Phytotaxa 127 (1): 58–65 (2013)
www.mapress.com/phytotaxa/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.127.1.9

Encyonema hamsherae, a new diatom species from the Northern Rocky Mountains, USA

DIANE WINTER[1] & LOREN BAHLS[2]

[1]*Rhithron Associates, Inc., 29 Fort Missoula Rd., Missoula, MT 59804*
Email: dwinter@rhithron.com (corresponding author)
[2]*The Montana Diatom Collection, 1032 12th Avenue, Helena, MT 59601*

Abstract

A new species of *Encyonema* is described from the benthos of small mountain streams and rivers in western Montana and northern Wyoming. Previously this species had been identified incorrectly as *E. hebridicum* Grunow *ex* Cleve and *Cymbella affinis* Kützing or assigned the provisional name *Encyonema* sp. 1 MONTANA HAMSHER ANSP. Here we formally recognize this taxon as a new species, *Encyonema hamsherae.*

Introduction

This study introduces and describes a new *Encyonema* Kützing (1833: 589) species first observed in samples from the Pacific Northwest state of Montana in the United States. It has been previously reported under several other names including *Cymbella affinis* Kützing (1844: 80), *Encyonema hebridicum* (Gregory) Grunow in Cleve & Möller (1877: No. 37), and *Encyonema* sp. 1 MONTANA HAMSHER ANSP. The geographic locality in which it is most commonly observed is the south-central and western part of Montana as well as a few sites in northern Wyoming. These sites are generally in mountainous regions from smaller streams higher in their watersheds. This new *Encyonema* species may prove to be endemic to the Pacific Northwest and thus an indicator not only of geographic locality but of the clean, nutrient-poor low-order streams in which it most commonly occurs.

Methods and Material

The type sample of *Encyonema hamsherae sp. nov.* is composite periphyton from Shovel Creek in Madison County, south central Montana, 44° 50’ 38” N, 111° 59’ 43” W. This species is also found in river samples from several other locations around Montana and northern Wyoming. USGS NAWQA and Montana DEQ samples provide the sources for these other sample locations, all being collected from rocks or other solid substrate in riffle areas of rivers and streams. Table 1 gives the locations, elevation, stream order and number counted at each of these sites. All USGS NAWQA slides were prepared and analyzed following ANSP guidelines (Charles *et al.*, 2002) and the Montana samples were prepared and analyzed following Bahls (1993) methods.

 Accepted by M.B. Edlund: 7 Oct. 2011; edited version received at publisher: 4 Jun. 2013; published: 29 August 2013.

TABLE 1: Site names, number of *Encyonema hamsherae* in an 800 valve count, elevation and geographic location of sites used in this study. Site 31 is the type locality.

