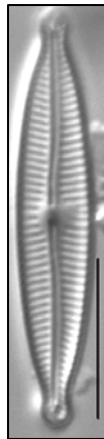
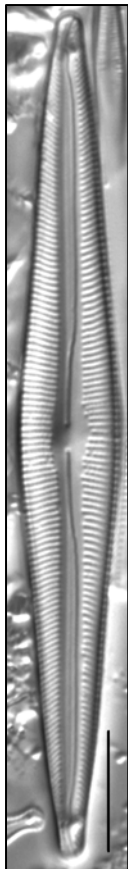


NORTHWEST DIATOMS



Volume 5 *Encyonopsis*

Loren L. Bahls
2013

Front Cover: Lake McDonald is the largest lake in Glacier National Park and the type locality for three new species of *Encyonopsis*: *E. montana* (left), *E. stafsholtii* (middle), and *E. czarneckii* (right). This National Park Service webcam photo was captured off the Internet on 6 January 2010. Glacier National Park webcams are available at:

<http://www.nps.gov/glac/photosmultimedia/webcams.htm>

NORTHWEST DIATOMS

VOLUME 5

Encyonopsis

**from western North America:
31 species from Alberta, Idaho, Montana,
Oregon, South Dakota, and Washington,
including 17 species described as new**

**Loren L. Bahls
2013**

Address of the author:

**Loren L. Bahls
1032 12th Avenue
Helena, MT 59601
USA**

eemahtuskie@gmail.com

ISBN 0945345852

ISBN 978-0-945345-85-5

**Copyright © 2013
Loren L. Bahls**

CONTENTS

SUMMARY.....	6
Abstract.....	7
Introduction.....	7
Materials and Methods	8
Taxonomy, Distribution and Ecology.....	9
Discussion.....	34
Acknowledgements.....	35
References.....	35
Tables for comparison of <i>Encyonopsis</i> species.....	38
TABLE 1: Key to <i>Encyonopsis</i> species.....	39
TABLE 2: <i>Encyonopsis neoamphioxys</i> group.....	41
TABLE 3: <i>Encyonopsis cesatii</i> group.....	41
TABLE 4: <i>Encyonopsis descripta</i> group.....	42
TABLE 5: <i>Encyonopsis microcephala</i> group.....	42
TABLE 6: <i>Encyonopsis subminuta</i> group.....	43
TABLE 7: <i>Encyonopsis perborealis</i> group.....	43
REGISTER OF TAXA.....	44

SUMMARY

Thirty-one species of *Encyonopsis* from western North America are documented with photographs of specimens on slides in the Montana Diatom Collection (MDC). Seventeen of these species are described as new: *Encyonopsis aequaliformis*, *E. albertana*, *E. anacondae*, *E. bobmarshallensis*, *E. czarneckii*, *E. dakotae*, *E. descriptiformis*, *E. hustedtii*, *E. kutenaorum*, *E. lacusalpini*, *E. lacuscaerulei*, *E. lacusglacialis*, *E. medicinalis*, *E. montana*, *E. stafsholtii*, *E. treinishii*, and *E. weilandii*. Also, one infraspecific taxon is elevated to species: *Cymbella microcephala* fo. *robusta* to *Encyonopsis robusta*. The study area encompasses mountainous and forested regions of Alberta, Idaho, Montana, Oregon, South Dakota, and Washington. Here species of *Encyonopsis* are found mostly in small headwater lakes, ponds, springs, seeps and streams. These waters are typically unpolluted, cold and weakly acidic to moderately alkaline, with high dissolved oxygen and low to moderate concentrations of nutrients and dissolved solids. Northwest Montana, west of the Continental Divide, is a biodiversity hotspot for *Encyonopsis* species. The potential is substantial for finding new species in other diatom genera among samples in the MDC and in other collections from remote regions of North America.

***Encyonopsis* (Bacillariophyta, Cymbellaceae) from western North America: 31 species from Alberta, Idaho, Montana, Oregon, South Dakota, and Washington, including 17 species described as new**

LOREN BAHLS

The Montana Diatom Collection, 1032 12th Avenue, Helena, Montana 59601 USA: Email: emahtuskie@gmail.com

Abstract

Thirty-one species of *Encyonopsis* from western North America are documented with photographs of specimens on slides in the Montana Diatom Collection (MDC). Seventeen of these species are described as new: *Encyonopsis aequaliformis*, *E. albertana*, *E. anacondae*, *E. bobmarshallensis*, *E. czarneckii*, *E. dakotae*, *E. descriptiformis*, *E. hustedtii*, *E. kutenaiorum*, *E. lacusalpini*, *E. lacuscaerulei*, *E. lacusglacialis*, *E. medicinalis*, *E. montana*, *E. stafsholtii*, *E. treinishii*, and *E. weilandii*. Also, one infraspecific taxon is elevated to species: *Cymbella microcephala* fo. *robusta* to *Encyonopsis robusta*. The study area encompasses mountainous and forested regions of Alberta, Idaho, Montana, Oregon, South Dakota, and Washington. Here species of *Encyonopsis* are found mostly in small headwater lakes, ponds, springs, seeps and streams. These waters are typically unpolluted, cold and weakly acidic to moderately alkaline, with high dissolved oxygen and low to moderate concentrations of nutrients and dissolved solids. Northwest Montana, west of the Continental Divide, is a biodiversity hotspot for *Encyonopsis* species. The potential is substantial for finding new species in other diatom genera among samples in the MDC and in other collections from remote regions of North America.

Key words: North America, diatoms, taxonomy, water quality, ecology, biodiversity, biogeography

Introduction

Encyonopsis Krammer (1997a: 156) may be distinguished from other diatom genera, particularly *Cymbella* C. Agardh (1830: 1), *Cymbopleura* Krammer (1999: 292), and *Encyonema* Kützing (1833: 589), by a combination of morphological characters, which include the following (adapted from Krammer 1997b):

1. Valves are not or only slightly asymmetric (dorsiventral) in outline on either side of the apical axis;
2. The raphe lies approximately along the valve midline between the dorsal and ventral sides, or is positioned somewhat ventrally;
3. Proximal raphe ends are deflected dorsally; distal raphe fissures are curved toward the ventral side;
4. A stigma may or may not be present on the dorsal side of the central nodule; and
5. Apical pore fields are absent.

Species of *Encyonopsis* live exclusively in fresh water, typically in cold waters rich in oxygen and with low to moderate concentrations of electrolytes (Krammer 1997b). Species and individuals of *Encyonopsis* are particularly common in mountains and at higher latitudes, but the

genus also occurs at lower elevations and in the tropics (Hustedt 1938, Krammer 1997b, Metzeltin & Lange-Bertalot 1998, 2002, 2007).

In North America, *Encyonopsis* is generally considered to have a limited number of species. For example, only two cymbelloid species currently included in the genus—*Cymbella cesatii* (Rabenhorst) Grunow *ex* A. Schmidt (1881: pl. 71, figs 48, 49) and *Cymbella microcephala* Grunow *in* Van Heurck (1885: 63)—were addressed by Patrick & Reimer (1975). However, much of North America remains to be explored for diatoms, especially remote regions with difficult access in northern and western parts of the continent. This paper reports on *Encyonopsis* species from one such region.

Materials and Methods

Slides consulted for this study are deposited in the Montana Diatom Collection (MDC) at the University of Montana Herbarium (MONTU). MONTU is a regional public herbarium registered with Index Herbariorum. Isotype slides, when available, have been deposited in the Academy of Natural Sciences Diatom Herbarium (ANSP), Philadelphia.

Especially relevant to this study are about 650 slides from government surveys of lakes conducted in the 1980s, 1990s and 2000s in remote regions of western Montana and southwestern Alberta (see Bahls 2010: p. 5, table 1). Additionally, in 2012 the MDC received 50 samples from other remote areas of the Pacific Northwest collected by volunteers with Adventurers and Scientists for Conservation (ASC 2012). The study area encompasses mountainous and forested regions of Alberta, Idaho, Montana, Oregon, South Dakota, and Washington. Physiographically, these regions are classified as the Canadian Rockies, Idaho Batholith, Middle Rockies, Northern Rockies, and North Cascades (USEPA 2000).

At each site, diatoms were collected from all available nearshore substrates, including aquatic macrophytes, rocks, fine sediments, and woody debris, using a tablespoon or a large-bore pipette with suction bulb. Subsamples were composited in a single container and preserved with Lugols (IKI) solution before transport to the laboratory, where they were treated with sulfuric acid (H_2SO_4), potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$), and hydrogen peroxide (H_2O_2) to remove organic matter (APHA *et al.* 1992). After several rinses in distilled water, cleaned diatom material was mounted permanently on slides using Hyrax or Naphrax and examined under light microscopy (LM) with differential interference contrast optics using a Leica DM LB2 research microscope and a Spot Insight Model 14.0 monochrome digital camera. Valve measurements were made from digital images using Spot Software (version 4.5).

Specific conductance and pH were measured in the field with a Hanna Instruments waterproof meter, model 98129. Other water chemistry measurements, which are summarized here to indicate water quality preferences of species, were made in the laboratory from grab samples that were collected at the time of benthic algae sampling. Water samples were analyzed by the Chemistry Laboratory of the Montana Department of Health and Human Services following methods proposed by the American Public Health Association (APHA *et al.* 1992).

Taxonomy, Distribution and Ecology

In each of the species descriptions that follow, direct comparisons are made with one or more of the most morphologically similar species. To facilitate comparison and identification of species, a dichotomous key (Table 1) and tables of selected diagnostic features (Tables 2–7) are also provided. All of the taxa presented here may be distinguished by features observed under light microscopy. Description and comparison of these species would also benefit from SEM imaging and analysis, which I was unable to provide.

For new species, images and measurements were taken from the holotype, isotype and paratype slides. A paratype is “a specimen [slide] cited in the protologue that is neither the holotype nor an isotype...” (ICBN 2006: 489). For existing species, the listed voucher slides were consulted for images and measurements. Distribution summaries for each species are based on the types and vouchers and on scans of additional slides in the MDC. Environmental data and ecological summaries are based on data recorded at the time of collection and archived in the Montana Diatom Database. An exclamation mark following a herbarium acronym (MONTU!) indicates that I have personally examined the referenced slide.

Division **Bacillariophyta**

Class **Bacillariophyceae** Haeckel 1878 emend. D.G. Mann in Round et al. 1990: 651

Subclass **Bacillariophycidae** D.G. Mann in Round et al. 1990: 651

Order **Cymbellales** D.G. Mann in Round et al. 1990: 653

Family **Cymbellaceae** Greville 1833: 263, 409

Genus ***Encyonopsis*** Krammer 1997a: 11

Encyonopsis aequaliformis Bahls, *sp. nov.* (Figs 1–7)

Valves lanceolate to elliptic-lanceolate, not or slightly dorsiventral. Apices distinctly capitate. Valve length 25–32 μm ; valve width 5.9–7.0 μm . Axial area narrow. Central area small, defined by a shortened median stria on each side. Raphe weakly lateral and nearly straight, close to the valve midline. Proximal raphe ends slightly dilated and bent toward the dorsal side. Distal raphe fissures hooked toward the ventral side. Striae moderately radiate, parallel to weakly convergent near the apices, 12–15 in 10 μm at valve center, 16–19 in 10 μm near the apices.

Holotype:—USA, Washington: Nada Lake, Chelan County, 47.4936° N, 120.7403° W, elev. 1524 m, coll. R. Davis, 16 September 2012. MDC sample 499701; holotype slide MDC 41-96 (Figs 1–7) (circled holotype specimen in Fig. 3) MONTU!

Isotypes:—MDC slide 126-90 MONTU!; circled specimens on ANSP! GC65168.

Paratypes:—USA, Washington: Lake Serene, Snohomish County, elev. 769 m, coll. R. Davis, 22 July 2012, MDC sample 494601; MDC slides 41-57, 126-51 MONTU!—USA, Washington: Small meltwater pond on Anderson Pass, Olympic National Park, 47.6975° N, 123.3275° W, elev. 1402 m, coll. R. Davis, 28 July 2012. MDC sample 494701; MDC slides 41-58, 126-52 MONTU!

Etymology:—*Encyonopsis aequaliformis* is named for its resemblance to *Encyonopsis aequalis* (W. Smith) Krammer (1997b: 133).

Observations:—*Encyonopsis aequaliformis* is distinguished from *E. aequalis* by the distinctly and consistently capitate, not rostrate, apices.

Distribution:—Collected to date from three small lakes and ponds in the North Cascade Mountains of Washington (type, paratypes).

Encyonopsis aequalis (W. Smith) Krammer (1997b: 133, figs 165:1–11, 15, 16; 167: 7–10). (Figs 8–14)

Basionym:—*Cymbella aequalis* W. Smith in Greville (1855: 255, fig. 9: 4). Type: SCOTLAND: “Ben-na-Muic-Dhui, Distr. Braemar, leg. Balfour”. Isotype: slide IX–63–C6, Walker Arnott 136, VH. Holotype in BM (Krammer 1997b).

Vouchers:—CANADA, Alberta: Summit Lake, Waterton Lakes National Park, 49.0078° N, 114.0258° W, elev. 1980 m, coll. B. Johnston, 23 July 2009. MDC sample 456901; MDC slide 124-57 (Figs 8–14) MONTU!—USA, Washington: Goat Rocks Pond, Lewis County, 46.4839° N, 121.4894° W, elev. 1418 m, coll. Craig Weiland, 1 October 2012. MDC sample 501501; MDC slides 42-14, 127-8 MONTU!

Observations:—Valves lanceolate with rostrate apices. Valve length 22–41 µm; valve width 5.6–7.6 µm. Striae weakly radiate, 12–16 in 10 µm at valve center, 17–20 in 10 µm near the apices. Distinguished from *E. aequaliformis* by rostrate, not capitate, apices.

