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A biostratigraphic study of late Tertiary freshwater diatoms from the Ogallala of western Kansas

by

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INTRODUCTION AND PREVIOUS WORK

The purpose of the present investigation was to examine in detail the succession of the diatom floras in each of six sections of the Ogallala Formation in western Kansas. The stratigraphic ranges of each taxon were determined and questions concerning the use of diatoms as tools in correlation between distant sites are discussed. The fossil associations are defined statistically by cluster analysis which is applied in order to group the aggregate of the samples that have similar associations of species among the different localities and horizons.

Introduction

Diatoms are unicellular algae with cell walls of silica, which belong to the division Bacillariophyta. The primary feature distinguishing diatoms from other algae is that the cell wall is highly silicified and composed of two overlapping halves that fit together as do the two parts of a Petri dish. The siliceous wall surrounding the diatom cell remains unaltered after the death and decay of the cell, and great numbers of empty walls accumulate at the bottom of any body of water in which diatoms live. When conditions are exceptionally favorable and of long duration, such accumulations may reach a considerable thickness.

The arrangement of these accumulations in an orderly sequence is based upon the geological law of superposition. This law states, that in a normal sequence of beds, younger rocks are always found on top of older rocks, since that was the original order of their deposition. In order to read earth history from its beginning, we must read from the bottom of the scale upward. The total succession of rocks, from the oldest to the most recent, have been arranged by geologists into a geologic time scale (Fig. 1). The geologic time scale is composed of named intervals of geologic time during which similarly named groups of rocks were deposited. These time units are used to refer to events that have taken place in the geologic past and provide a standard by which we can discuss the relative ages of the rocks and fossils they contain.

In constructing this time scale and naming its units, geologists developed another subdivision of historical geology, namely, stratigraphy. Stratigraphy is concerned with the composition, arrangement, and correlation (or matching up) of the rock layers of the earth's crust. Several types of stratigraphic units are used by stratigraphers in characterizing the rocks of the earth's crust. According to different concepts and criteria, they comprise various mutually overlapping but distinct types of stratigraphic units. Rock-stratigraphic (lithostratigraphic) units are subdivisions of the rocks in the earth's crust distinguished and delimited on the basis of lithologic characteristics. They are recognized and defined by observable physical features rather than by inferred geologic history. Rock-stratigraphic units are essentially the practical units of general geologic work that serve as a foundation for describing and studying lithology, local and regional structure, stratigraphy, economic resources, and geologic history. The formation is the fundamental unit in rock stratigraphic classification. A formation is a body of rock characterized by lithologic homogeneity. It is prevailingly but not necessarily tabular and is mappable at the earth's surface or traceable in the subsurface. The formation may in turn be divided into formally defined and named members, and members may contain beds (American Commission on Stratigraphic Nomenclature, 1961).

ERAS	PERIODS		EPOCHS	Million Years to Start of Period
	QUATERNARY		Pliestocene	1
Cenozoic	TERTIARY		Pliocene	11
			Miocene	25
			Oligocene	40
			Eocene	60
			Paleocene	70 ± 2
Mesozoic	CRETACEOUS			135 ± 5
	JURASSIC			180 ± 5
	TRIASSIC			225 ± 5
Paleozoic	PERMIAN			270 ± 5
	PENNSYLVANIAN	(CARBONIFEROUS)		350 ± 10
	MISSISSIPPIAN			
	DEVONIAN			400 ± 10
	SILURIAN			440 ± 10
	ORDOVICIAN			500 ± 15
	CAMBRIAN			600 ± 20
PRECAMBRIAN				?

Fig. 1. Geologic Time Scale. The Ogallala falls somewhere within the shaded area of the upper Tertiary

A biostratigraphic unit is a body of rock strata characterized by its content of fossils contemporaneous with the deposition of the strata. Biostratigraphic units are fundamentally different from rock-stratigraphic units. The boundaries of the two may coincide or lie at quite different stratigraphic horizons or cross each other. Fossil remains are widespread in sedimentary rocks and they provide several different kinds of stratigraphic information. Because of their complexity and variety, they are particularly distinctive and identifiable rock constituents. Fossils, as the remains of once-living forms, are sensitive indicators of environment of deposition. Finally, owing to the progressive and more or less orderly evolution of organisms, fossils are particularly valuable in time-correlation of strata and are essential in placing rocks in a world-wide geologic time scale. The zone is the general basic unit in biostratigraphic classification. It is a stratum or body of rock defined solely by the fossils it contains, without reference to lithology, inferred environment, or concepts of time (American Commission of Stratigraphic Nomenclature, 1961). In addition to rock-stratigraphic units and biostratigraphic units, stratigraphers also deal with time-stratigraphic (chronostratigraphic) units which are subdivisions of rocks considered solely as the record of a specific interval of time, and soil stratigraphic units which deal with the physical features and stratigraphic relations of soils.

The Ogallala

> "Extending from Kansas and Colorado far into Nebraska there is a calcareous formation of late Tertiary age to which I wish to apply the distinctive name Ogallala Formation. It is a portion, if not the whole, of the deposit which in Kansas and southward has been called the "Mortar beds," "Tertiary grit," and other names. It has been regarded as a portion of the Loup Fork For-

> mation. In its typical development the Ogallala Formation is a calcareous grit or soft limestone containing a greater or less amount of interbedded and intermixed clay and sand, with pebbles of various kinds sprinkled through it locally, and a basal bed of conglomerate at many localities. In places it merges into a light-colored sandy clay, generally containing much carbonate of lime in streaks or nodules. The pebbles it contains comprise many crystalline rocks, which appear to have come from the Rocky Mountains. These pebbles accumulate on the disintegrating surfaces of the Ogallala Formation, and they appear to have contributed largely to the gravel bed underlying the loess to the eastward."

It was with these words that Nelson Horatio Darton (1899) proposed the term Ogallala for the stratigraphically distinctive sediments that today form the surface of most of the Great Plains of North America. It is recognized as being continuous from the type locality near Ogallala station in western Nebraska, extending north and south through the Great Plains region for 800 miles (from South Dakota to the panhandle of Texas) and with a maximum extent of 300 miles from East to West (Frye, 1971) (Fig. 2). This widespread mantle "consists mainly of stream-laid sand, gravel, silt, and minor amounts of clay, all derived principally from the Rocky Mountains region. In places, the formation contains small deposits of volcanic ash, and locally there are important limestone beds and some erratic deposits of chert" (Smith, 1940). It rests with angular unconformity on older rocks of Permian to upper Cretaceous age and has a thickness which varies with the relief of the underlying topography.

Most of the geologists of Darton's time were cognizant of the stratigraphic distinction of these sediments but "only until quite recently," writes Johnson (1901), "has there been serious consideration of the possibility that they might have had origin in stream building." Hay (1890)

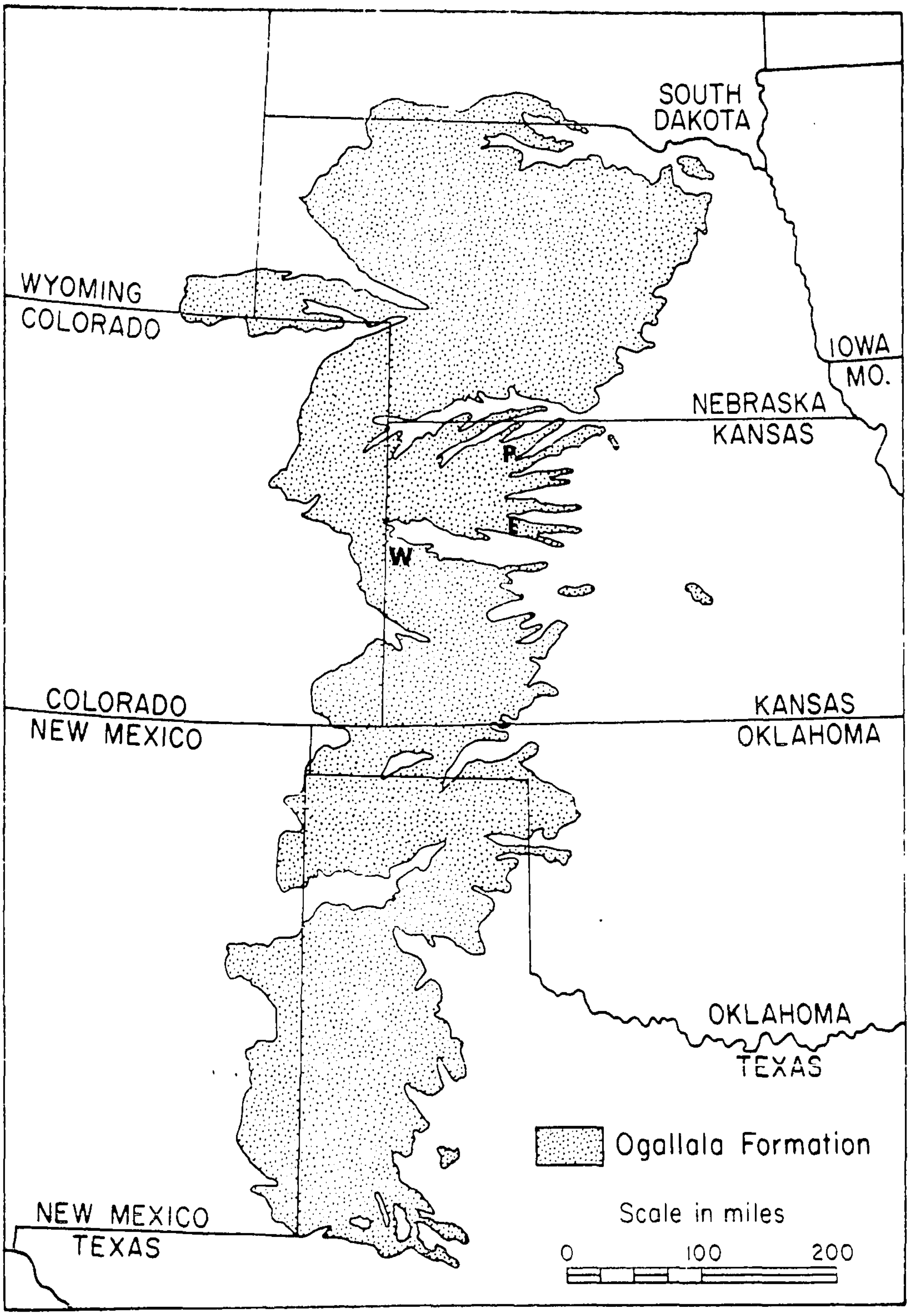


Fig. 2. Generalized distribution of the Ogallala Formation (based on all available published maps), from Frye (1971). The approximate locations of the Wallace (W), Phillips (P), and Ellis (E) County sites are indicated

suggests that these Tertiary deposits "were laid down in lakes or inland seas in which the currents could have been of but limited strength--probably too limited to permit of transportation of such coarse materials." He further suggests that during the depositional period "the shore of the lake with its attendant shingle and littoral debris and the mouths of the mountain-fed affluents from which the debris was derived, were progressively shifted farther and farther to the eastward, and that the coarser and finer phases of the Tertiary conglomerates throughout the whole area thus represent successive littoral deposits." Williston (1895) described "first an uplift, followed by erosion, during which the floor topography was given shape; second, a reverse movement, resulting in a series of extensive fresh water lakes extending from Dakota to Texas, in which deposits of debris from the Rocky Mountains was laid down; and, finally, uplift again, with erosion of the lake floors, leaving on the uplands an immense area of remarkably flat lands with a gentle inclination toward the east." According to Johnson (1901), it was the deep accumulations so distant from any field of erosion that necessarily indicated to these early workers a still water deposit. Detailed investigations of fossil remains excluded a marine origin, and he goes on to note that there had been no account for the presence of large gravel in wide distribution. The whole accumulation "is, in the main, to be sure, of fine material, as indeed any far-spread fluviatile accumulation necessarily is; but, it has been wrongly assumed to have the regular bedding of lake deposits. The occurrences everywhere in some degree of coarse materials at least renders the general explanation of origin by deposits in still water complex and difficult." Hawthorn (1897), in suggesting a fluviatile origin, admits that it is quite possible that during Tertiary time, in which there were so many changes in the velocity of the water carrying the sediments, lesser local lakes and lagoons and swamps and marshes may have existed in different places and for varying lengths of time. But, "when we consider the Tertiary as a whole and yet in detail, it must be admitted that the materials themselves have many indications of river deposits and very few of lake deposits. The irregularity of formation succession, the limited lateral extent of the beds of gravel, clay, and sand, the frequent steepness of the cross bedding planes, all correspond to river deposits, but are not characteristic of lake deposits."

Although it now seems clear that the Ogallala Formation is predominantly a stream deposit and that the sediments were derived from a source in the mountains to the west, there is far less certainty about the mechanism that initiated and terminated the episode of deposition. Prior to deposition of Ogallala sediments, there was extensive erosion of older formations. This erosion took place intermittently, and there was intervening periods of deposition. According to Smith (1940), the greater part of this erosion was probably effected by through-going streams from the mountains. At the close of Pre-Ogallala time, a widespread erosion surface extended from the Rocky Mountains front eastward to Central Kansas. These observations were drawn from the work of Fenneman (1931), who concluded that "the Rocky Mountain peneplain corresponds in geologic date with the surface of the Pliocene sediments that now cover the High Plains." Smith (1940), points out, however, that it was by no means a perfect peneplain, but was characterized by considerable local relief. A part of the bedrock relief is "a result of warping and subsidence that took place during or after the deposition of the Ogallala beds. It is possible also that certain of the bedrock valleys and basins antedated the Ogallala, but had been partly filled with older sediments before deposition of the Ogallala rocks began." As early as 1896, Gilbert observed that

> "due to some modification of conditions not as yet clearly understood, the process of erosion was completely arrested and process of deposition took its place: The streams which flowed from the mountains onto the plains, and thence eastward across the plains ('probably to the Gulf Coast regions, where lie the nearest early and middle Tertiary deposits' (Smith, 1940)), ceased to carve valleys in the region of the plains and began to deposit sediment. When they had filled their channels so that their beds lay higher than the neighboring country, they broke through their banks, shifting their courses to new positions, and they thus came to flow in succession over all parts of the plains and to distribute their deposits widely, so that the whole plain was covered by sands and gravels brought from the canyons and valleys of the Rocky Mountains."

According to Smith (1940), the volume of Ogallala sediments, obviously derived from crystalline rocks, is far too great to be accounted for by the mere wearing back of the mountain front. Only a stream that penetrated the interior canyons and valleys of the mountains could answer requirements of Ogallala sedimentation.

Just where along the stream course this change from stream degradation to aggredation took place is uncertain. It is inferred (Smith, 1940) that the locus of initial deposition corresponds approximately with the zone of maximum thickness in the formation. The conditions that may have resulted in stream aggredation have been investigated by a number of authors since Gilbert (1896) (Johnson, 1901; Chaney and Elias, 1936; Smith, 1940). If mountain uplift were the cause of deposition, the effect would have been a steepening of stream gradients, quickening of erosion, increased stream load, and possibly increased rainfall within the mountains. It is further expected that the deposition resulting from these factors would take place immediately beyond the hinge line of the uplift, where stream gradients remained unchanged, and that there the deposits would ultimately attain maximum thickness. If one assumes that the hinge line of the uplift was far to the east of the present mountain front, it is entirely feasible to account for the deposition of the Ogallala on this basis. (This assumption is based upon the fact that the thickness of the formation increases away from the mountain front. This also explains why the Ogallala is not a composit fan deposit, as supposed by some authors (Smith, 1940). The thickness of a fan deposit decreases outward from a point near its apex.) Chaney and Elias (1936) point to the climate as having been the dominant factor controlling deposition. On the basis of paleobotanical studies they considered not only the nature of the climatic trends during the Tertiary, but the probable effect of climatic control on the locus of deposition and the adequacy of climatic control to account for the deposition of earlier Tertiary formations in the plains region. Another suggestion (Smith, 1940) is that upwarping in the plains may have resulted in stream gradients being flattened, or actually reversed locally, with deposition having begun at points of change in gradient, which would gradually have extended both upstream and downstream, effecting an area considerably wider than that in which the warping actually took place. A chain of individual upwarps, if not too far separated, could have had a profound effect on areas upstream, and might have been sufficient to have effected the deposition of a continuous alluvial mantle.

Whatever the reasons for deposition, be they climatic, tectonic, or a combination of factors not necessarily synchronous, the deposition of the Ogallala was mainly of the channel and floodplain type. The coarser beds of sand, gravel, and grit represent channel deposits, the finer materials interpreted as representing floodwater deposits.

> "The filling of stream channels, led to more frequent overflow and thus to upbuilding of the floodplain. This soon led to shifting of the channels themselves, and probably to the development of anastomosing patterns. As filling progressed, the valley flat overlapped farther and farther on the slopes of the bordering hills, and the zone of deposition encroached farther and farther east and west. Relief was lowered, the valley plains grew broader, and finally the divides were overtopped, and there followed overlapping and coalescing of the depositional zones of individual streams. As depositional areas grew broader the rate of upbuilding must have declined, allowing greater time for the work of soil processes on the successive accretions of sediment. (Any agency that deposits thin layers of sediment in the presence of vegetation, at moderately long intervals between successive additions, allows opportunity for the kneading action of plant roots and other soil-binding processes to obliterate the original bedding and develop a structureless appearance (Smith, 1940). Theis (1936) goes so far as to postulate that the structureless material is principally of aeolian, i.e., wind borne, emplacement. Smith (1940) regards eolian deposition as a factor of subordinate importance in the Ogallala.) One vast, continuous alluvial plain came to extend from the slopes of the Rocky Mountains perhaps as far as the Flint Hills of Kansas. Probably the waters of the depositing streams were gradually dissipated as they neared the border of this plain, so that none escaped beyond" (Smith, 1940).

Throughout this heterogeneous assortment of sediments, there is virtually no distinctive bed that can be traced any appreciable distance. The deposits are interbedded and admixed in various proportions and are largely unconsolidated, although cementation of beds occurs to some degree throughout the formation. Calcium carbonate is a common constituent throughout almost all of the Ogallala. It is distributed both as fine material and as stringers of caliche and small- to medium-sized nodules. Calcium carbonate in many places binds the deposits so firmly as to produce a series of hard ledges, interbedded with beds that are only slightly cemented. Silica also is present as a cementing material in beds of opaline sandstone or as chert deposits. Beds of uniform sand may occur, but generally the sand ranges from fine to coarse and commonly is mixed with gravel, silt, or clay. Gravel beds containing lenses of sand, silt, and clay are common, but thick beds of uniform gravel are rare (Hodson, 1965). According to Frye, Leonard, and Swineford (1956), the Ogallala is considered "a conformable sequence, marked at the base by a profound unconformity easily recognized in the field, and at the top by a distinctive bed (the so-called algal limestone). The subdivision of the formation, however, is not so clear-cut. As is true in any alluvial complex, continuous "marker beds" do not exist and the establishment of rock units that can be defined entirely on the basis of their lithology and that can be mapped by conventional field methods has not been possible.

Previous Work

Little information has been published concerning Tertiary nonmarine diatoms of the Great Plains. The first systematic study of a Tertiary nonmarine assemblage from this area was made by Andrews (1970). This report also represented the first stratigraphic study of a Tertiary nonmarine diatom assemblage from the Great Plains. Numerous lists and counts appeared before that time (Cragin, 1891; Barbour, 1910; Wolle, 1889), with these highlighted by a detailed floristic treatment of an assemblage of Pliocene diatoms from Wallace County, Kansas (Hanna, 1932). In addition to these, a number of diatoms "found in the fossil state" were included in Elmore's, The Diatoms of Nebraska (Elmore, 1921).

One potential biostratigraphic tool that has been generally overlooked is diatoms (Lohman, 1964; Abbott and Vanlandingham, 1972). Within the Ogallala, attempts have been initiated using fossil vertebrates, grass seeds, gastropods, volcanic ash deposits, and general similarity of lithologies, but, due to the inconsistency of all of these factors, attempts at correlation are inconclusive at best. A number of authors have expressed an interest as to whether or not diatoms would prove useful as tools in correlation within the Ogallala (Zehr, 1974). Andrews (1970) showed that the composition of the assemblage, the relative number of taxa, and the absence of several widespread modern genera and species of nonmarine diatoms should prove useful in estimating the age of the sediment. According to Abbott and Vanlandingham (1972) "there are short-ranging and long-ranging forms that make age dating possible with diatoms. The fact that many diatom species are widely distributed and prolific makes them useful in correlation. There is thus good evidence that diatoms make useful index fossils . . . ."

