Global Journal of Science Frontier Research: I
Interdisciplinary
Volume 16 Issue 3 Version 1.0 Year 2016
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Mozingo Studies II. Similarity of the Planktonic and Deposited Diatom Assemblages

By Kurt A. Haberyan
Northwest Missouri State University, United States

Abstract- In paleolimnology, downcore assemblages are taken to be representative of the plankton that were living at some moment in the past. To evaluate the fidelity of the deposited diatom assemblage to that of the living plankton, a twenty-year series of whole-water plankton samples was compared to surface-sediment diatoms. When standardized and pooled, the 81 quarterly plankton samples were composed of *Aulacoseira* (51%), *Cyclostephanos* and other discoid diatoms (28%), *Asterionella* (9%), and *Fragilaria* (8%). In the deposited assemblage, however, the rank of the two most-common taxa was reversed: *Cyclostephanos*+ outnumbered *Aulacoseira* (47 and 34%, respectively). Some littoral taxa were over-represented in sediments (e.g. *Encyonema*) while others were under-represented (e.g. *Gyrosigma*). The reasons for these differences appear unrelated to frustule dissolution, but may insteadrelate to sampling frequency, sampling depth, and lake-specific characteristics.

Keywords: *plankton taphonomy; biocenosis; thanatocoenosis; paleoecology; paleolimnology.*

GJSFR-I Classification: *FOR Code: 040599*

Strictly as per the compliance and regulations of:

Mozingo Studies II. Similarity of the Planktonic and Deposited Diatom Assemblages

Kurt A. Haberyan

Abstract- In paleolimnology, downcore assemblages are taken to be representative of the plankton that were living at some moment in the past. To evaluate the fidelity of the deposited diatom assemblage to that of the living plankton, a twenty-year series of whole-water plankton samples was compared to surface-sediment diatoms. When standardized and pooled, the 81 quarterly plankton samples were composed of *Aulacoseira* (51%), *Cyclostephanos* and other discoid diatoms (28%), *Asterionella* (9%), and *Fragilaria* (8%). In the deposited assemblage, however, the rank of the two most-common taxa was reversed: *Cyclostephanos+* outnumbered *Aulacoseira* (47 and 34%, respectively). Some littoral taxa were over-represented in sediments (e.g. *Encyonema*) while others were under-represented (e.g. *Gyrosigma*). The reasons for these differences appear unrelated to frustule dissolution, but may insteadrelate to sampling frequency, sampling depth, and lake-specific characteristics.

Keywords: plankton taphonomy; biocenosis; thanatocoenosis; paleoecology; paleolimnology.

Mozingo Studies III: Fidelity of the deposited diatom assemblage with that of the plankton

I. Introduction

Paleolimnological reconstruction often relies on the faithful presence of certain plankton components in the sediments. It has long been known that, while many taxa may appear in the living plankton, only a small subset is represented in the sediments; thus cellular remains of 'soft-bodied' algae are generally not useful in paleolimnology. In contrast, some taxa are likely to be preserved in proportions that more closely approximate a long-term average of the actual plankton.

Despite the widespread acceptance, few studies have examined plankton-to-sediment fidelity. In smaller lakes, the deposited assemblage of diatoms may closely resemble the plankton (Battarbee 1978; Battarbee 1981; Haworth 1980); littoral taxa may be under-represented (Anderson 1989; Stewart and Lamoureux 2012), or over-represented (Rautio et al. 2000). In addition, the method of phytoplankton collection (e.g. nets) may not accurately represent the modern plankton (e.g. Battarbee 1979).

Diatom deposition in larger lakes is complicated by extended sinking time, unless diatoms are encased in fecal pellets from grazers. Fecal pellets account for at least 40% of deposited diatoms in southern Lake Tanganyika, but caused only minor distortions to the overall diatom record (Haberyan 1985). In other large lakes, however, deposited assemblages may be surprisingly distinct from the plankton. For example, in Lake Malaŵi the relative abundance of *Nitzschia* declined steadily with increasing sediment trap depth, but littoral taxa increased. In surface sediments from 92 m deep and about 1.3 km offshore, *Aulacoseira* was over-represented and *Nitzschia* was drastically under-represented (Haberyan 1990); some littoral taxa in these sediments were over-represented (*Fragilaria brevistriata, Rhopalodia*) while others were under-represented (*Nitzschia epiphyticoides, Surirella, Encyonema*) relative to the plankton (Haberyan 1988).

