The Glasgow Naturalist (online 2016) Volume 26, Part 3. Xx-xx

Staurastrum spinolobatum: a new species of placoderm desmid from the Shetland Islands

Christopher F. Carter[1*] & David B. Williamson[2]

[1]6 Church View, Wootton, Northampton, NN4 7LJ, England, UK
[2]15 Brocks Hill Drive, Oadby, Leicestershire, LE2 5RE, England, UK

*E-mail: Chris.Carter@6cvw.freeuk.com

The attractive landscape around the summit of Scrae Field, situated on Shetland Mainland near Quarff, (NGR: HU 416359; elevation 190 m), is characterised by several shallow (<0.5 m), permanent peat pools overlooked by the remains of a wartime radio station (Fig. 1). Comparison with archive material available from the Shetland Museum (2016), suggests that these pools may have formed within the foundations for the masts themselves or their associated buildings, rather than shaped from remnant peat cuttings. Permanent pools dominated by *Sphagnum* (bog moss), such as these, are prime candidates for desmids, a group of exquisitely patterned and highly symmetrical single-celled green algae (Brook *et al*. 2011; Lang *et al*., 2014), which can be easily collected from moss squeezings (see methods description) and have been reasonably well documented in the scientific literature. They have always been prime 'microscope objects' for their visual attraction since Victorian times, however there is presently a shortage of research focussing explicitly on desmids, which limits knowledge-gathering about their ecology. Nonetheless, it is worthwhile establishing a baseline of desmid distribution and biodiversity in the UK, especially given the paramount importance of phytoplankton communities in statutory lake quality assessment programmes (e.g. EU Water Framework Directive or 'WFD': Lang *et al*., 2014) and uncertainty surrounding climate change impacts on freshwater ecosystems. Extensive monitoring networks (e.g. Scottish Environment Protection Agency's WFD surveillance lochs) and official recording schemes such as the National Biodiversity Network or 'NBN' Gateway (https://nbn.org.uk/), together with input from the British Phycological Society (http://www.bpsalgalrecords.com/) and publications documenting news findings, offer excellent sources of information on freshwater algae. There is also a growing niche for citizen scientist participation in this area (P. Lang, *pers. comm*.).

Fig. 1. Photograph showing landscape view of Scrae Field, near the summit, Shetland: featuring the deep peat pool complex sampled for desmids (July, 2014) in foreground, and relict wartime radio station in backdrop. © Paul Leask, 2002.

The genus *Staurastrum* (see Fig. 5 for an annotated example) is one of a large and morphologically complex group of conjugating freshwater algae known as the 'placoderm desmids' (Chlorophyta, Zygnematales, Desmidiales). Whilst Algaebase (Guiry & Guiry, 2016) lists over 3,400 published *Staurastrum* taxa (species, intraspecific and forms), only around 500 are currently 'accepted' taxonomically, and approximately half of these desmids are officially recognised in the British Freshwater Algal Flora (John *et al*., 2011; Whitton *et al*., 2014). Recently, the European flora of *Staurastrum* was extensively revised by Coesel & Meesters (2013), although a major reference source for desmid identification remains the five volumes constituting the West *et al*. (1904–1923) monograph series, particularly for the British Isles.

On 3rd July 2014, during a walking holiday, one author (CFC) used the opportunity to sample some apparently permanent peat pools situated near the summit of Scrae Field, near Quarff, on the Shetland Islands, with the anticipation of finding some interesting desmids. This was done by allowing surplus water to drain from a clump of *Sphagnum*, collected from the pool edge, which was then stored in a re-sealable plastic bag for processing thereafter. Upon return from the field, the material was thoroughly shaken with additional water to loosen any attached algae and passed through a nylon gauze filter of about 0.5 mm pore size to remove larger objects. This material was settled overnight in tall glass vessels, after which the sediment was harvested from the bottom, refrigerated and examined within two weeks of collection using conventional brightfield optical microscopy, together with phase-contrast and polarised light microscopy where appropriate. Photographic records of the various live taxa present were obtained for subsequent analysis, prior to preserving the material in dilute (approx. 2.5%) formaldehyde to permit extended examination. This method of preservation eventually bleaches the chloroplasts but renders the cell ornamentation on desmids more visible (e.g. Fig. 3), thus aiding taxonomic identification; other preservatives such as Lugol's Iodine can disguise crucial diagnostic features and may not prevent bacterial growth (Goodyer, 2013).