PREPARATION OF MATERIALS AND METHOD OF STUDY

Description of Study Sites

Diatom-bearing strata from three sites in Wallace County, one from Phillips County, and two from Ellis County, Kansas, are the source of material upon which stratigraphic observations were made (Table 1). Due to the large amount of calcium carbonate, it is appropriate to call the rock a diatomaceous marl instead of diatomaceous earth. The largest single deposit, from which three sites were collected (sites G, H, and I), is located on what was formerly known in the literature as the Marshall ranch. The diatomaceous marl outcrops on the south side of the North Fork of Smoky Hill River in Sections 10, 11, and 12, T. 11 S., R. 38 W., Wallace County, and extends into Sec. 7, T. 11 S., R. 37 W., Logan County. The total length of the exposures, interrupted in places by loess, is slightly more than 3 miles. The thickness of the bed ranges from 2 or 3 feet in the middle of Section 11, to 11 feet in the eastern part of this section. The average thickness from here to the easternmost exposure in Logan County is about 7 feet. In the western half of Section 11, the diatomaceous marl is more limy and hard but in the northwest quarter of Section 10 it is somewhat softer. On the top of the bed there is nearly always a thin hard ledge of white limestone, usually full of small cavities representing molds of freshwater gastropods. This limestone is a few inches to one foot thick. At the base of the diatomaceous marl, there is generally a light gray clay with some mixture of calcareous matter and diatoms, but locally there is greenish sand in place of clay at the base. A number of mammalian and other bones have been found in this sand (State

Table 1. Number of samples and location of each of the six sites

Site	Samples	Location
A	3	Center W. line, Sec. 3, T. 12 S., R. 20 W., Ellis County
D	3	Center W. line, Sec. 3, T. 12 S., R. 20 W., Ellis County
F	4	Center W. line, Sec. 12, T. 2 S., R. 20 W., Phillips County
G	20	NE¼ Sec. 11, T. 11 S., R. 38 W., Wallace County
H	7	NW¼ Sec. 11, T. 11 S., R. 38 W., Wallace County
I	25	NE¼ Sec. 10, T. 11 S., R. 38 W., Wallace County

Geological Survey of Kansas (Anonymous, 1931)).

The constitution of the diatomaceous marl in fairly uniform throughout. Preliminary quantitative analysis of an average sample showed that the dry rock consists of about 81% of matter soluble in HCl. This is chiefly, if not entirely, fine, flaky calcium carbonate. About 90% to 95% of the remaining insoluble part consists of siliceous tests of diatoms, and of siliceous spicules of sponges. Fine to medium grained quartz sand with a slight mixture of feldspar constitutes the balance of the insoluble part.

The single Phillips County location (site F) was a roadcut site approximately 75 miles east of the Marshall ranch deposits. In addition to these sites in Wallace and Phillips Counties, a roadcut exposure in Ellis County was the location of an additional two sites (sites A and D).

This particular location, which is exposed in a road cut in the center of the West line of Sec. 3, T. 12 S., R. 20 W., has been investigated by scientists from several disciplines. Frye, Leonard, and Swineford (1956) have studied the faunal assemblages of mollusks from this location and, in more recent years, Zehr (1974, unpublished) and Thomasson (1976, unpublished) have studied the vertebrate fauna and angiosperm seed distributions, respectively, of this exposure.

The total length of this exposure is approximately 300 feet. The thickness, as measured by Frye, Leonard, and Swineford (1956), is 101 feet with the diatomaceous marl lentil averaging approximately 2 feet in thickness. The marl is soft, porous limestone and contains, in addition to diatoms, some silt and fine sand with locally abundant freshwater gastropod fossils as casts, molds, or entire shells. The constitution of this marl is in all other respects similar to that found at the Wallace County deposits.

Preparation of Materials

The diatomaceous marl exposed at each of the six sites was sampled in the following manner: a verticle sequence was selected from the approximate center of each exposure and sampled from bottom to top in 10 cm intervals. Each sample was collected with the aid of a rock hammer and chisel and placed in a labeled bag for further preparation. In the case of the Ellis County sites, a sequence at each end of the marl lentil was sampled in this way.

In the laboratory, individual samples were dropped into beakers of concentrated HCl, out of which the insoluble siliceous material was allowed to settle for several days. The acid was decanted off and the sample was washed several times with distilled water. The cleaned sample was then filtered into a second beaker through two layers of cheesecloth to remove the larger sand particles, then placed into labeled vials.

All microscopical studies were conducted by the examination of strewn slides made for each sample. For preparation of slides, several drops of water containing the cleaned material were added to a clean 22 x 22 mm coverslip, no. 1 thickness, and allowed to evaporate at room temperature. It was then inverted in a drop of Hyrax mounting medium on a glass slide. The slide was heated to evaporate the solvent, cooled, and labeled. Two slides from each of the 62 samples were prepared in this manner.

Method of Study

The process of sampling the diatom populations was accomplished by identifying and counting 532 frustules at each level. Even though it was assumed that the cleaned material would settle randomly on the coverslip, any possible effect on distribution was eliminated by counting only entire rows from near the middle of the coverslip. In most cases, the density of the material was such that only one traverse of the coverslip was necessary. All of the diatom valves that appeared under the field while traversing the coverslip to count 532 diatom valves were identified. Only the specimens representing at least half of a diatom valve were counted. The taxa found, number of each observed, and the total number counted in each sample are given in Appendix (Table 5). All counts were made using a Leitz Laborlux microscope equipped with a 1.32N.A. fluorite objective and an oil immersion condenser.

Of particular significance to this discussion of sampling procedure is the fact that most of the taxonomic determinations were made long before the actual counting began. It was decided at a very early stage of this investigation that a more realistic approach to understanding the diatom flora would be to acquire a preliminary notion of species diversity and not to identify specimens as they were being counted. A great deal of time, therefore, was spent taking picutres of as many specimens as possible before any counting was done, then sorting them into presumed taxa. Following this initial preparation, I spent a month at the Academy of Natural Sciences of Philadelphia where I was able to substantiate preliminary identifications as well as seek out the identity of unknowns. Photomicrographs of all taxa were made with a Leitz Ortholux microscope with attached Orthomat automatic camera. Kodak Panatomic-X was used and subsequently developed according to standard photographic techniques.

Application of Cluster Analysis

In the present investigation, the fossil associations are defined by a statistical technique called cluster analysis. Cluster analysis encompasses many diverse techniques for discovering structure within complex bodies of data. The object is to group either the data units (subjects) or the variables (attributes, characteristics, measurements) into clusters such that the elements within a cluster have a high degree of "natural association" among themselves while the clusters are "relatively distinct" from one another (Anderberg, 1973). Most cluster analysis methods require a measure of similarity to be defined for every pairwise combination of the entities to be clustered. When clustering data units, the proximity of individuals is usually expressed as a distance. These numerical measures of association are all comparable to each other, i.e., if the measure of association (distance) for one pair is 3.1 and for the other pair 5.8, then the first pair is associated more strongly than the second. With the intention of ascertaining just how similar each of the six sites is to one another, a pairwise comparison of the taxa present at each level (or sample) of each site was made with the taxa at each level of every other site. Does the succession of diatoms at site G, for example, resemble those at site I? Do the Ellis County sites resemble any of those in Wallace County? Do the lower five levels of site H resemble any five successive levels at site I? Is there any similarity between any of the levels; or are they statistically different? The following (simplified) discussion will help explain the application of cluster analysis in helping to answer these and similar questions:

	Taxon 1	Taxon 2	Taxon 3	Taxon 4	. . .	Taxon 203
Sample 1 (A000)	3	16	8	32	. . .	
Sample 2 (A010)	20	15	0	34	. . .	
Sample 3 (A020)	1	14	6	30	. . .	
Sample 4 (D000)	8	6	15	52	. . .	
.	.	.	.	.		
.	.	.	.	.		
.	.	.	.	.		
Sample 62 (I290)						

Using the data contained in Table 5, a pairwise comparison between all samples was undertaken and the association expressed as a distance:

$$\text{Euclidean distance coefficient (for the sample 1-sample 2 pairwise comparison} = \sqrt{(3-20)^2 +_2 (16-15)^2 + (8-0)^2 + (32-34)^2 + \ldots + \ldots}$$

The Euclidean distances for each pairwise association were then arranged in a matrix table:

	A000	A010	A020	D000 . . .
A000	0	3.2	3.6	4.8
A010	3.2	0	2.9	5.4
A020	3.6	2.9	0	6.7
D000	4.8	5.4	6.7	0
.				
.				
.				

The results were plotted as a dendrogram, with the Euclidean distance coefficient plotted on the ordinate and the 62 samples along the abscissa.

Paleoecological Interpretations

Coordinate with their utility as biostratigraphic indicator organisms, diatoms have also proven useful in paleoecological interpretations. Many species found in fossil assemblages are still represented in modern environments (Abbott and Vanlandingham, 1972). Studies of many fossil diatom floras give satisfactory evidence that diatoms lived in the same environments in the past as they do at present (Lohman, 1941). Lohman

(1960) has indicated that different species, and in some cases genera, are restricted to one or more specific habitats, reflecting their individual tolerances for water of various combinations of salinity, temperature, pH, and nutrients (Abbott and Vanlandingham, 1972).

Diatoms are affected by many different parameters in the environment, and it is probably a combination of factors that limit their distribution. Several investigators have designated "spectral ranges" for individual chemical and physical parameters. The ecological data discussed in this investigation have been standardized according to the spectral ranges as defined by Lowe (1974). The data itself has come from the following sources: 1) Patrick and Reimer (1966; 1975), 2) Lowe (1974), and 3) from information recorded in a card file kept at the Academy of Natural Sciences of Philadelphia for all diatom species for which such data is available.

ECOLOGICAL PARAMETERS
(After Lowe, 1974)

I. pH spectrum

1. Acidobiontic: occurring at a pH below 7 with best development below 5.5

2. Acidophilous: occurring at a pH around 7 with best development below 7

3. Indifferent: best development around a pH of 7

4. Alkaliphilous: occurring at a pH around 7 with best development over 7

5. Alkalibiontic: occurring only in alkaline water

II. Halobion spectrum

1. Polyhalobous: occurring in salt concentrations over 40,000 mg/l

2. Euhalobous: marine forms, occurring in salt concentrations of 30,000 to 40,000 mg/l

3. Mesohalobous: brackish-water forms occurring in salt concentrations of 500 to 30,000 mg/l

4. Oligohalobous: freshwater forms occurring in salt concentrations of less than 500 mg/l

   a. halophilous: stimulated by small amounts of salt
   b. indifferent: tolerates small amounts of salt
   c. halophobous: does not tolerate small amounts of salt

III. Current spectrum

1. Limnobiontic: characteristic only of standing waters

2. Limnophilous: characteristic of standing water but may be found in running water

3. Indifferent: common in both flowing and standing water

4. Rheophilous: characteristic of running water but may be found in standing water

5. Rheobiontic: characteristic only of running water

IV. "Habitat" spectrum

1. Planktonic: normally suspended in the water, distribution is current dependent

2. Tychoplanktonic: normally associated with periphytic or terrestrial habitats but often suspended in the water

3. Periphytic (aufwuchs, littoral): occurring on, but not penetrating, the substrate and submerged objects

   a. benthic: found living on the bottom or attached to rocks
   b. epiphytic: occurring on plants
   c. epizooic: occurring on animals
   d. attached: normally sessile
   e. unattached: normally "free"

RESULTS AND DISCUSSION

List of Species

A total of 203 taxa (representing 30 genera) were encountered during the course of this study (Appendix, Table 5). Sixty-four of these were not observed during the actual counting period. Table 2 records the total number of taxa per genus as well as the number of taxa per genus observed at each of the six sites.

The following section is an alphabetical listing of all taxa and includes pertinent comments concerning taxonomy and ecology. Following each citation is a reference to an illustration that can be found on subsequent pages of this work.

Achnanthes Bory

Achnanthes exigua Grun. var. exigua, in Cl. and Grun., K. Svenska Vet.-Akad. Handl., Ny Följd, 17(2):21. 1880. Pl. 1, Fig. 1-5.

Observed at five of the six sites (not counted at site H) with a much higher frequency at the Ellis County sites.

An alkaliphilous form that has been found in lakes, rivers, springs, and streams through a pH range of 6.8-9.0 (with an optimum around 8). It is periphytic, current indifferent, and indifferent to oligohalobous.

Achnanthes flexella (Kütz.) Brun var. flexella, Diat. Alpes Jura, p. 29, pl. 3, fig. 21. 1880. Pl. 1, Fig. 6-9.

A very characteristic species recorded at sites G, H, and I with counts as high as 23 at site I.

An acidophilous to indifferent form that has been found in lakes, ponds, and bogs (or in water courses draining such areas) through a pH

Table 2. List of genera found during the course of this study with total number of taxa within each genus and the distribution of these taxa at each of the six sites. The total number of taxa per genus does not include the 64 taxa that were photographed but never counted at any of the sites. The numbers in parenthesis do include these taxa

Genus	Total number of taxa per genus	Number of taxa per genus counted at each of the sites					
		A	D	F	G	H	I
Achnanthes	10(12)	7	8	8	5	3	4
Amphora	12(14)	6	4	6	7	5	3
Anomoeoneis	3(4)	2	1	1	2	2	2
Caloneis	5(7)	2	1	4	2	1	1
Cocconeis	1(1)	1	1	1	1	1	1
Cyclotella	1(1)	0	0	0	1	1	1
Cymatopleura	1(1)	1	0	0	0	0	0
Cymbella	16(25)	9	7	7	10	10	11
Denticula	1(1)	0	0	0	1	1	1
Diatoma	0(1)	0	0	0	0	0	0
Diploneis	1(1)	1	1	1	0	0	1
Epithemia	2(2)	1	1	1	0	0	1
Eunotia	5(9)	3	3	3	1	0	0
Fragilaria	12(13)	11	7	8	6	7	7
Gomphonema	8(10)	4	6	6	2	3	5
Hantzschia	3(5)	1	1	2	1	0	0
Mastogloia	1(1)	0	0	0	1	1	0
Melosira	5(5)	4	4	4	0	1	4
Meridion	1(1)	0	1	1	0	0	0
Navicula	21(34)	15	15	13	12	8	10
Neidium	1(8)	1	0	0	1	0	0
Nitzschia	9(11)	6	4	6	3	3	2
Opephora	1(1)	1	1	1	1	1	1
Pinnularia	7(9)	4	3	4	4	1	1
Rhoicosphenia	0(1)	0	0	0	0	0	0
Rhopalodia	2(2)	1	1	1	2	0	1
Stauroneis	4(5)	3	1	1	0	0	2
Surirella	1(3)	0	0	0	1	0	0
Synedra	3(13)	0	1	0	1	0	2
Tabellaria	2(2)	1	2	0	0	0	0
Totals	139(203)	85	74	79	65	49	61

range of 6.0-7.3. It is periphytic and planktonic, limnophilous, and halophobous.

Achnanthes grimmei Krasske var. grimmei, Abh. Ber. Ver. Naturk. Cassel, 56:30, pl. 1, fig. 10. 1925. Pl. 1, Fig. 10-11.

Observed at all of the sites except I, with particularly high counts recorded at site G.

An intact pseudoraphe valve was never associated (with confidence) with a raphe valve, but the identification is, nonetheless, considered a sound one.

The ecology of this species is insufficiently known, having been found so far only from mineral springs.

Achnanthes hungarica (Grun.) Grun. var. hungarica, in Cl. and Grun., K. Svenska Vet.-Akad. Handl., Ny Foljd, 17(2):20. 1880. Pl. 1, Fig. 12-15.

Never found in large numbers, this species reached its greatest frequency at site F and was recorded only twice at site A and once at site I.

It is an alkaliphilous form that has been recorded in lakes and ponds through a pH range of 6.4-8.3 (with an optimum around 8.5). It is periphytic, limnophilous to indifferent and oligohalobous to indifferent. This species is often associated with aquatic plants, especially Lemna.

Achnanthes lanceolata (Breb. in Kütz.) Grun. in Cl. and Grun., K. Svenska Vet.-Akad. Handl., Ny Foljd, 17(2):23. 1880. Pl. 1, Fig. 16.

Observed at very low frequencies at sites A, D, and F.

An alkaliphilous form that has been found in rather well-aerated waters of springs and streams through a pH range of 4.0-9.0 (with an optimum between 7.2-7.5). It is periphytic, rheophilous to rheobiontic, and salt indifferent. This species is generally a quite common one, occurring under a wide range of ecological conditions. It requires high oxygen concentrations and is considered calciphilous.

Achnanthes minutissima Kütz. var. minutissima, Linnaea, 8:578, pl. 16, fig. 54. 1833. Alg. Dec. 8, No. 75. 1833. Pl. 1, Fig. 17-23.

This species was recorded at all of the six sites and reached particularly high counts (48-49) at certain levels.

Taxonomically, this species is very similar to Achnanthes microcephala (Kütz.) Grun. and it was not an easy task deciding which one or if both were present in this material. I have concluded that the great variation in form belongs to only one taxon, realizing that a more in depth investigation is warranted.

A pH indifferent form that has been found at a very wide range of pH (4.3-9.2, with an optimum between 7.5-7.8). This species is one of the best indicators of high oxygen concentrations in alkaline waters. It is periphytic, current indifferent, and salt indifferent. It is also known to be iron and calcium indifferent.

Achnanthes sp. #1. Pl. 1, Fig. 29-30.

Recorded in low numbers at sites A, D, and F. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula.

Achnanthes sp. #2. Pl. 1, Fig. 27.

Recorded in very low numbers at sites A, D, and F.

This taxon appears close to either Achnanthes lutheri Hust. or perhaps Achnanthes oblongella Ostr. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula.

Achnanthes sp. #3. Pl. 1, Fig. 24.

Recorded only once at sites D and F.

This taxon might possibly be Achnanthes woltereck Hust. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula.

Achnanthes sp. #4. Pl. 1, Fig. 26.

Photographed from material collected at site A but never occurred in counts from any of the sites. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula.

Achnanthes sp. #5. Pl. 1, Fig. 25.

One specimen was counted at level G060. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula.

Achnanthes sp. #6. Pl. 1, Fig. 28.

Photographed from material collected at site A but never occurred in counts from any of the sites. Since a pseudoraphe valve has not been observed, there is also the possibility that this is a Navicula. It might possibly be Achnanthes linearis f. curta or Navicula cf. paludosa (Hust.) Hust.

Amphora Ehrenberg

Amphora ovalis (Kütz.) Kütz. var. ovalis, Bacill., p. 107, pl. 5, fig. 35, 39. 1844. Pl. 1, Fig. 31.

Recorded and counted only once at site G190.

An alkaliphilous form that has been found in standing or slowly flowing water through a pH range of 6.2-9.0 (with an optimum between 7.0-8.5). It is periphytic, indifferent to limnophilous, and salt indifferent. This species has never been found in large numbers and is considered calciphilous.

Amphora ovalis var. affinis (Kütz.) V.H. ex DeT., Syll. Alg., Vol. 2, sect. 1, p. 412. 1891. Pl. 1, Fig. 32, Pl. 2, Fig. 1.

Recorded at rather low frequencies at sites G, H, and I.

Ecologically this form is similar to the nominate variety.

Amphora reinholdi Hanna, Univ. of Kansas Science Bull. 20:372, pl. 31, fig. 1. 1932. Pl. 2, Fig. 2-6.

Recorded at sites G and H at low frequencies.

Unknown ecologically.

Amphora sp. #1. Pl. 2, Fig. 7.

Recorded at rather low frequencies at sites A, D, and F, with one specimen recorded at H050.

A very interesting form that does not appear to resemble any presently known taxon.

Amphora sp. #2. Pl. 2, Fig. 8-10.

Recorded only four times in the upper two levels at site I.

Amphora sp. #3. Pl. 2, Fig. 11.

Recorded at very low frequencies at sites A, D, and F.

Amphora sp. #4. Pl. 2, Fig. 13-17.

This taxon was particularly well represented at sites G and H and occurred at low frequencies at scattered levels of site I.