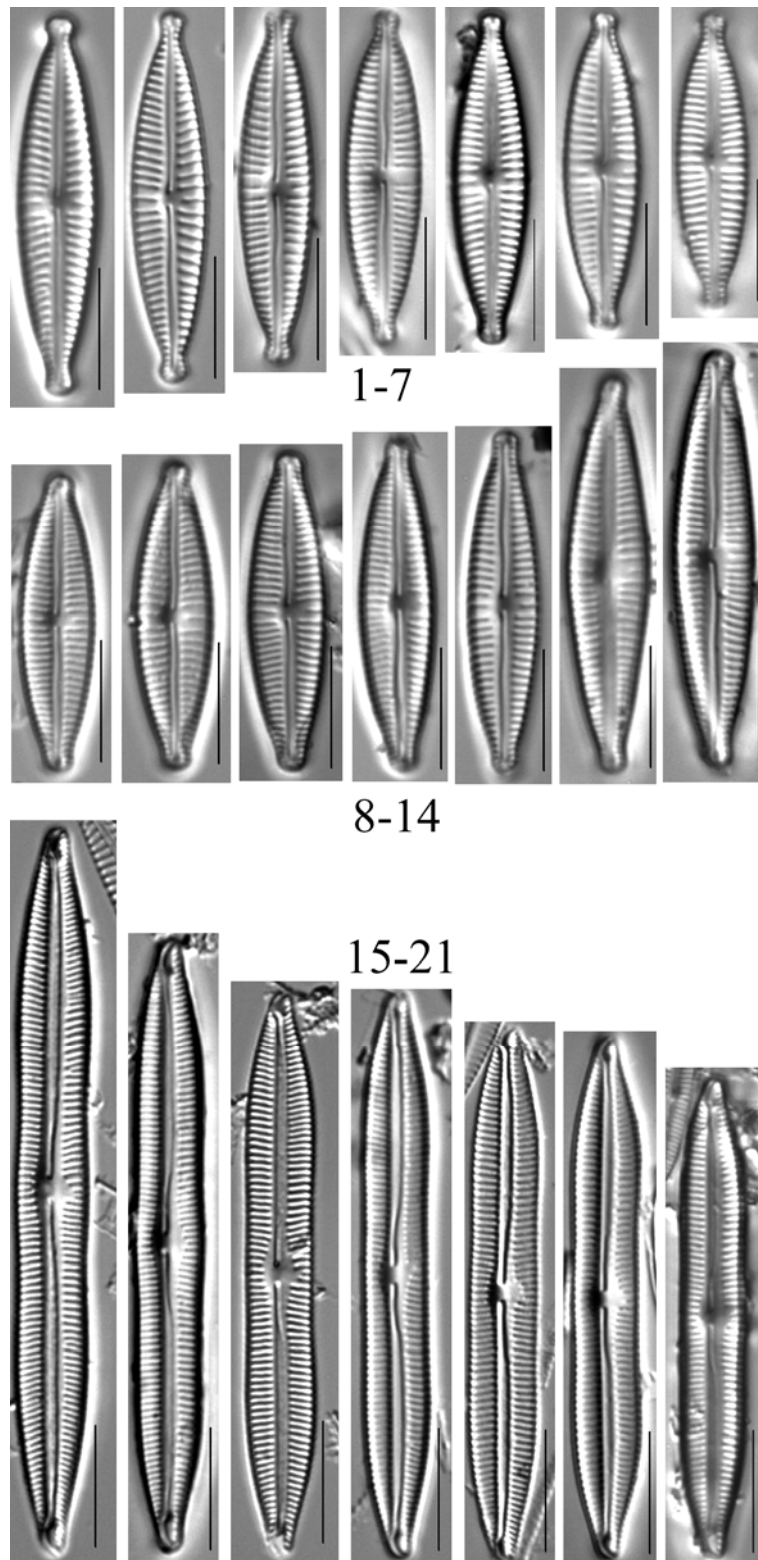
Distribution and Ecology:—*Encyonopsis aequalis* is widely distributed and locally abundant in lakes throughout the northern Rockies and North Cascade Mountains. These lakes are slightly alkaline (pH 7.0–7.5) with low specific conductance (10–60 µS/cm).

Encyonopsis albertana Bahls, *sp. nov.* (Figs 22–27)

Valves narrowly lanceolate, moderately dorsiventral, dorsal margin arched, ventral margin straight or weakly convex. Valve length 14.3–22.5 µm; valve width 3.1–4.1 µm. Apices rostrate, deflected ventrally. Axial area narrow, about 1/3 the distance from the ventral margin to the dorsal margin. Central area very small, continuous with the axial area. Raphe branches filiform and bowed, concave to the dorsal margin. Proximal raphe ends unexpanded, deflected dorsally; distal raphe fissures hooked toward the ventral margin. Striae radiate, 20–24 in 10 µm.

Holotype:—USA, Montana: East Spring Creek, Flathead County, 48.2258° N, 114.2672° W, elev. 890 m, coll. Montana DEQ, 9 September 2006. MDC sample 381501; holotype slide MDC 114-52 (Figs 22–27) (circled holotype specimen in Fig. 23) MONTU!

Isotypes:—MDC slide 30-53 MONTU!; circled specimens on ANSP! GC65170.



FIGURES 1–21: *Encyonopsis aequaiformis*, *E. aequalis*, *E. lacuscaerulei*. Figs 1–7: *Encyonopsis aequaliformis*, Nada Lake, WA (holotype). Fig. 3: Circled holotype specimen. Figs 8–14: *Encyonopsis aequalis*, Summit Lake, AB. Figs 15–21: *Encyonopsis lacuscaerulei*. Figs 15, 17–20: Blue Lake, MT (holotype). Fig. 18: Circled holotype specimen. Figs 16, 21: Savage Lake, MT. Scale bars = 10 μm.

Etymology:—*Encyonopsis albertana* is named for its occurrence in both Alberta and Montana.

Observations:—*Encyonopsis albertana* is distinguished from *E. krammeri* Reichardt (1997: 61) by its lower stria density: 20–24 in 10 μm , not 25–30 in 10 μm .

Distribution and Ecology:—*Encyonopsis albertana* is widely distributed and locally abundant in lakes, beaver ponds, and spring creeks in southwestern Alberta and northwestern Montana. These waters are alkaline (pH range 7.2–9.2) with moderate levels of dissolved solids (specific conductance range 141–255 $\mu\text{S}/\text{cm}$).

Encyonopsis alpina Krammer & Lange-Bertalot in Krammer (1997b: 196, fig. 150: 4, 7–10; 193: 1, 5, 7–9). Type: GERMANY: “Königsee bei Berchtesgaden”, holotype slide 5b IOK. (Figs 34–39)

Voucher:—USA, Montana: Dearborn River, Lewis & Clark County, 47.2797° N, 112.3961° W, elev. 1370 m, coll. A. Nixon, 10 September 2002. MDC sample 265801; MDC slide T4-13-2 (Figs 34–39) MONTU!

Observations:—Valves linear to linear-lanceolate, moderately dorsiventral, dorsal and ventral margins weakly convex. Apices narrow, capitate. Valve length 12.9–14.4 μm ; valve width 2.9–3.6 μm . Striae radiate, 26–32 in 10 μm . This taxon has a higher stria density and different ecology than *E. microcephala* (Grunow) Krammer (1997b: 91).

Distribution and Ecology:—*Encyonopsis alpina* has been collected from several lakes and streams in northwest Montana and southwest Alberta. In these waters pH ranges from 7.3 to 9.2 and specific conductance from 129 to 316 $\mu\text{S}/\text{cm}$.

Encyonopsis anacondae Bahls, sp. nov. (Figs 58–63)

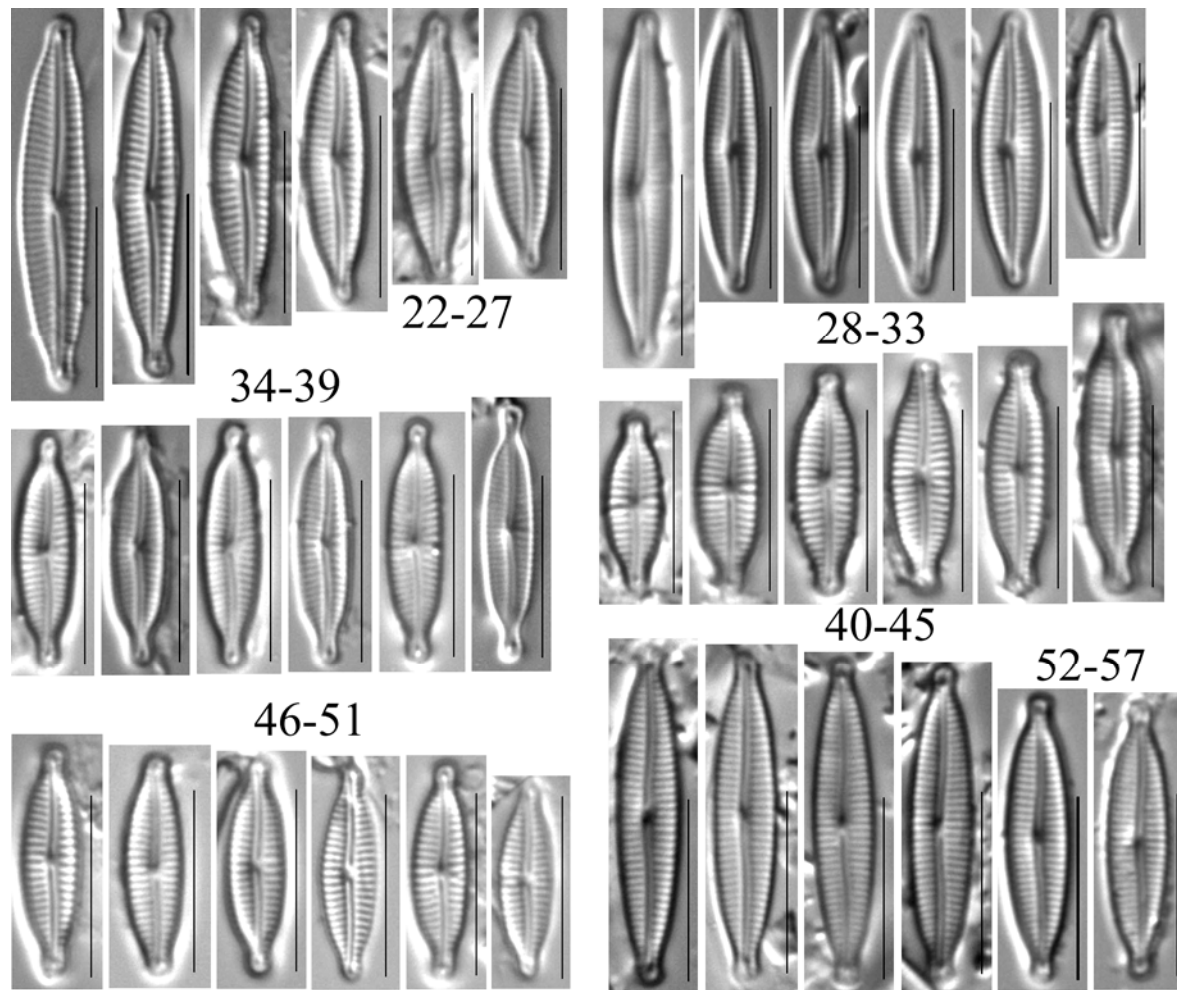
Valves narrowly linear to linear-lanceolate, slightly dorsiventral. Dorsal and ventral margins weakly convex. Valve length 16.6–24.4 μm ; valve width 3.2–4.0 μm . Apices rostrate, deflected slightly to the ventral side. Axial area narrow, near valve median line. Central area very small, barely wider than the axial area. Raphe filiform. Proximal raphe ends unexpanded, deflected toward the dorsal margin. Distal raphe fissures hooked toward the ventral margin. Striae weakly radiate, 25–28 in 10 μm .

Holotype:—USA, Montana: Upper Seymour Lake, Deer Lodge County, 46.0366° N, 113.2691° W, elev. 2512 m, coll. USFS, 12 July 1992. MDC sample 108502; holotype slide MDC P3-2-20 (Figs 58–63) (circled holotype specimen in Fig. 60) MONTU!

Etymology:—Named for the Anaconda Range and Anaconda Wilderness in southwest Montana.

Observations:—*Encyonopsis anacondae* is distinguished from *E. neerlandica* (Figs 70–75) by its linear (not lanceolate to rhombic-lanceolate) valves.

Distribution:—*Encyonopsis anacondae* is known only from the type locality.



FIGURES 22–57: *Encyonopsis microcephala* group. Figs 22–27: *Encyonopsis albertana*, East Spring Creek, MT (holotype). Fig. 23: Circled holotype specimen. Figs 28–33: *Encyonopsis krammeri*. Fig. 28: Bullhead Lake, MT. Figs 29–33: Ashley Lake, MT. Figs 34–39: *Encyonopsis alpina*, Dearborn River, MT. Figs 40–45: *Encyonopsis microcephala*. Figs 40, 45: Ruby River, MT. Figs 41–44: Snake River, OR. Figs 46–51: *Encyonopsis minuta*, East Spring Creek, MT. Figs 52–57: *Encyonopsis subminuta*. Fig. 52: Paradise Pond, MT. Figs 53–56: Lake McDonald, MT. Fig. 57: East Spring Creek, MT. Scale bars = 10 μ m.

***Encyonopsis bobmarshallensis* Bahls, sp. nov. (Figs 144–150)**

Valves lanceolate to linear-lanceolate, slightly dorsiventral. Apices rostrate to subcapitate. Valve length 8.7–18.7 μ m; valve width 2.7–3.6 μ m. Axial area very narrow. Central area small, but distinct. Raphe filiform. Proximal raphe ends not inflated, deflected dorsally. Distal raphe fissures curved toward the ventral side. Striae weakly radiate, 22–24 in 10 μ m.

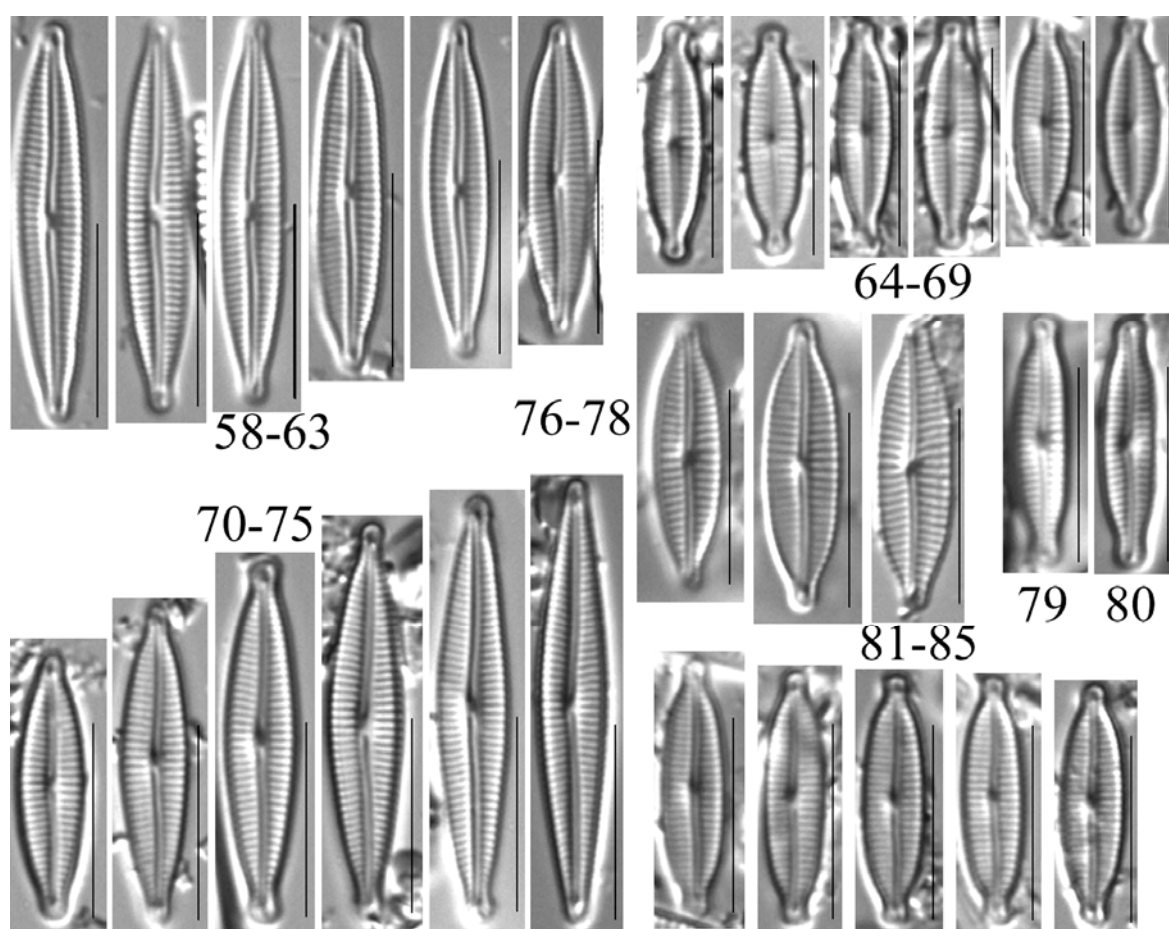
Holotype:—USA, Montana: Upper Trilobite Lake, Flathead County, Bob Marshall Wilderness, 47.9806° N, 113.1393° W, elev. 2012 m, coll. L. Bahls, 21 August 1983. MDC sample 087401; holotype slide MDC P2-25-10 (Figs 146–148, 150) (circled holotype specimen in Fig. 148) MONTU!