Site ID	Site Name	Count (#/800)	Elevation (m)	Latitude (°N)	Longitude (°W)
1	Alder Gulch (lower), MT	4	1759.6	45.2892	-111.9442
2	Alder Gulch (upper), MT	46	2141.8	45.2183	-111.9314
3	Avalanche Creek, MT	28	1517.9	46.7099	-111.4913
4	Barr Creek, MT	23	1424.9	47.5512	-112.6065
5	Beaver Creek, MT	49	1697.7	46.7439	-111.4085
6	Belly River (lower), MT	2	1400.9	48.9681	-113.6822
7	Belly River, MT	1	1421.6	48.9283	-113.7183
8	Browns Gulch (upper), MT	47	1927.6	45.2603	-111.9725
9	Browns Gulch (lower), MT	15	1703.8	45.3064	-111.9744
10	Camas Creek, MT	1	1054.3	48.6322	-114.1056
11	Castle Creek (Stillwater), MT	9	1633.4	45.4611	-109.8933
12	Castle Creek (Wheatland), MT	24	1323.1	46.4564	-109.9325
13	Columbus Creek (Columbus Peak), WY	31	1478.9	44.9114	-107.3950
14	Divide Creek, MT	1	1379.8	48.7453	-113.4319
15	East Fork Ashby Creek, MT	47	1238.4	46.8234	-113.5969
16	Elk Creek, MT	38	1530.7	46.6474	-111.2437
17	Keep Cool Creek, MT	1	1444.8	46.9764	-112.6197
18	Logan Creek (lower), MT	2	1246.0	48.3325	-114.6536
19	Logan Creek (upper), MT	7	1327.7	48.2919	-114.6508
20	McHessor Creek, MT	17	1481.3	45.3936	-112.4203
21	Middle Fork Dearborn River (lower), MT	6	1264.0	47.2103	-112.2756
22	Middle Fork Dearborn River (upper), MT	8	1476.8	47.1039	-112.3550
23	Middle Fork Flathead River, MT	2	963.8	48.5056	-113.9933
24	North Fork Dupuyer Creek, MT	14	1478.6	48.0942	-112.7167
25	North Fork Flathead River, MT	1	962.3	48.4933	-114.1253
26	North Fork Flatwillow Creek, MT	31	1393.9	46.8561	-109.0494
27	North Fork Smith River, MT	17	1738.3	46.6597	-110.5905
28	Oregon Gulch, MT	1	1057.7	47.1346	-114.9983
29	Rose Creek, MT	26	1422.8	47.5480	-112.6031
30	Rubideau Creek trib., MT	8	992.4	48.4989	-114.0178
31	Shovel Creek, MT	30	2135.0	44.8439	-111.9952
32	Snowshoe Creek, MT	20	1722.1	46.6844	-112.4661
33	South Fork Birch Creek, MT	2	1508.2	48.1344	-112.8975
34	South Fork Dupuyer Creek, MT	19	1455.4	48.0869	-112.6933
35	Spring brook alongside Belly River, MT	1	1399.3	48.9794	-113.6769
36	Tongue River, WY	7	1270.4	44.9137	-107.2993
37	Lodge Grass Cr. trib., MT	34	1646.8	45.0015	-107.6834
38	Trout Creek, MT	29	1117.1	46.7097	-111.7997