PLATE I

(Scale is 10 μ long)

Fig. 1-5. Achnanthes exigua var. exigua

Fig. 6-9. Achnanthes flexella var. flexella

Fig. 10-11. Achnanthes grimmei var. grimmei

Fig. 12-15. Achnanthes hungarica var. hungarica

Fig. 16. Achnanthes lanceolata var. lanceolata

Fig. 17-23. Achnanthes minutissima var. minutissima

Fig. 24. Achnanthes sp. #3

Fig. 25. Achnanthes sp. #5

Fig. 26. Achnanthes sp. #4

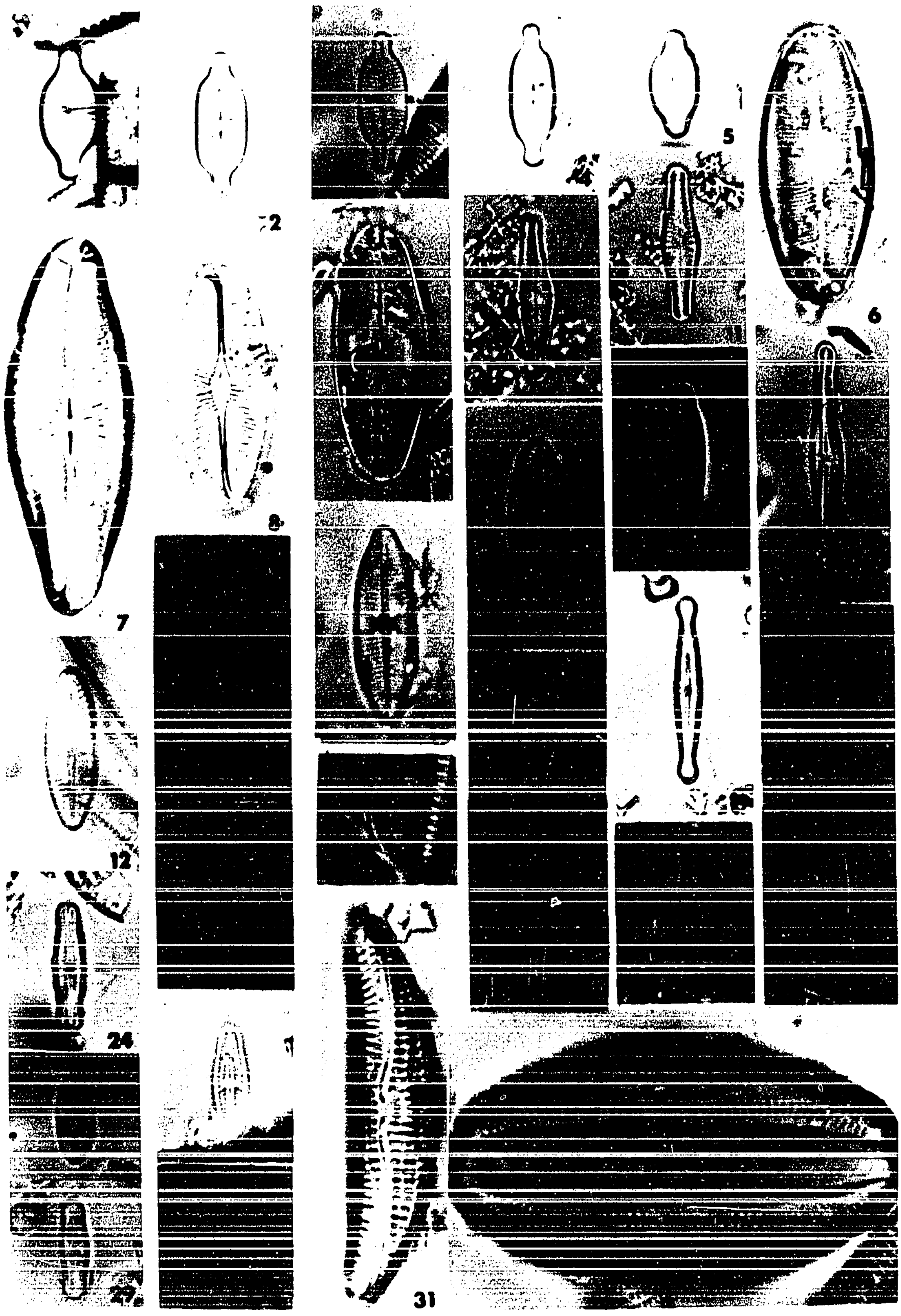
Fig. 27. Achnanthes sp. #2

Fig. 28. Achnanthes sp. #6

Fig. 29-30. Achnanthes sp. #1

Fig. 31. Amphora ovalis var. ovalis

Fig. 32. Amphora ovalis var. affinis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24
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31

Taxonomically, this taxon resembles *Amphora veneta* Kütz., but is unique in its possession of a raphe that curves into the ventral margin. This condition appears to be an anomaly of some sort, but was nonetheless a consistent feature of every specimen observed.

Amphora sp. #5. Pl. 2, Fig. 18-19.

This taxon is particularly characteristic but has not been confidently associated with any presently recorded form. *Amphora veneta* var. *capitata* Haworth (var. nov. 1974) comes as close as any.

It was observed at very low frequencies at scattered levels of sites A, F, and G.

Amphora sp. #6. Pl. 2, Fig. 22-23.

This taxon was recorded at very low frequencies at two levels of site A and one at site F.

Amphora sp. #7. Pl. 2, Fig. 20-21.

This taxon was recorded at very low frequencies at two levels of site A and two levels at site F.

Amphora sp. #8. Pl. 3, Fig. 1-2.

This taxon was recorded with some consistency through the levels of sites A,DD, F, G, and H.

Amphora sp. #9. Pl. 3, Fig. 3-5.

This taxon was recorded at only one level of site D and twice at G010.

Amphora sp. #10. Pl. 3, Fig. 12.

Photographed from material collected at site I but never occurred in counts from any of the sites.

Amphora sp. #11. Pl. 2, Fig. 12.

Photographed from material collected at site A but never occurred in

PLATE II
(Scale is 10 μ long)

Fig. 1. Amphora ovalis var. affinis

Fig. 2-6. Amphora reinholdi var. reinholdi

Fig. 7. Amphora sp. #1

Fig. 8-10. Amphora sp. #2

Fig. 11. Amphora sp. #3

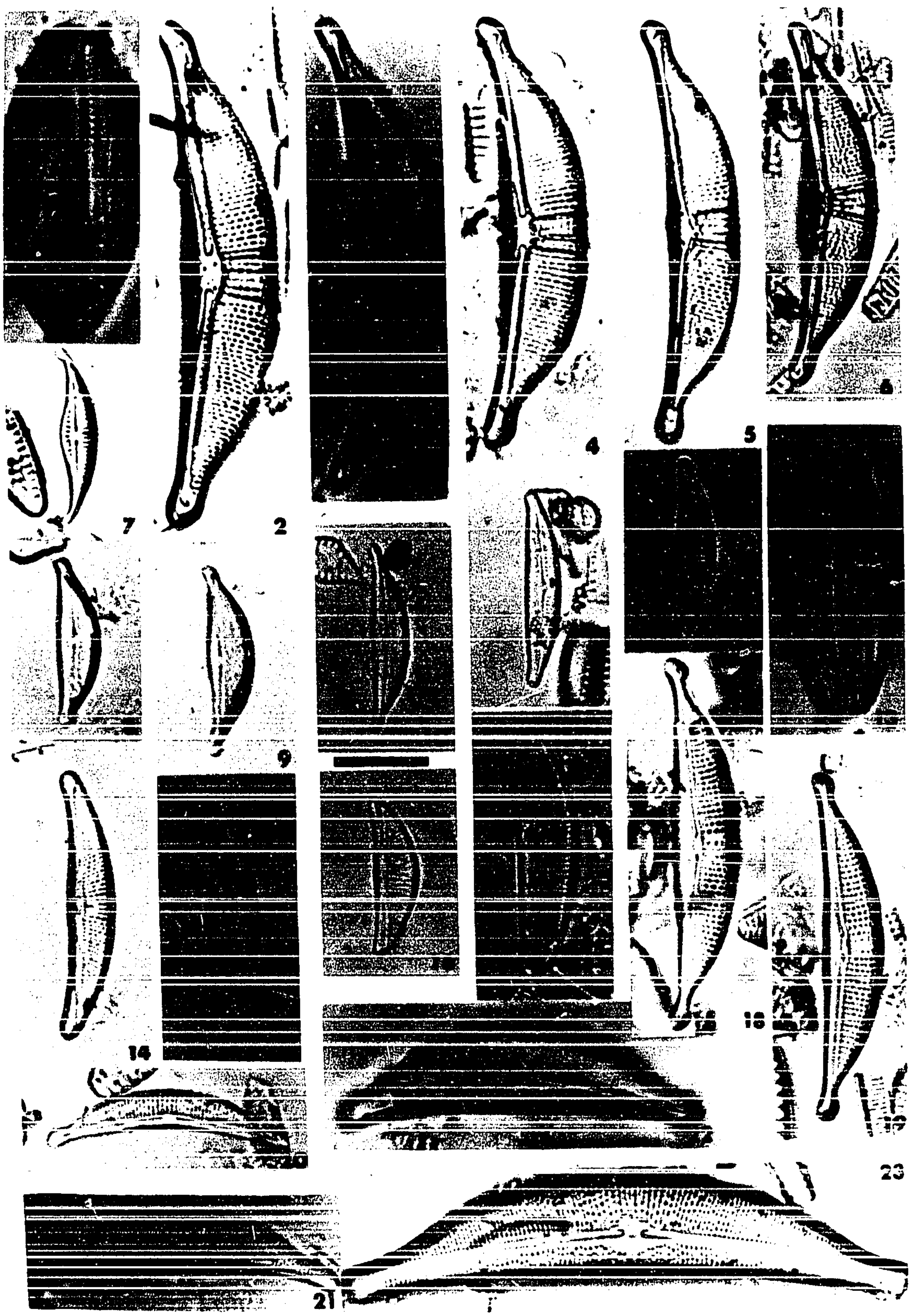
Fig. 12. Amphora sp. #11

Fig. 13-17. Amphora sp. #4

Fig. 18-19. Amphora sp. #5

Fig. 20-21. Amphora sp. #7

Fig. 22-23. Amphora sp. #6


7
2
4
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9
14
21
23

counts from any of the sites.

Anomoeoneis Pfitzer

Anomoeoneis costata (Kütz.) Hust. var. costata, in Rabh. Kryptog.-Fl. Deutschland, vol. 7(2), no. 6, pp. 744-747, fig. 1111. 1959. Pl. 3, Fig. 6-8.

Counted six times at A020 and once at A010.

This taxon has been found in inland waters with moderate to high salt concentration. A meschalob?

Anomoeoneis exilis var. lanceolata Mayer, Bot. Gesell. Munchen, p. 202, pl. 7, fig. 12-14. 1919. Pl. 3, Fig. 9-11.

This taxon was a consistent member of the populations at sites G, H, and I, with as many as 138 specimens recorded at certain levels at site G.

The nemerate variety is adapted to a wide range of ecological conditions but seems to prefer alkaline waters (an alkaliphil?). It is salt indifferent to oligohalobous (to halophobic) and has been reported from rivers, lakes, and bogs.

Anomoeoneis sphaerophora (Ehr.) Pfitz. var. sphaerophora, Bot. Abh. Geb. Morph. Physiol., 1(2):77, pl. 3, fig. 10. 1871. Pl. 4, Fig. 1-12.

Represented at all of the six sites in rather low numbers (18 at A020).

This is a highly variable taxon with a considerable number of named and intermediate forms. I am particularly concerned about the placement of such forms as those of figures 9, 10, and 11 of plate 4, and have gone so far as to consider one specimen as a different taxon.

An alkalibiontic form that has been found in lakes, ponds, streams, and intermittant pools through a pH range of 6.4-9.0 (with an optimum above 8.5). It is periphytic, rheophilous, and halophilous.

Anomoeoneis sp. #1. Pl. 3, Fig. 13.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Caloneis Cleve

Caloneis bacillum (Grun.) Cl. var. bacillum, Diatomiste, 2(17):99. 1894. Pl. 5. Fig. 1-4.

Recorded in low numbers from scattered levels at sites D, F, and G. An alkaliphilous form that has been found in lakes, rivers, streams, and bogs through a pH range of 4.3-9.0 (with an optimum between 7.5-8.0). It is periphytic, rheophilous, and salt indifferent. A soft, hard, or slightly brackish water species often found in standing alkaline waters.

Caloneis clevei var. tugelae (Cholnoky) Cholnoky, Hydrobiol., Bd. 20, Nr. 4, p. 317. 1962. Pl. 5, Fig. 12.

Recorded once at F030.

Caloneis clevei var. ? Pl. 5, Fig. 13.

Recorded three times at A010 and three times at F030.

Caloneis limosa (Kutz.) Patr. var. limosa, Diatoms of the U.S., p. 587, pl. 54, fig. 10. 1966. Pl. 5, Fig. 5-8.

A consistently occurring taxon of sites G and I and at three levels at site H.

This very characteristic species is an alkaliphilous form that has been found in lakes, ponds, and streams through a pH range of 6.7-8.0.

PLATE III
(Scale is 10 μ long)

Fig. 1-2. *Amphora* sp. #8

Fig. 3-5. *Amphora* sp. #9

Fig. 6-8. *Anomoeoneis costata* var. *costata*

Fig. 9-11. *Anomoeoneis exilis* var. *lanceolata*

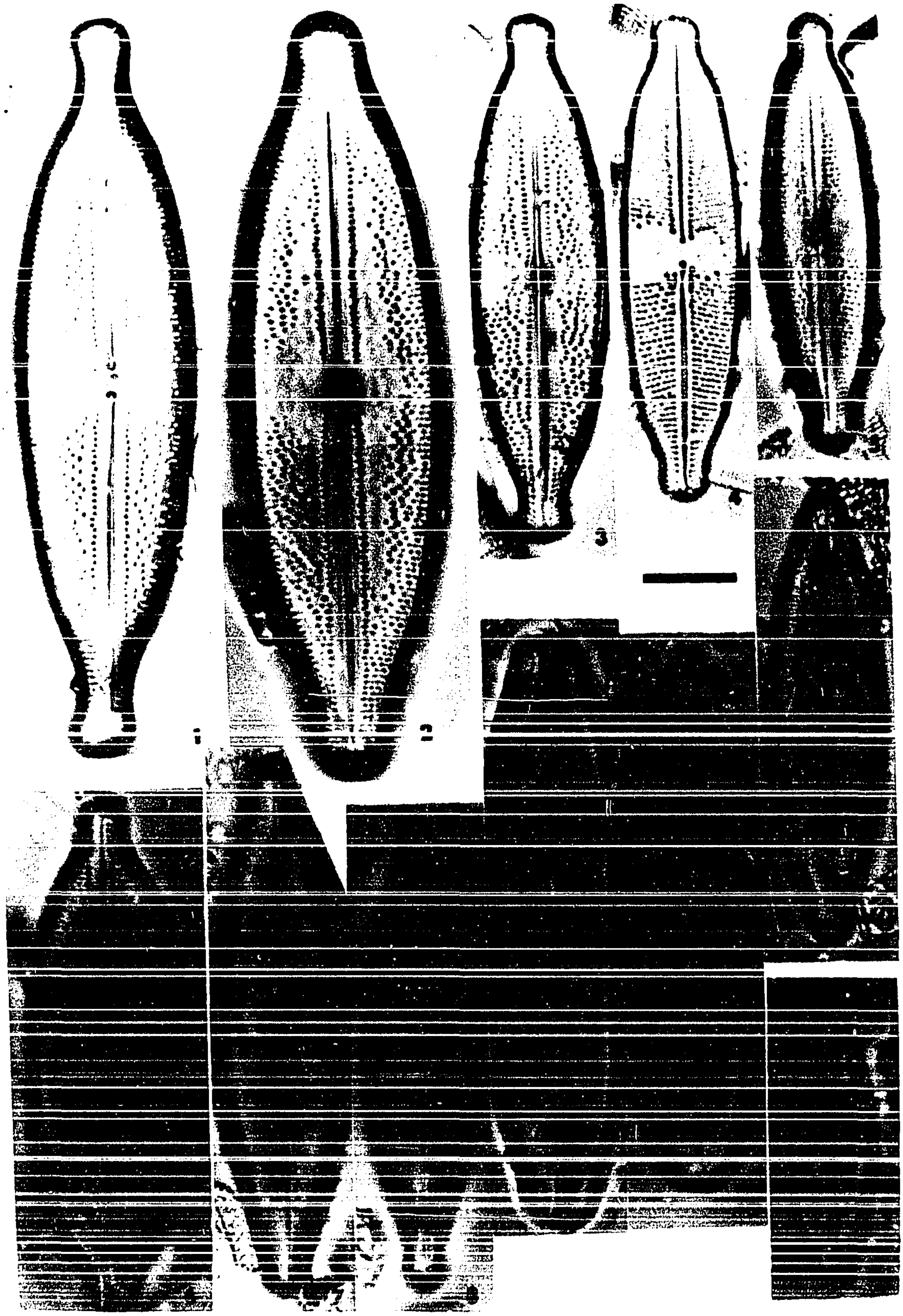
Fig. 12. *Amphora* sp. #10

Fig. 13. *Anomoeoneis* sp. #1

PLATE IV
(Scale is 10 μ long)

Fig. 1-12. Anomoeoneis sphaerophora

var. sphaerophora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3

It is periphytic, limnobiontic, and salt indifferent (to oligohalobous), but also found in brackish water. This species seems to prefer water with a fair amount of calcium.

Caloneis westii (Wm. Sm.) Hendey var. westii, An Intro. Account Small. Algae British Coastal Waters, p. 230, pl. 44, fig. 5-10, pl. 45, fig. 1-13. 1964. Pl. 5, Fig. 11, Pl. 6, Fig. 1-2.

Recorded once at A020 and F010.

Caloneis sp. #1. Pl. 5, Fig. 9-10.

Photographed from material collected at sites A and F but never occurred in counts from any of the sites.

Caloneis sp. #2. Pl. 5, Fig. 14.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Cocconeis Ehrenberg

Cocconeis placentula Ehr. var. placentula. Infusionsthierchen, p. 194. 1838. Pl. 6, Fig. 3-7.

Occurring consistently at all sites except H, where it was found at only the two lowest levels. It was particularly frequent at site G where counts in the 60's-80's were recorded. A considerable variation in size and shape has been observed for this species.

A widespread alkaliphilous form that has been found in both running and standing waters (more frequently in standing) through a pH range of 4.7-9.0 (with an optimum around 8). It is periphytic (epiphytic), current indifferent, and salt indifferent. It has also been found to be calcium indifferent.

PLATE V
(Scale is 10 μ long)

Fig. 1-4. *Caloneis bacillum* var. *bacillum*

Fig. 5-8. *Caloneis limosa* var. *limosa*

Fig. 9-10. *Caloneis* sp. #1

Fig. 11. *Caloneis westii* var. *westii*

Fig. 12. *Caloneis clevei* var. *tugelae*

Fig. 13. *Caloneis clevei* var. ?

Fig. 14. *Caloneis* sp. #2


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11

Cyclotella Kutzing

Cyclotella kansensis Hanna var. kansensis, Univ. of Kansas Science Bull., 20(21):376, pl. 31, fig. 6. 1932. Pl. 6, Fig. 8-10.

A very consistent representative of the populations at sites G, H, and I. Counts of over 150 specimens were common at site G and H, mostly less than 10 at site I.

This taxon was first described by Hanna from the same Wallace County marl deposits as those being investigated in this paper. According to Hanna (1932), "it is true that many of the older names and some of the modern are represented by such small and generalized figures that they can never be certainly determined, and it is possible that some one or more of them may have been applied to the present form. Rather than assume such to be the case without reasonable assurance of correctness, it seems best to provide a new name with an adequate illustration, although this is done reluctantly. The species is extremely small but beautifully and fairly constantly sculptured. The central beaded zone possesses no geometric pattern."

The beaded central area is indeed a characteristic feature of this taxon, but it should be emphasized that it is not always so intensely beaded and approaches Cyclotella meneghiniana Kütz. in these forms.

The ecology of Cyclotella kansensis Hanna is insufficiently known.

Cymatopleura Wm. Smith

Cymatopleura cochlea Brun. var. cochlea, Mem. Soc. Physique d'Histoire Nat. Geneve, 31(1):25, pl. 22, fig. 5. 1891. Pl. 6, Fig. 11.

This taxon was recorded only twice from A020.