The exact method used to collect desmid samples has some measure of individual preference tempered by practical travel constraints, the vulnerability of the site to disturbance and the availability of facilities for examination. The methods usually follow West & West (1904) and have subsequently been refined by other authors (e.g. John *et al*., 2013); there are two basic techniques. One procedure involves dragging a phytoplankton net to skim the weedy margins of lakes or otherwise sample directly from open water. Although desmids are inherently planktonic they frequently associate with or settle onto the foliage of submerged aquatic plants such as *Sphagnum*, *Utricularia* (bladderwort) or *Myriophyllum* (water milfoil), and may be referred to as 'metaplankton'. Hence the alternative method is usually more appropriate for sampling small pools where marginal aquatic plants can be accessed easily by hand, like those on Scrae Field, by utilising a handful of submerged foliage and either squeezing or shaking it and re-washing material into a container. This process may be repeated several times in order to capture a representative desmid population i.e. extract as many cells as possible from the available substratum.

The examination of material was conducted in several stages for logistical reasons: an initial sort was carried out within 2 days of collection using lower quality portable instruments, thus allowing samples to be graded for desmid abundance and interest whilst obtaining a preliminary view of the contents. Samples were thus prioritised and split accordingly: some 'fresh' material was posted onto the second author immediately and the remainder was preserved to facilitate specimen photography. This work was performed using an Olympus CX41 trinocular head microscope with semi-apochromatic 'fluorite' objectives, usually oil immersion x100, coupled to a 'Paxcam3' USB (MIS Inc) dedicated camera in which an uncorrected raw image is captured directly into a relational database 'Paxit' with calibrated magnification facilities. The line drawings (Figs 2, 4 & 5) were obtained using a Nikon Labophot microscope with a Nikon drawing attachment.

In total, 10 desmid taxa were found in the *Sphagnum* moss sampled from this peat pool complex on the Shetland Islands (Table 1). This tally included the occurrence of an unidentified *Staurastrum* species. We concluded, from a range of specimens, that it did not closely conform to any existing description in an extensive range of literature including West & West (1904), West & West (1904–12), West *et al*. (1923), Grönblad (1942), Prescott et al (1982), Williamson (1992), Brook *et al*. (2011), Coesel & Meesters (2013), Goodyer (2013), and Lang *et al*. (2014). We propose this represents a new scientific discovery upon which we have concentrated this study.

Desmid Taxon
Cosmarium amoenum Ralfs
Cosmarium sphagnicolum West & G.S.West (sometimes as *sphagnicola*)
Hyalotheca dissiliens Ralfs
Netrium digitus Hustedt
Staurastrum brebissonii W.Archer (now *Staurastrum pilosum* Brébisson)
Staurastrum margaritaceum Ralfs
Staurastrum spec. nov. (= *Staurastrum spinolobatum*)
Staurastrum trapezicum Boldt
Staurodesmus extensus (Andersson) Teiling. (Sometimes as (Borge) Teiling)
Xanthidium variabile (Nordstedt) West & G.S.West

Table 1. Desmid species observed in material collected from several deep peat pools situated at Scrae Field, Shetland Islands, July 2014.

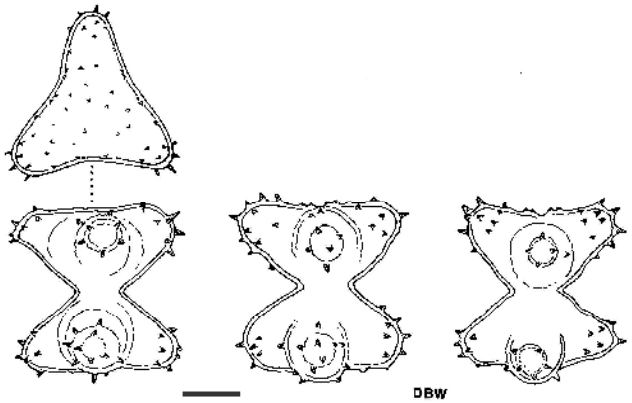

Fig. 2. Line drawings of the new desmid species, *Staurastrum spinolobatum*, showing both side (front) and apical (top) views. Scale bar = 10 μm.

