DIATOMS OF THE UPPER OHIO RIVER AND TRIBUTARIES:

ATLAS OF SPECIES AND THEIR SIGNIFICANCE IN RIVER ECOLOGY

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Abstract

We are finishing a taxonomic study of diatoms of the upper Ohio River and selected tributaries and plan to publish it as a user friendly book. It will contain photographs and descriptions of >200 species belonging to 64 genera. The diatoms were processed from collections made during the summer of 2001. The book is designed to be used by people with little or no technical training in diatom taxonomy. The user friendly features of the book include a key to genera illustrated with photographs of not just the taxa, but also of the specific features described in the key. The photographs include living specimens, showing chloroplast arrangement, light micrographs of prepared specimens, and scanning electron micrographs. The book has also a glossary of taxonomic and ecological terms. With the description of each species we give its habitat preference and distribution taken from the literature.

Introduction

- Previous work on diatoms of this region was exclusive of the Ohio River, and focused primarily on the Scioto River Basin (Collins and Kalinsky, 1977). The purpose of this book is
- present a taxonomic study of the Upper Ohio River Bacillariophyta.
- create a floristic assessment of the species that occur in the basin.
- This study can serve as a basis for water quality evaluation using diatoms.
- Although all the taxa described here and their photographs are for the Ohio River basin, the book will be of use to anyone working on rivers of North America because diatoms are cosmopolitan in distribution.

Chapter 1: The Ohio River and the river basin

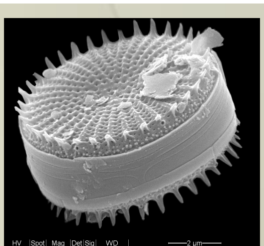
- 1.0 Introduction into the Ohio River and its Importance in the Basin
- 1.1 General Geology of Upper Basin
- 1.2 River Run – *What is it and Why?*

Chapter 2: Algae and water quality in the Ohio River

- 2.0 Introduction
- 2.1 What are algae?
- 2.2. What do we know about algal communities in the Ohio River Basin?
- 2.3 Algae as environmental indicators
- 2.4 Diatoms as environmental indicators

Chapter 3: Just what are Diatoms (*Bacillariophyceae*)?

- 3.0 Introduction
- 3.1 The Diatom Cell: Structure
  - Includes an illustrated table with structural features of the diatom cell wall
- 3.2 A word about Diatom nomenclature



Chapter 4: Methods for Processing Diatoms

- 4.0 Sample Collection
- 4.1 Sample Preparation
- 4.2 Microscope Identification and Enumeration
- 4.3 Photographic Techniques

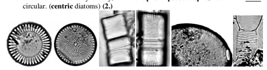
Chapter 5: Key to Common diatom genera found in the Ohio River

Key to the common genera of diatoms found in the Ohio River Basin

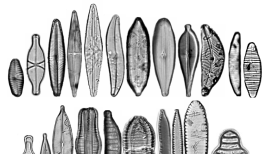
This key is based on Compère (2001), Patrick and Reimer 1966, 1975, Collins and Kalinski ( ), Husted (19), Krammer & Lange Bertalot 1986-1991 and Round et al. 1990. Current diatom taxonomy is in a state of flux, especially at the genus level. We have selected to include in this key the genera most commonly used in environmental studies, noting when possible, the new taxonomic designations.

The Glossary has special terms used in this key: Diatoms cells consist of **Frustules** (siliceous boxes) each with two **valves** (the lid and bottom of the "box")

1. a. Valve with radial symmetry, with no **raphe** or **pseudoraphe**; valve view often circular. (**centric** diatoms) **(2.)**

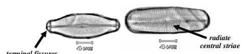


b. Valve otherwise shaped, usually **bacillar** or broadly oval, generally provided with a raphe or a pseudoraphe; valve view very rarely circular (**pennate** diatoms) **(13.)**



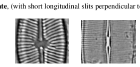
The KEY SECTION TO ORDER

transversally expanded ***Sellaphora*** (**Plate 13** Previously *Navicula pupula*)



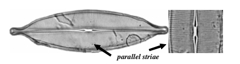
b. Polar nodules not thickened **(63.)**