Paratype:—USA, Montana: Dean Lake, Flathead County, Bob Marshall Wilderness, 47.9237° N, 113.1073° W, elev. 2245 m, coll. L. Bahls, 23 August 1983. MDC sample 087501; slide MDC P2-25-11 (Figs 144, 145, 149) MONTU!

Etymology:—Named for the type locality: Bob Marshall Wilderness, Montana.

Observations:—Distinguished from *E. perborealis* Krammer (1997b: 109) by lower stria density (22–24 in 10 µm, not 26–30 in 10 µm) and from *E. moseri* Krammer (1997b: 104) by the presence of a central area, more linear valve shape, and lower stria density. Distinguished from *E. kutenaorum* (Figs 139–143) by the smaller valves, smaller central area and lower stria count.

Distribution:—Known only from two small alpine lakes on the Continental Divide in the heart of the Bob Marshall Wilderness. Water quality data are not available.



FIGURES 58–85: *Encyonopsis subminuta* group. Figs 58–63: *Encyonopsis anacondae*, Upper Seymour Lake, MT (holotype). Fig. 60: Circled holotype specimen. Figs 64–69: *Encyonopsis lacusalpini*, Upper Trilobite Lake, MT (holotype). Fig. 69: Circled holotype specimen. Figs 70–75: *Encyonopsis neerlandica*. Figs 70, 71, 73: Upper Geiger Lake, MT. Fig. 72: Lake near Tin Cup Lake, MT. Fig. 74: Hoodoo Lake, MT. Fig. 75: Lake Winona, MT. Figs 76–78: *Encyonopsis* sp. cf. *subminuta*. Fig. 76: Upper Whitefish Lake, MT. Fig. 77: Pumphouse Pond, MT. Fig. 78: Lake Winona, MT. Figs 79, 80: *Encyonopsis* sp. cf. *microcephala*, Yaak River, MT. Figs 81–85: *Encyonopsis subminuta*, Medicine Grizzly Lake, MT. Scale bars = 10 µm.

Encyonopsis cesatii (Rabenhorst) Krammer (1997b: 152, figs 182: 1–13) (Figs 91–97)

Basionym:—*Navicula cesatii* Rabenhorst (1853: 39, fig. 6: 89). Type: ITALY: “Im Piemontesischen“, lectotype slide [designated by Krammer] 1188F IOK (Krammer 1997b).

Synonym:—*Cymbella cesatii* Grunow ex A. Schmidt et al. (1881: figs 71: 48, 49).

Voucher:—USA, Montana: East Spring Creek, Flathead County, 48.2258° N, 114.2672° W, elev. 890 m, coll. R. Sada, 9 September 2006. MDC sample 381501; MDC slide 114-52 (Figs 91–97) MONTU!

Observations:—Valves lanceolate, not or slightly dorsiventral. Apices subrostrate. Valve length 22.0–38.8 µm; valve width 4.6–5.9 µm. Central area very small. Striae radiate, 16–20 in 10 µm at valve center, 21–22 in 10 µm near the apices. *Encyonopsis cesatii* has smaller valves than *E. montana* (Figs 86–90). Maximum valve width of *E. cesatii* is about 6 µm; valves of *E. montana* range from 6.0 to 8.8 µm wide. *Encyonopsis falaisensis* (Grunow) Krammer (1997b: 116) (Figs 103–106) has more linear valves and a larger central area. *Encyonopsis stafsholtii* (Figs 98–102) has rhombic-lanceolate valves and higher stria density.

Distribution and Ecology:—*Encyonopsis cesatii* is widely distributed and locally abundant throughout the study area. At sites with water quality data, pH ranges from 7.8 to 9.1 and specific conductance from 112 to 379 µS/cm.

Encyonopsis czarneckii Bahls, *sp. nov.* (Figs 107–112)

Valves linear-lanceolate, slightly dorsiventral. Apices capitate. Valve length 19.6–30.1 µm; valve width 3.7–5.2 µm. Axial area narrow, near valve midline. Central area small, asymmetric, rounded on the dorsal side, defined by two unevenly shortened striae on the ventral side. Raphe weakly lateral, filiform near the proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral side. Striae radiate throughout, 22–24 in 10 µm at valve center, 24–26 in 10 µm near the apices.

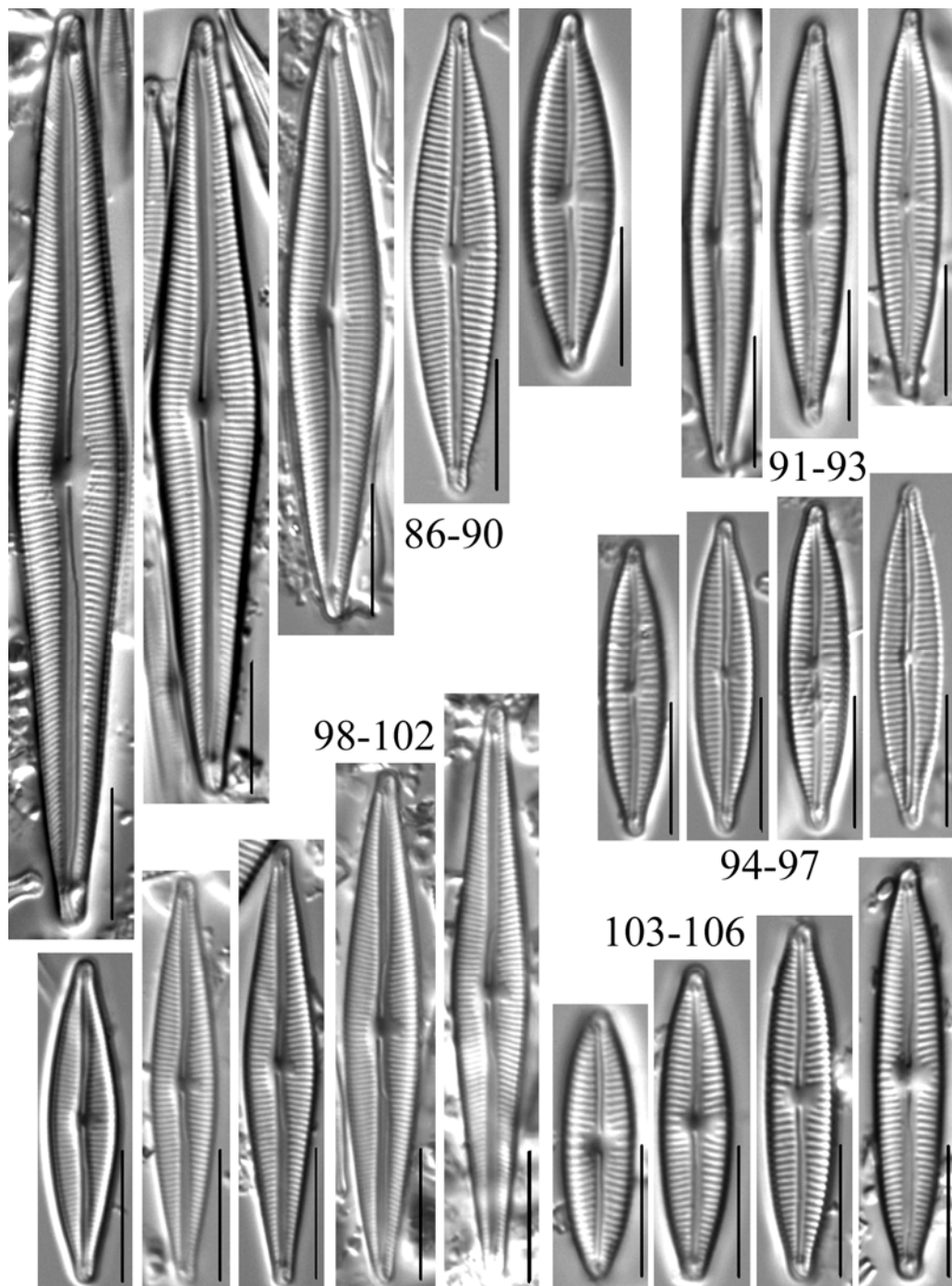
Holotype:—USA, Montana: Lake McDonald, Glacier National Park, Flathead County, 48.5876° N, 113.8966° W, elev. 961 m, coll. L. Bahls, 13 July 1993. MDC sample 128301; holotype slide MDC P3-10-12 (Figs 107–112) (circled holotype specimen in Fig. 109) MONTU!

Isotype:—ANSP! GC65173.

Etymology:—Named in honor of the late American diatomist Dave Czarnecki.

Observations:—*Encyonopsis descripta* (Hustedt) Krammer (1997b: 123) has a rounded and more or less symmetric central area. Valves of *Encyonopsis dakotae* (Figs 113–117) are larger and have a lower stria density and a larger central area. *Encyonopsis medicinalis* (Figs 123–128) is smaller with elliptic-lanceolate valves.

Distribution and Ecology:—*Encyonopsis czarneckii* is widely distributed and locally abundant in lakes of the northern Rocky Mountains. On the date the type sample was collected, pH measured 8.7 and specific conductance measured 92 $\mu\text{S}/\text{cm}$.



FIGURES 86–106: *Encyonopsis cesatii* group. Figs 86–90: *Encyonopsis montana*. Figs 86–88: Lake McDonald, MT (holotype). Fig. 86: Circled holotype specimen. Figs 89, 90: Kootenai Pond, MT. Figs 91–97: *Encyonopsis cesatii*, East Spring Creek, MT. Figs 98–102: *Encyonopsis stafsholtii*. Fig. 98: Lower Wolverine Lake, MT. Figs 99–102: Lake McDonald, MT (holotype). Fig. 100: Circled holotype specimen. Figs 103–106: *Encyonopsis falaisensis*, Haystack Seep, MT. Scale bars = 10 μm .

Encyonopsis dakotae Bahls, *sp. nov.* (Figs 113–117)

Valves linear-lanceolate and slightly dorsiventral. Apices capitate. Valve length 24–32 μm ; valve width 4.8–6.5 μm . Axial area narrow, close to valve midline. Central area transverse, asymmetric, rounded on the dorsal side, defined by two or three irregularly shortened striae on the ventral side. Raphe weakly lateral, filiform near the proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral side. Striae radiate throughout, 18–20 in 10 μm at valve center, 21–23 in 10 μm near the apices.

Holotype:—USA, South Dakota: Cheyenne River, Fall River County, 43.3561° N, 103.4243° W, elev. 960 m, coll. Fall River County CD, 8 June 2004. MDC sample 359203; holotype slide MDC 107-24 (Figs 113–117) (circled holotype specimen in Fig. 113) MONTU!

Isotype:—MDC slide 27-61 MONTU!

Etymology:—Named for the state of South Dakota.

Observations:—Distinguished from other species in the *E. descripta* complex by the size and shape of the valves, shape of the central area, and density of the striae.

Distribution:—*Encyonopsis dakotae* is known only from the type locality.

Encyonopsis descripta (Hustedt) Krammer (1997b: 123, figs 155: 1–14) (Fig. 122)

Basionym:—*Navicula descripta* Hustedt (1943: 170, fig. 25). Type: SWITZERLAND: Ma2/86. Schwarzee 38. Grund. Davos. BRM (Simonsen 1987).

Synonyms:—*Navicula descripta* Hustedt (Simonsen 1987: 311, pl. 470, figs 10–11); *Cymbella descripta* (Hustedt) Krammer & Lange-Bertalot (1985: 25, figs 8: 13–15).

Voucher:—USA, Montana: Lake Winona, Glacier National Park, 48.7294° N, 114.2352° W, elev. 1055 m, coll. J. Pierce, 7 September 1999. MDC sample 194201; MDC slide P4-2-9 (Fig. 122) MONTU!

Observations:—Valves not or slightly dorsiventral, linear-lanceolate with capitate apices. Valve length 25.7–29.9 μm ; valve width 5.4–6.6 μm . Central area round, nearly symmetric. Striae 18–20 in 10 μm near the valve center, 20–22 in 10 μm near the apices. Distinguished from *E. descriptiformis* (Figs 118–121) by the linear-lanceolate valves and capitate (not rostrate to apiculate) apices, and from other species in the *E. descripta* complex by the round central area.

Distribution and Ecology:—Uncommon in remote, unpolluted mountain lakes with pH 7.0 to 8.2 and specific conductance of 64 to 250 $\mu\text{S}/\text{cm}$.

Encyonopsis descriptiformis Bahls, *sp. nov.* (Figs 118–121)

Valves not or slightly dorsiventral, lanceolate with rostrate to short apiculate apices. Valve length 22.6–34.1 μm ; valve width 5.6–6.7 μm . Axial area narrow, close to valve midline. Central area round, slightly asymmetric. Raphe weakly lateral, filiform near the proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral side. Striae radiate throughout, 18–20 in 10 μm near the valve center, 20–22 in 10 μm near the apices.

Holotype:—USA, Montana: Upper Whitefish Lake, Flathead County, 48.6866° N, 114.5781° W, elev. 1348 m, coll. J. Pierce, 18 August 1998. MDC sample 177701; MDC slide P3-24-7 (Figs 118–121) (circled holotype specimen in Fig. 118) MONTU!

Paratypes:—USA, Montana: Johns Lake, Glacier National Park, Flathead County, 48.6372° N, 113.8547° W, elev. 1021 m, coll. L. Bahls, 24 October 2007. MDC sample 408001; MDC slides 118-13, 118-63 MONTU!—USA, Montana: Lower Quartz Lake, Glacier National Park, Flathead County, 48.7972° N, 114.1731° W, elev. 1277 m, coll. E. Weber, 3 July 2008. MDC sample 459101; MDC slide 124-42 MONTU!

Etymology:—This species is named for its resemblance to *Encyonopsis descripta* (Hustedt) Krammer (1997b: 123) (Fig. 122).

Observations:—*Encyonopsis descriptiformis* is distinguished from *E. descripta* by its lanceolate (not linear-lanceolate) valves and rostrate to apiculate (not capitate) apices, and from other species in the *E. descripta* complex by the large round central area.

Distribution and Ecology:—*Encyonopsis descriptiformis* is uncommon in remote, unpolluted mountain lakes. Here pH ranges from 6.9 to 7.4 and specific conductance from 20 to 130 $\mu\text{S/cm}$.

Encyonopsis falaisensis (Grunow) Krammer (1997b: 116, figs 161: 1–7, 162: 8–24, 163: 1–5, 164: 1–13, 22, 23) (Figs 103–106)

Basionym:—*Navicula falaisensis* Grunow in Van Heurck (1880: 108, fig. 14: 5). Type: BELGIUM: “Bouillion, leg. Delogne”, lectotype Nr. 127 in VH (Krammer 1997b).