Given the widespread use of diatoms in paleolimnological analysis, it is important to validate the relationship between planktonic and deposited assemblages. The purpose of this study, therefore, is to investigate the fidelity of the diatom assemblage in the sediments by comparing it to regular samples of live phytoplankton from the lake.

a) Site description

Mozingo Lakeis a reservoir in northwestern Missouri (40.45° N, 94.78° W; Fig. 1). The maximum depth of the lake is 15 m, of which 2.6 m was the former stream channel that had been deeply incisedinto the floodplain. The watershed of the lake has an area of 5013 hectares, aside from the 400 ha of the lake itself. Physical, chemical, and planktonic characteristics of the lake have been characterized previously (Haberyan 2016 and submitted): since impoundment in 1994, the pH has averaged 7.99, nitrate-N averaged 0.60 mg/L, orthophosphate 0.28 mg/L, and silica 1.48 mg/L. Phytoplankton biovolume has averaged 5.9 x 10^6 um^3/mL, mostly represented by cyanobacteria (49%), cryptophytes (42%), and diatoms (6%).

II. Methods

Mozingo Lake was sampled from 1994 to 2014, generally from a mid-lake station over the former floodplain (Station 1), about 330m north of the dam and 30m east of the drowned stream channel (Fig. 1; 40.3514°N, 94.774°W). An alternate location, Station 2, was sampled during inclement conditions (e.g. storms and thin ice), using a floating dock where the lake was 3m deep (40.3566°N, 94.7765°W). For this analysis, 81

Author: Department of Natural Sciences, Northwest Missouri State University, Maryville, Missouri 64468 U.S.A.
e-mail: khaber@nwmissouri.edu

quarterly samples were considered (samples from mid-January, -April, -July, and -October).

Phytoplankton samples were collected with wide-mouth glass jars (at least 600mL in volume and less than 118mm tall), submerged to a depth of approximately 30cm with the mouth downward, then slowly turned upright. Samples were preserved with Lugol's solution within two hours. After at least four days of settling, the supernatant was siphoned off; the remaining liquid was swirled and 0.035mL was placed on a slide, covered with a cover slip, and sealed with clear nail polish to delay drying. Community composition was characterized on an Olympus CH-2 microscope at 150x until at least 100 living algal units (unicells, colonies, or filaments) had been encountered. Cells without cytoplasm were considered to be resuspended and were ignored. Identifications were based on Krammer and Lange-Bertalot (1991). Taxa were sorted into 12 morphogroups due the similarity of some genera when mounted in water. *Navicula*+ herein includes *Neidium, Acnanthidium,* and similar pennate diatoms (however *Asterionella* and *Fragilaria* were distinct), while *Cyclostephanos*+includes *Cyclostephanos, Stephanodiscus, Cyclotella* and other discoid diatoms.

Sediments were collected from a depth of 11m at Station 1 in July 2014, using a Peterson dredge that had been modified to descend open and collect the uppermost sediments. The sample was mixed thoroughly and four subsamples were examined as smear slides at 100x. Another subsample was processed for diatoms at room-temperature in HNO_3 and H_2O_2 until the sediment was completely oxidized (Stoermer et al. 1995). After three rinses, an aliquot was dried on a coverslip, mounted in Naphrax®, and examined with an Olympus CH-2 microscope. Diatoms were identified at 1000x using Krammer and Lange-Bertalot (1991) and counted at 400x until at least 400 valves had been encountered. While taxa were identified to genus, data were compiled into the same morphogroups as the planktonic data.

For comparison with the sediment assemblage, diatoms in live phytoplankton samples were volumetrically normalized, sample by sample, to the equivalent number per milliliter of lake water. These were then totaled for each morphogroup and converted to a composite percentage. Percentage data were transformed with the square-root transformation prior to a chi-squared test ($p = 0.05$) in which the abundances in sediments (i.e. observed data) were compared to the planktonic abundances (i.e. expected values).

III. Results

The volumetrically-normalized phytoplankton samples were dominated by cryptophytes, cyanobacteria, and diatoms. Among the planktonic diatoms, the most common were*Aulacoseira* (48% of all diatoms)and *Cyclostephanos*+ (18%) (Table 1). On the smear slides the most common structures were cells of *Aulacoseira granulata*, followed by *Stephanodiscus, Cyclotella*, *Synedra,* and tests of testate amoebae. Rarely-encountered structures included other algae (*Encyonema, Cocconeis, Rhopalodia, Gyrosigma, Pinnularia, Schroderia*), sponge spicules, grass cuticles, post-abdominal claws, and *Bosmina* head shields. In the acid-processed sediment, 423 diatom valves were encounted; almost 47% belonged to *Cyclostephanos*+ (including *Cyclotella bodanica, C. compta,* and *C. ocellata*) and 34% belonged to *Aulacoseira granulata*.