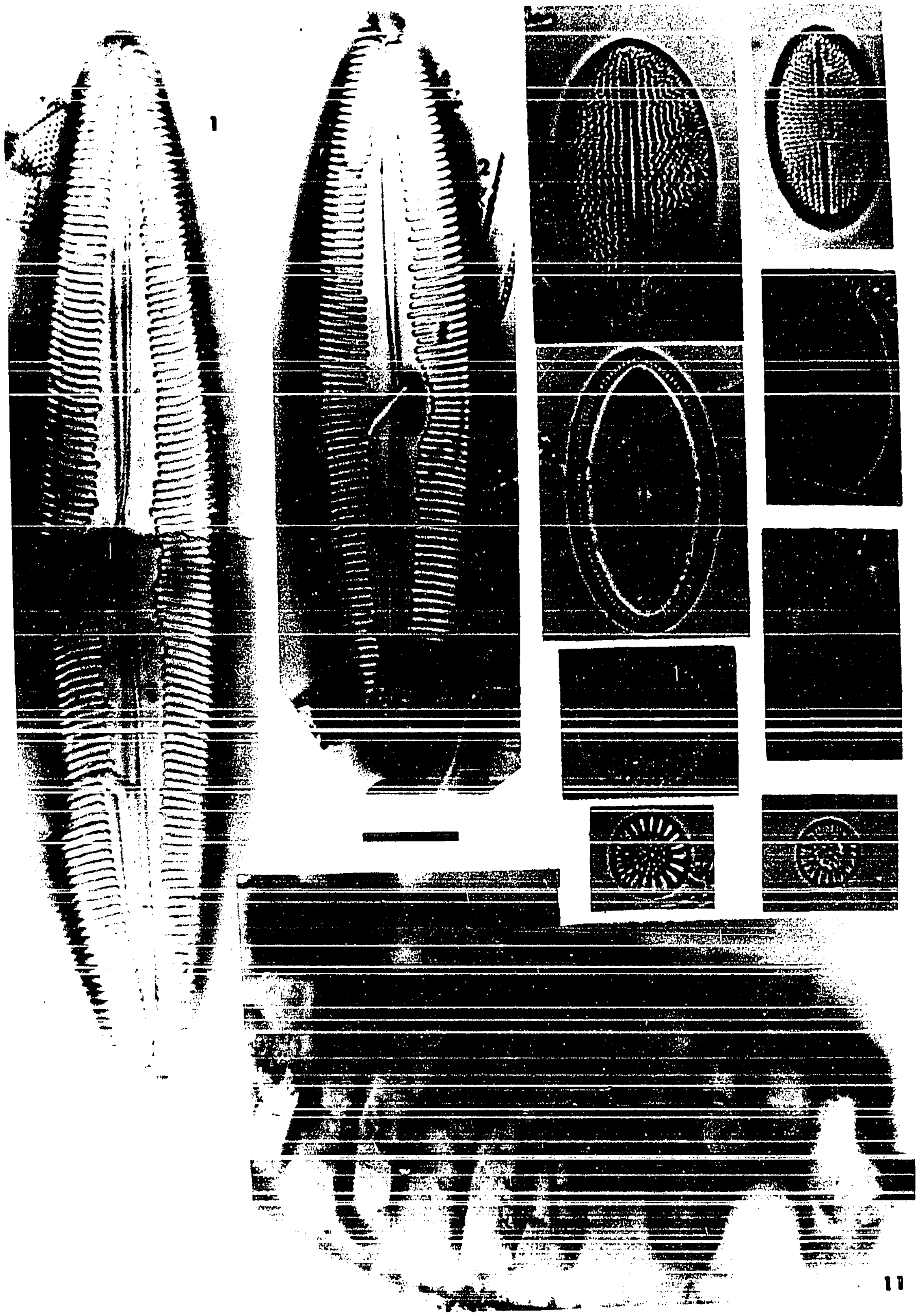
PLATE VI
(Scale is 10 μ long)

Fig. 1-2. Caloneis westii var. westii

Fig. 3-7. Cocconeis placentula var. placentula

Fig. 8-10. Cyclotella kansensis var. kansensis

Fig. 11. Cymatopleura cochlea var. cochlea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Cymbella Agardh

Cymbella acutiuscula Cl. var. acutiuscula, K. Svenska Vet.-Akad. Handl., Ny Foljd, 26(2):164, pl. 4, fig. 26. 1894. Pl. 7, Fig. 1.

This taxon has a distribution in four of the six sites, being recorded only once at D020, G060, and H000, and twice at I290.

The ecology of this taxon is insufficiently known.

Cymbella aspera (Ehr.) H. Perag. var. aspera, in Pell., Diatomees, pt. 3:237. 1889. Pl. 7, Fig. 2.

This taxon was recorded once at A020.

An alkaliphilous form that has often been reported from seeps and bogs (but also found in streams and lakes in shallower water) through a pH range of 6.3-9.0 (with an optimum between 7.0-8.5). It is periphytic, current indifferent, and salt indifferent to oligohalobous. It is also considered calcium indifferent.

Cymbella aspera var. ? Pl. 7, Fig. 3.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Cymbella austriaca Grun. var. austriaca, in A.S., Atlas Diat., pl. 9, fig. 10. 1875. Pl. 8, Fig. 1-3.

This taxon was a unique representative of five of the seven levels of site H.

An acidophilous form characteristic of alpine waters having a pH less than 6. It is limnophilous and salt indifferent.

Cymbella cesatii (Rabh.) Grun. ex A.S. var. cesatii, Atlas Diat., pl. 71, fig. 48, 49. 1881. Pl. 8, Fig. 4-9.

PLATE VII
(Scale is 10 μ long)

Fig. 1. *Cymbella acutiuscula* var. *acutiuscula*

Fig. 2. *Cymbella aspera* var. *aspera*

Fig. 3. *Cymbella aspera* var. ?


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This taxon is only one of two (the other is Cymbella minuta var. silesiaca) that was recorded in all of the 62 samples of the six sites. Counts in the 30's-60's were commonly recorded through sites G, H, and I, usually less than 20 for sites A, D, and F.

Within certain size ranges, this taxon is similar in shape and appearance to Cymbella angustata (Wm. Sm.) Cl. According to Patrick and Reimer (1975), "it is best distinguished by the narrow, very subtle ends in contrast to the broader, distinctly rostrate to capitate ends of Cymbella angustata. When clearly visible, the distal raphe ends are more bayonet-shaped than comma-shaped as in Cymbella angustata, even though both are similarly prolonged from sub-terminal nodules."

Three fairly distinct forms of this taxon can be distinguished from this Ogallala material, represented in plate 8 as figures 4-5, 6-7-8-9, and 10-11-12, respectively. With respect to the distinction between Cymbella cesatii and Cymbella angustata, a continuum can be established, through pictures, which places Cymbella cesatii at one end and Cymbella augustata at the other. But, where do those forms belong that lie along the middle of such a continuum? Since they do not appear to belong to either taxon, it is best to consider all forms as members of one highly variable taxon.

The distinction between these forms and a third, larger member of this complex has resulted in the establishment of Cymbella cesatii var. ? as a taxonomic entity unto itself.

The ecology of Cymbella cesatii is insufficiently known.

Cymbella cesatii var. ? Pl. 8, Fig. 10-12.

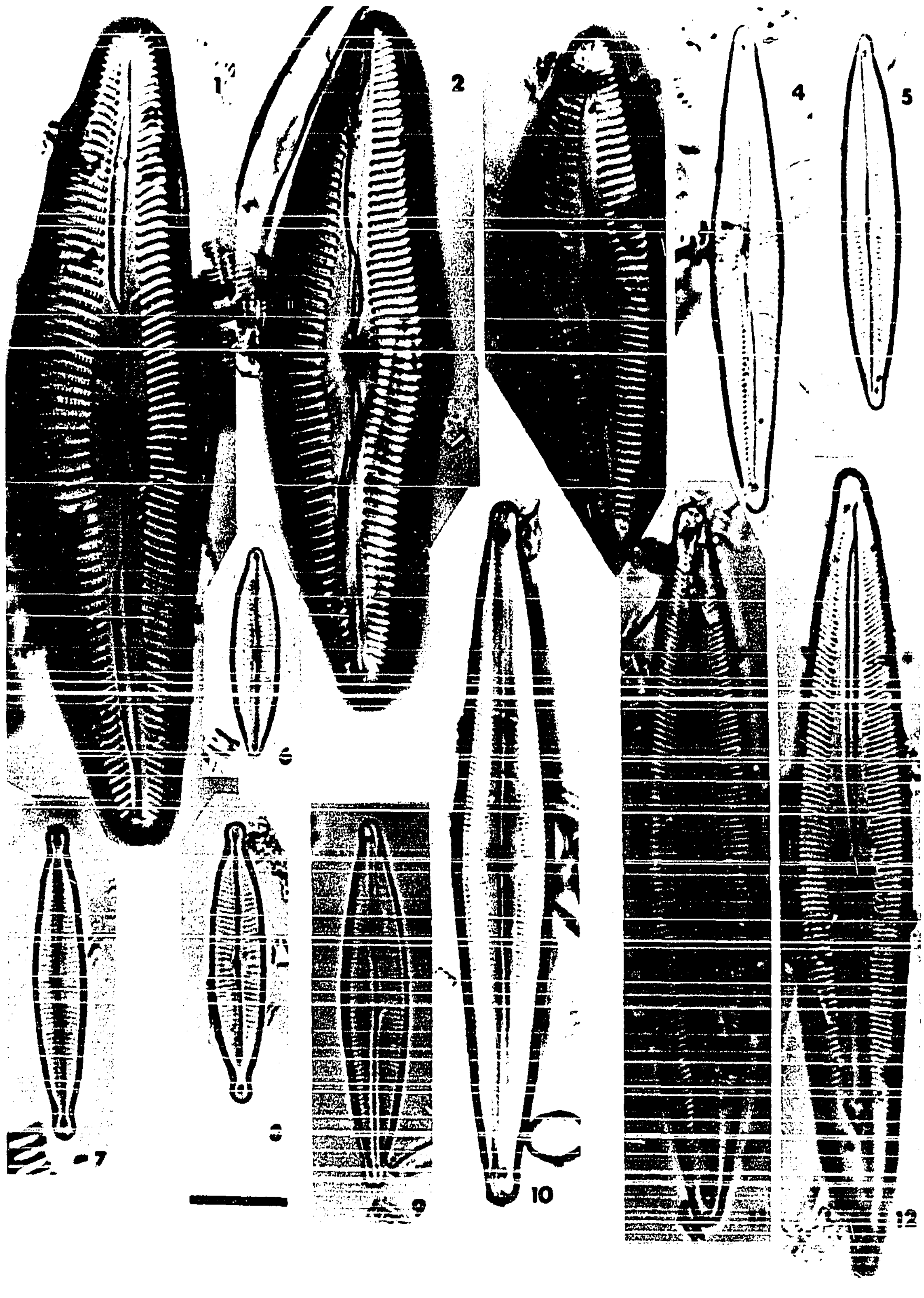
This taxon was common to sites A, D, F, and H in numbers less than 15.

PLATE VIII
(Scale is 10 μ long)

Fig. 1-3. Cymbella austriaca var. austriaca

Fig. 4-9. Cymbella cesatii var. cesatii

Fig. 10-12. Cymbella cesatii var. ?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This form is considered sufficiently distinct from the other members of this species complex to be considered as a separate taxon.

Cymbella cistula (Ehr. in Hempr. and Ehr.) Kirchn. var. cistula, in Cohn, Kryptog.-Fl. Schlesien, Band 2(1):189. 1878. Pl. 9, Fig. 1-9.

This taxon was observed at every level at sites F, H, and I in numbers below 30, as well as at sites A, D, and G in somewhat lesser numbers.

An alkaliphilous form that has been found in lakes and streams through a pH range of 4.3-8.6 (with an optimum around 8). It is periphytic (epiphytic), limnophilous to limnobiontic, and salt indifferent to oligohalobous. This species appears to reach its optimal development in waters close to saturation with oxygen.

Cymbella hauckii V.H. var. hauckii, in Hauck and Richter, Phycotheca Universalis, Faxc. 3, No. 147. 1887. Pl. 10, Fig. 1-6.

This taxon was recorded at sites G (at levels G040 and G190) and I. According to Patrick and Reimer (1975) this taxon is "difficult to distinguish upon first glance from Cymbella acutiuscula." This is particularly true in the case of some of the smaller forms of Cymbella acutiuscula. Cymbella hauckii possesses a considerable degree of variation with respect to shape.

The ecology of this taxon is insufficiently known.

Cymbella inaequalis (Ehr.) Rabh. var. inaequalis, Deutschland's Kryptog.-Fl., Band 2, Abt. 2, p. 38. 1847. Pl. 10, Fig. 7.

Photographed from material collected at site A but never occurred in counts from any of the sites.

This is a particularly distinctive taxon which has been mistakenly renamed by Andrews (1970) as a new species from the Kilgore deposit in

PLATE IX
(Scale is 10 μ long)

Fig. 1-9. Cymbella cistula var. cistula

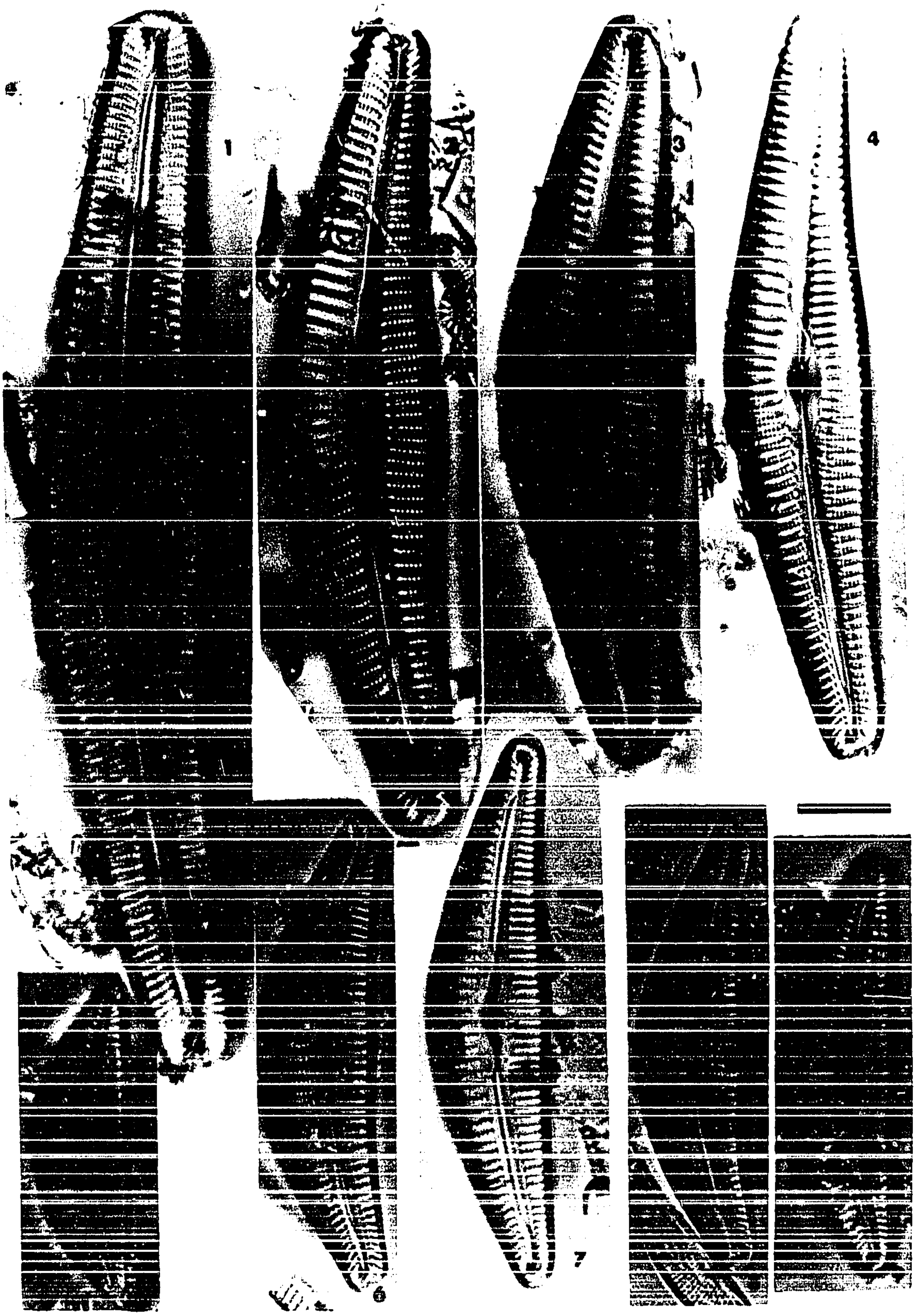
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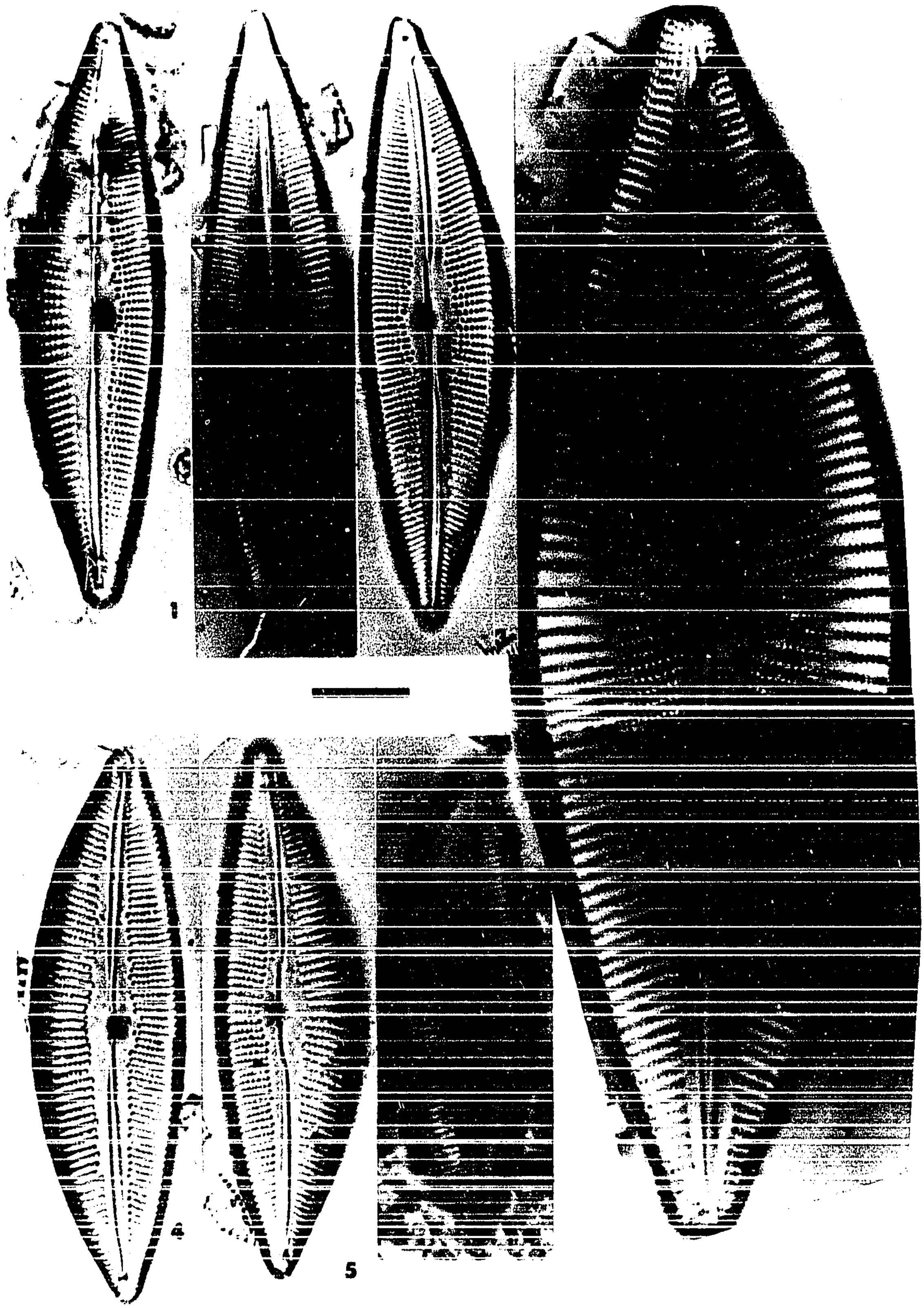
PLATE X
(Scale is 10 μ long)

Fig. 1-6. Cymbella hauckii var. hauckii

Fig. 7. Cymbella inaequalis var. inaequalis


1
4
5

Nebraska with the comment that because of its large size and distinctive punctation, Navicula niobrara "should be an excellent marker fossil."

Cymbella inaequalis is often reported from lakes, with some records from moderate-sized rivers.