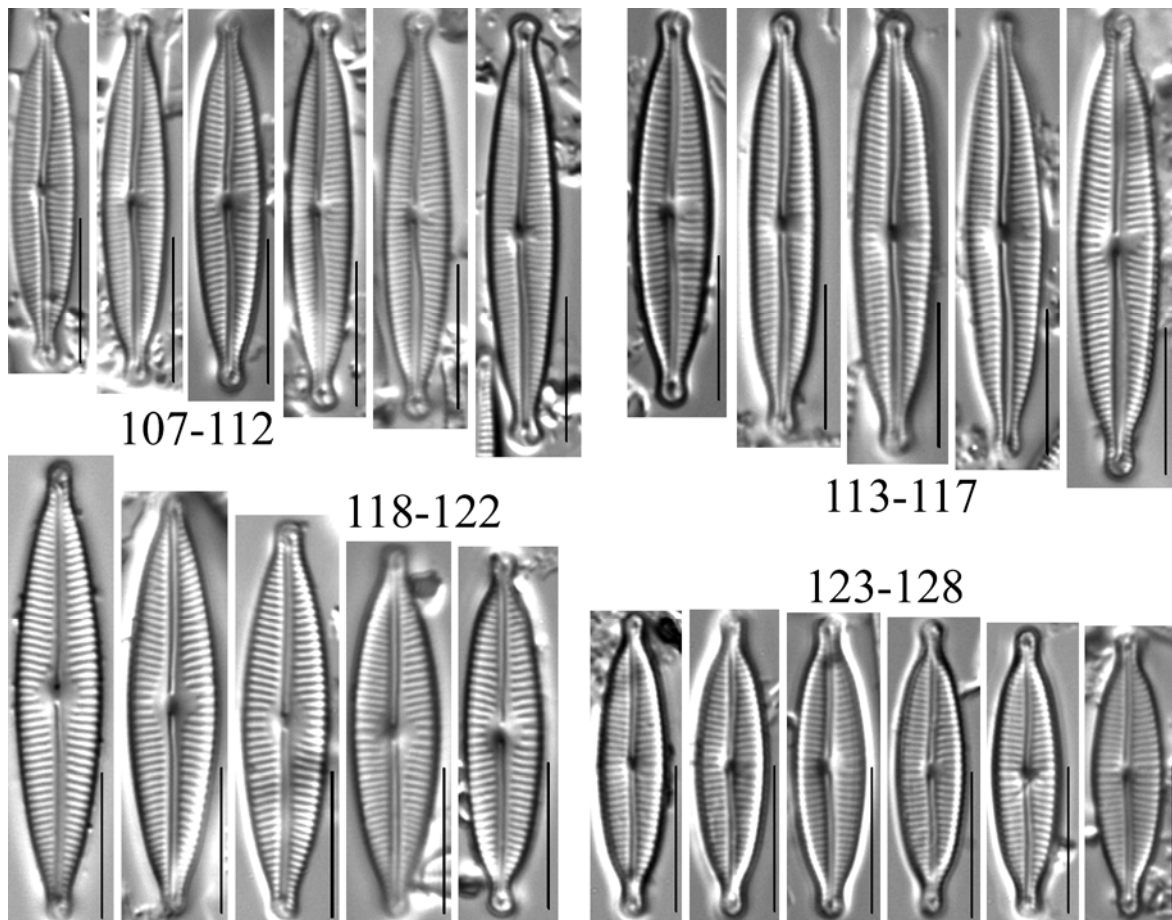
Synonym:—*Cymbella falaisensis* (Grunow) Krammer & Lange-Bertalot (1985: 26, figs 6: 9–22).

Voucher:—USA, Montana: Haystack Seep, Glacier National Park, 48.7381° N, 113.7456° W, elev. 1585 m, coll. E. W. Schweiger, 23 July 2009. MDC sample 453001; MDC slide 123-71 (Figs 103–106) MONTU!

Observations:—Valves not or slightly dorsiventral, lanceolate to linear-lanceolate with short subrostrate apices. Valve length 19.8–36.4 μm ; valve width 5.0–6.1 μm . Central area moderately large, rounded, asymmetric. Striae 16–18 in 10 μm at valve center, 19–22 in 10 μm near the

apices. *Encyonopsis falaisensis* is distinguished from other species in the *E. cesatii* complex by the larger central area and more linear valves, especially in larger specimens.

Distribution and Ecology:—*Encyonopsis falaisensis* is uncommon in small headwater ponds, seeps and streams in the Northern Rockies, where pH ranges from 7.8 to 8.5 and specific conductance from 139 to 181 $\mu\text{S}/\text{cm}$.



FIGURES 107–128: *Encyonopsis descripta* group. Figs 107–112: *Encyonopsis czarneckii*, Lake McDonald, MT (holotype). Fig. 109: Circled holotype specimen. Figs 113–117: *Encyonopsis dakotae*, Cheyenne River, SD (holotype). Fig. 113: Circled holotype specimen. Figs 118–121: *Encyonopsis descriptiformis*, Upper Whitefish Lake, MT (holotype). Fig. 118: Circled holotype specimen. Fig. 122: *Encyonopsis descripta*, Lake Winona, MT. Figs 123–128: *Encyonopsis medicinalis*, Medicine Grizzly Lake, MT (holotype). Fig. 128: Circled holotype specimen. Scale bars = 10 μm .

***Encyonopsis hustedtii* Bahls, sp. nov. (Figs 129-133)**

Valves linear to linear-lanceolate, not or scarcely dorsiventral. Apices capitate. Valve length 14.4–19.6 μm ; valve width 3.3–4.0 μm . Axial area narrow. Central area rounded, variable in size. Raphe filiform, proximal ends unexpanded, deflected dorsally. Distal raphe fissures comma-shaped, curved to the ventral side. Striae weakly radiate throughout, 23–26 in 10 μm .

Holotype:—CANADA, Alberta: Blakiston Beaver Pond A, Waterton Lakes National Park, 49.0928° N, 113.8864° W, elev. 1520 m, coll. B. Johnston, 2 June 2009. MDC sample 453301; MDC slide 123-91 (Figs 129–133) (circled holotype specimen in Fig. 129) MONTU!

Paratypes:—USA, Montana: California Creek, Madison County, 45.3686° N, 112.1108° W, elev. 1548 m, coll. R. Sada, 23 July 2007. MDC sample 413301; MDC slide 116-91 MONTU!—USA, Montana: Kintla Spring Seep, Glacier National Park, Flathead County, 48.9461° N, 114.3419° W, elev. 1231 m, coll. L. Bahls, 31 July 2008. MDC sample 431401; MDC slide 118-87 MONTU!—USA, Montana: Rock Creek, Powell County, 47.0008° N, 113.0319° W, elev. 1268 m, coll. A. Welch, 11 September 2003. MDC sample 331101; MDC slide B6-1-24 MONTU!

Observations:—*Encyonopsis hustedtii* is distinguished from *E. robusta* (Figs 134–138) by a higher stria density (23–26 in 10 µm, not 19–22 in 10 µm). The two taxa are sometimes found together in the same habitats.

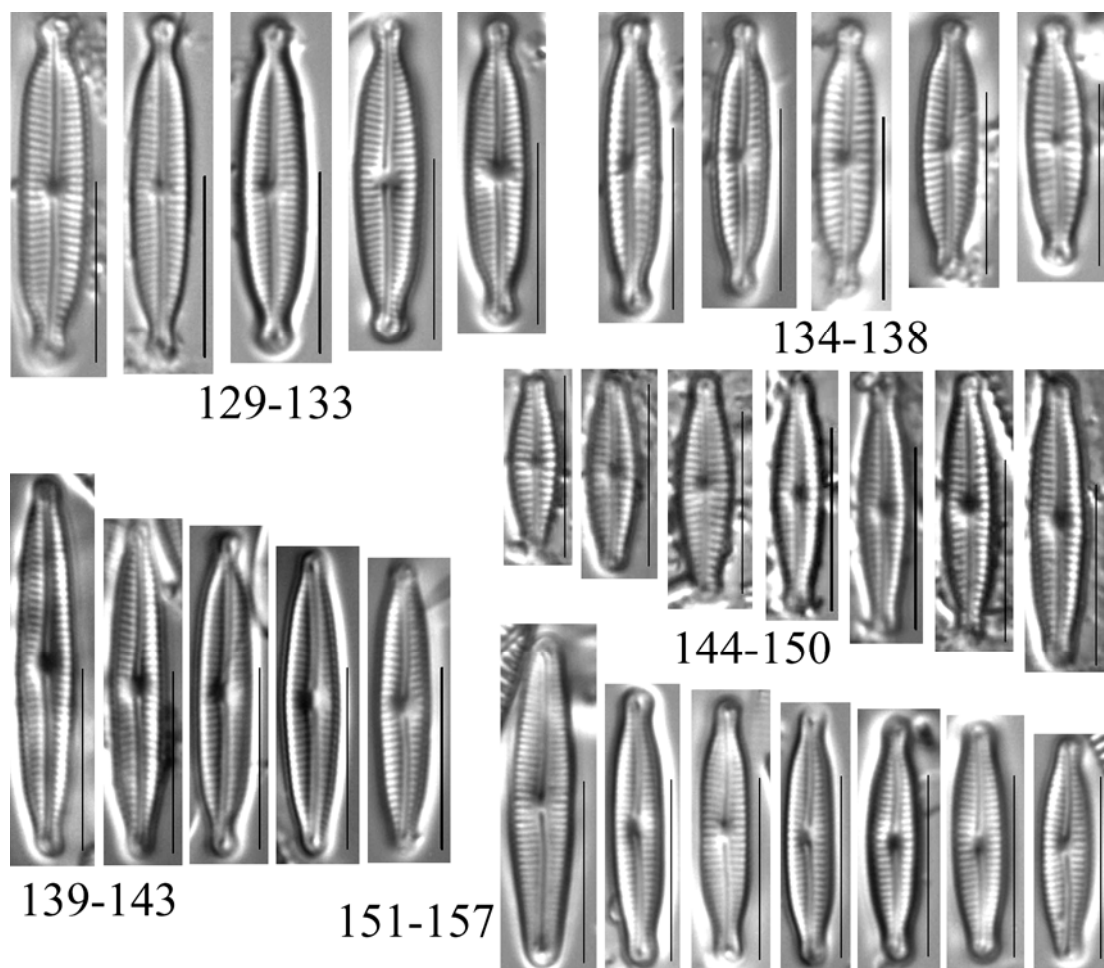
Distribution and Ecology:—Widespread and locally common in small streams, springs, and mossy seeps in the Northern Rockies. These waters typically have somewhat alkaline pH (7.29–8.00) and low to moderate concentrations of dissolved solids (255–411 µS/cm).

Encyonopsis krammeri Reichardt (1997: 61, figs 1–20). Type: GERMANY: “Quellweiher der kleinen Ammerquellen in das Graswang-Tal in den Ammergauer Alpen“, coll. E. Reichardt, 16 October 1993. Holotype slide S1525-T01 B; isotype slide Zu 4/82 HB (Krammer 1997b) (Figs 28–33)

Vouchers:—USA, Montana: Bullhead Lake, Glacier National Park, 48.7863° N, 113.7338° W, elev. 1585 m, coll. L. Bahls, 28 June 2007. MDC sample 398401; MDC slide 117-73 (Fig. 28) MONTU!—USA, Montana: Ashley Lake, Flathead County, 48.2044° N, 114.6157° W, elev. 1204 m, coll. L. Bahls, 15 July 1993. MDC sample 125501; MDC slide P3-9-3 (Figs 29–33) MONTU!

Observations:—Valves narrowly lanceolate and moderately dorsiventral. Valve length 11.4–20.7 µm; valve width 2.9–4.4 µm. Apices rostrate. Axial area narrow; central area absent. Striae weakly radiate, 25–30 in 10 µm. *Encyonopsis krammeri* is similar in size and shape to *E. albertana* (Figs 22–27), but has a higher stria density: 25–30 in 10 µm, not 20–24 in 10 µm.

Distribution and Ecology:—*Encyonopsis krammeri* has been collected from two lakes in the northern Rocky Mountains in northwest Montana (vouchers). The pH of these lakes measured 8.0 and 9.1 and specific conductance measured 93 and 164 µS/cm.



FIGURES 129–157: *Encyonopsis perborealis* group. Figs 129–133: *Encyonopsis hustedtii*, Blakiston Beaver Pond A, AB (holotype). Fig. 129: Circled holotype specimen. Figs 134–138: *Encyonopsis robusta*, Blakiston Beaver Pond A, AB. Figs 139–143: *Encyonopsis kutenaiorum*, Lower Wolverine Lake, MT (holotype). Fig. 143: Circled holotype specimen. Figs 144–150: *Encyonopsis bobmarshallensis*. Figs 144, 145, 149: Dean Lake, MT. Figs 146–148, 150: Upper Trilobite Lake, MT (holotype). Fig. 148: Circled holotype specimen. Figs 151–157: *Encyonopsis perborealis*. Figs 151–153, 156, 157: Lower Wolverine Lake, MT. Figs 154, 155: Big Therriault Lake, MT. Scale bars = 10 μ m.

***Encyonopsis kutenaiorum* Bahls, sp. nov.** (Figs 139–143)

Valves linear-lanceolate, slightly dorsiventral. Apices rostrate to subcapitate. Valve length 16.5–21.2 μ m; valve width 3.2–3.5 μ m. Axial area narrow. Central area large, orbicular, at least one-half valve width. Raphe filiform. Proximal raphe ends weakly expanded, deflected toward the dorsal side. Distal raphe fissures hooked ventrally. Striae radiate, 23–26 in 10 μ m.

Holotype:—USA, Montana: Lower Wolverine Lake, Lincoln County, 48.9697° N, 114.9200° W, elev. 2070 m, coll. L. Bahls, 20 September 2012. MDC sample 498201; holotype slide MDC 126-73 (Figs 139–143) (circled holotype specimen in Fig. 143) MONTU!

Isotypes:—MDC slide 41-79 MONTU!; circled specimens on ANSP! GC65171.

Paratype:—USA, Montana: Lake of the Isle, Deer Lodge County, 46.0727° N, 113.1868° W, elev. 2537 m, coll. USFS, 17 July 1992. MDC sample 117201; MDC slide P3-5-15 MONTU!

Etymology:—Named for the Kutenai (Kootenai, Kootenay) Tribe of indigenous people.

Observations:—Distinguished from other small species of *Encyonopsis* with similar outline (*E. albertana*, *E. krammeri*) by the large rounded central area. Distinguished from *E. bobmarshallensis* (Figs 144–150) by the larger valves, larger central area and higher stria count.

Distribution and Ecology:—Collected from two small high elevation lakes in western Montana (type and paratype localities). The pH of these lakes measured 9.0 and 6.7, and specific conductance measured 100 and 36 $\mu\text{S}/\text{cm}$, respectively.

Encyonopsis lacusalpini Bahls, *sp. nov.* (Figs 64–69)

Valves elliptic-lanceolate, not or slightly dorsiventral. Apices subcapitate. Valve length 11.3–12.6 μm ; valve width 3.0–3.4 μm . Axial area narrow. Central area lacking. Raphe filiform. Proximal raphe ends not expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral margin. Striae parallel to weakly radiate, somewhat more widely spaced near the valve center, 26–29 in 10 μm .

Holotype:—USA, Montana: Upper Trilobite Lake, Flathead County, 47.9806° N, 113.1393° W, elevation 2012 m, coll. L. Bahls, 21 August 1983. MDC sample 087401; holotype slide MDC P2-25-10 (Figs 64–69) (circled holotype specimen in Fig. 69) MONTU!

Isotype:—MDC slide B4-19-6 MONTU!.

Etymology:—Named for the habitat type: alpine lake.

