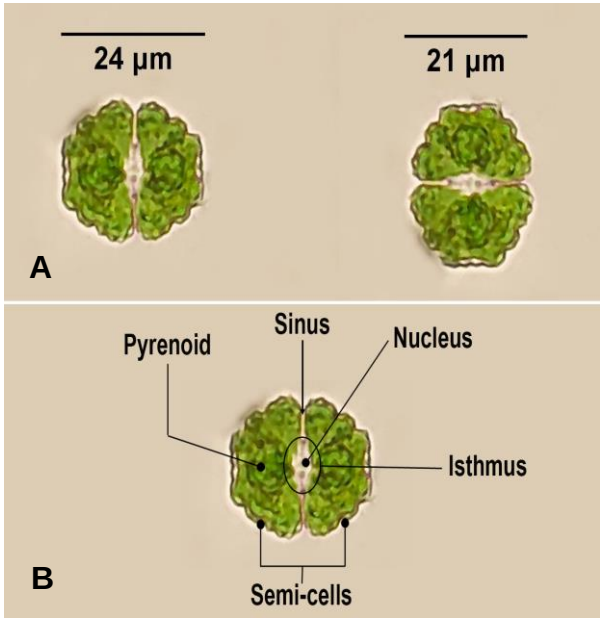


**Figure 8. *Cosmarium* sp.1: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Cosmarium* sp.2

*Cosmarium* sp.2 cell has 29 µm long and 28 µm wide (Figure 9). The semi-cells appear to be elliptical with rounded apex; there are thorn-like/spine-like structures throughout the outer membrane; the pyrenoids have a dark green color that looks very different from the green of the cell as a whole; the sinus between the two semi-cells is widely opened.

*Cosmarium* sp.2 is the only *Cosmarium* species in this study that was observed to have ornamentation on its cell walls in the form of thorn-like/spine-like structures.

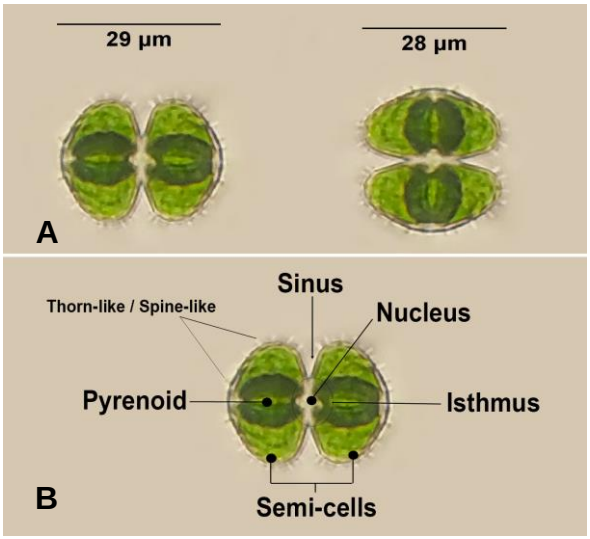


**Figure 9. *Cosmarium* sp.2: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Euastrum* spp.

*Euastrum* cells are somewhat flattened and have angular lobes. Two identical semi-cells are formed from deep sinus constriction (Belcher & Swale, 1978). The semi-cells are oval, elliptical or pyramid-shaped and distinctly compressed when viewed from the side (Janse van Vuuren *et al*., 2006; Taft, 1945). The cell walls appear to be smooth or have ornamentations such as warts, granules, and spines depending on the species (Janse van Vuuren *et al*., 2006). Apex usually truncate with an incision. The nucleus is clearly visible and is located in the isthmus.

The number *Euastrum* species found in this study were 5 (five) species, namely *Euastrum didelta*, *Euastrum bidentatum*, *Euastrum pulchellum*, *Euastrum denticulatum*, and *Euastrum turgidum* (Figure 10).