Cymbella laevis Naeg. ex Kütz. var. laevis, Sp. Alg., p. 58. 1849.

Pl. 11, Fig. 1-4.

This taxon was observed twice at I050, once at H000 and H020, and had only a scattered distribution through site G.

The ecology of this taxon is insufficiently known.

Cymbella mexicana (Ehr.) Cl. var. mexicana, K. Svenska Vet.-Akad. Handl., Ny Foljd, 26(2):177. 1894. Pl. 11, Fig. 5-8, Pl. 12, Fig. 1.

This taxon had a consistent distribution through all but one level of site G, and scattered distributions through sites A, D, F, and I. It was not found at site H.

According to Patrick and Reimer (1975), Cymbella mexicana has radiate striae with "shorter striae interposed around the central area." None of the specimens I have observed from this material have had shorter striae interposed at mid-valve.

The ecology of this taxon is insufficiently known. It is most often reported from hard waters (alkaliphilous?).

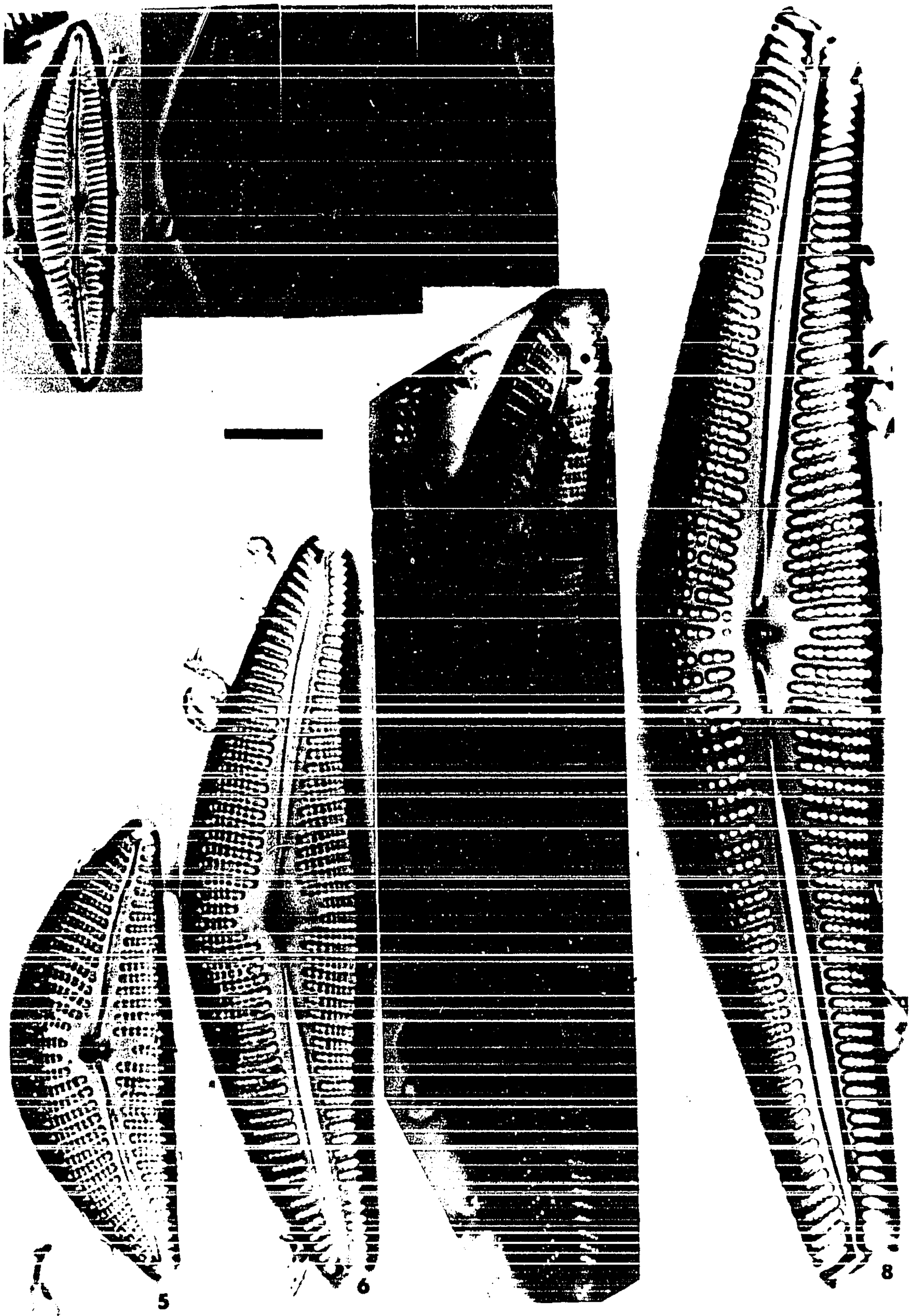
Cymbella microcephala Grun. var. microcephala, in V.H., Syn. Diat. Belgique, pl. 8, fig. 36, 37-39. 1880. Pl. 12, Fig. 2.

This taxon had consistent distributions through the upper five levels of site G and through all of sites H and I. It was found only three times at A020.

PLATE XI
(Scale is 10 μ long)

Fig. 1-4. Cymbella laevis var. laevis

Fig. 5-8. Cymbella mexicana var. mexicana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This taxon appears to belong to the highly variable Cymbella cesatii species complex.

An alkaliphilous form that has been found in streams and lakes (and other well-aerated habitats) through a pH range of 4.3-9.0. It is periphytic, current indifferent, and salt indifferent to oligohalobous. It is also considered calcium indifferent.

Cymbella minuta var. pseudogracilis (Choln.) Reim., Diatoms of the U.S., p. 50, pl. 9, fig. 1a-2b. 1975. Pl. 12, Fig. 3.

Photographed from material collected at sites A and I but never occurred in counts from any of the sites. Found so far in this country in slightly to moderately alkaline waters.

Cymbella minuta var. silesiaca (Bleisch ex Rabh.) Reim., Diatoms of the U.S., p. 49, pl. 8, fig. 7a-10b. 1975. Pl. 12, Fig. 4-11.

This taxon was only one of two taxa (along with Cymbella cesatii var. cesatii) that was recorded in all 62 samples of the six sites. Counts at various levels of both sites G and I reached as high as the 120's. As delimited presently, this taxon enjoys considerable variation. Further study is necessary before this variation within the Ogallala is completely understood.

This species complex is very widespread and is tolerant of a wide range of ecological conditions. In the U.S., it appears to be pH indifferent to oligohalobous.

Cymbella muelleri Hust. var. muelleri, Arch. Hydrobiol. Suppl., 15(3):425. 1938. Pl. 12, Fig. 12-18; Pl. 13, Fig. 1-4.

This taxon had a fairly consistent distribution through all of the six sites but at frequencies that were rather low.

An alkaliphilous (alkalibiontic?) form that has been found in springs and lakes through a pH range of 7.5-8.2 (with an optimum around 8). It is one of the most important indicator forms of alkaline springs and waterfalls in this pH range.

Cymbella pusilla Grun. var. pusilla, in A.S., Atlas Diat., pl. 9, fig. 36, 37. 1875. Pl. 13, Fig. 5.

This taxon was a unique representative of the populations at site G although it occurred at low frequencies and was distributed rather randomly.

This species is found most often in waters with a moderately high conductivity, i.e., springs, drying ponds, and occasionally in brackish waters of estuaries. It is pH indifferent and oligohalobous to mesohalobous.

Cymbella sp. #1. Pl. 13, Fig. 6-9.

This taxon was recorded only once at F020.

Cymbella sp. #2. Pl. 13, Fig. 10-12; Pl. 14, Fig. 1.

This taxon was a very common representative of the populations at sites H and I. One specimen was also recorded from A010.

Cymbella sp. #4. Pl. 14, Fig. 2-3.

Photographed from material collected at sites H and I but never occurred in counts from any of the sites.

Cymbella sp. #5. Pl. 14, Fig. 4-5.

This taxon was recorded only twice from I070.

Cymbella sp. #6. Pl. 14, Fig. 6-7.

Photographed from material collected at site I but never occurred in counts from any of the sites. This taxon might be Cymbella norwegica f.

PLATE XII
(Scale is 10 μ long)

Fig. 1. *Cymbella mexicana* var. *mexicana*

Fig. 2. *Cymbella microcephala* var. *microcephala*

Fig. 3. *Cymbella minuta* var. *pseudogracilis*

Fig. 4-11. *Cymbella minuta* var. *silesiaca*

Fig. 12-18. *Cymbella muelleri* var. *muelleri*

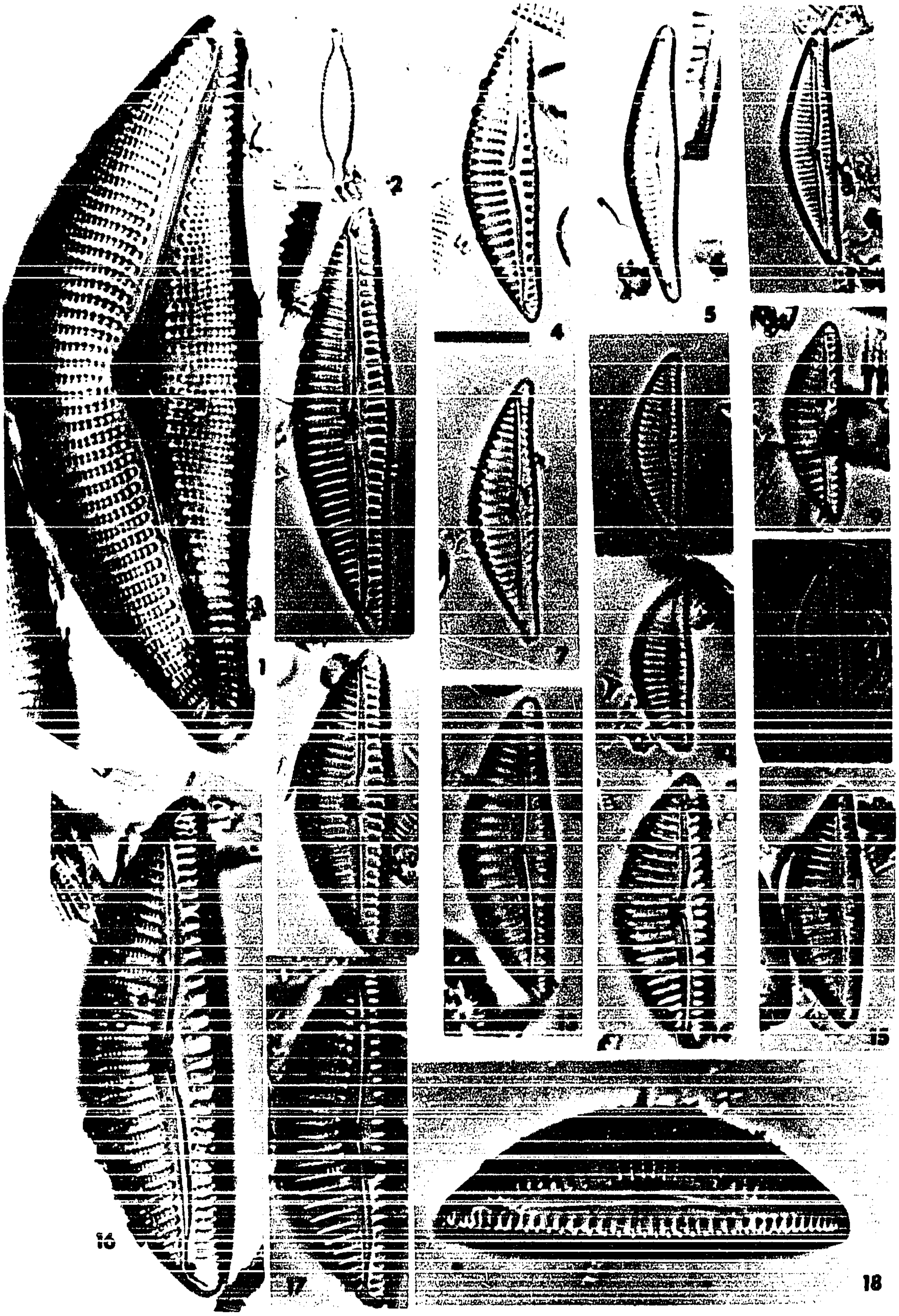

PLATE XIII
(Scale is 10 μ long)

Fig. 1-4. Cymbella muelleri var. muelleri

Fig. 5. Cymbella pusilla var. pusilla

Fig. 6-9. Cymbella sp. #1

Fig. 10-12. Cymbella sp. #2


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minor Fusey (1940).

Cymbella sp. #7. Pl. 14, Fig. 8-9.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Cymbella sp. #9. Pl. 14, Fig. 10-11.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Cymbella sp. #10. Pl. 14, Fig. 12.

Photographed from material collected at site G but never occurred in counts from any of the sites. Cymbella rautenbackiae Cholnoky and Cymbella helvetica Kütz. have been considered as possible taxa into which this form belongs.

Cymbella sp. #11. Pl. 14, Fig. 13.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Denticula Kutzing

Denticula elegans var. kittoniana (Grun.) DeT., Syll. Alg., vol. 2, sect. 2, p. 558. 1892. Pl. 14, Fig. 15-21.

This taxon was distributed through sites G, H, and I, being found at every sample at sites H and I and through the upper 9 samples of site G. Counts reached over 100 at several levels and as high as 225 at I200.

An alkaliphilous form in alpine regions, but more abundant in acid habitats on the plains. It seems to prefer waters of high conductivity and is more frequently aerophilous than littoral in standing water.

Diatoma Bory

Diatoma vulgare var. grande (Wm. Sm.) Grun., Verh. Zool.-Bot. Ges. Wien, 12:364. 1862. Pl. 14, Fig. 14.

Photographed from material collected at site H but never occurred in counts from any of the sites. An alkalibiontic form that seems to prefer cool, flowing water with a fairly high nutrient content. It is pH indifferent to halophobic, and epiphytic on the marginal hydrophytes of streams, rivers, and ditches.

Diploneis Ehrenberg

Diploneis oblongella (Naeg. ex Kütz.) Ross var. oblongella, Natl. Mus. Canada Bull., No. 97, p. 212. 1947. Pl. 14, Fig. 22-25.

This taxon enjoyed a consistent distribution through sites A, D, and F and was recorded once at I150, I160, I200, and I210.

According to Patrick and Reimer (1966) "the only difference between the taxa Diploneis ovalis and Diploneis oblongella is their size. Since the size seems to intergrade, the two species have been considered synonyms."

An alkaliphilous form that has been found in fresh to slightly brackish water of lakes and rivers through a pH range with an optimum over 8. It is aerophilous and periphytic, current indifferent, calcium indifferent, and salt indifferent to oligohalobous.

Epithemia Brebisson

Epithemia adnata var. proboscidea (Kütz.) Patr., Diatoms of the U.S., p. 181, pl. 24, fig. 5. 1975. Pl. 14, Fig. 26.

This taxon was observed only once at I180.

According to Patrick and Reimer (1975), this taxon may be the same as Epithemia porcellus Kütz.

An alkaliphilous form that is epiphytic on aquatic plants of the littoral zone.

Epithemia sp. #1. Pl. 15, Fig. 1-8.

This taxon was recorded at every level of sites A, D, and F in numbers as high as 27 (at A020).

The characteristic curvature of this form resembles no presently known member of this genus.

Eunotia Ehrenberg

Eunotia curvata (Kütz.) Lagerst. var. curvata, Ofv. K. Svenska Vet.-Akad. Forh., 41(2):61. 1884. Pl. 15, Fig. 9-10.

Found at every level of site D, randomly distributed through sites A and F, and recorded once at G050.

An acidophilous to indifferent (to slightly alkaliphilous?) form that has been found in springs, rivers, ponds, and lakes through a pH range of 4.0-9.0 (with an optimum between 5.5-6.0). It has its best development in swamps or shallow ponds. It is tychoplanktonic or periphytic, current indifferent, and salt indifferent to halophobous. This taxon is widely distributed in water or low mineral content and is calcium indifferent.

Eunotia galcialis Meist. var. glacialis, Beitr. Kryptog.-Fl. Schweiz., 4(1), p. 85, pl. 10, fig. 2-3. 1912. Pl. 15, Fig. 12.

This taxon was recorded only once at A000.

PLATE XIV

(Scale is 10 μ long)

Fig. 1. Cymbella sp. #2

Fig. 2-3. Cymbella sp. #4

Fig. 4-5. Cymbella sp. #5

Fig. 6-7. Cymbella sp. #6

Fig. 8-9. Cymbella sp. #7

Fig. 10-11. Cymbella sp. #9

Fig. 12. Cymbella sp. #10

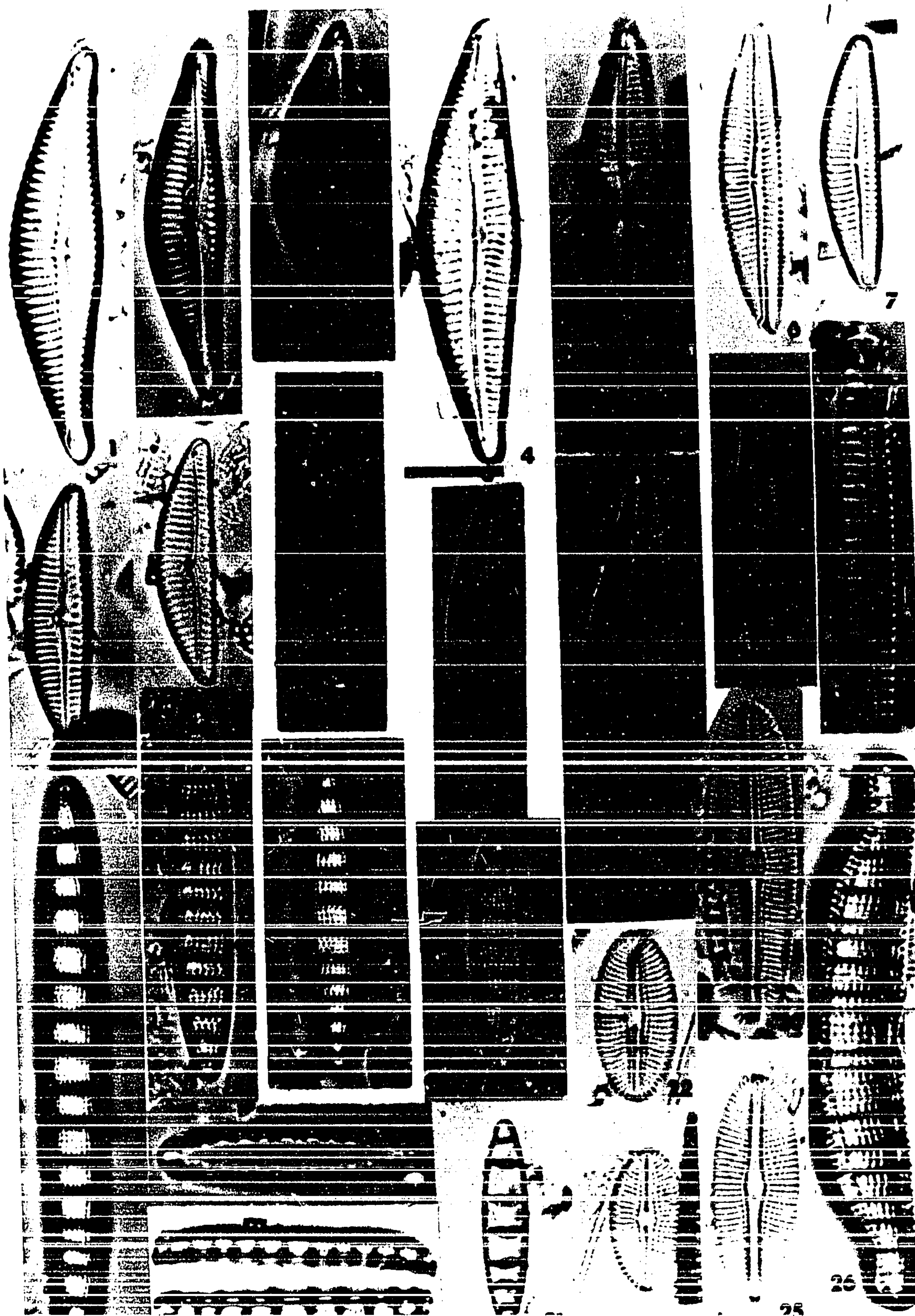
Fig. 13. Cymbella sp. #11

Fig. 14. Diatoma vulgare var. grande

Fig. 15-21. Denticula elegans var. kittoniana

Fig. 22-25. Diploneis oblongella var. oblongella

Fig. 26. Epithemia adnata var. proboscidea



It is found in acid to circumneutral water of low mineral content, and usually in cool water.