Observations:—*Encyonopsis lacusalpini* is distinguished from smaller specimens of *E. subminuta* Krammer & Reichardt in Krammer (1997b: 96) by the somewhat narrower valves and more widely spaced striae near the valve center.

Distribution:—Collected only from the type locality, a small lake on the Continental Divide in the heart of the Bob Marshall Wilderness.

Encyonopsis lacuscaerulei Bahls, *sp. nov.* (Figs 15–21)

Valves linear, not or slightly dorsiventral, triundulate or with slightly concave dorsal and ventral margins. Apices subrostrate, deflected ventrally. Valve length 36–61 μm ; valve width 5.5–6.8 μm . Axial area narrow. Central area rounded, asymmetric, about one half the valve width. Raphe lateral, filiform near the proximal and distal ends. Proximal raphe ends weakly inflated, deflected dorsally. Distal raphe fissures very prominent, comma-shaped, concave toward the ventral side. Striae radiate throughout, 17–20 in 10 μm .

Holotype:—USA, Montana: Blue Lake, Flathead County, 48.6580° N, 114.7654° W, elev. 1006 m, coll. J. Pierce, 18 August 1997. MDC sample 173402; holotype slide MDC P3-20-15 (Figs 15, 17–20) (circled holotype specimen in Fig. 18) MONTU!

Paratype:—USA, Montana: Savage Lake, Lincoln County, 48.4205° N, 115.8167° W., elev. 700 m, coll. J. Pierce, 14 September 1997. MDC sample 147402; MDC slide P3-21-17 (Figs 16, 21) MONTU!

Etymology:—Named for the type locality: Blue Lake, Montana.

Observations:—The linear triundulate valves distinguish *E. lacuscaerulei* from all other species.

Distribution and Ecology:—*Encyonopsis lacuscaerulei* was collected from aquatic vegetation in two lower elevation lakes in northwest Montana (type and paratype localities). Here pH measured 8.0 and 8.3, and specific conductance measured 350 and 230 $\mu\text{S}/\text{cm}$, respectively.

Encyonopsis lacusglacialis Bahls, *sp. nov.* (Figs 158–162)

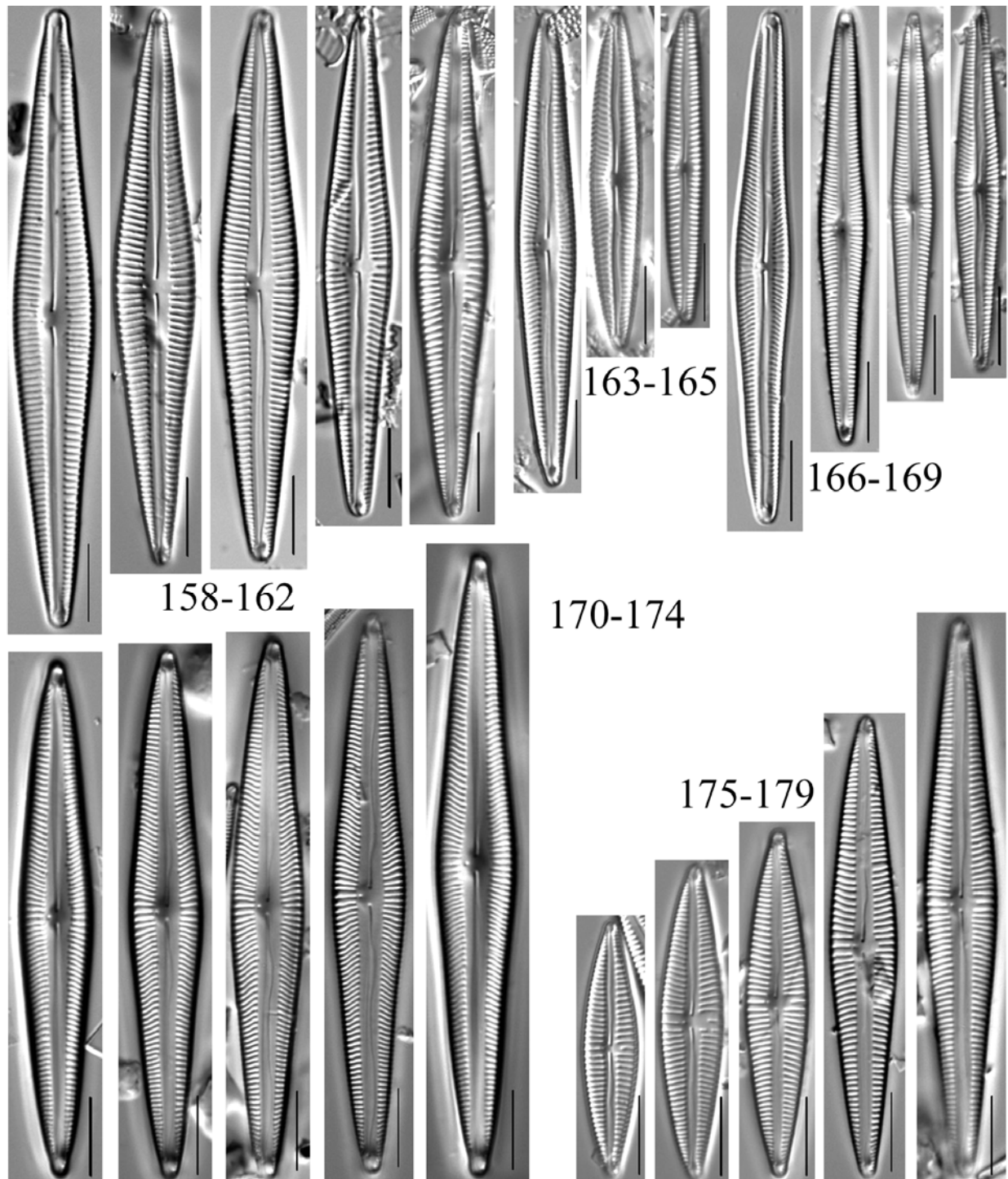
Valves rhombic-lanceolate, not or slightly dorsiventral. Apices narrowly rounded, not protracted. Valve length 58–80 μm ; valve width 8.8–11.1 μm . Axial area lanceolate, continuous with the undistinguished central area. Raphe lateral, filiform at the proximal and distal ends. Proximal raphe ends weakly inflated, deflected dorsally. Distal raphe fissures comma-shaped, concave toward the ventral margin. Striae radiate, parallel to weakly convergent near the apices, 10–13 in 10 μm at the valve center, 16–18 in 10 μm near the apices. A single stigma lies at the proximal end of the median stria on the dorsal side.

Holotype:—CANADA, Alberta: Summit Lake, Waterton Lakes National Park, 49.0078° N, 114.0258° W, elev. 1980 m, coll. B. Johnston, 23 July 2009. MDC sample 456901; holotype slide MDC 124-27 (Figs 158, 160) (circled holotype specimen in Fig. 158) MONTU!

Isotypes:—MDC slide 40-52 MONTU! ANSP! GC65122.

Paratypes:—USA, Idaho: Gold Lake, Shoshone County, 46.9431° N, 115.2749° W, elev. 1860 m, coll. J. Pierce, 29 September 1998. MDC sample 179501; MDC slide P3-25-20 (Fig. 159) MONTU!—USA, Montana: Blodgett Lake, Ravalli County, 46.2520° N, 114.4545° W, elev. 2073 m, coll. USFS, 10 September 1991. MDC sample 110901; MDC slide P3-4-1 (Fig. 161) MONTU!—USA, Montana: Bailey Lake, Ravalli County, 46.1322° N, 114.5092° W, elev. 2030 m, coll. J. Pierce, 11 September 1998. MDC sample 179401; MDC slide P3-25-17 (Fig. 162) MONTU!—USA, Washington: Nada Lake, Chelan County, 47.4936° N, 120.7403° W, elev. 1524 m, coll. R. Davis, 16 September 2012. MDC sample 499701; MDC slides 41-96, 126-90 MONTU!

Etymology:—Named for the habitat type: glacial lake.



FIGURES 158–179: *Encyonopsis neoamphioxys* group. Figs 158–162: *Encyonopsis lacusglacialis*. Figs 158, 160: Summit Lake, AB (holotype). Fig. 158: Circled holotype specimen. Fig. 159: Gold Lake, ID. Fig. 161: Blodgett Lake, MT. Fig. 162: Bailey Lake, MT. Figs 163–165: *Encyonopsis neoamphioxys*. Fig. 163: Flower Lake, MT. Fig. 164: Pond near Curley Lake, MT. Fig. 165: Drosera Fen, MT. Figs 166–169: *Encyonopsis subspicula*. Figs 166–168: Drosera Pond, MT. Fig. 169: Pond near McDonald Mountain, MT. Figs 170–174: *Encyonopsis treinishii*, Nada Lake, WA (holotype). Fig. 173: Circled holotype specimen. Figs 175–179: *Encyonopsis weilandii*. Fig. 175: Small meltwater pond, WA. Fig. 176: Summit Lake, AB. Figs 177–179: Goat Rocks Pond, WA (holotype). Fig. 178: Circled holotype specimen. Scale bars = 10 μ m.

Observations:—*Encyonopsis spicula* (Hustedt) Krammer (1997b: 145) and *E. stoermeri* Lange-Bertalot & Metzeltin (2009: 139), tropical species from Sumatra and Panama, respectively, have smaller valves and lower stria densities than *E. lacusglacialis*. *Encyonopsis subspicula* Krammer (1997b: 144) (Figs 166–169) has higher stria density and even smaller valves.

Distribution and Ecology:—*Encyonopsis lacusglacialis* has been collected from five higher elevation lakes in the Northern Rockies and North Cascades (types), where it occurs in low numbers. In lakes with water quality data, pH ranges from 6.5 to 7.6 and specific conductance from 7 to 60 $\mu\text{S}/\text{cm}$.

Encyonopsis medicinalis Bahls, *sp. nov.* (Figs 123–128)

Valves elliptic-lanceolate, not or slightly dorsiventral. Apices rostrate to subcapitate. Valve length 14.0–21.4 μm ; valve width 4.8–5.9 μm . Axial area narrow. Central area small, asymmetric. Raphe filiform. Proximal raphe ends not expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral side. Striae radiate, 20–23 in 10 μm at valve center, 22–24 in 10 μm near the apices.

Holotype:—USA, Montana: Medicine Grizzly Lake, Glacier National Park, 48.5683° N, 113.4892° W, elev. 1696 m, coll. L. Bahls, 14 August 2007. MDC sample 405401; holotype slide MDC 117-37 (Figs 123–128) (circled holotype specimen in Fig. 128) MONTU!

Isotypes:—MDC slides 117-87, 38-38 MONTU! ANSP! GC64938.

Etymology:—Named for the type locality: Medicine Grizzly Lake.

Observations:—This taxon is smaller and has different valve and end shapes than *E. czarneckii* and *E. dakotae*. *Encyonopsis descripta* and *E. descriptiformis* have round central areas.

Distribution and Ecology:—Widespread and locally common in lakes in Glacier National Park and the Northern Rockies. At the type locality on the date the type sample was collected, pH measured 9.1 and specific conductance was 93 $\mu\text{S}/\text{cm}$.

Encyonopsis microcephala (Grunow) Krammer (1997b: 91, figs 143: 1, 4, 5, 8–26) (Figs 40–45)

Basionym:—*Cymbella microcephala* Grunow in Van Heurck (1885: 63, pl. 8, figs 36–39). Type: BELGIUM: “Brüssel“, lectotype slide 211 in VH (Krammer 1997b).

Vouchers:—USA, Montana: Ruby River, Madison County, 45.5064° N, 112.3292° W, elev. 1420 m, coll. P. Phillips, 8 August 2000. MDC sample 207701; MDC slide T1-16-17 (Figs 40, 45) MONTU!—USA, Oregon: Snake River, Malheur County, 43.7308° N, 117.0709° W, elev. 671 m, coll. J. Naymik, 12 June 2002. MDC sample 248803; MDC slide T3-19-18 (Figs 41–44) MONTU!

Observations:—Valves linear-elliptic and moderately dorsiventral with abruptly protracted subcapitate to capitate apices. Valve length 9.0–16.0 μm ; valve width 3.1–4.1 μm . Central area absent. Striae parallel to weakly radiate, 24–26 in 10 μm . Striae about the central area are more widely spaced. *Encyonopsis microcephala* is distinguished from other small *Encyonopsis* species by the squarish valves and the rather low stria density. The boxy shape of the valves is created by the presence of “shoulders”, which are lacking or not as prominent in other small *Encyonopsis* species, for example *E. alpina*, *E. minuta*, and *E. subminuta*.

Distribution and Ecology:—This is perhaps the most common and widely distributed species of *Encyonopsis* worldwide. Among the species recorded here, *Encyonopsis microcephala* has the widest ecological amplitude and is the least demanding in terms of water quality. On the date the voucher sample was collected, Ruby River had a pH of 8.35 and a specific conductance of 599 $\mu\text{S/cm}$.

Encyonopsis minuta Krammer & Reichardt in Krammer (1997b: 95, figs 143a: 1–29). Type: GERMANY, Bavaria: “Graben im Riedbachried bei Treuchtlingen, an altem Schilf”, coll. E. Reichardt, 26 November 1994. Holotype slide 49B IOK (Krammer 1997b). (Figs 46–51)

Voucher:—USA, Montana: East Spring Creek, Flathead County, 48.2258° N, 114.2672° W, elev. 890 m, coll. Montana DEQ, 9 September 2006. MDC sample 381501; MDC slide 114-52 (Figs 46–51) MONTU!

Observations:—Valves lanceolate, moderately dorsiventral, with rostrate apices. Valve length 11.0–14.1 μm ; valve width 3.1–3.7 μm . Striae parallel to weakly radiate, 24–27 in 10 μm . Valves of *E. minuta* do not have the prominent “shoulders” and boxy appearance of *E. microcephala* valves.

Distribution and Ecology:—Widespread and locally abundant in the study area, in mountain lakes and spring creeks. At collection sites with water quality data, pH ranged from 8.0 to 9.1 and specific conductance from 93 to 129 $\mu\text{S/cm}$.

Encyonopsis montana Bahls, *sp. nov.* (Figs 86–90)

Valves broadly lanceolate in smaller specimens to rhombic-lanceolate in larger specimens, with short rostrate apices deflected ventrally. Valves not or slightly dorsiventral. Valve length 26–75 μm ; valve width 5.7–8.8 μm . Axial area narrow. Central area small, asymmetric, rounded on the dorsal side, rounded (large specimens) to irregularly notched (small specimens) on the ventral side. Raphe lateral, becoming filiform near proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures comma-shaped, curved toward the ventral side. Striae weakly radiate (center) to strongly radiate (ends), 18–22 in 10 μm .

Holotype:—USA, Montana: Lake McDonald, Glacier National Park, Flathead County, 48.5876° N, 113.8966° W, elev. 961 m, coll. L. Bahls, 13 July 1993. MDC sample 128301; holotype slide MDC P3-10-12 (Figs 86–88) (circled holotype specimen in Fig. 86) MONTU!

Isotype:—ANSP! GC65173.

Paratype:—USA, Montana: Kootenai Pond, Glacier National Park, Flathead County, 48.9311° N, 113.8903° W, elev. 1340 m, coll. L. Bahls, 22 July 2009. MDC sample 451501; MDC slide 123-54 (Figs 89, 90) MONTU!

Etymology:—This species is named for the mountainous region of collection and for the state of Montana.