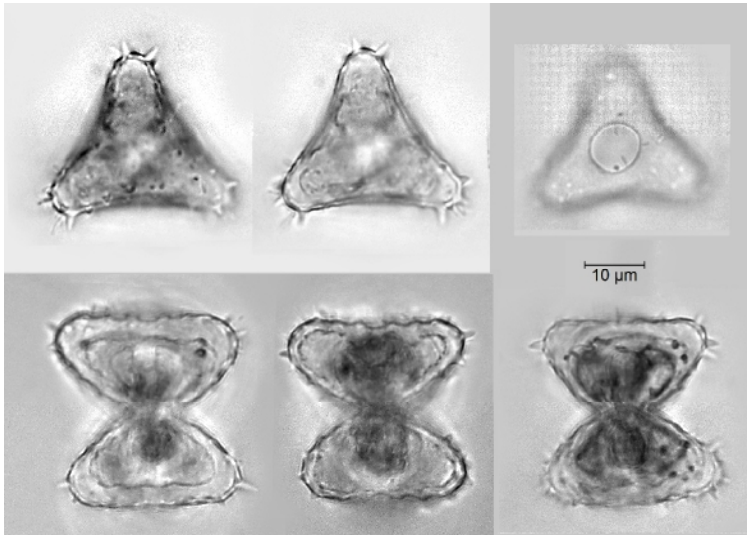

Fig. 3. Photomicrographs of the new desmid species, *Staurastrum spinolobatum*, showing both side and apical views at different focal points.

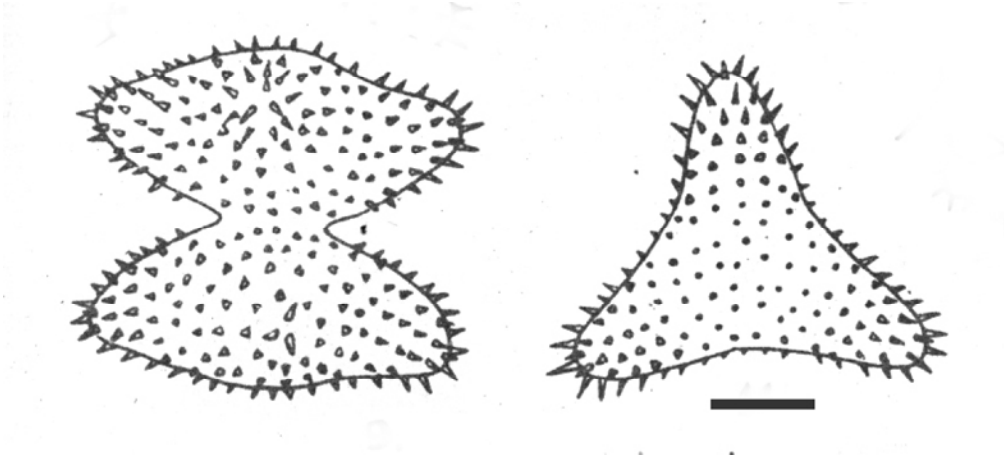

Fig. 4. Line drawing of *Staurastrum erasum*, after West *et al.* (1923). Scale bar = 10 μm.

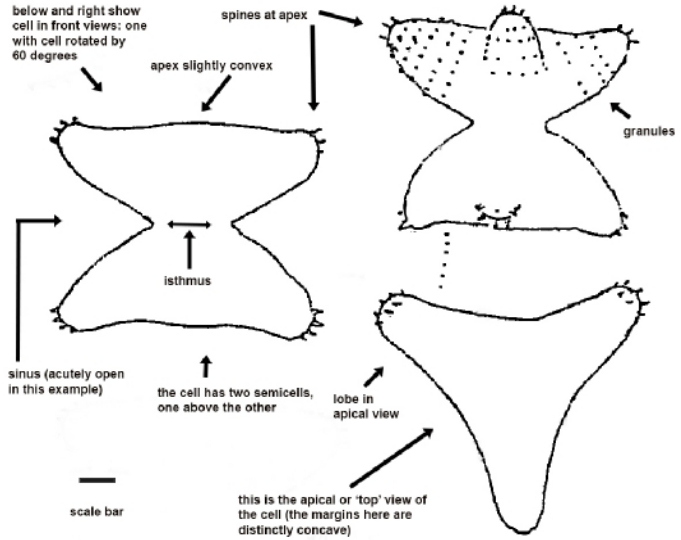

Fig. 5. Annotated line drawing of *Staurastrum brebissonii* var. *laticeps*, after Grönblad (1942). Scale bar = 10 μm.

Though sparsely occurring in the sample material (approx. 3 cells per 20 µl dropped onto a microscope slide) sufficient specimens of this, previously unknown, *Staurastrum* species were used to produce detailed line drawings (Fig. 2) and corresponding photomicrographs (Fig. 3) in two different orientations i.e. front and vertical (or apical) view. We therefore propose a newly described desmid species, *Staurastrum spinolobatum*, with averaged cell dimensions given in the formal description below. A deposition of the iconotype (i.e. Fig. 2) and holotype equivalent (a preserved sample) were placed in the Natural History Museum, London on 16th February 2016, reference BM001222079.