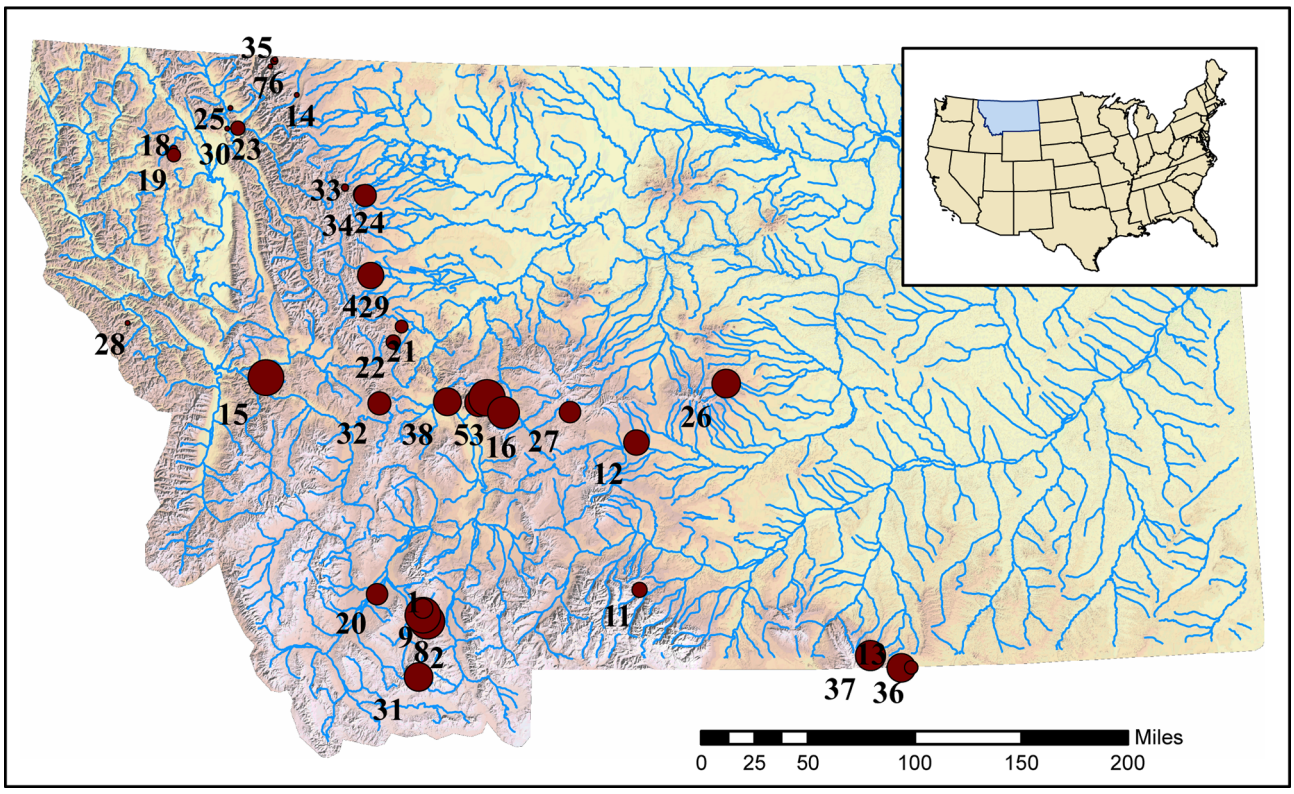


FIGURE 1: Sites in Montana and Wyoming where *Encyonema hamsherae* has been recorded. Numbers for each site correspond to those in Table 1. Circle size is proportional to number of *E. hamsherae* valves recorded in an 800 valve count; please refer to Table 1 for abundance data for each site. Only those sites with associated physical and water chemistry data are listed in Table 2.

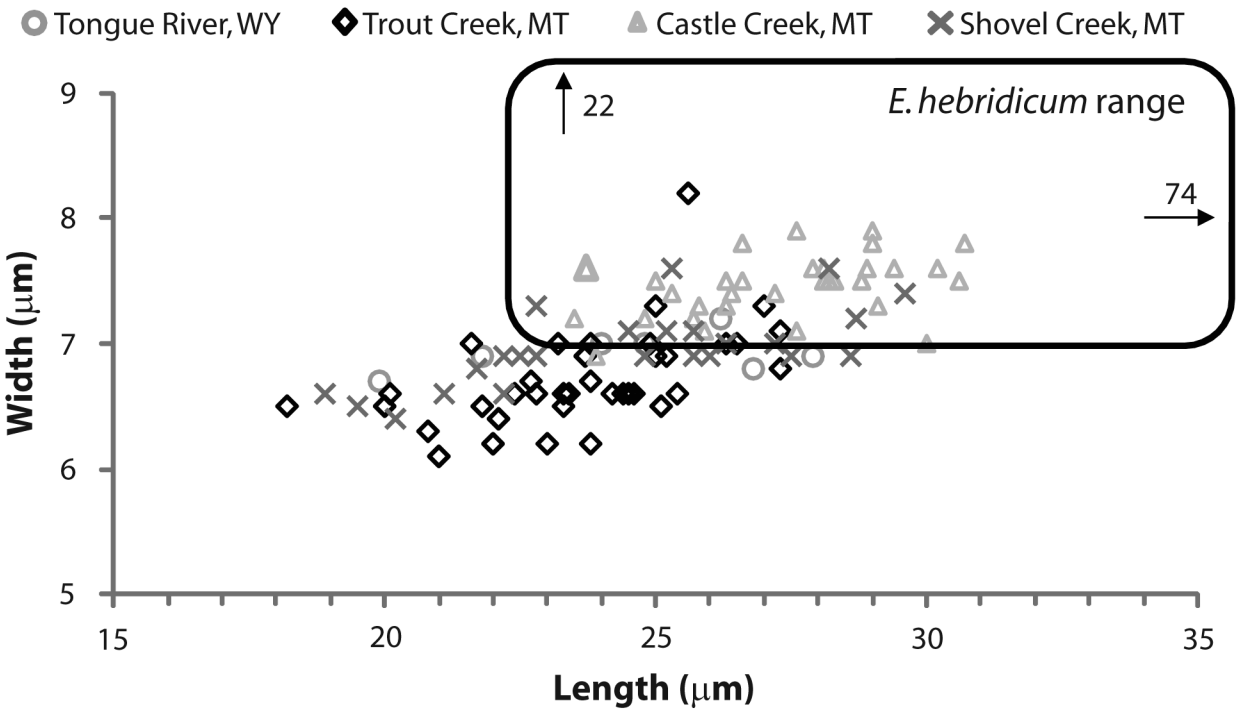


FIGURE 2a:Length and width measurements of different populations of *E. hamsherae sp. nov.* from Montana and Wyoming, the range for *E. hebridicum* given by Krammer (1997) is shown by the rounded box.