Eunotia major var.? Pl. 15, Fig. 13-14; Pl. 16, Fig. 1.

Photographed from material collected at site A but never occurred in counts from any of the sites.

This taxon, especially the specimen photographed in Fig. 1 of Plate 16, is very similar to Eunotia formica Ehr., but lacks the characteristic wedge-capitate ends of that species. I have decided not to call it Eunotia formica but, instead, consider it a variety of Eunotia major. Except for a much shorter length, the specimen photographed in Fig. 1 of Plate 16 is remarkably similar to Eunotia major var. gigantea Freng.

Eunotia major is a species that seems to prefer slightly acid water with low mineral content. It is found in swamps, bogs, lakes, and flowing water.

Eunotia praerupta Ehr. var. praerupta, Phys. Abh. Akad. Wiss. Berlin, for 1841:414. 1843. Pl. 16, Fig. 3.

This taxon was randomly distributed through sites A, D, and F in very low numbers.

Usually found in northern or mountainous localities in acid to circumneutral waters. It is considered oligohalobous.

Eunotia vanheurckii Patr. var. vanheurckii, Not. Nat. Acad. Nat. Sci. Philadelphia, No. 312, p. 12, fig. 12. 1958. Pl. 15, Fig. 11.

Photographed from material collected at site A but never occurred in counts from any of the sites.

According to Patrick and Reimer (1966), the ventral margin of this species is "straight or slightly concave, often thickened about halfway

PLATE XV
(Scale is 10 μ long)

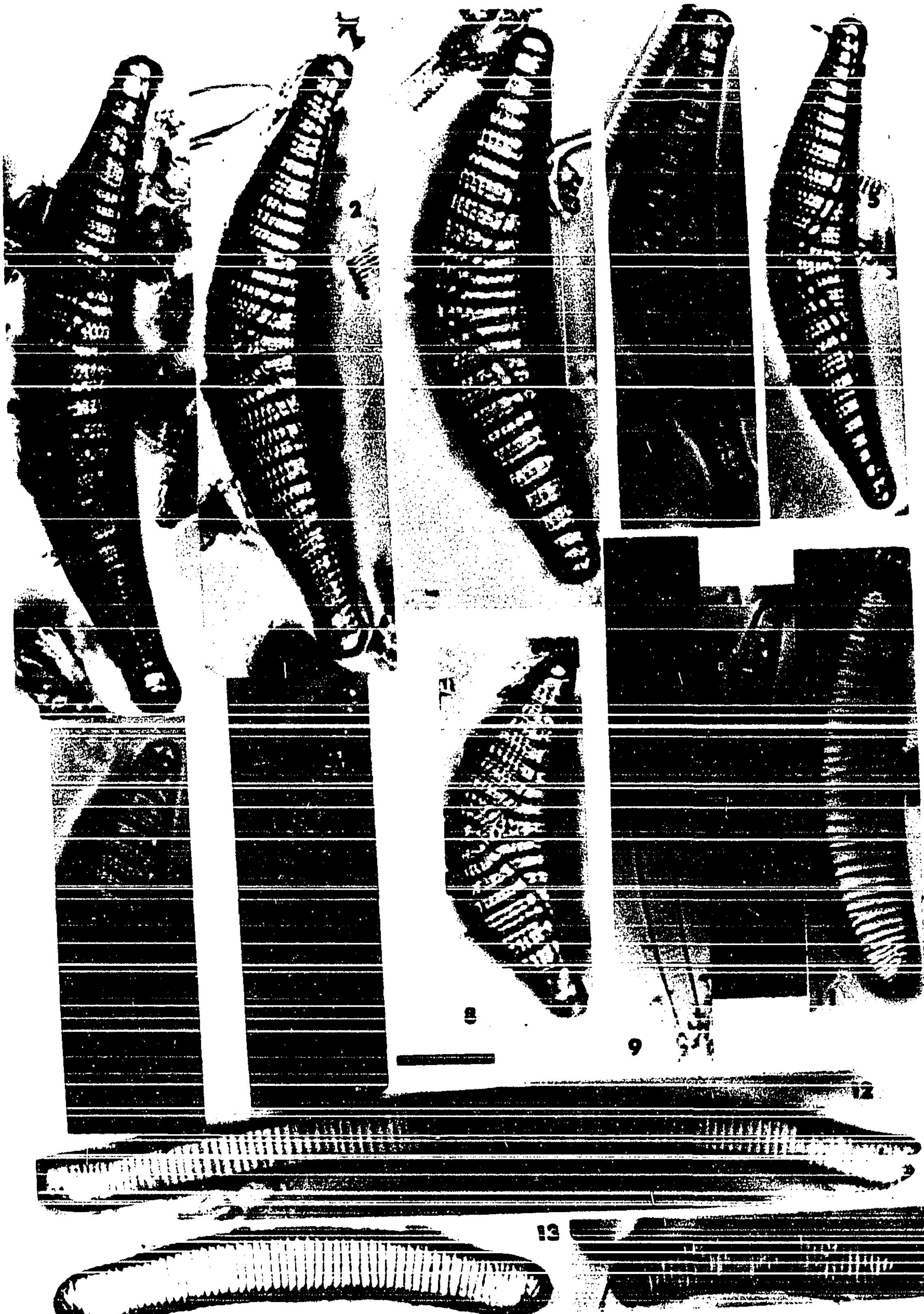
Fig. 1-8. Epithemia sp. #1

Fig. 9-10. Eunotia curvata var. curvata

Fig. 11. Eunotia vanheurckii var. vanheurckii

Fig. 12. Eunotia glacialis var. glacialis

Fig. 13-14. Eunotia major var. ?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between the center and the apices of the valve."

The only specimen observed in the present investigation lacks such ventral thickenings.

This species has been found in ponds, lakes, and swamps.

Eunotia sp. #1. Pl. 16, Fig. 2.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Eunotia sp. #2. Pl. 16, Fig. 5.

Recorded once at D010.

Eunotia sp. #3. Pl. 16, Fig. 4.

Recorded once at F020.

Eunotia sp. #4. Pl. 16, Fig. 6.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Fragilaria Lyngbye

Fragilaria brevistriata Grun. var. brevistriata, in V.H., Syn. Diat. Belgique, p. 157. 1885. Pl. 16, Fig. 7-14.

Except for its absence at but a very few levels, this taxon was consistently distributed through all of the six sites, in numbers that reached into the 100's at sites A, D, and F.

A considerable number of varieties and forms have been recognized for this taxon, most of which have not been seriously considered in this paper. A continuum can be established through the smaller to the larger forms and the supposed distinctions between them are lost. Fragilaria brevistriata f. intermedia Manguin, Fragilaria brevistriata f. elongata

Venkataraman, and Fragilaria brevistriata var. elliptica Heribaud represent just a few of these.

An alkaliphilous form that has been found in lakes, ponds, and bogs through a pH range of 6.5-9.0 (with an optimum of between 7.5-7.8). It is periphytic, current indifferent, salt indifferent to halophilous, and tolerant of fresh water of a wide range of conductivity.

Fragilaria brevistriata var. inflata (Pant.) Hust. in Pasch., Sussw.-Fl. Mitteleuropas, Heft 10, Aufl. 2, p. 145, fig. 152. 1930. Pl. 16, Fig. 15-24.

This taxon was recorded from 61 of the 62 samples, and in numbers that were particularly high through site I. A majority of the counts at the levels of site I were over 150 and as high as 489 at I260. A number of named varieties exist for many of the forms that have been observed in this study. The distinction between many of them is nonexistent and have, therefore, not been considered.

This is an alkaliphilous (7.4-9.0) form that seems to prefer waters of fairly high conductivity.

Fragilaria construens (Ehr.) Grun. var. construens, Verh. Zool.-Bot. Ges. Wien, 12:371. 1862. Pl. 16, Fig. 27-28.

This taxon was recorded once at A010 and four times at A020.

An alkaliphilous form that has been found in lakes, ponds, springs, and streams through a pH range of 6.0-9.0 (with an optimum between 7.7-7.8). It is periphytic and tychoplanktonic, current indifferent, calcium indifferent, and salt indifferent.

Fragilaria construens var. binodis (Ehr.) Grun., Verh. Zool.-Bot. Ges. Wien, 12:371. 1862. Pl. 16, Fig. 26.

This taxon was recorded only once at A000.

A species that seems to prefer cool, fresh water, and can tolerate water with a fairly high conductivity. It is common in the littoral zone of running and stagnant water lakes and is salt indifferent with a pH tolerance between 6.4-8.6.

Fragilaria construens var. exigua (Wm. Sm.) Schulz, Arch. f. Hydrobiol. Bd. 12, S. 750, fig. 9-16. 1920. Pl. 16, Fig. 25.

This very peculiar taxon was one of only a very few that was not photographed during preliminary investigations. During the counting period, it was recorded five times at A020 and never seen again. The ecology of this taxon is insufficiently known

Fragilaria construens var. venter (Ehr.) Grun. in V.H., Syn. Diat. Belgique, pl. 45, fig. 21b, 22, 23, 24b, 26a-b. 1881. Pl. 17, Fig. 1-14.

Except for a very few samples, this taxon was distributed consistently through all of the six sites. It was recorded in particularly high numbers at site I (93, 97, 136).

This taxon is highly variable in shape, and includes a wide variety of forms.

A widely distributed, alkaliphilous form that has been found in lakes, streams, springs, and bogs through a pH range of 6.0-9.0. It is tychoplanktonic or periphytic, limnobiontic, salt indifferent, and seems to prefer water of fairly high nutrient content.

Fragilaria construens var. ? Pl. 17, Fig. 15-16.

This taxon was distributed consistently through sites A, D, and F and recorded only three times at H020. It is an interesting form and its

PLATE XVI

(Scale is 10 μ long)

Fig. 1. Eunotia major var. ?

Fig. 2. Eunotia sp. #1

Fig. 3. Eunotia praerupta var. praerupta

Fig. 4. Eunotia sp. #3

Fig. 5. Eunotia sp. #2

Fig. 6. Eunotia sp. #4

Fig. 7-14. Fragilaria brevistriata var. brevistriata

Fig. 15-24. Fragilaria brevistriata var. inflata

Fig. 25. Fragilaria construens var. exigua

Fig. 26. Fragilaria construens var. binodis

Fig. 27-28. Fragilaria construens var. construens


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taxonomic position is unknown.

Fragilaria lapponica Grun. var. lapponica, in V.H., Syn. Diat. Belgique, pl. 45, fig. 35. 1881. Pl. 17, Fig. 21-30.

Except for a very few samples, this taxon was distributed consistently through all of the six sites. Numbers in the 40's-80's were recorded at sites A, D, and F with somewhat lesser numbers recorded for most of the other samples.

As considered presently, this taxon is a highly variable one. A number of named varieties and forms, (e.g., Fragilaria lapponica f. lanceolata Hust.), have been disregarded as a consequence of preliminary iconographic studies.

A pH indifferent form that has been found in stagnant water lakes through a pH range of 6.8-7.8. It seems to prefer waters of low mineral content and is salt indifferent.

Fragilaria pinnata var. lancettula (Schum.) Hust. in A.S., Atlas Diat., pl. 297, fig. 51, 59-64. 1913. Pl. 17, Fig. 17-19.

This taxon was distributed consistently through site A, less so through sites D, F, and G, and only distributed randomly through sites H and I.

A form that seems to prefer fresh to slightly brackish water or water of high conductivity. It has been found in waters of pH between 4.0-8.8.

Fragilaria pinnata var. ? Pl. 17, Fig. 20.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Fragilaria vaucheriae (Kütz.) Peters, var. vaucheriae, Bot. Not., for 1938(1/3):167, fig. 1c-g. 1938. Pl. 17, Fig. 31-35

This taxon seems to be related to Synedra rumpens Kütz.

It is an alkaliphilous form that has been found in standing water, as well as the flowing waters of rivers, streams, springs, and lakes through a pH range of 5.0-9.0 (with an optimum between 6.5-9.0). It is periphytic, current indifferent to rheophilous, and salt indifferent to oligohalobous.

Fragilaria virescens Ralfs var. virescens, Ann. Mag. Nat. Hist. 12:110, pl. 2, fig. 6. 1843. Pl. 17, Fig. 39-40.

This taxon was recorded five times from I080 and twice from I120.

A widely distributed pH indifferent (to acidophilous) form that has been found in streams, lakes, ponds, and ditches through a pH range of 6.4-6.8. It is current indifferent and salt indifferent to halophobous.

Fragilaria sp. #1. Pl. 17, Fig. 36-38.

This taxon was recorded at every level of site F, and three times at A000 and once at D000.

Gomphonema Agardh

Gomphonema acuminatum Ehr. var. acuminatum, Phys. Abh. Akad. Wiss. Berlin, for 1831:88. 1832. Further described, Infusionsthierchen, p. 217, pl. 18, fig. 4. 1838. Pl. 18, Fig. 1-3.

This taxon was distributed consistently through sites H and I in numbers usually less than 10, but as high as 29 at I140.

An alkaliphilous form that is best known as a littoral form in stagnant waters (and in springs, bogs, and lakes) of pH between 5.4-9.0 (with

PLATE XVII

(Scale is 10 μ long)

Fig. 1-14. Fragilaria construens var. venter

Fig. 15-16. Fragilaria construens var. ?

Fig. 17-19. Fragilaria pinnata var. lancettula

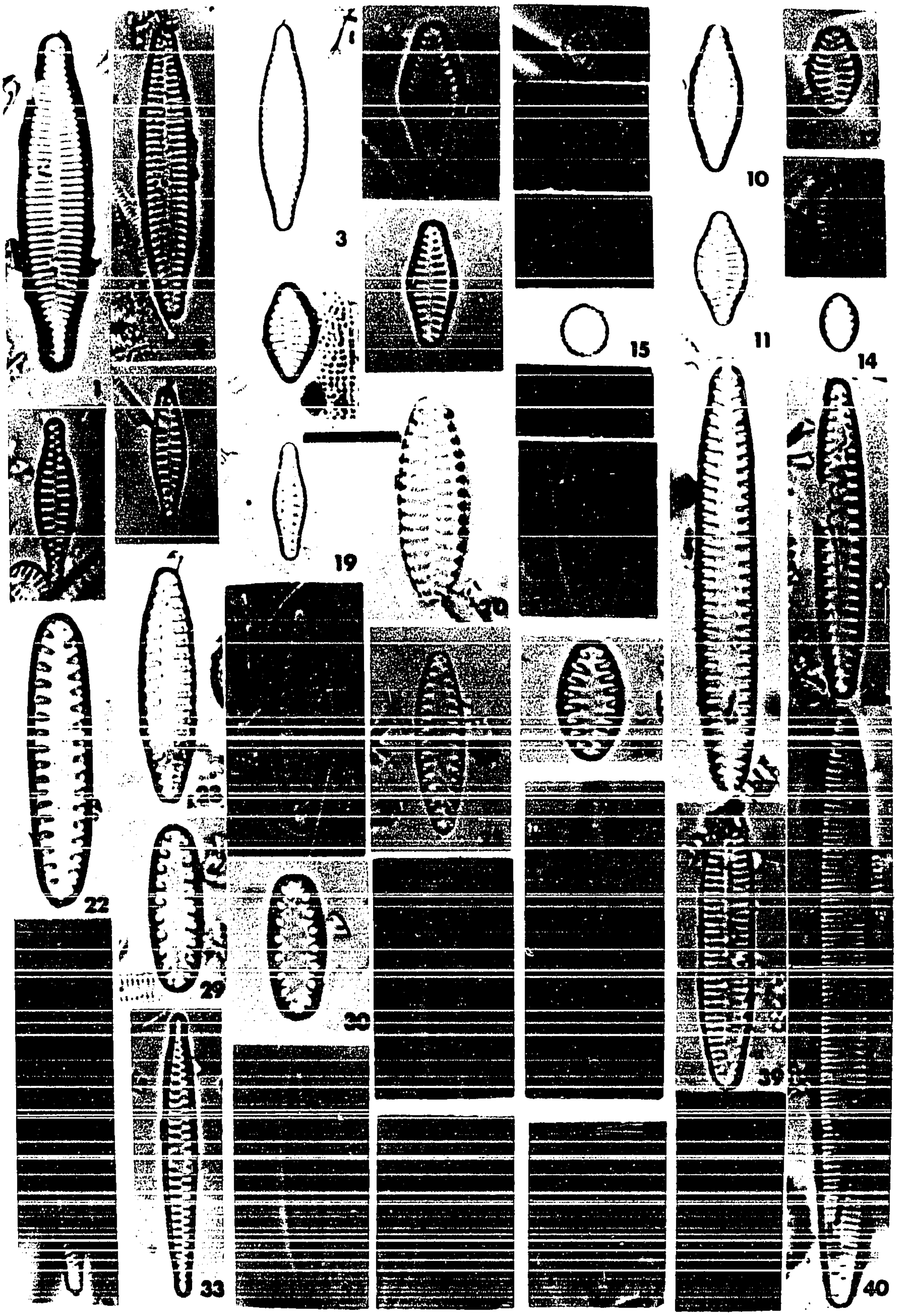
Fig. 20. Fragilaria pinnata var. ?

Fig. 21-30. Fragilaria lapponica var. lapponica

Fig. 31-35. Fragilaria vaucheriae var. vaucheriae

Fig. 36-38. Fragilaria sp. #1

Fig. 39-40. Fragilaria virescens var. virescens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an optimum around 8). It is periphytic, limnophilous, and salt indifferent to oligohalobous.

Gomphonema affine var. insigne (Greg.) Andrews, U.S. Gov. Surv. Prof. Paper 683-A:A20, pl. 3, fig. 12-16. 1970. Pl. 18, Fig. 4-15; Pl. 19, Fig. 1-10.

Except for its absence in but a very few samples, this taxon was distributed consistently through all of the six sites. It was recorded in numbers as high as 107, usually in the range of 20-50.

According to Andrews (1970), "the most distinctive characteristic of G. affine var. insigne in the Kilgore deposit is its high degree of variability both in external shape and internal ornamentation. The great variation in length together with nearly constant width causes considerable variation in external form. Some of the longer specimens resemble G. intricatum or even G. intricatum var. vibrio in external outline. In addition there is considerable variation in the fineness of the striae, whereas the spacing of the striae remains relatively constant. These factors seem however, to indicate only a high degree of variation within a single taxon. Because of the intergradation between individuals in the population, any attempt at differentiating the taxon into several species or varieties seems to be both arbitrary and useless."

This is a taxon that seems to prefer medium hard, circumneutral water. It has not been recorded in very acid or extremely soft water.