Observations:—In valve shape, *E. montana* resembles Krammer's morphotype 1 of *E. cesatii* var. *geitleri* (Krammer 1997b: 154, figs 184:4–7). However, *E. montana* attains a larger size (up to 75 µm long and 8.8 µm wide) and has more strongly radiate striae near the apices. Krammer reports specimens of *E. cesatii* var. *geitleri* from Europe up to 60 µm long and 8 µm wide and his images show striae near the apices to be weakly radiate. *Encyonopsis perfloridana* Metzeltin (Metzeltin & Lange-Bertalot 2002: 26, figs 60:1-5) is larger with lower stria density.

Distribution and Ecology:—Widely distributed and locally abundant in lakes and ponds in the Northern Rockies and North Cascades. For collection sites with water quality data, pH ranges from 7.0 to 8.7 and specific conductance from 13 to 139 µS/cm.

Encyonopsis neerlandica Van de Vijver et al. (2012: 44, figs 1–23). Type: THE NETHERLANDS: Galgenmatenvén, Ambt Delden, Twente (province of Overijssel), sample D1010-41 (52°15'23.35"N, 6°40'20.70"O), leg. G. Verweij, coll. 27/05/2010, slide no. BR-4270 (holotype BR, slide PLP-214 (isotype University of Antwerp, Belgium), slide ZU8/49 (isotype BRM). (Figs 70–75)

Vouchers:—USA, Montana: Upper Geiger Lake, Lincoln County, 48.0150° N, 115.5526° W, elev. 1634 m, coll. USFS, 1 September 1992. MDC sample 116301; MDC slide P3-5-6 (Figs 70, 71, 73) MONTU!—USA, Montana: Lake 1 mile east of Tin Cup Lake, Ravalli County, 45.9459° N, 114.3696° W, elev. 2186 m, coll. R. Hammer, 7 August 1991. MDC sample 109601; MDC slide P3-3-5 (Fig. 72) MONTU!—USA, Montana: Hoodoo Lake, Mineral County, 46.9783° N, 115.0033° W, elev. 1787 m, coll. J. Pierce, 14 August 1998. MDC sample 177601; MDC slide P3-24-1 (Fig. 74) MONTU!—USA, Montana: Lake Winona, Glacier National Park, 48.7289° N, 114.2339° W, elev. 1065 m, coll. E. W. Schweiger, 23 September 2008. MDC sample 439301; MDC slide 121-92 (Fig. 75) MONTU!

Observations:—Van de Vijver et al. (2012) described this species as having narrowly lanceolate valves 15–26 µm long by 3.5–4.5 µm wide with rostrate to subcapitate apices and radiate striae numbering 24–28 in 10 µm. Valves of Montana specimens (Figs 70–75) are lanceolate in smaller specimens to rhombic-lanceolate in larger specimens with rostrate to subcapitate apices, or apices not protracted in the largest specimens. Montana specimens measure 13.7–23.9 µm long and 3.3–4.4 µm wide. Striae are parallel to weakly radiate, 25–28 in 10 µm.

Small valves of *E. neerlandica* are very similar to specimens of *E. subminuta* (Figs 52–57, 81–85). However, the larger rhombic-lanceolate valves of *E. neerlandica*, especially those that lack protracted apices, easily distinguish this species from *E. subminuta*. In the study area, the two species often occupy the same habitat and one must examine the entire size range to separate them with confidence. Van de Vijver et al. (2012) compare this taxon to several other species of *Encyonopsis*.

Distribution and Ecology:—In Europe, Van de Vijver et al. (2012) reported this species from oligotrophic to mesotrophic, oxygen-rich and circumneutral moorland pools with low to moderate conductivity. In western North America, *Encyonopsis neerlandica* is widely distributed and locally abundant in mountain lakes. At collection sites with water quality data, pH ranges from 6.7 to 7.2 and specific conductance from 14 to 250 $\mu\text{S}/\text{cm}$.

Encyonopsis neoamphioxys Krammer (1997b: 141, fig. 168: 1–7, 11–13). Type: AUSTRIA: “Kitzbühel, Schwarzsee“, slide T3/19 HB. (Figs 163–165)

Synonym:—*Navicula amphioxys* sensu Kützing (1844: 91, fig. 28: 37)

Vouchers:—USA, Montana: Flower Lake, Lincoln County, 48.3553° N, 115.6286° W, elev. 1159 m, coll. J. Pierce, 3 September 1997. MDC sample 174101; MDC slide P3-21-10 (Fig. 163) MONTU!—USA, Montana: Pond near Curley Lake, Madison County, 45.6253° N, 112.0825° W, elev. 2622 m, coll. E. Bindseil, 22 September 2012. MDC sample 499301; MDC slide 126-86 (Fig. 164) MONTU!—USA, Montana: Drosera Fen, Lewis & Clark County, 47.1053° N, 112.6061° W, elev. 1841 m, coll. L. Bahls, 3 September 2009. MDC sample 452601; MDC slide 123-66 (Fig. 165) MONTU!

Observations:—Valves lanceolate to linear-lanceolate, moderately dorsiventral; ventral margin slightly convex to almost flat. Valve length 41–58 μm ; valve width 4.7–7.7 μm . Striae radiate, 14–16 in 10 μm at valve center, 16–18 in 10 μm near the apices. A single stigma lies at the proximal end of the median dorsal stria. May be distinguished from other taxa in this group (Figs 158–179) by the more dorsiventral valves and slightly convex to nearly flat ventral margin.

Distribution and Ecology:—Uncommon in the study area. Collected in small numbers from three ponds and fens (see vouchers). At these sites pH ranged from 6.0 to 7.2 and specific conductance from 30 to 257 $\mu\text{S}/\text{cm}$.

Encyonopsis perborealis Krammer (1997b: 109, figs 154: 1–12). Type: NORWAY: “See an der Straße zwischen Lakselv und Nordkap, Auftrieb in einem Algenklumpen“, holotype slide 631C IOK. (Figs 151–157)

Vouchers:—USA, Montana: Big Therriault Lake, Lincoln County, 48.9306° N, 114.8778° W, elev. 1707 m, coll. L. Bahls, 18 September 2012. MDC sample 497701; MDC slide 126-68 (Figs 154, 155) MONTU!—USA, Montana: Little Therriault Lake, Lincoln County, 48.9400° N, 114.8906° W, elev. 1689 m, coll. L. Bahls, 21 September 2012. MDC sample 498601; MDC

slide 126-78, MONTU!—USA, Montana: Lower Wolverine Lake, Lincoln County, 48.9697° N, 114.9200° W, elev. 2070 m, coll. L. Bahls, 20 September 2012. MDC sample 498201; MDC slide 126-73 (Figs 151–153, 156, 157) MONTU!

Observations:—Valves linear to linear-lanceolate, slightly dorsiventral, with rostrate to subcapitate apices. Valve length 9.7–18.6 µm; valve width 2.5–3.8 µm. Central area small. Striae weakly radiate, 26–30 in 10 µm. Distinguished from *E. moseri* Krammer & Lange-Bertalot in Krammer (1997b: 104) and *E. bobmarshallensis* (Figs 144–150) by the higher stria density (26–30 in 10 µm, not 24–25 or 22–24 in 10 µm, respectively).

Distribution and Ecology:—Widely distributed and locally abundant in higher elevation lakes and streams in the northern Rocky Mountains. At sites with water quality data, pH varies from 8.0 to 9.0 and specific conductance from 100 to 176 µS/cm.

Encyonopsis robusta (Hustedt) Bahls, *comb. et stat. nov.* (Figs 134–138)

Basionym:—*Cymbella microcephala* fo. *robusta* Hustedt (1939: 561, figs 14–15). Type: FRANCE: T2/98. Gave d'Ossau, Moos an Felsen, Pyrenäen. 9.b. BRM (Simonsen 1987).

Synonyms:—*Cymbella microcephala* fo. *robusta* Hustedt (Simonsen 1987: 249, pl. 371, figs 22–25); *Encyonopsis microcephala* var. *robusta* (Hustedt) Krammer (1997b: 92, figs 148: 8, 9).

Vouchers:—CANADA, Alberta: Blakiston Beaver Pond A, Waterton Lakes National Park, 49.0928° N, 113.8864° W, elev. 1520 m, coll. B. Johnston, 2 June 2009. MDC sample 453301; MDC slide 123-91 (Figs 129–138) MONTU!—USA, Montana: Kintla Spring Seep, Glacier National Park, Flathead County, 48.9461° N, 114.3419° W, elev. 1231 m, coll. L. Bahls, 31 July 2008. MDC sample 431401; MDC slide 118-87 MONTU!—USA, Montana: Haystack Seep, Glacier National Park, Flathead County, 48.7381° N, 113.7456° W, elev. 1585 m, coll. E. W. Schweiger, 23 July 2009. MDC sample 453001; MDC slide 123-71 MONTU!

Observations:—Valves are linear to linear-lanceolate and not or just slightly dorsiventral. Apices are capitate. Valve length is 13.1–16.7 µm; valve width is 2.9–3.5 µm. The axial area is narrow. The central area is small and rounded. Raphe is filiform with unexpanded proximal ends that are deflected dorsally. Distal raphe fissures are comma-shaped and curved to the ventral side. Striae are weakly radiate throughout and number 19–22 in 10 µm. Krammer (1997b) gives the stria density for this taxon as 21–22 in 10 µm. *Encyonopsis hustedtii* (Figs 129–133) has a higher stria density (23–26 in 10 µm). *Encyonopsis robusta* does not belong with *E. microcephala*. It has a different autecology and lacks the dorsiventral aspect of *E. microcephala*.

Distribution and Ecology:—Widespread and locally common in small streams, springs, and mossy seeps in the Northern Rockies. These waters typically have somewhat alkaline pH and low to moderate concentrations of dissolved solids. *Encyonopsis robusta* may occupy the same habitats as *E. hustedtii* (e.g., Blakiston Beaver Pond A and Kintla Spring Seep).

Encyonopsis stafsholtii Bahls, *sp. nov.* (Figs 98–102)

Valves rhombic-lanceolate, slightly dorsiventral. Apices gradually protracted, narrowly subrostrate, deflected ventrally. Valve length 24.9–44.7 μm ; valve width 5.1–6.3 μm . Axial area narrow. Central area asymmetric, rounded on the dorsal side, defined by 1 to 3 irregularly shortened striae on the ventral side. Raphe lateral, filiform at the proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures hooked toward the ventral side. Striae radiate, 22–25 in 10 μm .

Holotype:—USA, Montana: Lake McDonald, Glacier National Park, Flathead County, 48.5876° N, 113.8966° W, elev. 961 m, coll. L. Bahls, 13 July 1993. MDC sample 128301; holotype slide MDC P3-10-12 (Figs 99–102) (circled holotype specimen in Fig. 100) MONTU!

Isotype:—ANSP! GC65173.

Paratype:—USA, Montana: Lower Wolverine Lake, Lincoln County, 48.9697° N, 114.9200° W, elev. 2070 m, coll. L. Bahls, 20 September 2012. MDC sample 498201; paratype slide MDC 126-73 (Fig. 98) MONTU!

Etymology:—Named in honor of Mr. Jon E. Stafsholt on the occasion of his 70th birthday. Mr. Stafsholt has been a loyal life-long friend of a friend of the diatoms.

Observations:—*Encyonopsis stafsholtii* is similar in morphology to *E. montana* (Figs 86–90), but smaller. And unlike small valves of *E. montana*, which are lanceolate (Figs 89, 90), small valves of *E. stafsholtii* (Fig. 98) retain their rhombic-lanceolate shape. Large valves of *E. neerlandica* (Figs 70–75) are also rhombic-lanceolate, but this species lacks a central area. *Encyonopsis cesatii* (Figs 91–97) has strictly lanceolate valves with more abruptly protracted rostrate apices. *Encyonopsis cesatii* morphotype 2 from Finnish Lapland (Krammer 1997b: 153, fig. 183: 11) is very similar to *E. stafsholtii* and may be conspecific.

Distribution and Ecology:—Widely distributed and locally abundant in lakes of the Northern Rockies. At sites with water quality data, pH varies from 7.9 to 9.0 and specific conductance from 92 to 171 $\mu\text{S}/\text{cm}$.

Encyonopsis subminuta Krammer & Reichardt in Krammer (1997b: 96, figs 144: 1–11). Type: SWITZERLAND: “Quellsumpf beim Dorf Splügen, Schweiz, Moos“, holotype slide 347E IOK. (Figs 52–57, 81–85)

Vouchers:—USA, Montana: Paradise Pond, Glacier National Park, 48.4792° N, 113.3692° W, elev. 1600 m, coll. L. Bahls, 7 September 2006. MDC sample 375701; MDC slide 117-10 (Fig 52) MONTU!—USA, Montana: Lake McDonald, Glacier National Park, Flathead County, 48.5876° N, 113.8966° W, elev. 961 m, coll. L. Bahls, 13 July 1993. MDC sample 128301; MDC slide P3-10-12 (Figs 53–56) MONTU!—USA, Montana: East Spring Creek, Flathead County, 48.2258° N, 114.2672° W, elev. 890 m, coll. Montana DEQ, 9 September 2006. MDC sample 381501; MDC slide 114-52 (Fig. 57) MONTU!—USA, Montana: Medicine Grizzly

Lake, Glacier National Park, 48.5683° N, 113.4892° W, elev. 1696 m, coll. L. Bahls, 14 August 2007. MDC sample 405401; MDC slide 117-37 (Figs 81–85) MONTU!

Observations:—Valves lanceolate to elliptic-lanceolate, largely symmetric with respect to the apical axis. Apices subcapitate. Valve length 12.9–20.3 µm; valve width 3.2–4.1 µm. Central area absent. Striae parallel to weakly radiate, 25–30 in 10 µm. Striae at midvalve evenly spaced. *Encyonopsis subminuta* is distinguished from *Encyonopsis microcephala* by its nearly symmetric lanceolate to elliptic-lanceolate valves and evenly spaced striae at midvalve.

Distribution and Ecology:—*Encyonopsis subminuta* is the most frequently occurring and most abundant *Encyonopsis* species in the study area. It has been recorded in 628 lakes and streams, often in large numbers. Based on 140 records of water quality variables and associated diatom counts, abundance-weighted mean pH is 8.0 with a standard error of 0.1, and abundance-weighted mean specific conductance is 388 µS/cm with a standard error of 149 µS/cm.

Encyonopsis subspicula Krammer (1997b: 144, figs 168: 8, 9; 169: 1–9). Type: USA, New Hampshire: “Bemis Lake, White Mountains“, fossil, coll. M. C. Stodder, holotype slide 1173F IOK. (Figs 166–169)

Vouchers:—USA, Montana: Drosera Pond, Lewis & Clark County, 47.1003° N, 112.5964° W, elev. 1799 m, coll. J. Pierce, 21 October 2011. MDC sample 490902; MDC slide 125-71 (Figs 167, 168) MONTU!—USA, Montana: Drosera Pond, Lewis & Clark County, 47.1003° N, 112.5964° W, elev. 1799 m, coll. J. Pierce, 21 October 2011. MDC sample 491301; MDC slide 125-75 (Fig. 166) MONTU!—USA, Montana: Pond near McDonald Mountain, Lincoln County, 48.1616° N, 115.6427° W, elev. 1220 m, coll. J. Pierce, 24 July 1997. MDC sample 173101; MDC slide P3-20-4 (Fig. 169) MONTU!