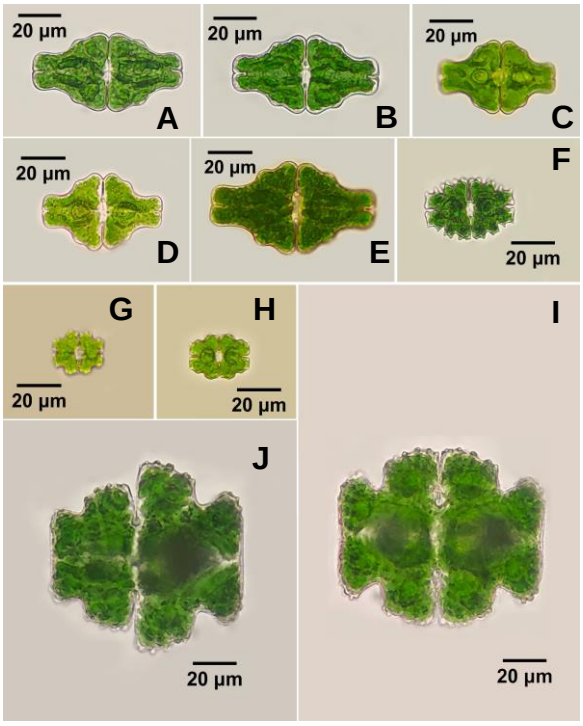


**Figure 10. *Euastrum* species found in this study: (A-E) *Euastrum didelta*; (F) *Euastrum bidentatum*; (G) *Euastrum denticulatum*; (H) *Euastrum pulchellum*; (I-J) *Euastrum turgidum***

The result of the measurement of *Euastrum* cell lengths and widths is presented in Table 3 in detail. The length of the cells measured in this study is the length of the two semi-cells from end to end.

**Table 3. The Cell Lengths and Widths of *Euastrum* spp.**

| Species | Cell Length | | Cell Width | |
|---|---|---|---|---|
| | N | D/N (µm) | N | D/N (µm) |
| *Euastrum didelta* | 6 | 67 | 12.5 | 32 |
| | 6.5 | 62 | 12.5 | 32 |
| | 8 | 50 | 12.5 | 32 |
| | 5.6 | 71 | 9.5 | 42 |
| *Euastrum bidentatum* | 10 | 40 | 15 | 27 |
| *Euastrum denticulatum* | 17 | 24 | 24 | 17 |
| *Euastrum pulchellum* | 14 | 29 | 20.5 | 20 |
| *Euastrum turgidum* | 4.5 | 89 | 5 | 80 |

**Notes: N (**Number of Objects fit in the Diameter of the Field of View); **D** (Diameter of Field of View at 400× Magnification: 0.4 mm)

Table 3 shows the range of *Euastrum* spp. cell sizes according to cell length and width. The cell length ranges from 24-89 µm and the cell width ranges from 17-80 µm. The largest species of *Euastrum* based on this study is *Euastrum* sp.1 with a length of 89 µm and a width of 80 µm. The smallest species is *Euastrum denticulatum* with a length of 24 µm and width of 17 µm.

*Euastrum didelta*

*Euastrum didelta* is vary widely in the cell size among all *Euastrum* species found in this study. The cell length of *E. didelta* ranges from 50-71 µm and the cell width ranges from 32-42 µm (Figure 11b). The smallest *E. didelta* cell sizes observed in the study were 50 µm long, 32 µm wide and 14 µm wide of the apex.

The semi-cells are trapezoidal in shape (Silva & Felisberto, 2015) and divided by deep median constrictions that are almost completely enclosed with a slight opening at the end. The cell walls appear to be smooth without any ornamentations. The polar lobe with truncated apex, forming a lip; thick cell walls and adorned with punctuations (Silva & Felisberto, 2015). Aquino *et al*. (2017) described the semi-cells of *E. didelta* as pyramidal in shape with rounded lateral margin and apical margin truncate (Figure 11a).

*Euastrum didelta* originally described by Ralfs in 1848 and currently is accepted taxonomically. *E. didelta* has 4 (four) heterotypic synonyms, namely *E. didelta* var. *didelta* Turpin ex Ralfs 1848, *E. didelta* f. *ansatiforme* Schmidle 1898, *E. didelta* var. *ansatiforme* (Schmidle) F. Ducellier 1915, and *E. didelta* var. *cuneatiforme* Ducellier 1915 (Guiry & Guiry, 2021).