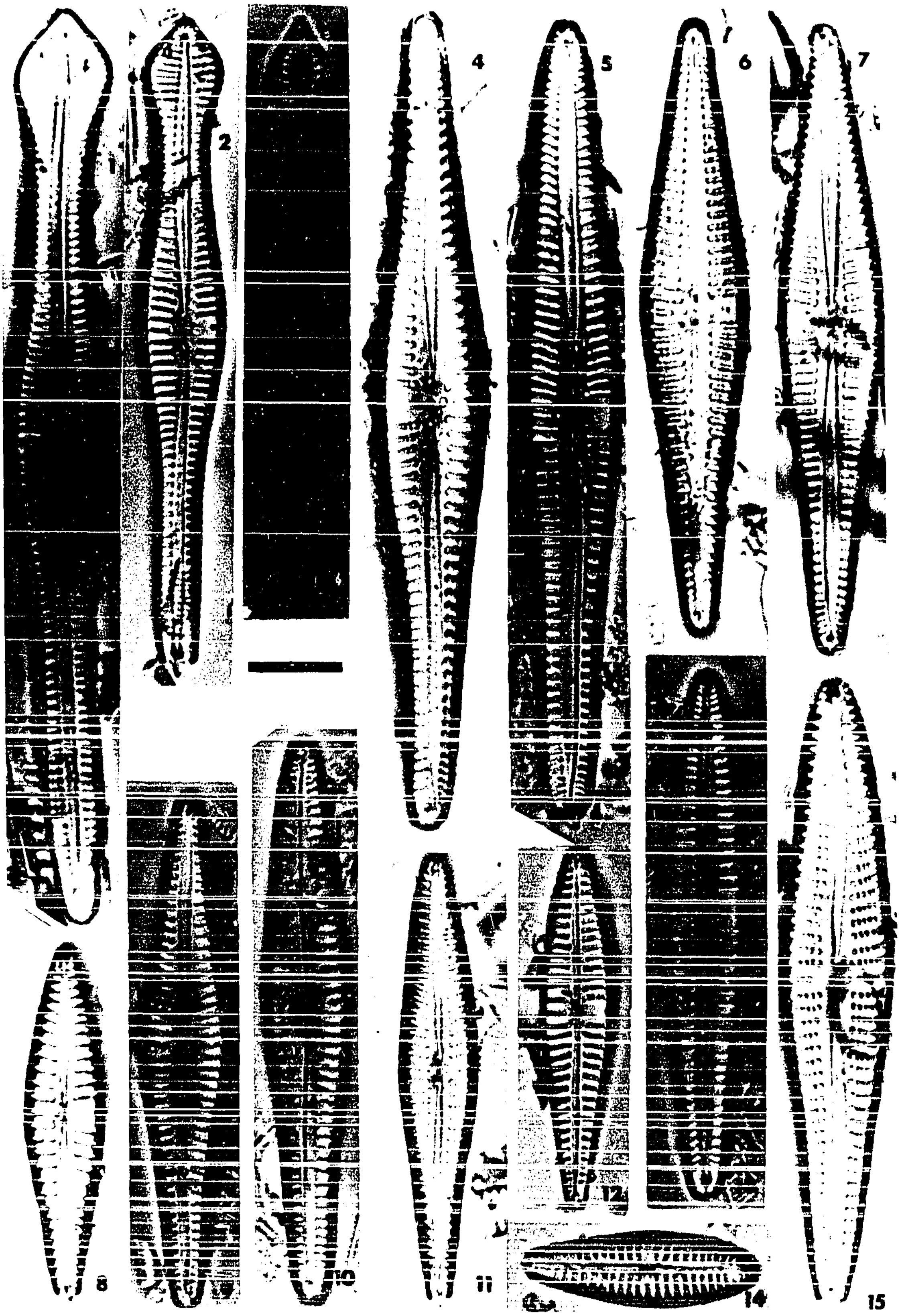
Gomphonema angustatum (Kütz.) Rabh. var. angustatum, Fl. Europaea Alg., sect. 1, p. 283. 1864. Pl. 19, Fig. 11-14.

This taxon had only a very random distribution in three sites, being recorded three times at D020, once at F000, I070, I080, and I150.

PLATE XVIII
(Scale is 10 μ long)

Fig. 1-3. Gomphonema acuminatum var. acuminatum

Fig. 4-15. Gomphonema affine var. insigne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An alkaliphilous form that has been found in ponds, springs, and streams through a pH range of 6.0-9.0 (with an optimum between 7.5-7.7). It is periphytic, current indifferent, and salt indifferent.

Gomphonema angustatum var. ? Pl. 19, Fig. 15-19.

This taxon had only a random distribution in four sites, being recorded twice at A010, and once at A000, F010, F030, I250, and I290.

Gomphonema dichotomum Kütz. var. dichotomum, Linnaea 8:569, pl. 15, fig. 48. 1833 (pro parte). Pl. 19, Fig. 20-25.

This taxon had a very consistent distribution (in numbers commonly less than 15) through sites G, H, and I. It had a more random distribution in sites A, D, and F.

Ecologically, this species seems to prefer circumneutral fresh water.

Gomphonema gracile Ehr. emend V.H. var. gracile, Syn. Diat. Belgique, p. 125. 1885. Pl. 20, Fig. 2.

This taxon was recorded once at F000.

A pH indifferent to alkaliphilous form of littoral and occasionally planktonic communities in water of pH 5.5-9.0 (with an optimum between 7.2-7.4). It is also considered periphytic, limnobiontic to limnophilous, calcium indifferent, tolerant of a wide range of conductivity, salt indifferent to oligohalobous (to halophobic), and seems to prefer water of low nutrient content.

Gomphonema martini Fricke var. martini, in A.S., Atlas Diat., pl. 238, fig. 22-25. 1904. Pl. 20, Fig. 1.

Photographed from material collected at site F but never occurred in counts from any of the sites.

PLATE XIX

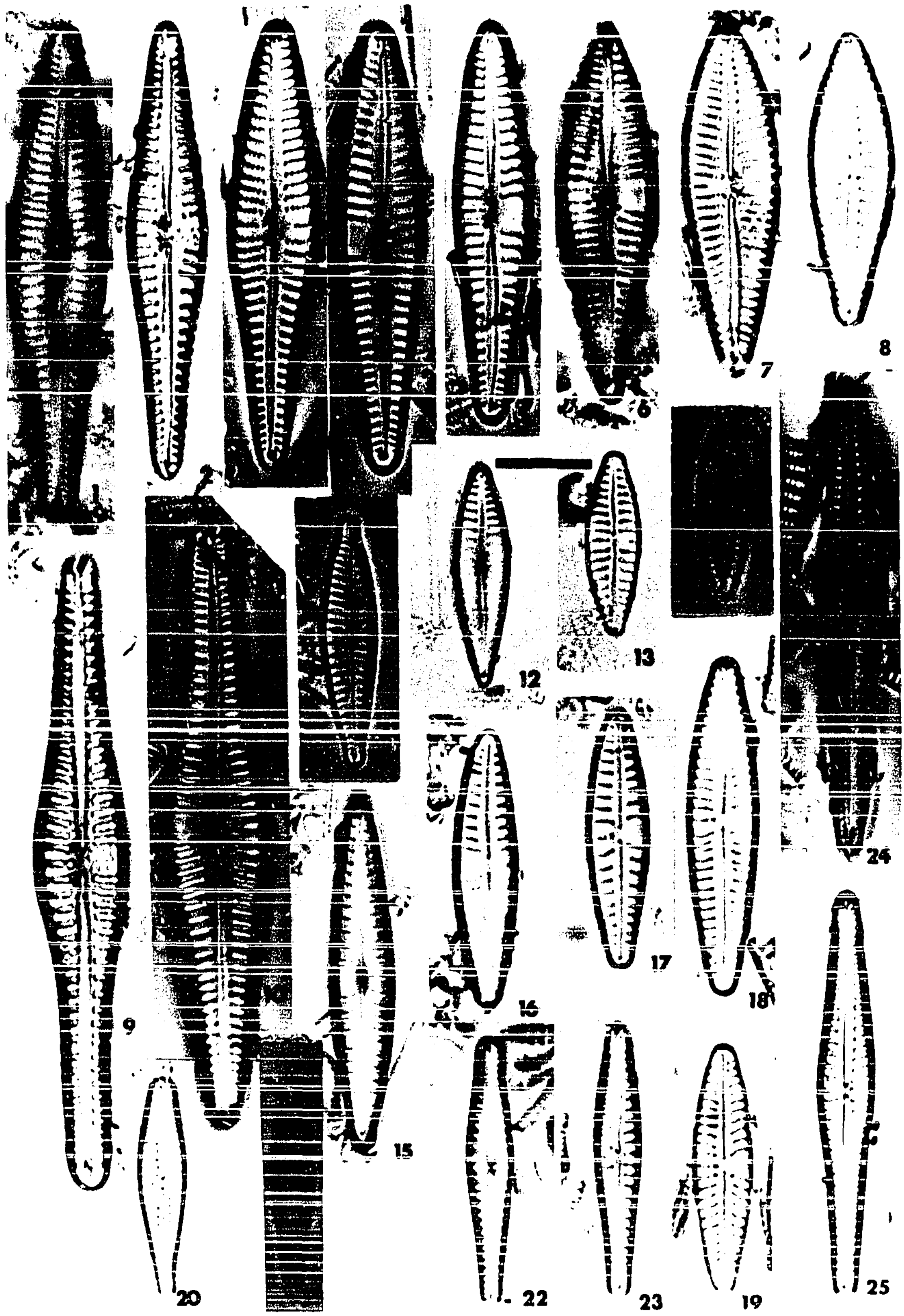
(Scale is 10 μ long)

Fig. 1-10. Gomphonema affine var. insigne

Fig. 11-14. Gomphonema angustatum var. angustatum

Fig. 15-19. Gomphonema angustatum var. ?

Fig. 20-25. Gomphonema dichotomum var. dichotomum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Gomphonema subclavatum (Grun.) Grun. var. subclavatum in V.H., Syn. Diat. Belgique, pl. 23, fig. 38-41. 1880. (Text p. 125, 1885). Pl. 20, Fig. 3-5.

This taxon was recorded once from D000 and twice from D010.

A littoral form that seems to prefer circumneutral water. It is oligohalobous to halophilous.

Gomphonema tackei Hust. var. tackei, Abh. Nat. Ver. Bremen, 32(1):205, fig. 16-18. 1942. Pl. 20, Fig. 6-9.

This taxon was randomly distributed in very low numbers through sites A, D, and F.

The ecology of this species is insufficiently known.

Gomphonema sp. #1. Pl. 20, Fig. 10.

Photographed from material collected at site G but never occurred in counts from any of the sites.

This taxon is most likely an anomaly. It has the appearance of a Gomphonema but appears to lack a raphe.

Hantzschia Grunow

Hantzschia amphioxys (Ehr.) Grun. in Cl. and Grun. var. amphioxys, K. Svenska Vet.-Akad. Handl., Ny Foljd, 17(2):103. 1880. Pl. 20, Fig. 12-14.

This taxon was recorded once at F000.

An alkaliphilous form of very broad ecological tolerance that has been found in water of pH 5.4-9.2 (with an optimum between 7.8-8.0). It is periphytic, aerophilous (also in soils), current indifferent, calcium indifferent, and salt indifferent to oligohalobous.

Hantzschia amphioxys f. capitata O. Mull., Pflanzengeschichte Pflanzengeographie, Bd. 43, Heft 4, p. 34, pl. 2, fig. 26. 1909. Pl. 20, Fig. 15.

Photographed from material collected at site A but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Hantzschia amphioxys var. vivax Grun. in Cl. and Grun., K. Svenska Vet.-Akad. Handl., Ny Foljd, 17(2):103. 1880. Pl. 20, Fig. 17.

Photographed from material collected at sites A and F but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Hantzschia uticensis (Grun.) Hust. var. uticensis, in A.S., Atlas Diat., pl. 329, fig. 23. 1921. Pl. 20, Fig. 16.

This taxon was recorded once at G170.

The ecology of this taxon is insufficiently known.

Hantzschia vivax (Wm. Sm.) M. Peragallo var. vivax, in Tempere and Peragallo, Diat. Monde Ent. p. 56, No. 103-104. 1908. Pl. 20, Fig. 11.

This taxon was recorded once at A000, A020, D010, and F000.

The ecology of this taxon is insufficiently known.

Mastogloia Thwaites ex Wm. Smith

Mastogloia elliptica var. danseii (Thwaites) Cl., K. Svenska Vet.-Akad. Handl., Ny Foljd, 27(3):152-153. 1895. Pl. 21, Fig. 1-4.

This taxon was recorded at every level of site G in numbers usually less than 10. It was also recorded three times at H000 and once at H050.

A halophilic to mesohalobous taxon characteristic of coastal areas.

PLATE XX
(Scale is 10 μ long)

Fig. 1. Gomphonema martini var. martini

Fig. 2. Gomphonema gracile var. gracile

Fig. 3-5. Gomphonema subclavatum var. subclavatum

Fig. 6-9. Gomphonema tackei var. tackei

Fig. 10. Gomphonema sp. #1

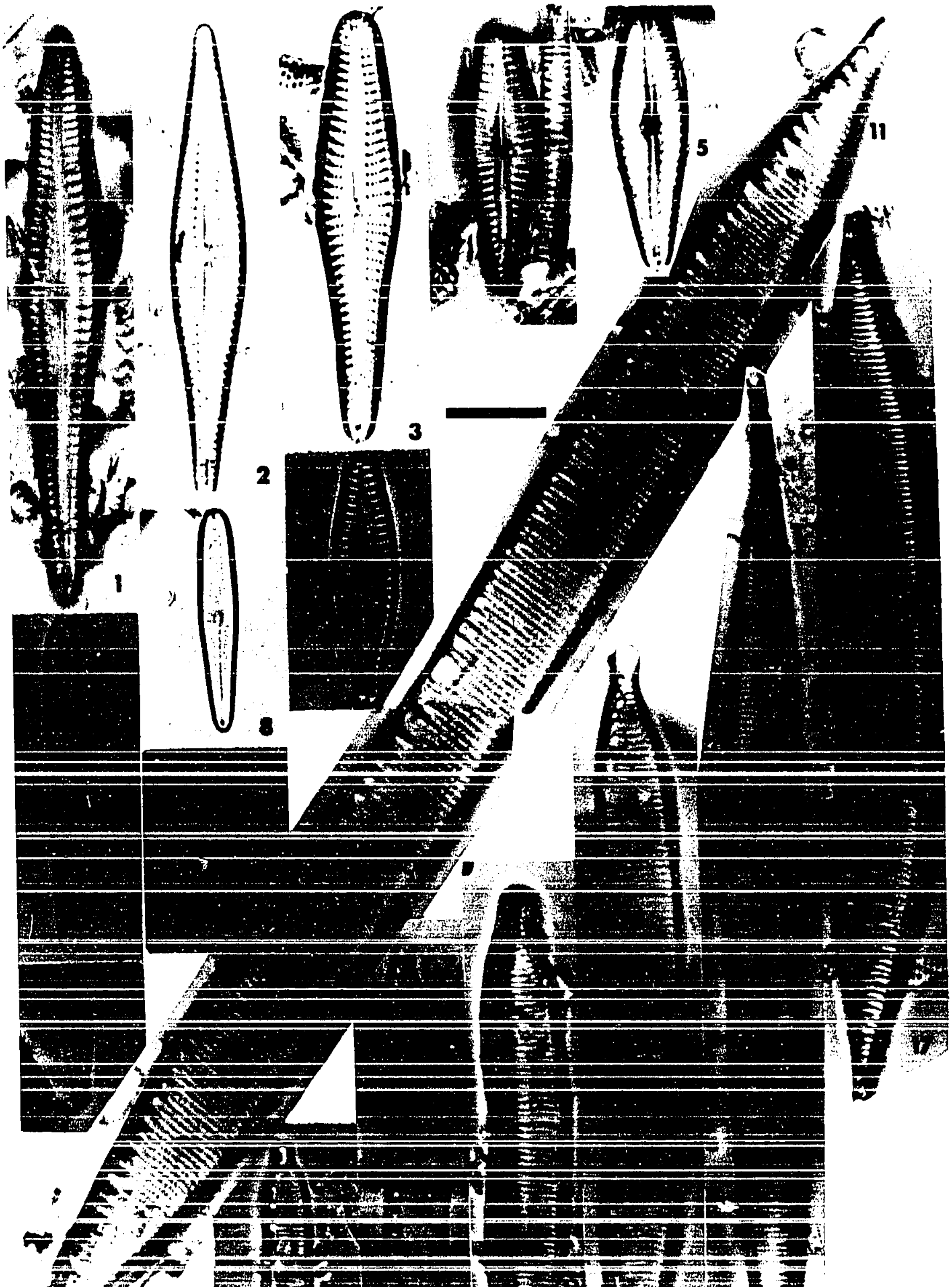
Fig. 11. Hantzschia vivax var. vivax

Fig. 12-14. Hantzschia amphioxys var. amphioxys

Fig. 15. Hantzschia amphioxys f. capitata

Fig. 16. Hantzschia uticensis var. uticensis

Fig. 17. Hantzschia amphioxys var. vivax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It is also found in the littoral zone of inland lakes with some salinity.

Melosira Agardh

Melosira distans (Ehr.) Kütz. var. distans, Bacill., p. 54, pl. 2, fig. 12. 1844. Pl. 21, Fig. 5-7.

This taxon was recorded twelve times at A020, once at A000, and had a consistent distribution from I120 through I250 (with one specimen recorded at I280) in numbers as high as 176.

An acidophilous form that has been found in rivers, lakes, ponds, and ditches through a pH range of 4.2-6.6 (with an optimum around 6.5). It is periphytic and planktonic, current indifferent, and halophobous.

Melosira distans var. decipiens (Grove in A.S.) Cl.-Euler, Nov. Act. Reg. Soc. Upsal., p. 21, fig. 111-n. 1951. Pl. 12-13.

This taxon was recorded at every level of sites A, D, and F in numbers averaging around 15, and was randomly distributed through sites H and I at H040, H056, I050, I170, and I180.

The ecology of this taxon is insufficiently known.

Melosira italica (Ehr.) Kütz. var. italica, Bacill., p. 55, pl. 2, fig. 6. 1844. Pl. 21, Fig. 8-9, 14-15.

This taxon was recorded at every level of sites A, D, and F in numbers averaging around 30, and as high as 121 (at D020). It was also recorded twice at I060.

An alkaliphilous to pH indifferent form that has been found in lakes, ponds, rivers, and ditches through a pH range of 6.7-8.0 (with an optimum not less than 8). It is planktonic to periphytic (to tychoplanktonic), current indifferent, and salt indifferent to halophobous.

Melosira italica var. ? Pl. 21, Fig. 10-11.

This taxon was recorded at every level of site D and once at F020.

Melosira sp. #1. Pl. 21, Fig. 16-17.

This taxon was recorded at all levels of sites A and D, three of four levels of site F, and once at I110, twice at I120, once at I150, and twice at I170. Less than five specimens were recorded at most of these levels.

This is a very peculiar form that has not been associated with any named taxon.

Meridion Agardh

Meridion circulare (Grev.) Ag. var. circulare, Consp. Crit. Diat., pt. 3, p. 40. 1831. Pl. 21, Fig. 18-21.

This taxon was distributed randomly at sites D and F: once at D000, F000, F020, and F030.

An alkaliphilous form that has been found in lakes, ponds, rivers, streams, and springs through a pH range of 6.4-9.0 (with an optimum around 8). It is periphytic or tychoplanktonic, markedly rheobiontic (to rheophilous), calciphilous, salt indifferent to halophobous, and is considered an indicator of high oxygen concentration.

Navicula Bory

Navicula absoluta Hust. var. absoluta, Arch. f. Hydrobiol. 43:435, Taf. 38, fig. 80-85. 1950. Pl. 21, Fig. 22-23.

This taxon was distributed very randomly through sites A, D, and I in numbers of one and two in all cases except D010 where 10 specimens were recorded.

The ecology of this species is insufficiently known.

Navicula amphibola Cl. var. amphibola, Acta Aoc. Fauna Fl. Fennica, 8(2): 33. 1891. Pl. 22, Fig. 1-3.

This taxon was recorded once at D020 and once at F020.

An alkaliphilous to indifferent form that has been found in stagnant lakes, streams, rivers, pools, and bogs through a pH range of 6.6-7.6. It is current indifferent, and salt indifferent to oligohalobous.

Navicula anglica var. subsalsa (Grun.) Cl., K. Svenska Vet.-Akad. Handl., Ny Foljd, 27(3):22. 1895. Pl. 21, Fig. 27-29.

This taxon had only a scattered distribution through site G and was recorded once at D020. No more than two specimens were recorded at any level.

A widespread, alkaliphilous form that has been found in hard or slightly brackish water. It is found in the littoral or bottom mud, is rheophilous, and salt indifferent to oligohalobous.

Navicula cincta (Ehr.) Ralfs. var. cincta, in Pritch., Hist. Infusoria, 4th ed., p. 901. 1861. Pl. 22, Fig. 8-10.

This taxon was distributed consistently through sites A, D, F, and G and distributed only randomly through H (once at K000) and I (once at I070 and I290). Numbers were commonly less than 15 and as high as 32 (at G080).

An alkaliphilous form that prefers slightly brackish or hard water. It has been found in lakes and alkaline springs and is considered halophilous.

PLATE XXI
(Scale is 10 μ long)

Fig. 1-4. Mastogloia elliptica var. danseii

Fig. 5-7. Melosira distans var. distans

Fig. 8-9. Melosira italica var. italica

Fig. 10-11. Melosira italica var. ?