63. a. Striae **lineolate**, (with short longitudinal slits perpendicular to the striae) **(64.)**

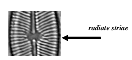


b. Striae **punctate**, or fine structure indistinct **(65.)**

64. a. Striae parallel; central area small, rounded, sometimes indistinct; valves lanceolate to linear lanceolate, not markedly fusiform ***Craticula*** (**Plate 12**) (previously *Navicula halophila* or *Navicula cuspidata)*



b. Striae radiate in the middle of the valve ***Navicula*** sect. ***Navicula*** (see also ***Geissleria*** previously ***Navicula***.) **(Plates 12 & 13)**.



65. (63) a. Striae more or less clearly punctate. Central area transversally elongated,

Example of KEY TO GENERA

Chapter 6: Descriptions of freshwater diatom genera

- Includes features of cleaned and live material.
- Each genera page lists the species found in the river
- Each page also describes the habitat and distribution from the literature.

Aulacoseira

Description

- **Aulacoseira** forms medium to long chains and therefore is visible mostly in girdle view. The ornamentation on the mantel is distinct even under low power light microscopy, and the patterns are species specific. The frustules are heavily silicified and can be polymorphic between species, which makes the genus very complex. Cells are held together by linking spines found at the margins of the valve.
- **Live cells** show several irregularly arranged small chloroplasts per cell.

Note: Old taxonomic keys lump the genus *Aulacoseira* within the genus *Melosira*, (see Round *et al.* 1990). Also the degree of silicification is thought to be linked to silica availability and growth rates of *Aulacoseira*. This is thought to be the cause of the polymorphic nature of some species. (Stoermer and Julius, 2003).

***Aulacoseira* species**

- *A. ambigua* (Grun.) Simons.
- *A. granulata var. angustissima f. curvata* (Grun
- *A. granulata* (Ehr.) Simons.
- *A. islandica* (O.Müller)
- *A. italica* (Ehr.) Simons.
- *A. lirata* (Ehr.) Ross.
- *A. muzzanensis* (Meister) Krammer.

Habitat and distribution:

Aulacoseira species are only found in freshwaters and some have adapted to life in lakes, ponds, and large rivers. Some species survive sediment burial for extended periods of time. And their colony size is an important factor in controlling sinking rates; most species are tychoplanktonic.

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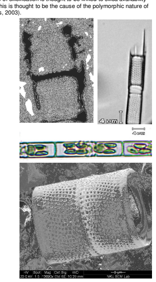


from top

Aulacoseira islandica Cleaned, *1000X*
Aulacoseira granulata cleaned with spines 1000X
Aulacoseira with chloroplasts 40X
Aulacoseira sp. SEM. distinct pattern on frustule.

Amphora

Description

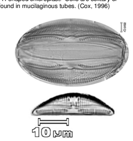
- **Amphora,** are usually viewed in girdle view displaying both valves simultaneously because of the way the valves are shaped and connected. Because of this, many descriptions of the species include a measurement of both valves connected (width). Valves are asymmetrical to the apical axis (parallel to the raphe) and the raphe appear closer to the dorsal margin and is usually sigmoid to some degree. There is usually also a hyaline area (clear space) above the terminus of the raphe.
- **Live specimens** show a single H-shaped chloroplast in girdle view; also contain two pyrenoids that are in the spaces of the H-shaped chloroplast. Cells are solitary or attached to by mucilaginous stalks or found in mucilaginous tubes. (Cox, 1996)

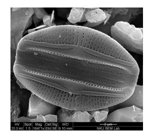
***Amphora* species**

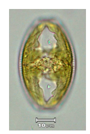
- *A. aequalis* Krammer
- *A. inariensis* Krammer
- *A. normanii* Rab.
- *A. ovalis* (Kütz.) Kütz.
- *A. pediculus* (Kütz.) Grun.
- *A. veneta* Kütz.

Habitat and distribution

- Amphora is a common benthic epiphytic diatom growing often in streams attached to substrata like aquatic plants or other algae. The genus is very tolerant of high salinity, and most species within the genera are marine or found in hypersaline environments.