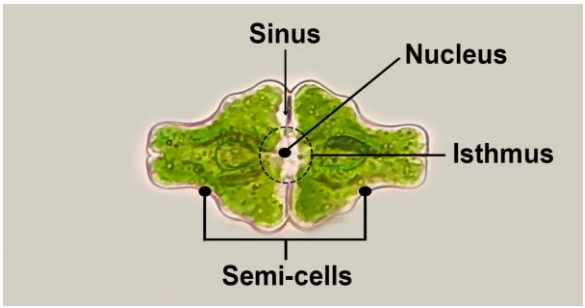


**Figure 11a. *E. didelta* Cell Morphology**

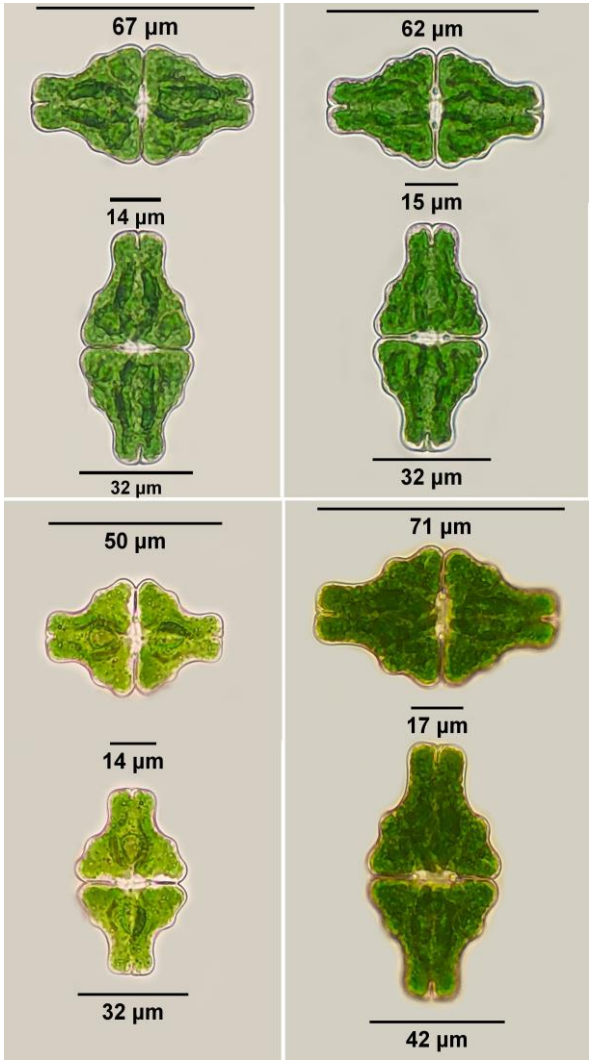


**Figure 11b. *Euastrum didelta* Cell Size Ranges**

*Euastrum bidentatum*

*Euastrum bidentatum* has 40 µm long and 27 µm wide (Figure 12). The semi-cells are divided by deep median constrictions (sinus); apical margin angular and with a wide incision V-shaped (Aquino *et al*., 2017; Silva & Felisberto, 2015). The cell walls are ornamented with spine-like structures (spiniferous processes at the terminal angles). The ornamental pattern on the cell walls made this species look somewhat like *Micrasterias*. Aquino *et al.* (2017) and Felisberto & Rodrigues **(**2004**),** described the semi-cells of *E. bidentatum* as 3-lobed semi-elliptical in shape with rounded poles and with undulate margins. Prescott (1970)**,** described the semi-cells of *E. bidentatum* as pyramidal in shape.

*E. bidentatum* originally described by Nägeli in 1849. According to the database on Algaebase.org, it has homotypic synonym *E. elegans* var. *bidentatum* (Nägeli) J.P. Jacobsen 1875 and 2 (two) heterotypic synonyms namely *E. bidentatum* f. *bidentatum* Nägeli 1849 and *E. bidentatum* var. *glabrum* Grönblad 1942 (Guiry & Guiry, 2021).