Observations:—Valves lanceolate, slightly dorsiventral. Apices gradually attenuated, rounded, not protracted. Valve length 47.2–76.4 µm; valve width 5.7–8.6 µm. Axial area narrow; central area small, asymmetric, rounded on the dorsal side. Raphe lateral, filiform at the proximal and distal ends. Striae radiate, parallel then weakly convergent toward the apices, 16–20 in 10 µm. A single stigma lies at the proximal end of the median dorsal stria. Distinguished from other North American species in this group (Figs 158–179) by valve size and shape, stria density, and degree of dorsiventrality. *Encyonopsis spicula* (Hustedt) Krammer (1997b: 145) and *E. stoermeri* Lange-Bertalot & Metzeltin (2009: 139), both tropical species, have lower stria densities.

Distribution and Ecology:—*Encyonopsis subspicula* has been collected from five small lakes, ponds and fens in northwest Montana, where it occurs in low numbers. All of these waters are somewhat acidic (pH 6.0–6.5) with low specific conductance (10–150 µS/cm).

Encyonopsis treinishii Bahls, sp. nov. (Figs 170–174)

Valves rhombic-lanceolate, not or slightly dorsiventral. Apices subrostrate, broadly rounded. Valve length 61.8–79.9 µm; valve width 7.9–10.3 µm. Axial and central areas relatively wide,

together forming a narrow longitudinal lanceolate space. Raphe lateral, filiform at the proximal and distal ends. Proximal raphe ends weakly expanded, deflected dorsally. Distal raphe fissures comma-shaped, concave toward the ventral margin. Striae radiate, becoming parallel then convergent toward the apices, 12–15 in 10 µm at valve center, 14–17 in 10 µm near the apices. Striae near the central area are curved and then recurved (sinuous). A single stigma lies at the proximal end of the median stria on the dorsal side.

Holotype:—USA, Washington: Nada Lake, Chelan County, 47.4936° N, 120.7403° W, elev. 1524 m, coll. R. Davis, 16 September 2012. MDC sample 499701; holotype slide MDC 41-96 (Figs 170–174) (circled holotype specimen in Fig. 173) MONTU!

Isotypes:—MDC slide 126-90 MONTU!; circled specimens on ANSP! GC65169.

Etymology:—Named in honor of Gregg Treinish, Founder and Executive Director of Adventurers and Scientists for Conservation. Volunteers for ASC collected several of the samples that were examined for this paper, including the type sample for this species.

Observations:—*Encyonopsis spicula* (Hustedt) Krammer (1997b: 145), a tropical species, has narrower valves (7.5–8.5 µm) and striae that are relatively straight, not recurved. *Encyonopsis stodderi* (Cleve) Krammer (1997b: 162), a fossil species from New Hampshire, is significantly larger and lacks the central stigma.

Distribution and Ecology:—Besides the type locality, *E. treinishii* has been collected from four small lakes, ponds and fens in northern Idaho, Glacier National Park (MT), and Mount Rainier National Park (WA). In these waters pH ranges from 6.0 to 7.5 and specific conductance from 10 to 58 µS/cm.

Encyonopsis weilandii Bahls, *sp. nov.* (Figs 175–179)

Valves lanceolate, not or slightly dorsiventral. Apices rounded, weakly subrostrate or not protracted. Valve length 33.0–72.0 µm; valve width 7.5–9.7 µm. Axial area narrow. Central area small, defined by a shortened median stria on the ventral side. Raphe lateral, proximal and distal ends filiform. Proximal raphe ends weakly expanded and deflected dorsally. Distal raphe fissures comma-shaped, concave to the ventral margin. Striae radiate, becoming parallel then convergent near the apices, 12–14 in 10 µm at valve center, 15–18 in 10 µm near the apices. The median striae on the dorsal and ventral sides are more distant from their mates than the remaining striae. A single stigma lies at the proximal end of the median dorsal stria.

Holotype:—USA, Washington: Goat Rocks Pond, Lewis County, 46.4839° N, 121.4894° W, elev. 1418 m, coll. Craig Weiland, 1 October 2012. MDC sample 501501; holotype slide MDC 42-14 (Figs 177–179) (circled holotype specimen in Fig. 178) MONTU!

Isotypes:—MDC slide 127-8 MONTU!; circled specimens on ANSP! GC65172.

Paratypes:—CANADA, Alberta: Summit Lake, Waterton Lakes National Park, 49.0078° N, 114.0258° W, elev. 1980 m, coll. B. Johnston, 23 July 2009. MDC sample 456901; MDC slide 124-57 (Fig. 176) MONTU!—USA, Washington: Small meltwater pond on Anderson Pass, Olympic National Park, 47.6975° N, 123.3275° W, elev. 1402 m, coll. R. Davis, 28 July 2012. MDC sample 494701; MDC slides 41-58 (Fig. 175), 126-52 MONTU!—USA, Washington: Pond near Schreiber's Meadow, Whatcom County, 48.7050° N, 121.8206° W, elev. 1061 m, coll. R. Davis, 3 September 2012. MDC sample 499601; MDC slides 41-95, 126-89 MONTU!

Etymology:—Named after Craig Weiland, a volunteer with Adventurers and Scientists for Conservation who collected the type sample.

Observations:—*Encyonopsis weilandii* is easily distinguished from other species in this group by the displacement of the median dorsal and ventral striae.

Distribution and Ecology:—Besides the holotype and paratype localities, *E. weilandii* has been collected from several lakes in the Bitterroot Range on the Montana/Idaho border. These lakes have circumneutral pH and low concentrations of dissolved solids.

Encyonopsis* sp. cf. *microcephala (Figs 79, 80)

Voucher:—USA, Montana: Yaak River, Lincoln County, 48.4956° N, 115.9183° W, elev. 580 m, coll. L. Bahls, 20 July 1977. MDC sample 033101; MDC slide B4-10-1 (Figs 79, 80) MONTU!

Observations:—Valves linear, moderately dorsiventral. Apices subcapitate, relatively wide. Valve length 13.3 µm; valve width 3.0 µm. Axial area very narrow. Central area small, about 1/3 width of valve. Raphe filiform. Proximal raphe ends weakly inflated, deflected dorsally. Distal raphe fissures curved to the ventral side. Striae radiate, 27 in 10 µm. This taxon is narrower and has a larger central area than *E. microcephala*.

Distribution and Ecology:—Known only from the Yaak River, where it occurs in small numbers. Measured pH at the collection site was 7.8, specific conductance 108 µS/cm.

Encyonopsis* sp. cf. *subminuta (Figs 76–78)

Vouchers:—USA, Montana: Upper Whitefish Lake, Flathead County, 48.6866° N, 114.5781° W, elev. 1348 m, coll. J. Pierce, 18 August 1998. MDC sample 177701; MDC slide P3-24-7 (Fig. 76) MONTU!—USA, Montana: Pumphouse Pond, Missoula County, 47.4468° N, 113.6231° W, elev. 1262 m, coll. J. Pierce, 6 August 1998. MDC sample 176801; MDC slide P3-22-18 (Fig. 77) MONTU!—USA, Montana: Lake Winona, Glacier National Park, 48.7294° N, 114.2352° W, elev. 1055 m, coll. J. Pierce, 7 September 1999. MDC sample 194201; MDC slide P4-2-9 (Fig. 78) MONTU!—USA, Montana: Holland Lake, Missoula County, 47.4494° N, 113.5975° W, elev. 1230 m, coll. J. Pierce, 6 August 1998. MDC sample 127403; MDC slide P3-22-20 MONTU!

Observations:—Valves linear-elliptic, weakly dorsiventral. Apices short, subrostrate. Valve length 14.2–18.4 μm ; valve width 3.5–4.7 μm . Axial area narrow. Central area small, a bit wider than the axial area. Raphe filiform. Proximal raphe ends deflected dorsally. Distal raphe fissures hooked toward the ventral margin. Striae weakly radiate, 22–24 in 10 μm . Distinguished from other species in this group by the linear-elliptic valve shape, short protracted apices, and lower stria density.

Distribution and Ecology:—Collected in small numbers from four lakes and ponds in northwest Montana (vouchers). At these sites pH varied from 7.2 to 8.6 and specific conductance from 118 to 250 $\mu\text{S/cm}$.

Discussion

The 31 species reported here comprise a significant fraction of the global *Encyonopsis* flora. In his monograph on the genus, Krammer (1997b) addressed a total of 83 species that were known at the time. A recent query of the California Academy of Sciences' Catalogue of Diatom Names (CAS 2011) generated a list of 116 *Encyonopsis* species and 13 infraspecies taxa.

In western North America, species of *Encyonopsis* are found mostly in small headwater lakes, ponds, springs, seeps and streams in remote mountain regions. These waters are typically unpolluted, cold, and weakly acidic to moderately alkaline (pH 6.0–9.2), with low to moderate concentrations of nutrients and dissolved solids (specific conductance 10–600 $\mu\text{S/cm}$) and high levels of dissolved oxygen (Montana Department of Environmental Quality, unpublished data). Nearly all of the type and voucher localities reported here are in National Forests and National Parks.

Northwest Montana, west of the Continental Divide, is a biodiversity hotspot for *Encyonopsis* species. One lake on the Kootenai National Forest near the US border with British Columbia (Lower Wolverine Lake, back cover) supports 12 species of *Encyonopsis*, including five described as new. Another lake only a few kilometers distant (Little Therriault Lake, back cover) supports 10 species, including three not found in Lower Wolverine Lake, two of which are also new to science. The 15 species supported by these two lakes comprise nearly half of the known *Encyonopsis* flora from western North America. Most, if not all, of the new species reported in this paper are either local or regional endemics.

The Northern Rockies region is also a biodiversity hotspot for the genus *Stauroneis* Ehrenberg (1843: 45). Bahls (2010) reported 50 species of *Stauroneis* from the region, including 16 described as new. Based on my scan of slides from the MDC in search of *Stauroneis* and *Encyonopsis* taxa, the probability of finding new species here in other genera is substantial. Critical examination of slides in the MDC and in other collections from remote regions of North America have great potential for better defining the continent's unique endemic diatom flora, for expanding our knowledge of diatom biogeography, and for estimating the total number of diatom species worldwide.

Acknowledgements

This contribution would not have been possible without the pioneering work of Kurt Krammer and the many samples collected by field workers and volunteers listed in the voucher and type descriptions. Thanks to Marina Potapova for patiently explaining to me the rules of botanical nomenclature and to Richard Moe for help with Latin names. This work was originally submitted to *Phytotaxa* and retains the format of that journal. David Williams and two anonymous reviewers made several helpful comments and suggestions for improving the manuscript.

References

- Agardh, C.A. (1830) *Conspectus Criticus Diatomacearum*. Part 1. *Litteris Berlingianis*, Lund, 16 pp.
- APHA (1992) *Standard Methods for the Examination of Water and Wastewater*, 18th Edition, Greenberg, A.E., Clesceri, L.S. & Eaton, A.D. (eds.). American Public Health Association, Washington, D.C., 1100 pp.
- ASC (2012) *High Mountain Lake Diatom Collection*, Adventurers and Scientists for Conservation, Bozeman, Montana. Available at: <http://www.adventureandscience.org/diatom-lake.html/> (accessed 14 January 2013).
- Bahls, L. (2010) *Stauroneis* in the Northern Rockies. In: Bahls, L. (ed.), *Northwest Diatoms*, Vol. 4. The Montana Diatom Collection, Helena, 179 pp.
- CAS (2011) *Catalogue of Diatom Names*, California Academy of Sciences. San Francisco. Available from: <http://research.calacademy.org/> (accessed 14 January 2013).
- Ehrenberg, C.G. (1843) Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin* 1841: 291–445.
- Geitler, L. (1975) Formwechsel, sippenspezifischer Paarungsmodus und Systematik bei einigen pennaten Diatomeen. *Plant Systematics and Evolution* 124: 7–30.
- Greville, R.K. (1855) Report on a collection of Diatomaceae made in the district of Braemar by Professor Balfour and Mr. Gerge Lawson. *Annals and Magazine of Natural History*, 2nd series, 15: 252–261.
- Hustedt, F. (1938). Systematische und ökologische Untersuchungen über die Diatomeen-Flora von Java, Bali und Sumatra nach dem Material der Deutschen Limnologischen Sunda-Expedition. *Archiv für Hydrobiologie*, Supplement 15: 393–506.
- Hustedt, F. (1939) Diatomeen aus den Pyrenäen. *Bericht der Deutschen Botanischen Gesellschaft* 56: 543–572.

- Hustedt, F. (1943) Die Diatomeenflora einiger Hochgebirgsseen der Landschaft Davos in den schweizer Alpen. *Internationale Revue der gesamten Hydrobiologie und Hydrographie* 43: 124–197, 225–280.
- ICBN (2006) *International Code of Botanical Nomenclature (Vienna Code)*. A.R.G. Gantner Verlag KG, Ruggell, Liechtenstein, 568 pp.
- Krammer, K. (1997a) Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 1. Allgemeines und *Encyonema* Part. *Bibliotheca Diatomologica*, Band 36, J. Cramer, Berlin, 382 pp.
- Krammer, K. (1997b) Die cymbelloiden Diatomeen. Eine Monographie der weltweit bekannten Taxa. Teil 2. *Encyonema* part., *Encyonopsis* and *Cymbellopsis*. *Bibliotheca Diatomologica*, Band 37, J. Cramer, Berlin, 469 pp.
- Krammer, K. (1999) Validierung von *Cymboppleura* nov. gen. In Lange-Bertalot, H. (ed.), *Iconographia Diatomologica*, Vol. 6. A.R.G. Gantner Verlag K.G., Vaduz, p. 292.
- Krammer, K. & Lange-Bertalot, H. (1985) Naviculaceae. Neue und wenig bekannte Taxa, neue Kombinationen und Synonyme sowie Bemerkungen zu einigen Gattungen. *Bibliotheca Diatomologica*, Band 9, J. Cramer, Berlin, 230 pp.
- Kützing, F.T. (1833) Synopsis Diatomacearum oder Versuch einer systematischen Zusammenstellung der Diatomeen. *Linnaea* 8: 529–620.
- Kützing, F.T. (1844) *Die Kieselchaligen. Bacillarien oder Diatomeen*. Nordhausen, 152 pp.
- Lange-Bertalot, H. & Metzeltin, D. (2009) A dystrophic mountain lake in Panama—hot spot of new and rare neotropical diatoms. *Nova Hedwigia*, Beiheft 135: 137–166.
- Metzeltin, D. & Lange-Bertalot, H. (1998) Tropical diatoms of South America I. In: Lange-Bertalot, H. (ed.), *Iconographia Diatomologica*, Vol. 5. Koeltz Scientific Books, Königstein, 695 pp.
- Metzeltin, D. & Lange-Bertalot, H. (2002) Diatoms from the “Island Continent” Madagascar. In: Lange-Bertalot, H. (ed.), *Iconographia Diatomologica*, Vol. 11. A.R.G. Gantner Verlag K.G., Ruggell, 286 pp.
- Metzeltin, D. & Lange-Bertalot, H. (2007) Tropical diatoms of South America II. In: Lange-Bertalot, H. (ed.), *Iconographia Diatomologica*, Vol. 18. A.R.G. Gantner Verlag K.G., Ruggell, 877 pp.
- Patrick, R. & Reimer, C.W. (1975) *Diatoms of the United States exclusive of Alaska and Hawaii*. Vol. 2, Part 1. Monograph 13, The Academy of Natural Sciences of Philadelphia, 213 pp.