Formal description of *Staurastrum spinolobatum* Williamson & Carter:
Cells about as long as broad, semi-cells in front view triangular with a broad flat apex, which, depending on cell orientation may show a central V-shaped depression (refer to Fig. 5 annotation). This depression is about 3 µm deep and located towards the rounded edges of the apex between pairs of granules; there may thus be up to three such depressions on each semi-cell but only one will be in focus at one time. The angles are broadly rounded with some prominent rather stout short spines around them. The isthmus is narrow, the sinus widely open at about 90°. The vertical view is three-lobed with spiny round angles and slightly concave sides. Range of dimensions: Length (28.5 – 31.0 µm); Breadth without spines (27.0 – 29.2 µm); Length of spines up to 3 µm; Isthmus (8.5 – 10.0 µm); Length/Breadth ratio (1.0 – 1.14).

After thorough examination of the relevant literature, only two species were found that bore a tenuous resemblance to *Staurastrum spinolobatum* (Figs 2 & 3); these being *Staurastrum erasum* Bréb. (Fig. 4) and *Staurastrum brebissonii* W. Archer var. *laticeps* Grönblad 1942 (Fig. 5: illustrated herewith to explain the terminology associated with desmid taxonomy). Note that Coesel & Meesters (2013) regard *Staurastrum erasum* Bréb as a synonym of *Staurastrum brebissonii* var. *ordinatum* Schmidle (West *et al*., 1923). *Staurastrum erasum* is usually depicted (see Fig 4) with a slightly convex apex and narrowly rounded angles; note that the semi-cells of *S. erasum* comprise a different shape to our *S. spinolobatum* specimens (having a more acute sinus and a smaller L/B ratio i.e. "squatter") and are typically somewhat larger (L > 33 µm; B> 35 µm); the spines are also smaller and denser on these cells. Whilst Grönblad's *S. brebissonii* var. *laticeps* is closer in outline (see Fig 5), it is considerably larger (L. 53 µm, Br. 70 µm, Isth. 19 µm) than *S. spinolobatum*. Closer comparative inspection reveals other significant differences i.e. narrower angles to the lobes thus making them almost appear produced, with less robust spines, as well as having a squatter aspect and a more acute sinus in terms of semi-cell shape. In summary, our proposed new species may be recognised by its dimensions, the outwardly directed spines set into broad lobes and the near right-angled sinus which gives the distinct shape.

The desmid flora of the Shetland Islands was first investigated by West & West (1904), who listed 31 *Staurastrum* taxa, although these were essentially collected from larger water bodies lying closer to sea level, that were perhaps more accessible compared to our own upland sampling site. Similarly, *Staurastrum erasum* was recorded from nearby (approx. 1 km) Loch Brindister, downstream in the same catchment and itself having a diverse *Staurastrum* community, comprising 10 species (West *et al*., 1923) . Almost 90 years after the West's original publication, Williamson (1992) re-surveyed the Shetland Islands and generally concluded that the desmid flora was largely unchanged, also recording 31 *Staurastrum* species. On this occasion, *Staurastrum erasum* itself was also found in Loch Tingwall but this lies several miles to the north and in an entirely different catchment, suggesting this species occurs more widely than *S. spinolobatum*, the only record being restricted to the Scrae Fields site. Future phylogenetic work could potentially divulge whether *S. erasum* and *S. spinolobatum* were closely related. A further 20 years on, many of these Shetland lakes were revisited, along with a number of bog pools situated at a higher elevation than typically sampled for the area (C.F. Carter, unpublished), as these upland habitats can be desmid-rich yet relatively unexplored (Goodyer, 2013). Of about 57 samples taken, 13 were from pools corresponding to this type. At Scrae Field, the presence of accompanying desmid species e.g. *Xanthidium octocorne* (proposed UK red list taxa: Brodie *et al*. 2007), *Staurastrum trapezicum* and *Cosmarium sphagnicolum* suggest this is a good quality site in terms of habitat condition, however we are unable to speculate further without supporting data (e.g. water chemistry). A firm conclusion regarding any overall trend of desmid diversity in the Shetland Islands could not be reached as the season was exceptionally dry, which meant that some previously examined (e.g. by the Wests) sampling sites were unavailable for direct comparison. There were however, some signs of nutrient enrichment at localities adjoining improved pasture, some instances of non-native pondweed, *Elodea* sp.:(C.F. Carter, *pers. comm*.) and notable road-widening near some of the earlier catalogued sites; these may be worthy of further research with respect to human impact on desmid biodiversity and conservation status (Brodie *et al*., 2007).