Relative abundances of diatom morphogroups varied markedly between planktonic and sediment samples (Table 1). *Cyclostephanos*+ was over-represented in sediments (by a factor of 2.5), as was *Navicula*+ (3.9x); other taxa were rare in the plankton but strongly over-represented in sediments (up to 1000x). Taxa that were under-represented in the sediments included *Aulacoseira* (0.71x), *Fragilaria* (0.30x), and *Asterionella*+ (0.13). Despite these differences, the chi-squared test indicated no significant difference in the assemblages ($\chi^2 = 9.299$, df = 11, p = 0.594).

IV. Discussion

Sedimented diatoms represent those in the plankton, but proportionality is not necessarily preserved; even relative ranks may vary (Table 1). For the living phytoplankton samples, the most common taxa were, in order, *Aulacoseira, Cyclostephanos+, Asterionella,* and *Fragilaria*; together, these account for 97.4% of all diatoms. However, in the sediment sample the rank was different: *Cyclostephanos+, Aulacoseira, Cocconeis, Fragilaria, Navicula+,*and *Asterionella*, together accounting for 96.1% of all diatoms. Shannon-Weiner diversity was nearly identical (0.587 and 0.598), and the assemblages were not significantly different according to the chi-squared test ($p = 0.594$).

The differences between the modern phytoplankton and sediment assemblages does not seem to reflect diatom habitat: while some benthic taxa were over-represented in the sediments (*Cocconeis, Navicula, Encyonema, Gomphonema*), others were under-represented (*Gyrosigma, Rhopalodia, Epithemia*). Understandably, several taxa that were exceedingly rare in the plankton ($< 0.04\%$) were absent from the sediments, suggesting that additional counts from the sediments may reveal their presence.

For paleolimnologists, it may be of some concern that *Aulacoseira* was the most common genus among diatom frustules in the plankton (48%), but it ranked second in the sediments (34%). This is similar to a study on Lake Saanajärvi, Finland (Rautio et al. 2000), where *Aulacoseira* was under-represented in sediments (6.4% in plankton and 0.3% in sediments) and *Cyclotella* was over-represented (40.2% in plankton and 48.7% in sediments). In Mozingo, dissolution cannot account for these differences, because *Aulacoseira* frustules were less dissolved than was *Cyclostephanos*+; thus dissolution does not explain the over-representation of *Cyclostephanos*+ in sediments.

It is also possible that the number of counted diatoms in the sediment (n = 423) is too small to accurately reflect the deposited assemblage, but the 95% confidence interval for this sample size is ±5% (Mosimann 1965); this may account for differences among the rare taxa, but not for taxa whose relative abundances differed by 10% or more: *Aulacoseira, Cyclostephanos*+*, Asterionella,* and *Fragilaria.*

Other studies have reported that littoral diatoms are over-represented in sediments (Anderson 1989; Rautio et al. 2000; Stewart and Lamoureux 2012). Data from Mozingo Lake confirms these: littoral diatoms comprise 1.0% of the planktonic diatoms but 10.8% of the sediment diatoms (Table 1). However, this distinction is largely due to *Encyonema*, *Cocconeis,* and *Gomphonema* (7.2% of sediment diatoms); other taxa are under-represented, including *Gyrosigma, Epithemia,* and *Rhopalodia*. Therefore, while littoral taxa in general seem to be over-represented in sediments of small lakes, certain littoral taxa do not follow this trend. This conclusion supports by Rautio et al. (2000), who found that some littoral taxa were over-represented in sediments (e.g. *Achnanthes, Cocconeis, Fragilaria*) while others were under-represened (e.g. *Cymbella, Denticula, Eunotia*). Within a genus, some species were under-represented while others were over-represented (e.g. *Navicula*).

In a core from large, deep lake Lake Tanganyika, *Aulacoseira* (then called *Melosira*) was more common inside fecal pellets than outside, while *Stephanodiscus* was more common outside of pellets; this suggested that copepod feeding preferences influenced differential diatom deposition (Haberyan 1985). In another deep lake, Lake Malaŵi, sediment trap collections differed progressively with depth compared to plankton, and the sediment assemblage magnified this trend. In that case, both *Stephanodiscus* and *Aulacoseira* (then called *Melosira*) were over-represented in sediments, in part because *Nitzschia* was strongly under-represented (Haberyan 1990). In both of these studies, *Aulacoseira* was over-represented in sediments, contrary to Mozingo Lake, where *Aulacoseira* is under-represented. The difference may, in part, reflect the shallow depth of Mozingo (15 m), compared to the previously-studied sample sites (> 90 m); in Mozingo, lateral transport and sinking distances are much shorter, and fecal pellets are likely to be less important in diatom deposition. Nonetheless, the rapid sinking of *Aulacoseira* is well known (e.g. Lund 1954), and *Aulacoseira* should be over-represented relative to slower-sinking taxa like *Stephanodiscus.*