- Rabenhorst, L. (1853) *Die Süßwasser-Diatomaceen (Bacillarien) für Freunde der Mikroskopie*. Eduard Kummer, Leipzig, 72 pp.
- Reichardt, E. (1997) Bermerkenswerte Diatomeenfunde aus Bayern. IV. Zwei neue Arten aus den Kleinen Ammerquellen. *Berichte der Bayerischen Botanischen Gesellschaft* 68: 61–66.
- Schmidt, A. (1881) *Atlas der Diatomaceen-kunde*. Reprint 1984, Koeltz Scientific Books, Königstein, Tafel 71, figs 48, 49.
- Simonsen, R. (1987) *Atlas and catalogue of the diatom types of Friedrich Hustedt*. Vol. 1: Catalogue, 525 pp.; Vol. 2: Atlas, Taf. 1–395; Vol. 3: Atlas, Taf. 396–772. J. Cramer, Stuttgart.
- USEPA. (2000) *Level III ecoregions of the continental United States* (map). U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon.
- Van de Vijver, B., Verweij, G., Van der Wal, J. & Mertens, A. (2012) *Encyonopsis neerlandica*, a new freshwater diatom species (Bacillariophyta) from moorland pools in The Netherlands. *Phytotaxa* 66: 43–48.
- Van Heurck, H. (1880) *Synopsis des Diatomées de Belgique*. Atlas. Ducaju & Cie, Anvers, plates 1–30.
- Van Heurck, H. (1885) *Synopsis des Diatomées de Belgique*. Texte. Martin Brouwers & Co., Anvers, 235 pp.

Tables for comparison of *Encyonopsis* species from western North America

The following tables are provided to help distinguish *Encyonopsis* species from western North America. The tables rely mainly on the following morphological features:

Valve length
Valve width
Presence or absence of stigmata
Presence or absence of a central area
Size of central area
Valve shape
End shape
Degree of valve dorsiventrality
Stria density

Table 1 is a dichotomous key to the 31 taxa named and described herein. Tables 2–7 give diagnostic features for species in six groups that are defined as follows:

Species with stigmata

Encyonopsis neoamphioxys group Table 2

Species without stigmata, > 20 µm long

Encyonopsis cesatii group Table 3
—valves linear, linear-lanceolate, lanceolate or rhombic-lanceolate
—apices sub-rostrate

Encyonopsis descripta group Table 4
—valves lanceolate, linear-lanceolate or elliptic-lanceolate
—apices rostrate or capitate

Species without stigmata, < 20 µm long

Encyonopsis microcephala group Table 5
—central area indistinct, more or less continuous with axial area
—valves moderately dorsiventral

Encyonopsis subminuta group Table 6
—central area indistinct, more or less continuous with axial area
—valves not or slightly dorsiventral

Encyonopsis perborealis group Table 7
—central area distinct, wider than axial area
—valves not or slightly dorsiventral

TABLE 1: Key to *Encyonopsis* species from western North America.

1. Valves mostly greater than 40 µm long.....	2
1. Valves mostly less than 40 µm long.....	8
2. Stigma absent.....	3
2. Stigma present.....	4
3. Valves linear.....	<i>E. lacuscaerulei</i>
3. Valves lanceolate to rhombic-lanceolate.....	<i>E. montana</i>
4. Valves dorsiventral, ventral margin weakly arched.....	<i>E. neoamphioxys</i>
4. Valves not dorsiventral, dorsal and ventral margins equally arched.....	5
5. Striae near midvalve wavy, recurved.....	<i>E. treinishii</i>
5. Striae near midvalve straight.....	6
6. Central striae evenly spaced.....	7
6. Central striae more widely spaced.....	<i>E. weilandii</i>
7. Valve width 8.8–11.1 µm.....	<i>E. lacusglacialis</i>
7. Valve width 5.7–8.6 µm.....	<i>E. subspicula</i>
8. Valves mostly 20–40 µm long.....	9
8. Valves mostly less than 20 µm long.....	17
9. Striae less than 16 in 10 µm at valve center.....	10
9. Striae more than 16 in 10 µm at valve center.....	11
10. Ends capitate.....	<i>E. aequaliformis</i>
10. Ends rostrate.....	<i>E. aequalis</i>
11. Central area large, rounded.....	12
11. Central area small, irregular.....	14
12. Valves lanceolate.....	<i>E. descriptiformis</i>
12. Valves linear-lanceolate.....	13
13. Ends capitate.....	<i>E. descripta</i>
13. Ends subrostrate.....	<i>E. falaisensis</i>
14. Valves lanceolate.....	<i>E. cesatii</i>
14. Valves rhombic-lanceolate or linear-lanceolate.....	15
15. Valves rhombic-lanceolate.....	<i>E. stafsholtii</i>
15. Valves linear-lanceolate.....	16
16. Valves mostly less than 5 µm wide, striae 22–26 in 10 µm.....	<i>E. czarneckii</i>
16. Valves mostly more than 5 µm wide, striae 18–23 in 10 µm.....	<i>E. dakotae</i>
17. Valves moderately dorsiventral, narrowly lanceolate.....	18
17. Valves not or slightly dorsiventral, variously shaped.....	19
18. Striae 20–24 in 10 µm.....	<i>E. albertana</i>
18. Striae 25–30 in 10 µm.....	<i>E. krammeri</i>
19. Valves linear to linear-lanceolate, margins weakly arched.....	20
19. Valves lanceolate to elliptic-lanceolate, margins strongly arched.....	26
20. Central area small or absent.....	21
20. Central area variable, distinct.....	23
21. Ends capitate.....	<i>E. alpina</i>
21. Ends rostrate to subcapitate.....	22
22. Ends rostrate.....	<i>E. anacondae</i>
22. Ends subcapitate.....	<i>E. perborealis</i>

23. Ends capitate.....	24
23. Ends rostrate to subcapitate.....	25
24. Striae 23–26 in 10 µm.....	<i>E. hustedtii</i>
24. Striae 19–22 in 10 µm.....	<i>E. robusta</i>
25. Central area large, reaching nearly to valve margins.....	<i>E. kutenaiorum</i>
25. Central area smaller, variable in size.....	<i>E. bobmarshallensis</i>
26. Valves largely lanceolate, without shoulders.....	27
26. Valves more elliptic, with shoulders.....	28
27. Valves 11–14 µm long.....	<i>E. minutum</i>
27. Valves 15–26 µm long.....	<i>E. neerlandica</i>
28. Valves dorsiventral.....	<i>E. microcephala</i>
28. Valves not dorsiventral.....	29
29. Central area present.....	<i>E. medicinalis</i>
29. Central area absent.....	30
30. Valves 11–13 µm long, striae at midvalve more widely spaced.....	<i>E. lacusalpini</i>
30. Valves 13–20 µm long, striae at midvalve evenly spaced.....	<i>E. subminuta</i>

TABLE 2: *Encyonopsis neoamphioxys* group (Figs 158–179).

	<i>E. lacusglacialis</i>	<i>E. neoamphioxys</i>	<i>E. subspicula</i>	<i>E. treinishii</i>	<i>E. weilandii</i>
Valve length	58–80	41–58	47–76	62–80	33–72
Valve width	8.8–11.1	4.7–7.7	5.7–8.6	7.9–10.3	7.5–9.7
Valve shape	Rhombic-lanceolate	Lanceolate to Linear-lanceolate	Lanceolate	Rhombic-lanceolate	Lanceolate
Valves dorsiventral?	No	Yes	No	No	No
End shape	Narrowly rounded	Narrowly rounded	Narrowly rounded	Sub-rostrate	Sub-rostrate
Stria density center	10–13	14–16	16–18	12–15	12–14
Stria density apices	16–18	16–18	18–20	14–17	15–18
Central striae evenly spaced?	Yes	Yes	Yes	Yes	No
Striae near center straight or curved?	Straight	Straight	Straight	Curved	Straight

TABLE 3: *Encyonopsis cesatii* group (Figs 15–21, 86–106).

	<i>E. cesatii</i>	<i>E. falaisensis</i>	<i>E. lacuscaerulei</i>	<i>E. montana</i>	<i>E. stafsholtii</i>
Valve length	22–39	20–36	36–61	26–75	25–45
Valve width	4.6–5.9	5.0–6.1	5.5–6.8	5.7–8.8	5.1–6.3
Valve shape	Lanceolate	Lanceolate to Linear-lanceolate	Linear, triundulate	Lanceolate to Rhombic-lanceolate	Rhombic-lanceolate
Central area size	Small	Large	Medium	Small, asymmetric	Small, asymmetric
Stria density center	16–20	16–18	17–18	18–20	22–23
Stria density apices	21–22	19–22	19–20	20–22	24–25

TABLE 4: *Encyonopsis descripta* group (Figs 1–14, 107–128).

	<i>E. aequaliformis</i>	<i>E. aequalis</i>	<i>E. czarneckii</i>	<i>E. dakotae</i>	<i>E. descripta</i>	<i>E. descriptiformis</i>	<i>E. medicinalis</i>
Valve length	25–32	22–41	20–30	24–32	26–30	23–34	14–21
Valve width	5.9–7.0	5.6–7.6	3.7–5.2	4.8–6.5	5.4–6.6	5.6–6.7	4.8–5.9
Valve shape	Lanceolate	Lanceolate	Linear-lanceolate	Linear-lanceolate	Linear-lanceolate	Lanceolate	Elliptic-lanceolate
End shape	Capitate	Rostrate	Capitate	Capitate	Capitate	Rostrate	Rostrate to Sub-capitate
Central area	Small	Small	Small, asymmetric	Small, asymmetric	Large, rounded	Large, rounded	Small, asymmetric
Stria density, center	12–15	12–16	22–24	18–20	18–20	18–20	20–23
Stria density, apices	16–19	17–20	24–26	21–23	20–22	20–22	22–24

TABLE 5: *Encyonopsis microcephala* group (Figs 22–51, 79–80).

	<i>E. albertana</i>	<i>E. alpina</i>	<i>E. krammeri</i>	<i>E. microcephala</i>	<i>E. sp. cf. microcephala</i>	<i>E. minuta</i>
Valve length	14.3–23.5	12.9–14.4	11.4–20.7	9.0–16.0	13.3	11.0–14.1
Valve width	3.1–4.1	2.9–3.6	2.9–4.4	3.1–4.1	3.0	3.1–3.7
Valve shape	Narrowly lanceolate	Linear to Linear-lanceolate	Narrowly lanceolate	Linear-elliptic	Linear	Lanceolate
End shape	Rostrate	Capitate	Rostrate	Sub-capitate	Sub-capitate	Rostrate
Stria density	20–24	26–32	25–30	24–26	27	24–27
“Shoulders”?	No	No	No	Yes	No	No

TABLE 6: *Encyonopsis subminuta* group (Figs 52–78, 81–85).

	<i>E. anacondae</i>	<i>E. lacusalpini</i>	<i>E. neerlandica</i>	<i>E. subminuta</i>	<i>E. sp. cf. subminuta</i>
Valve length	16.6–24.4	11.3–12.6	13.7–23.9	12.9–20.3	14.2–18.4
Valve width	3.2–4.0	3.0–4.0	3.3–4.4	3.2–4.1	3.5–4.7
Valve shape	Narrowly linear-lanceolate	Elliptic-lanceolate	Lanceolate to Rhombic-lanceolate	Lanceolate to Elliptic-Lanceolate	Linear-elliptic
End shape	Rostrate	Sub-capitate	Rostrate to Sub-capitate	Sub-capitate	Sub-rostrate
Stria density	25–28	26–29	25–28	25–30	22–24

TABLE 7: *Encyonopsis perborealis* group (Figs 129–157).

	<i>E. bobmarshallensis</i>	<i>E. hustedtii</i>	<i>E. kutenaiorum</i>	<i>E. perborealis</i>	<i>E. robusta</i>
Valve length	8.7–18.7	14.4–19.6	16.5–21.2	9.7–18.6	13.1–16.7
Valve width	2.7–3.6	3.3–4.0	3.2–3.5	2.5–3.8	2.9–3.5
Valve shape	Linear-lanceolate	Linear to Linear-lanceolate	Linear-lanceolate	Linear to Linear-lanceolate	Linear to Linear-lanceolate
End shape	Rostrate to Sub-capitate	Capitate	Rostrate to Sub-capitate	Rostrate to Sub-capitate	Capitate
Stria density	22–24	23–26	23–26	26–30	19–22

REGISTER OF TAXA

Encyonopsis

<i>aequaliformis</i>	9, Figs 1–7 (p. 11)
<i>aequalis</i>	10, Figs 8–14 (p. 11)
<i>albertana</i>	10, Figs 22–27 (p. 13)
<i>alpina</i>	12, Figs 34–39 (p. 13)
<i>anacondae</i>	12, Figs 58–63 (p. 14)
<i>bobmarshallensis</i>	13, Figs 144–150 (p. 21)
<i>cesatii</i>	15, Figs 91–97 (p. 16)
<i>czarneckii</i>	15, Figs 107–112 (p. 19)
<i>dakotae</i>	17, Figs 113–117 (p. 16)
<i>descripta</i>	17, Fig. 122 (p. 19)
<i>descriptiformis</i>	18, Figs 118–121 (p. 19)
<i>falaisensis</i>	18, Figs 103–106 (p. 16)
<i>hustedtii</i>	19, Figs 129–133 (p. 21)
<i>krammeri</i>	20, Figs 28–33 (p. 13)
<i>kutenaiorum</i>	21, Figs 139–143 (p. 21)
<i>lacusalpini</i>	22, Figs 64–69 (p. 14)
<i>lacuscaerulei</i>	22, Figs 15–21 (p. 11)
<i>lacusglacialis</i>	23, Figs 158–162 (p. 24)
<i>medicinalis</i>	25, Figs 123–128 (p. 19)
<i>microcephala</i>	25, Figs 40–45 (p. 13)
<i>minuta</i>	26, Figs 46–51 (p. 13)
<i>montana</i>	26, Figs 86–90 (p. 16)
<i>neerlandica</i>	27, Figs 70–75 (p. 14)
<i>neoamphioxys</i>	28, Figs 163–165 (p. 24)
<i>perborealis</i>	28, Figs 151–157 (p. 21)
<i>robusta</i>	29, Figs 134–138 (p. 21)
<i>stafsholtii</i>	30, Figs 98–102 (p. 16)
<i>subminuta</i>	30, Figs 52–57, 81–85 (pp. 13, 14)
<i>subspicula</i>	31, Figs 166–169 (p. 24)
<i>treinishii</i>	32, Figs 170–174 (p. 24)
<i>weilandii</i>	32, Figs 175–179 (p. 24)
sp. cf. <i>microcephala</i>	33, Figs 79, 80 (p. 14)
sp. cf. <i>subminuta</i>	33, Figs 76–78 (p. 14)

Back Cover: Little Therriault Lake (top) and Lower Wolverine Lake (bottom) are hotspots of *Encyonopsis* biodiversity. They are located only a few kilometers apart on the Kootenai National Forest in northwest Montana. Together, these two lakes support 15 of the 31 *Encyonopsis* species reported here. Species common to both lakes are *E. alpina*, *E. czarneckii*, *E. medicinalis*, *E. montana*, *E. perborealis*, *E. stafsholtii*, and *E. subminuta*. In addition, Little Therriault Lake supports *E. falaisensis*, *E. krammeri*, *E. kutenaiorum*, *E. lacusalpini*, and *E. minuta*, and Lower Wolverine Lake supports *E. albertana*, *E. cesatii*, and *E. neerlandica*. These lakes are alkaline (pH 9.0–9.2) with low to moderate concentrations of dissolved solids (specific conductance 100–140 $\mu\text{S}/\text{cm}$). Photos by the author.