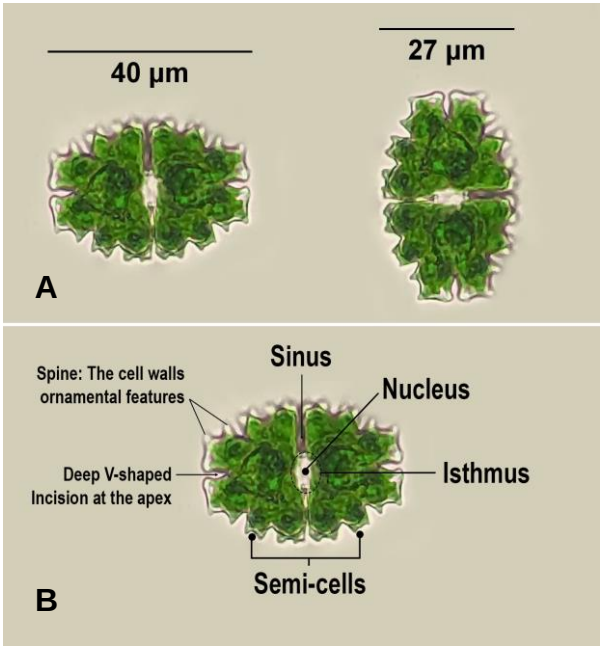


**Figure 12. *Euastrum bidentatum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Euastrum denticulatum*

*Euastrum denticulatum* is the smallest species of *Euastrum* found in this study with 24 µm long and 17 µm wide (Figure 13). The semi-cells appear to be subtrapeziform (Aquino *et al*., 2017) and semi-quadrangular (Silva & Felisberto, 2015) in shape, 3-lobed with tiny spine at each angles as the ornamental features of the cell walls. Apical lobes appear wide with deep V-shaped median notch. The sinus between the two semi-cells is enclosed.

*E. denticulatum* originally described by Gay in 1884 and is currently regarded as a synonym of *Euastrum amoenum* F. Gay. *E. denticulatum* has two heterotypic synonyms that are *E. denticulatum* var. *granulatum* West 1892 and *E. denticulatum* var. *angusticeps* Grönbald 1921 (Guiry & Guiry, 2021).

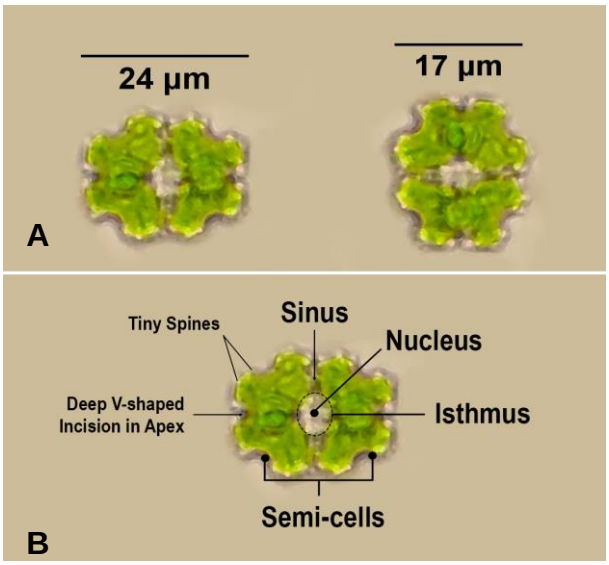


**Figure 13. *Euastrum denticulatum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Euastrum pulchellum*

*Euastrum pulchellum* has 29 µm long and 20 µm wide (Figure 14). Morphologically, *E. pulchellum* semi-cells look somewhat like *E. denticulatum* but with longer apical lobes. The semi-cells are quadrangular in shape with tiny spine at each angle as well; sinus between the two semi-cells is enclosed. The apical lobes appear wide with deep narrow median incision straight towards the pyrenoid.

*E. pulchellum* originally described by Brébisson in 1856 and is currently accepted taxonomically (Guiry & Guiry, 2021).