Chapter 7: Photographic plates and descriptions of species with environmental preferences

Order Eupodiscales 1000X

Plate 1

1-2. ***Melosira varians*** **Agardh**
Height/Diameter ratio = 1.80
Dimensions: 8-35 µm diameter, 4-14 length of valve, KLB 1991-1997. vol. 2/3, p. 7, pl 4/1-8

3. ***Aulacoseira ambigua*** **(Grun.) Simons.**
Synonym: *Melosira ambigua*
Height/Diameter ratio = 1.0
Dimensions:

4-6. ***Aulacoseira granulata*** **(Ehrenb.) Simons.**
Synonym *Melosira granulata*
Height/Diameter ratio = 2.14
Dimensions:

7. ***Aulacoseira granulata form curvata.***
Synonym: *Melosira granulata f. curvata*
Height/Diameter ratio =
Dimensions:

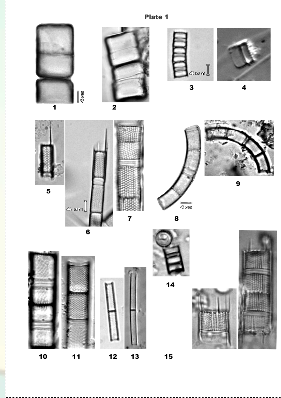
8. ***Aulacoseira islandica*** **(O. Müll.) Simons.**
Synonym name Melosira islandica
Height/Diameter ratio = 2.14
Dimensions:

9. ***Aulacoseira italica*** **(Ehrenb.) Kutz.**
Synonym: *Melosira italica*
Height/Diameter ratio = 2.56 – 5.33

10. ***Aulacoseira lirata*** **(Ehrenb.) Ross**
Synonym: Melosira distans var. lirata
Height/Diameter ratio = 1.0

11. ***Aulacoseira muzzanesis*** **(Meist.) Krammer**
Synonym: Melosira granulate var muzzanensis
Height/Diameter ratio = 0.67

Plate 1



Order Eupodiscales 1000X

Ecology of Species Plate 1

1-2. ***Melosira varians*** **Agardh** KLB 1991-1997. vol. 2/3, p. 7, pl 4/1-8
Height/Diameter ratio (OR) = 1.80
Dimensions: height 4-7 µm, diameter 8-35 µm (most 14-18µm)

Height/Diameter ratio 0.3-1.4 but usually <1. Pores very small, can't be seen with the light microscope.

Cylindrical cells, usually seen in girdle view appearing clear and lack pores or ornamentation. In this view we see both valves that come together at an equal distance. Usually forms long chains and is planktonic.

A freshwater species that can tolerate a gradual rise in osmotic pressure (salinity <.9 o/oo). It is an alkaline water species with a pH optimum of 8.5, but has also been found abundant in neutral to acidic waters. It can tolerate moderate oxygen deficiency (>50% saturation). It is an indicator of eutrophic waters since it is a facultative nitrogen-heterotroph that needs periodically elevated concentrations of organically bound nitrogen. (Steinitz-Kannan 1979, Schoeman 1973, Van Dam et al. 1994

3. ***Aulacoseira ambigua*** **(Grun.) Simons.**
Synonym: *Melosira ambigua* (Grun.) O. Müll.
Height/Diameter ratio = 1.0
Dimensions: height 5-13 µm, diameter 4-17 µm.

This species has forms with coarse pores (16-19/10 µm) and also fine pores (20-25/10 µm). Cells cylindrical forming long chains. Ratio of Height/Diameter usually 0.75 but can be up to 2. Cylindrical cells with very faint ornamentation; they have a vertically squished appearance, and can appear square. Usually the spines/pervalvar teeth are present at the ends of the valve faces.

This species is considered a eutrophic indicator. It is alkaliphilous (mainly found at pH >7), found in fresh-brackish water (salinity <.9 o/oo). It is a nitrogen autotroph that tolerates elevated concentrations of organically bound N; it can tolerate moderate oxygen levels above 50% saturation (Van Dam et al. 1994).