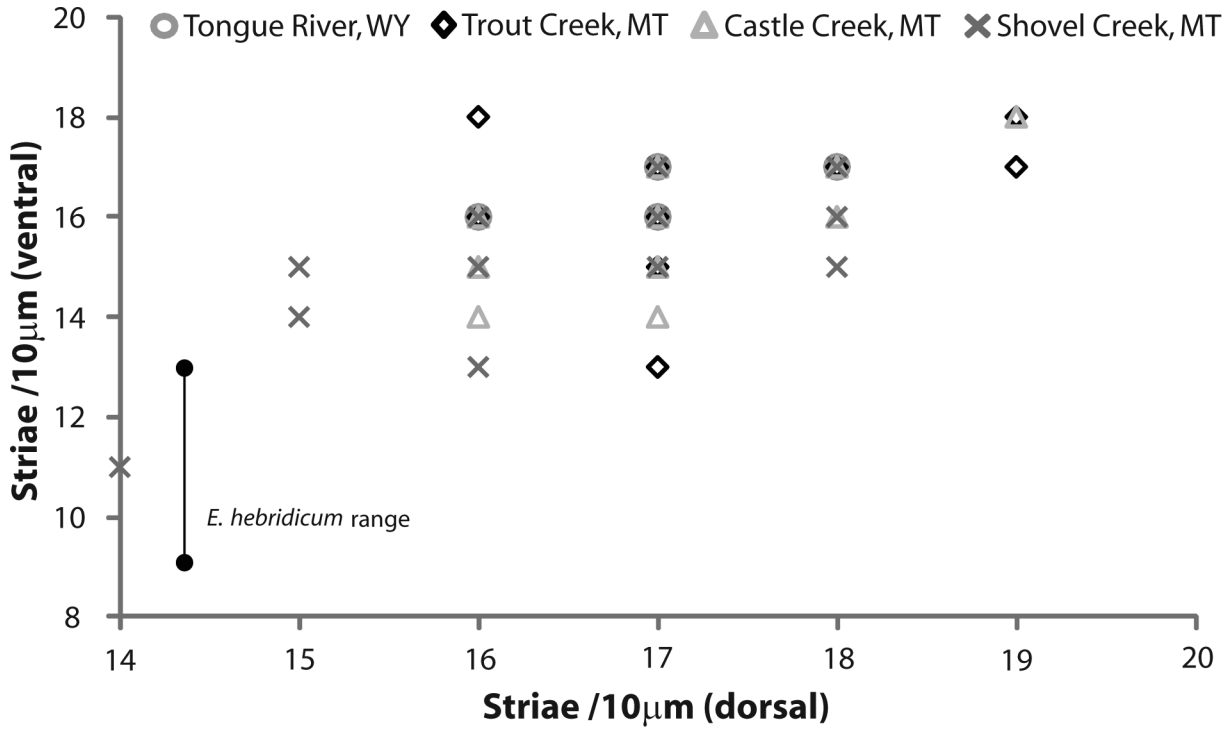


FIGURE 2b:Dorsal and ventral striae densities of these sample populations, range for *E. hebridicum* (Krammer, 1997) is illustrated by the line in the lower left of the graph.