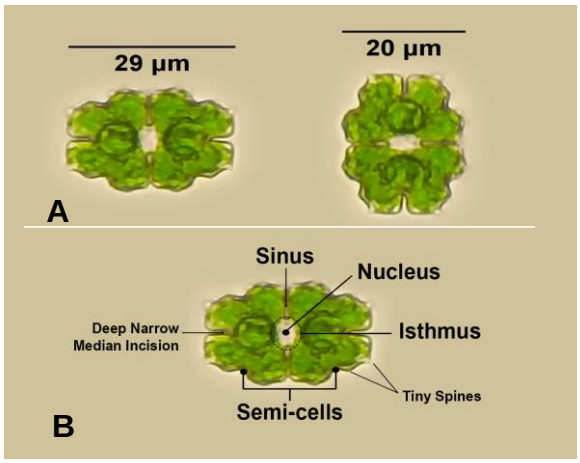


**Figure 14. *Euastrum pulchellum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

*Euastrum turgidum*

*Euastrum turgidum* is one of the largest *Euastrum* species found in this study with 89 μm long and 80 μm wide. In this study, *E. turgidum* cells were also observed after binary fission with asymmetrical cell shapes with 80 μm long and 38-80 μm wide (Figure 15). The semi-cells appear to be trapezoid in shape and are divided by deep closed-sinus. The apical lobe is very wide, straight and truncate (Scott & Prescott, 1960), approximately 75% of the width of the cell.

*E. turgidum* was first described by Wallich in 1855 and published in his paper in 1860 (Guiry & Guiry, 2021; Scott & Prescott, 1960). *Euastrum turgidum* is the scientific name of this species that is currently accepted taxonomically (Guiry & Guiry, 2021).

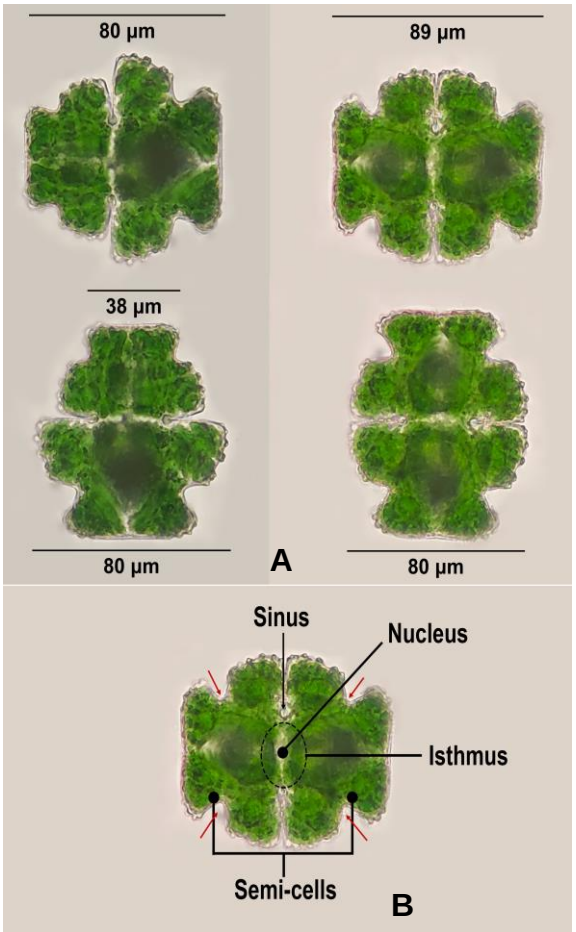


**Figure 15. *Euastrum turgidum*: (A) Cell Dimension (length and Width) and (B) Cell Morphology**

## Conclusion

The conclusions based on the results of this study are as follows, 6 (six) species of *Cosmarium* found in this study: *C. botrytis*, *C. biretum*, *C. granatum*, *C. trilobulatum*, *Cosmarium* sp.1, and *Cosmarium* sp.2. The dimensional range of the *Cosmarium* cells is 17-80 μm long and 14-57 μm wide, and 5 (five) species of *Euastrum* found in this study: *E. didelta*, *E. bidentatum*, *E. pulchellum*, *E. denticulatum*, and *E. turgidum*. The dimensional range of the *Euastrum* cells is 24-89 μm long and 17-80 μm wide.

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