Other factors that may contribute to the observed differences include sediment focussing, which transports sediments enriched in littoral taxa to offshore locations; such transport of dead frustules may outweigh outwash of live ones. In addition, differences may relate to sampling frequency (which may fail to capture important monthly variations) and to sampling depth; samples from 30 cm deep may not be representative of the entire water column.Finally, a variety of site-specific factors may influence differential diatom deposition, such as lake morphology and chemistry (Flower 1993).

While the differences between plankton and deposited assemblages may not be severe enough to alter qualitative interpretation of diatom stratigraphies, they may indeed affect quantitative interpretations, for example those based on transfer functions that relate diatom percentages to estimates of water chemistry. It is therefore important that we paleolimnologists be appropriately cautious when interpreting estimates of ancient lake conditions.

V. Acknowledgements

This work was supported by Northwest Missouri State University. Equipment and facilities were provided by the Department of Natural Sciences (formerly the Department of Biological Sciences). The manuscript was prepared during a sabbatical leave provided by Northwest Missouri State University.

References Références Referencias

1. Anderson NT (1989) A whole-basin diatom accumulation rate for a small eutrophic lake in Northern Ireland and its palaeoecological implications. J Ecol 77:926-946.
2. Battarbee RW (1978) Relative composition, concentration, and calculated influx of diatoms from a sediment core from Lough Erne, Northern Ireland. Pols Arch Hydrobiol 25:9-16.
3. Battarbee RW (1979) Early algological records: help or hindrance to palaeolimnology. Nova Hedwigia 64: 379-394.
4. Battarbee RW (1981) Changes in the diatom microflora of a eutrophic lake since 1900 from a comparison of old algal samples and the sedimentary record. Holarc Ecol 4: 73-81.
5. Flower RJ (1993) Diatom preservation: experiments and observations on dissolution and breakage in modern and fossil material. Hydrobiologia 269:473-484.
6. Haberyan KA (1985) The role of fecal pellets in the deposition of diatoms in Lake Tanganyika. Limnol Oceanogr 30:1010-1023.
7. Haberyan KA (1988) Phycology, sedimentology, and paleolimnology near Cape Maclear, Lake Malaŵi, Africa. Ph.D. Dissertation, Duke University. 246pp.

8. Haberyan KA (1990) The misrepresentation of the planktonic diatom assemblage in traps and sediments: southern Lake Malaŵi, Africa. J Paleolimnol 3: 35-44.
9. Haberyan KA (2016) Mozingo Studies I: Ice phenology and limnological legacies in a midcontental reservoir. J Limnol 75, DOI 10.4081 /jlimnol.2016.1407.
10. Haberyan KA (submitted) Mozingo Studies III: Upsurge and the trophic cascade in a mid-continental reservoir. Aquatic Ecol.
11. Haworth EY (1980) Comparison of continuous phytoplankton records with the diatom stratigraphy in the recent sediments of Blelham Tarn. Limnol Oceanogr 25:1093-1103.
12. Krammer K, Lange-Bertalot H (1991) Bacillariophyceae. Süβwasserflora von Mitteleuropa 2. Fischer, Stuttgart, Germany.
13. Lund JWG (1954) The seasonal cycle of the plankton diatom *Melosira italica* (Ehr.) Kütz. subsp. *subarctica* O. Müll. J Ecol 42:151-179.
14. Mosimann JE (1965) Statistical methods for the pollen analyst: multinomial and negative multinomial techniques. Pages 636-673 in B. Kummel and D. Raup, editors. Handbook of paleontological techniques. W. H. Freeman, San Francisco, California, USA.
15. Rautio M, Sorvari S, Korhola A (2000) Diatom and crustacean zooplankton comunities, their seasonal variability and representation in the sediments of subarctic Lake Saanajarvi. In Lami, A., N. Cameron & A. Korhola (Eds), Paleolimnology and ecosystem dynamics at remote European Alpine lakes. J Limnol 59 (Suppl. 1): 81-96.
16. Stewart KA, Lamoureux SF (2012) Seasonal and microhabitat influences on diatom assemblages and their representation in sediment traps and surface sediments from adjacent High Arctic lakes: Cape Bounty, Nelville Island, Nunavut. Hydrobiologia 683:265-286.
17. Stoermer EF, Edlund MB, Pilskaln CH, Schelske CL (1995) Siliceous microfossil distribution in the surficial sediments of Lake Baikal. J Paleolimnol 14:69-82.