New Species Description

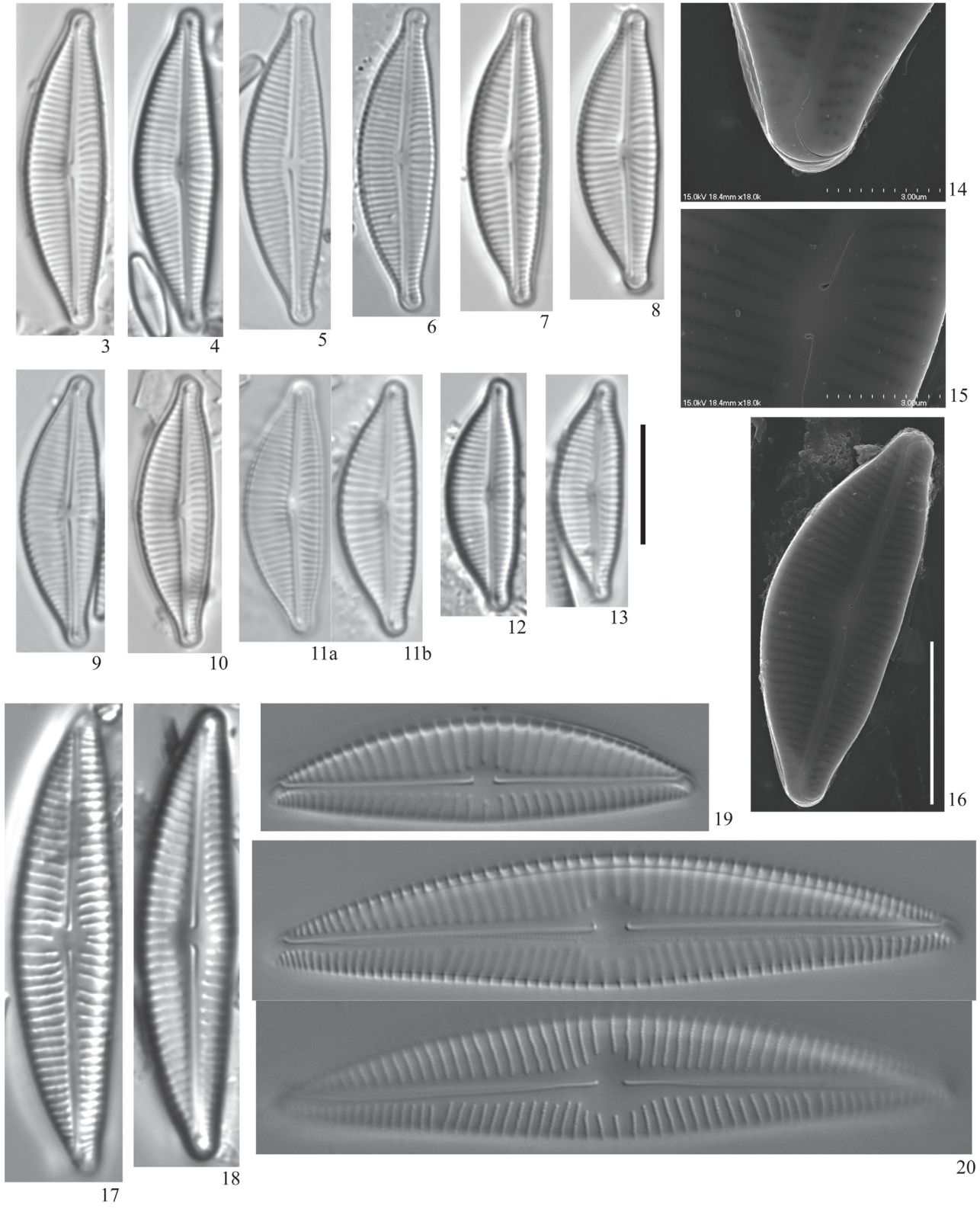
Division **Bacillariophyta**
Class **Bacillariophyceae** Haeckel 1878
Subclass **Bacillariophycidae** D.G. Mann in Round *et al.* 1990
Order **Cymbellales** D.G. Mann in Round *et al.* 1990
Family **Cymbellaceae** Greville 1833
Genus ***Encyonema*** Kützing 1833

Encyonema hamsherae Winter & Bahls *sp. nov.* (Figs 3–16)

Valvae parce usque ad valde dorsiventrales. Labrum dorsuale curvum, labrum ventrale leviter convexum, termini porrecti et leviter capitati. Raphe recta, termini proximi leviter dorsuali modo deflexi, termini distales valde ventrali modo deflexi. Axialis area angusta, media area leviter extensa, stigma absens. Mediae striae leviter radiales evenientes paene parallelae ad terminos. Valva 19–30 µm longa, 6.5–7.5 µm lata, dorsuales mediae striae (14) 16–18 per 10 µm, ventrales mediae striae (11) 15–17 (18) per 10 µm.