4-6. ***Aulacoseira granulata*** **(Ehrenb.) Simons.**
Synonym *Melosira granulata* (Ehr.) Ralfs
Height/Diameter ratio = 2.14
Dimensions: height 5-24 µm, diameter 4-30 µm.

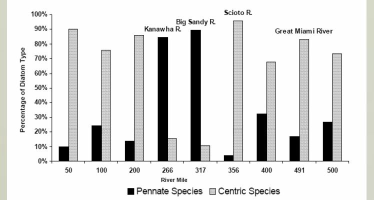
Cells have strong ornamentation, large pores and more silicified appearance. Also have a long spine and several smaller spines at the ends of the valve.

Chapter 8: Diatom Data obtained from River Run 2001

- 7.0 Annotated Checklist of Taxa
- 7.1 Table of Occurrences
- 7.2 Water Chemistry
- 7.3 Diatom Communities in the Upper Ohio River Basin

Example, Table of species occurrences down the river

	Rm-1	Rm-2	Rm-25	Rm-50	Rm-75	Rm-100	Rm-150	Rm-173	Rm-200	Rm-250	Rm-266	Rm-300	Rm-305	Rm-317	Rm-350	Rm-356	Rm-400	Rm-415	Rm-450	Rm-491	Rm-500
Acanthoceras zachariasii (Brun) Simons.							X														
Achnanthes wellsiae C.W.Reimer			X																		
Achnanthidium biasolettianum (Grun.) Round & Bukht.				X		X						X			X						X
Achnanthidium exiguum **var.** ***heterovalvum*** (Krasske)						X											X				
Achnanthidium exilis (Kütz.) Round & Bukht.														X							
Achnanthidium microcephalum Kütz.											X			X			X				X
Achnanthidium minutissimum (Kütz.) Czarn.	X	X	X	X		X	X	X				X		X	X		X		X		X
Amphora aequalis Krammer														X							
Amphora inariensis Krammer														X	X						
Amphora normanii Rab.														X	X						X
Amphora ovalis (Kütz.) Kütz.	X			X	X	X				X		X				X	X	X		X	
Amphora pediculus (Kütz.) Grun.	X					X		X		X							X				
Amphora pediculus (Kütz.) Grun.							X					X		X	X					X	
Amphora veneta Kütz.																			X		X
Asterionella formosa Hass.	X	X	X	X		X	X		X			X			X				X		
Aulacoseira ambigua (Grun.) Simons.	X	X	X	X	X	X	X		X	X		X			X		X			X	X
Aulacoseira granulata (Ehr.) Simons.	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X
Aulacoseira granulata **var.** ***angustissima*** **f.** ***curvata*** **(Grun.)**	X		X	X	X	X	X		X												
Aulacoseira islandical **(O.Müller)**	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X	X	X
Aulacoseira italica **(Ehr.) Simons.**	X	X	X	X		X		X			X					X	X		X		X
Aulacoseira lirata **(Ehr.) Ross.**						X			X												X
Aulacoseira muzzanensis **(Meister) Krammer.**						X		X	X	X			X		X	X	X		X	X	X
Bacillaria paxillifer **(O. F. Müll.) Hendy**																					
Brachysira neoexilis **L.-Bert.**	X	X	X		X	X					X				X						
Caloneis amphisbaena **(Bory) Cl.**						X										X					



Example of diatom community changes down river

Chapter 9: The role of diatoms in Ohio River ecology

Appendices for Diatoms of the Upper Ohio River

Appendix I. Table of Species Size Range from the Literature

Appendix II. Different Methodologies for Diatom Studies

Appendix III. Diatom Activity Guide-
- Activity I. How to collect Diatoms
- Activity III: Role of Diatoms in aquatic ecosystems.
- Activity II. How to culture and keep a Microcosm

Appendix IV. Information and Materials Related to Diatom Study
- A. Recipe of Lugol's Iodine for Diatom Preservation
- B. List of Diatom Herbaria
- C. Suppliers of Diatom Materials mounting media, plankton nets, diatometers How to build your own diatometer and net Sources for diatom cultures.
- D. Contacts for Programs on the Ohio River: ORBCRE, ORSANCO, Rivers Institute at Hanover College, The Ohio River Foundation.

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