Table 1: Relative abundances of diatom morphogroups in planktonic and acid-processed sediment samples, as percent of all diatom frustules. Sediment: plankton ratio compares relative abundances and is rounded to two significant figures. Abbreviation: est., estimated.

Morphogroup	Taxa included	Percent of diatoms in plankton	Percent of diatoms in sediment	Sediment: plankton ratio
Aulacoseira	*Aulacoseira* only	48.239	34.3	0.71
Cyclostephanos+	*Cyclostephanos, Cyclotella,Stephanodiscus,* and other discoid diatoms	18.831	46.8	2.5
Asterionella	*Asterionella formosa* only	16.085	2.1	0.13
Fragilaria+	*Fragilaria crotonensis* and others	14.296	4.3	0.30
Synedra	*Synedra ulna* only	1.546	1.9	1.2
Navicula+	*Navicula, Neidium, Acnanthidum,* and similar pennate diatoms	0.928	3.6	3.9
Encyonema	*Encyonema* only	0.028	1.2	43
Gyrosigma	*Gyrosigma* only	0.035	0.0	0
Cocconeis	*Cocconeis* only	0.005	5.0	1000
Gomphonema	*Gomphonema* only	0.003	1.0	330
Epithemia	*Epithemia* only	0.002	0.0	0
Rhopalodia	*Rhopalodia* only	0.002	0.0	0
Number of frustules counted		16,194 (est.)	423	
Shannon-Weiner Diversity		0.587	0.598	

Figure caption

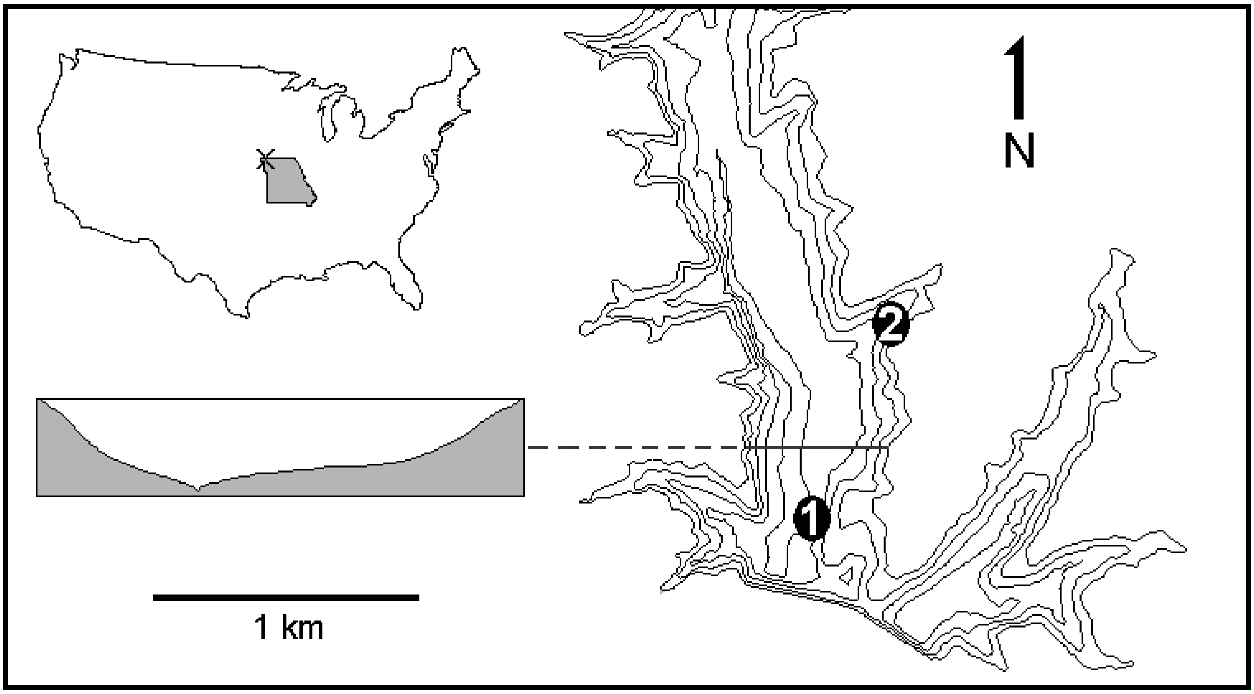

Figure 1: Bathymetric map of the southern third of Mozingo Lake; contour interval 3 m. Vertical exaggeration of transverse profile is 3.7. Inset shows Missouri and the lake's location ("x")