Valves moderately to strongly dorsiventral. Dorsal margin arched, ventral margin slightly convex, ends protracted and slightly capitate. Raphe straight, proximal ends slightly dorsally deflected, distal ends strongly ventrally deflected. Axial area narrow, central area slightly expanded, stigma absent. Striae slightly radiate in center becoming nearly parallel at ends. Valve length 19–30 µm, valve width 6.5–7.5 µm, dorsal central striae (14) 16–18 in 10 µm, ventral central striae (11) 15–17 (18) in 10 µm.

Type:— USA. Montana: Madison County, Shovel Creek, 44° 50’ 38” N, 111° 59’ 43” W, composited periphyton sample collected 18 September 2002, collected by Al Nixon, Montana DEQ, (Circled specimen (Fig. 3) on slide *15–94, Montana Diatom Collection sample number 263001(1)* (MONTU!), **holotype, designated here**; circled specimen on slide *T4-11-7, Montana Diatom Collection sample number 263001(1)* (MONTU), **isotype, designated here**).



FIGURES 3–20: Figures 3–16, *Encyonema hamsherae sp. nov.* Figures 17–20. *Encyonema hebridicum*. Figs 3 (holotype), 4, 7, 8, 10–13. Shovel Creek, Montana; Figs 5, 9. Castle Creek (Stillwater), Montana; Fig. 6. Tongue River, Wyoming; Figs 14–16. Trout Creek, Montana; Figs 17, 18. Kootenai Fen, Glacier National Park, Montana (MDC sample # 451707 (1), University of Montana Herbarium (MONTU) accession #39–85); Figs 19, 20. (isotype) Lulea Lappmark, Sweden (Cleve and Möller Nr. 37), Fig. 20 shows two focal planes of same valve. Scale bars are 10 µm unless otherwise noted.

Habitat:—Lotic sites in northern Wyoming and western Montana

Distribution:—montane northwestern United States

Etymology:—Dedicated to Dr. Sarah Hamsher

Other Information:—Collected 18 September 2002; composited periphyton sample; collected by Al Nixon, Montana DEQ; Environmental data: specific conductance = 359 µS/cm; pH = 8.74; total alkalinity = 176 mg/L; temperature = 10.4 C; dissolved oxygen = 11.41 mg/L; total phosphorus = 0.006 mg/L; nitrate + nitrite = 0.05 mg/L.

Comparison with related taxa

Encyonema hamsherae occurs in samples collected from streams in the northern Rocky Mountains of Montana and northern Wyoming. A single illustration of a morphologically similar specimen identified as belonging to the "*Sippencomplex Encyonema hebridicum* Grunow *ex* Cleve" in Krammer (1997; Tafel 123, fig. 9) led to confusion regarding morphological variability of *E. hebridicum* and the initial misidentifications of *E. hamsherae*. No site location is given for this single illustration so we are unable at this time to extend the geographic range of *E. hamsherae* beyond Montana and Wyoming.

The length and width of *E. hamsherae* from populations in Montana are smaller than, but within the lower range for *E. hebridicum* (Fig. 2a); however, the finer striae count (Fig. 2b) and difference in overall valve morphology clearly distinguish this new species from *E. hebridicum* (Figs 16–20); one hundred and eleven individuals from the four most abundant populations were measured to determine the size range for this species. The populations of *E. hamsherae* differ significantly from the isotypes of *E. hebridicum* (Figs 19–20) illustrated by Krammer (1997, Tafel 121, figs 2–4) and Patrick and Reimer (1975, pl. 4, fig. 7) being smaller, having a higher striae count and more compact overall shape with capitate valve ends.