We report a new desmid species, *Staurastrum spinolobatum*, discovered from a permanent peat pool complex in the Shetland Islands. Although the ecology of *S. spinolobatum* appears restricted and is

largely unknown, its co-occurrence with high conservation value species (e.g. *Xanthidium octocorne*) may suggest potential indicator value (e.g. Coesel, 2001; Brodie *et al*., 2007) for future habitat integrity assessments. However, further research is required to unravel its ecology, as is the case for many other 'rare' desmids (e.g. Lang *et al*., 2014). We hope our work promotes wider awareness and especially, encourages amateur naturalists to become interested in desmids and explore their familiar habitats, like bog pools and lake fringes, to discover for themselves the unseen diversity of microscopic life.

ACKNOWLEDGMENTS

The authors are very grateful to P. Lang for suggestions that have greatly improved the manuscript. We would like to thank P. Coesel (co-author of the European *Staurastrum* Flora) for examining our data and offering his own opinion that this was indeed a new species, confirmed by email in October 2015. We would like to thank P. Leask, who lives locally, for permission to use his photograph of the Scrae Field site, drawing our attention to the Shetland Museum archives and assisting with the collection of subsequent desmid material and field measurements.

REFERENCES

Brodie, J., John, D.M., Tittley, I., Holmes, M.J. & Williamson, D.B. (2007). *Important Plant Areas for algae: a provisional review of sites and areas of importance for algae in the United Kingdom*. Plantlife International, Salisbury, U.K.

Brook, A.J., Williamson, D.B. & John, D.M. (2011). Phylum Chlorophyta (Green Algae) Family Mesotaeniaceae ('Saccoderm Desmids') 609 – 741. In John *et al*. 2011.

Coesel, P.F.M. (2001) A method for quantifying conservation value in lentic freshwater habitats using desmids as indicator organisms. *Biodiversity and Conservation*, 10, 177-187.

Coesel, P.F.M. & Meesters, K.J. (2013) *European Flora of the Desmid Genera Staurastrum and Staurodesmus*. KNNV Publishing, Zeist, The Netherlands.

Goodyer, E. (2013). Quantifying the Desmid Diversity of Scottish Blanket Mires. PhD Thesis, University of Aberdeen.

Grönblad, R. (1942). Algen, hauptsächlich Desmidiaceen, aus dem Finnischen, Norwegischen und Schwedischen Lappland. *Acta Soc. Sci. Helsingfors, N.S.B, Opera Biol*. 2(5): 1–46

Guiry, M.D. & Guiry, G.M. (2016). *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 25 January 2016.

John, D.M., Whitton, B.A. & Brook, A.J., (editors) 2011 *The Freshwater Algal Flora of the British Isles*, 2nd Edition. Cambridge University Press, Cambridge.

Lang, P., Krokowski, J. & Goodyer, E. (2014). Some uncommon desmids (Chlorophyta, Zygnemophyceae) encountered in the phytoplankton of Scottish lochs. *The Glasgow Naturalist*, 26 (1), 119-122.

Prescott, G.W., Bicudo, Carlos E. de M. & Vinyard, W.C. (1982) *A Synopsis of North American Desmids. Part II, Desmidiaceae: Placodermae* Section 4. University of Nebraska Press, Lincoln and London.

Shetland Museum (2016). Shetland Museum and archives searched 25th January 2016. Photograph A101099 circa 1940. www.shetlandmuseumandarchives.org.uk.

West, W. & West, G.S. (1904). Freshwater Algae from the Orkneys and Shetlands. *Transactions and Proceedings of the Botanical Society of Edinburgh*. 23: 3–40. (Note: The paper and meeting are dated 1904 but Vol 23 Part 1 was published in 1905 and the full edition of Vol 23 was published in 1908.)

West, W. & West G.S. (1904–12) *A Monograph of the British Desmidiaceae*. *Vols 1-4*. Ray Society, London. (Plates available at http://rbg-web2.rbge.org.uk/DIADIST/)

West, W., West, G.S. & Carter, N. (1923). *A Monograph of the British Desmidiaceae*. *Vol. 5*. Ray Society, London. (Plates available at http://rbg-web2.rbge.org.uk/DIADIST/)

Whitton, B.A., John, D.M., Kelly, M.G. & Haworth, E.Y. (2014) A Coded List of Freshwater Algae of the British Isles. Fifth Edition. World-wide Web electronic publication. http://www.ceh.ac.uk/services/coded-list-freshwater-algae-2014

Williamson, D.B. (1992). A contribution to our knowledge of the desmid flora of the Shetland Islands. *Bot. J. Scotland*. 46: 233–285.