The gross morphology and radiate central striae are similar to several *Cymbella* C.A. Agardh (1830: 1) species: *Cymbella excisa* Kützing (1844: 80) (Krammer 2002, plate 9, fig. 16), *C. exigua* Krammer (2002: 30, 159, pl. 10, figs 19–22), *C. affinis* Kützing (Krammer & Lange-Bertalot 1986, fig. 125: 17; Krammer 2002, pl. 21) and *C. affiniformis* Krammer (2002: 45, 162, , pl. 25, figs 1–8). *Encyonema hamsherae* differs from these *Cymbella* species by lacking a stigma, having a narrower central area, a straight rather than lateral raphe with opposing deflection of proximal and distal raphe endings, and generally finer striae count. The ends of *E. hamsherae* valves are always protracted and captitate, but can vary to some extent in their orientation, from straight to being ventrally deflected in some valves (Fig. 9).

A common variation in morphology occurs in *E. hamsherae* populations from several locations. In these valves the ventral margin is not smoothly convex, but is somewhat flatter with several small indentations located along the ventral margin where the ventral striae change from radial to parallel orientation (Figs 9, 12, 13). This morphological variation is observed more often in smaller specimens and can be present in up to 10 percent of the population. Janus cells (McBride & Edgar 1998) are also observed in cells of various sizes, with often distinctly different striae density on each valve. Figure 11 illustrates both valves of a Janus cell; Figure 11a has a central striae count of 14 in 10 µm for the dorsal side and 11 in 10 µm for the ventral side, whereas Figure 11b has a striae count of 17 in 10 µm for both sides.

Ecology

Encyonema hamsherae is present in many stream and river sites from northern Wyoming and western Montana (Figure 1). Bahls (unpubl.) has noted that *E. hebridicum* present in Glacier National Park occurs in small lakes and fens (Figs 17, 18). Examination of herbarium samples recording *E. hebridicum* from the Academy of Natural Sciences of Philadelphia confirms this observation; samples from lakes contain *E. hebridicum* and those from smaller streams (in Montana) contain *E. hamsherae*. Additionally, most specimens of *E. hebridicum* illustrated in Krammer (1997) are from lakes or standing waters; type material is in fossil material from northern Sweden.

The largest numbers of *E. hamsherae* are from sites located on small headwater streams suggesting its preference for colder, nutrient-poor waters. Where it is rare, especially in larger streams, cells of *E. hamsherae* may have been transported to these sites from smaller upstream tributaries. This is further suggested by greater numbers of *E. hamsherae* occurring in the upstream sample of station pairs on the same stream (e.g. Sites 1 & 2, 8 & 9, 11 & 12). In general, *Encyonema hamsherae* is found at elevations ranging from about 1000 to 2100 m. *Encyonema hamsherae* appears to prefer small, cold, well-oxygenated headwater streams with moderate levels of alkalinity and dissolved solids (Table 2). Populations with morphological features similar to *E. hamsherae* have been reported from Kentucky and the Appalachian region of eastern United States (K. Manoylov, pers. comm.; M. Potapova, pers. comm.). The full range of cell sizes and shapes, striae counts, and other features of these populations need to be examined before they can be included in *E. hamsherae*.

TABLE 2: Site and water chemistry data associated with *Encyonema hamsherae* localities listed in Table 1, where available. Site 31 is the type locality. *Alkalinity for the Wyoming site (36) represents total calcium carbonate, whereas alkalinity values at Montana sites combines hydroxide + carbonate + bicarbonate. NA indicates data for this variable is unavailable.

Site ID	Site Name	Year	pH	Temp. (°C)	Flow (cms)	Cond. (µS/cm)	DO (mg/L)	Tot. N (µg/L)	Tot. P (µg/L)	Alk. (mg/L)
3	Avalanche Creek, MT	2005	7.94	15.7	0.04	451	10.72	600	16	240
5	Beaver Creek, MT	2004	8.45	12.96	0.08	405	8.84	NA	12	220
12	Castle Creek, MT	2004	7.8	9.0	0.05	379	9.33	150	2	160
15	East Fork Ashby Creek, MT	2004	8.48	11.45	0.06	369	9.93	NA	21	230
16	Elk Creek, MT	2004	8.35	12.64	0.04	447	9.66	NA	2	220
18	Logan Creek (lower), MT	2003	7.64	11.26	0.42	262	13.25	270	20	NA
19	Logan Creek (upper), MT	2003	7.55	10.79	0.14	228	12.25	330	88	NA
21	Middle Fork Dearborn River (lower), MT	2002	8.23	12.25	0.27	351	8.94	120	2	124
22	Middle Fork Dearborn River (upper), MT	2002	8.38	11.43	0.0039	252	9.14	160	1	90
24	North Fork Dupuyer Creek, MT	2002	8.5	8.2	0.11	339	10.8	170	1	150
28	Oregon Gulch, MT	2004	7.44	8.9	0.41	141	5.38	NA	3	110
29	Rose Creek, MT	2009	8.45	23	0.00	6530	10.6	0	53	464
31	Shovel Creek, MT	2002	8.74	10.4	0.045	359	11.41	160	6	176
32	Snowshoe Creek, MT	2004	6.99	8.84	0.10	277	9.06	NA	2	210
33	South Fork Birch Creek, MT	2002	8.11	8.36	2.97	282	9.02	140	18	102
34	South Fork Dupuyer Creek, MT	2002	8.5	12.4	0.13	395	10.5	130	2	198
36	Tongue River, WY	2009	8.07	2.6	0.05	266	11.7	257	10	133*
38	Trout Creek, MT	2005	7.89	15.3	0.68	438	10	500	7	190

Acknowledgements

We greatly appreciate the help of Dr. Marina Potapova at the Diatom Herbarium at the Academy of Natural Sciences in Philadelphia for providing isotype images of *Encyonema hebridicum* as well as helping find NAWQA samples used in the comparisons. Dr. Jeffery Stone at the University of Nebraska kindly provided the SEM images of *Encyonema hamsherae*. We also wish to thank our reviewers for the many suggestions and improvements they brought to the paper.

References

Agardh, C.A. (1830) *Conspectus Criticus Diatomacearum.* Part 1. Lundae. Litteris Berlingianis, pp. 1–16.

Bahls, L. (1993) Periphyton bioassessment methods for Montana streams. Montana Department of Health and Environmental Sciences; Water Quality Bureau, Helena, Montana, 61 pp.

Charles, D.F, Knowles, C. & Davis, R.S. (2002) Protocols for the analysis of algal samples as part of the U.S. Geological Survey National Water-Quality Assessment Program. Report No. 02–06, Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia, 124 pp.

Cleve, P.T. & Möller, J.D. (1877) *Diatoms*. Part I, No. 1–48. Esatas Edquists Boktryckeri, Upsala.

Krammer, K. (1997) Die cymbelloiden Diatomeen, Eine Monographie der weltweit bekannten Taxa. Teil 2. *Encyonema* part, *Encyonopsis* and *Cymbellopsis*. *Bibliotheca Diatomologica*, Band 37. J. Cramer, Berlin/Stuttgart, 469 pp.

Krammer, K. (2002) *Cymbella. Diatoms of Europe: Volume 3.* A.R.G. Gantner Verlag K.G, 584 pp.

Krammer, K. & Lange-Bertalot, H. (1986) Bacillariophyceae, 1. Teil: Naviculaceae. Band 2 *in*: Ettl, H., Gerloff, J., Heynig, H. & Mollenhauer, D. (Eds), *Süßwasserflora von Mitteleuropa.* Gustav Fischer Verlag, Stuttgart, 876 pp.

Kützing, F.T. (1833) Synopsis Diatomacearum oder Versuch einer systematischen Zusammenstellung der Diatomeen. *Linnaea* 8(5): 529–620, pls. XIII–XIX.

Kützing, F.T. (1844) *Die Kieselschaligen. Bacillarien oder Diatomeen*. Nordhausen. 152 pp., 30 pls.

McBride, S.A. & Edgar, R.K. (1998) Janus cells unveiled: frustular morphometric variability in *Gomphonema angustatum*. *Diatom Research* 13(2): 293–310.
http://dx.doi.org/10.1080/0269249X.1998.9705452

Patrick, R. & Reimer, C. (1975) Diatoms of the United States, exclusive of Alaska and Hawaii, Volume 2, Part 1. *Monographs of the Academy of Natural Sciences of Philadelphia*, No. 13.