Fig. 12-13. Melosira distans var. decipiens

Fig. 14-15. Melosira italica var. italica

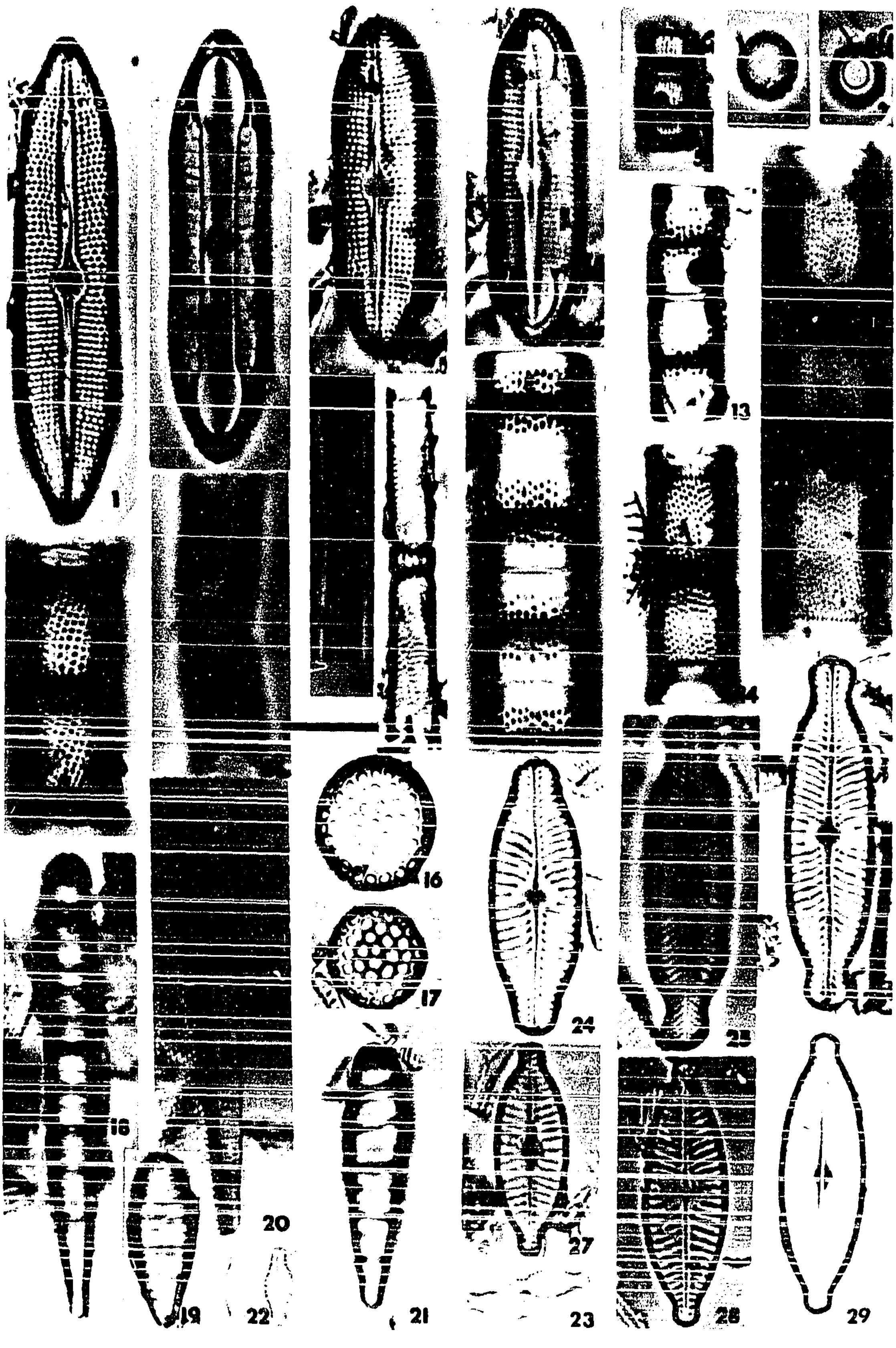
Fig. 16-17. Melosira sp. #1

Fig. 18-21. Meridion circulare var. circulare

Fig. 22-23. Navicula absoluta var. absoluta

Fig. 24-26. Navicula dicephala var. abiskoensis

Fig. 27-29. Navicula anglica var. subsalsa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Navicula confervacea var. peregrina (Wm. Sm.) Grun. in V.H., Syn. Diat. Belgique, pl. 14, fig. 37. 1880. Pl. 22, Fig. 12-13.

This taxon was recorded seven times at D010.

An alkaliphilous to indifferent form that is often an aerophil or in very shallow water of pH 5.0-8.4 (with an optimum around 8.4). It seems to prefer soft, warm water, and is periphytic and salt indifferent.

Navicula cryptocephala Kütz. var. cryptocephala, Bacill., p. 95, pl. 3, fig. 20, 26. 1844. Pl. 22, Fig. 14.

This taxon was recorded four times at A020.

An alkaliphilous form that has been found in fresh to slightly brackish waters of lakes, rivers, and bogs through a pH range of 5.4-9.0 (with an optimum around 8). It is current indifferent, calcium indifferent, and salt indifferent to halophilous.

Navicula cuspidata (Kütz.) Kütz. var. cuspidata, Bacill., p. 94, pl. 3, fig. 24, 37. 1844. Pl. 22, Fig. 11; Pl. 23, Fig. 1.

This taxon was recorded once at A010, A020, D000, and G180.

An alkaliphilous form that has been found in lakes, streams, and ponds through a pH range of 6.3-9.0 (with an optimum between 8.3-8.6). It is periphytic, current indifferent, and salt indifferent to oligohalobous.

Navicula cuspidata var. heribaudi Peragallo in Heribaud., Diat. d'Auv., Seit 108, Taf. 4, fig. 16. 1903. Pl. 23, Fig. 2-3.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An alkaliphilous form that is periphytic and salt indifferent.

PLATE XXII
(Scale is 10 μ long)

Fig. 1-3. Navicula amphibola var. amphibola

Fig. 4-7. Navicula platensis var. platensis

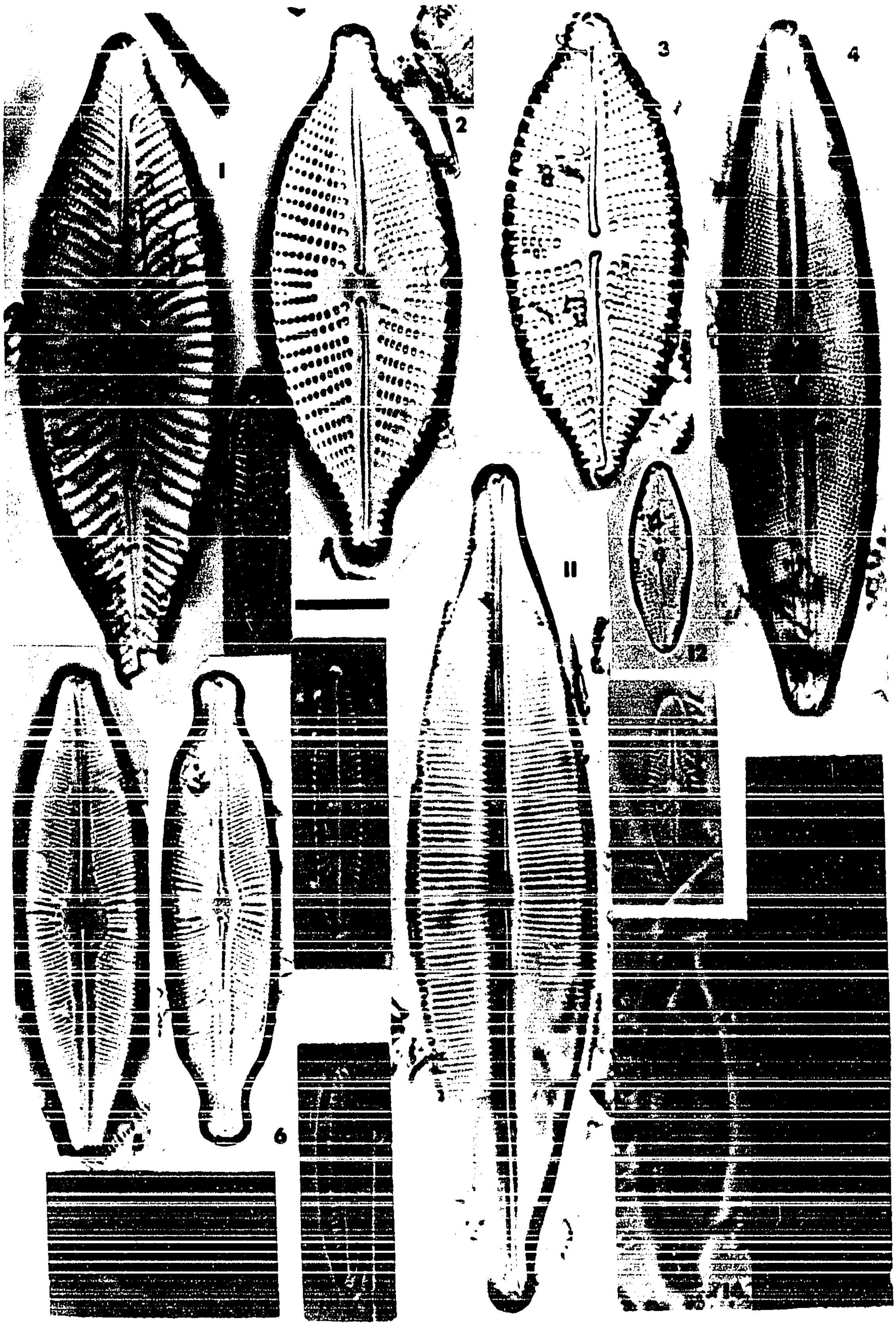
Fig. 8-10. Navicula cincta var. cincta

Fig. 11. Navicula cuspidata var. cuspidata

Fig. 12-13. Navicula confervacea var. peregrina

Fig. 14. Navicula cryptocephala var. cryptocephala

Fig. 15. Navicula halophila f. tenuirostris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Navicula cuspidata var. major Meist. Beitr. Krypt.-Fl. Schw., Bd. 4, Heft 1, p. 134, pl. 20, fig. 10. 1912. Pl. 23, Fig. 4.

Photographed from material collected at site A but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Navicula dicephala var. abiskoensis (Hust.) Cl.-Euler, Diat. Schwed. Finnl. 1953. Pl. 21, Fig. 24-26.

This taxon was recorded at every level of stie A and only very randomly distributed in numbers of one or two specimens at sites D, F, G, and I.

An alkaliphilous form of the littoral and benthic zones. It is considered salt indifferent to oligohalobous.

Navicula gregaria Donk. var. gregaria, Quart. Jour. Micr. Sci., New Ser., 1:10-11, pl. 1, fig. 10. 1861. Pl. 23, Fig. 5-6.

This taxon was recorded at every level of sites D and F, twice at A010, once at H040, and distributed randomly in numbers of one and two specimens at site G.

This species seems to prefer brackish water and fresh water with a high mineral content.

Navicula halophila f. tenuirostris Hust., Internat. Rev. Ges. Hydrobiol., 42(1):52, fig. 76. 1942. Pl. 22, Fig. 15.

Photographed from material collected at site A but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Navicula lanceolata (Ag.) Kütz. var. lanceolata, Bacill., p. 94, pl. 28, fig. 38; pl. 30, fig. 48. 1844. Pl. 23, Fig. 18.

This taxon was recorded at every level of site D, and at the upper two of the three levels at site A. One and two specimens were recorded at each level.

An alkaliphilous form that has been found in the littoral of lakes and ponds through a pH range of 6.3-9.0 (with an optimum around 8). It is periphytic, limnophilous, salt indifferent to oligohalobous, and seems to prefer water of high mineral content.

Navicula lanceolata var. ? Pl. 23, Fig. 17.

Photographed from material collected at site H but never occurred in counts from any of the sites.

Navicula mediocris Krasske var. mediocris, Hedwigia, 72:113, fig. 15. 1932. Pl. 23, Fig. 12-14.

This taxon was recorded at every level of sites A, D, and F in numbers above 50 in most cases and as high as 222 at F030. It was also recorded twice at I060 and once at I160.

The raphe of this species is often much reduced and frequently missing entirely.

The ecology of this species is insufficiently known.

Navicula platensis (Freng. in Freng. and Cordini) Cholnoky var. platensis, Nova Hedwigia, Bd. i, S. 55-101, Taf. 4. 1964. Pl. 22, Fig. 4-7.

This taxon was recorded once at D010, D020, F000, and F030.

The ecology of this taxon is insufficiently known.

Navicula pupula var. rectangularis (Greg.) Grun., in Cl. and Grun., K. Svenska Vet.-Akad. Handl., Ny Foljd, 17(2):45. 1880. Pl. 23, Fig. 9-11.

This taxon had a somewhat consistent distribution through sites A, D, F, and G and was scattered randomly at five levels of site I. Numbers of specimens at any level were never more than 4.

A pH indifferent to alkaliphilous form that has been found in ponds and salt bogs through a pH range of 6.2-8.2. It is periphytic (and benthic), current indifferent, salt indifferent to oligohalobous, and seems to prefer water of higher mineral content than the nominate variety.

Navicula pygmaea Kütz. var. pygmaea, Sp. Alg., p. 77. 1849. Pl. 23, Fig. 15-16.

This taxon was distributed randomly through sites F and G and a little more consistently distributed through sites A and D. Numbers of specimens at any level were never more than 3.

An alkalibiontic to alkaliphilous form that has been found in fresh water of high mineral content and in brackish water. It is considered mesohalobous.

Navicula radiosa Kütz. var. radiosa, Bacill., p. 91, pl. 4, fig. 23. 1844. Pl. 23, Fig. 7-8.

This taxon was recorded at every level of sites A, D, and F and was distributed randomly through sites G and H. Numbers of specimens at any level were commonly less than 10 and as high as 37 (at A020).

An alkaliphilous to pH indifferent form that has been found in lakes and streams through a pH range of 4.3-9.0 (with an optimum between 6.5-7.0). It is periphytic, current indifferent, calcium indifferent, and salt indifferent to oligohalobous.

Navicula radiosa var. tenella (Breb. ex Kütz.) Grun., in V.H., Syn. Diat. Belgique, p. 84. 1885. Pl. 24, Fig. 1-2.

PLATE XXIII
(Scale is 10 μ long)

Fig. 1. Navicula cuspidata var. cuspidata

Fig. 2-3. Navicula cuspidata var. heribaudi

Fig. 4. Navicula cuspidata var. major

Fig. 5-6. Navicula gregaria var. gregaria

Fig. 7-8. Navicula radiosa var. radiosa

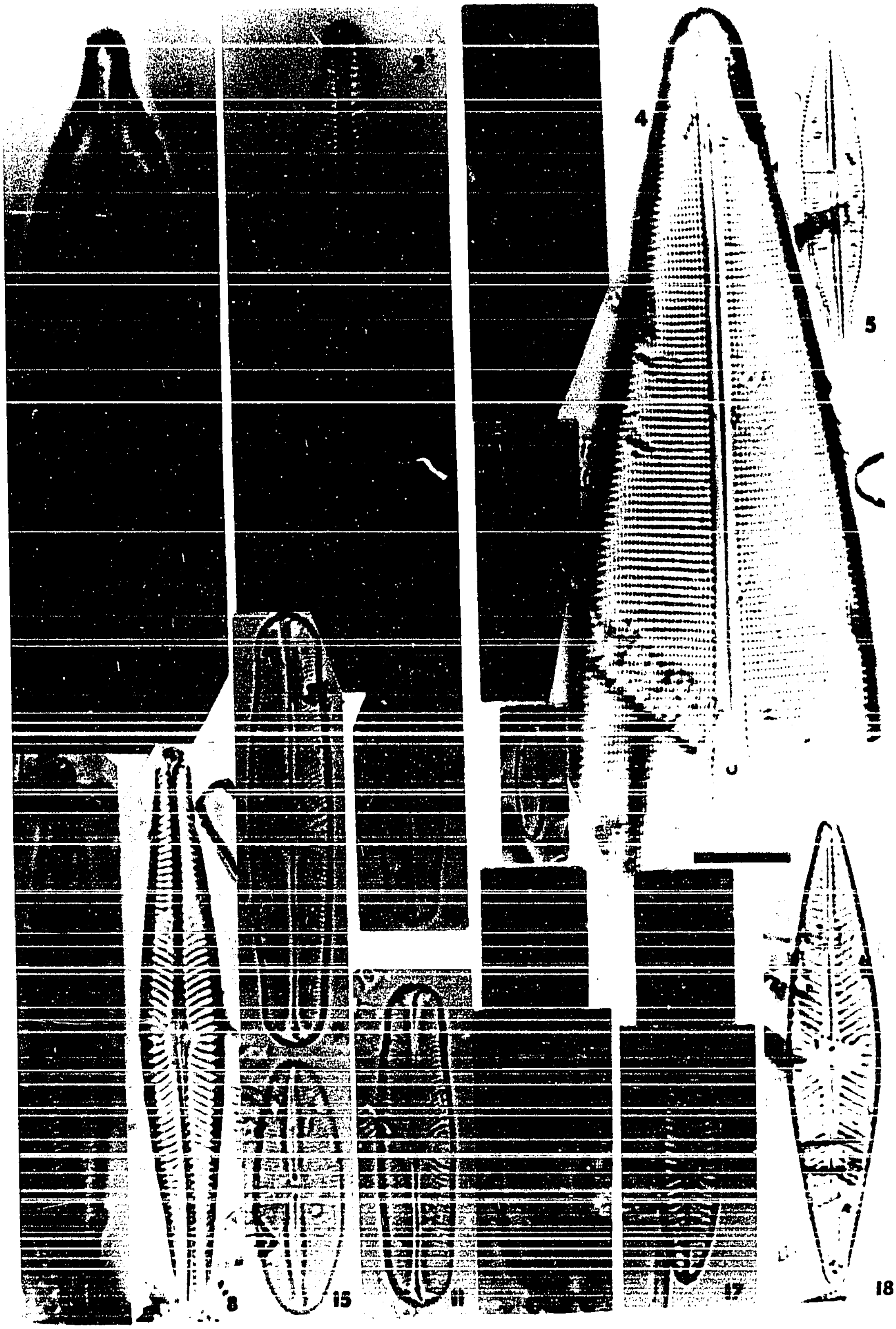
Fig. 9-11. Navicula pupula var. rectangularis

Fig. 12-14. Navicula mediocris var. mediocris

Fig. 15-16. Navicula pygmaea var. pygmaea

Fig. 17. Navicula lanceolata var. ?

Fig. 18. Navicula lanceolata var. lanceolata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Except for its absence in but a very few samples, this taxon was distributed consistently through all of the six sites. Numbers were less than 8 through sites A, D, F, and I, and between 20-5- through sites G and H.

An alkaliphilous to pH indifferent form that is especially frequent in the littoral zone of small, stagnant lakes. It is strictly a fresh-water form that does not occur in brackish or salt water, and is considered current indifferent and periphytic.

Navicula semen Ehr. emend Donk. var. semen, Nat. Hist. British Diat., p. 21, pl. 3, fig. 8. 1870-1873. Pl. 24, Fig. 3.

Photographed from material collected at site F but never occurred in counts from any of the sites.

A pH indifferent form (7.0-8.0) that has been found in the littoral zone of stagnant water lakes. It seems to prefer cool water of low mineral content, is sometimes an aerophil, and is salt indifferent to halophobous.

Navicula simplex Krasske var. simplex, in Pasch., Sussw.-Fl. Mitteleuropas, Heft 10, Aufl. 2, p. 296, fig. 500. 1930. Pl. 24, Fig. 4.

This taxon was found once at A020, F000, H040, and I240.

The ecology of this taxon is insufficiently known.

Navicula vulpina Kütz. var. vulpina, Bacill., p. 92, pl. 3, fig. 43. 1844. Pl. 24, Fig. 18-19.

This taxon was found once at G120 and G200, and was distributed very randomly through sites H and I in numbers never more than 5.

An alkaliphilous form that has been found in lakes, rivers, and springs through a pH range of 7.4-7.7. It is also considered oligohalobous.

Navicula sp. #1. Pl. 24, Fig. 5-7.

This taxon had a very scattered distribution through four sites (A010, G030, G050, G060, G140, H000, I250, I270, and I280). Numbers recorded were never more than 4 and usually only 1.

Taxonomically, this form approaches Navicula nuwukiana Patrick and Freese.

Navicula sp. #2. Pl. 24, Fig. 8.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Navicula sp. #3. Pl. 24, Fig. 9-12.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Navicula sp. #4. Pl. 24, Fig. 13-14.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Navicula sp. #5. Pl. 24, Fig. 15-17.

This taxon was recorded twice at F020; once at H010, I160, and I180; and was distributed randomly through site G in numbers never more than 3.

Navicula sp. #6. Pl. 24, Fig. 20-21.

This taxon was recorded once at A010 and twice at F030.

Navicula sp. #7. Pl. 25, Fig. 1.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Navicula sp. #8. Pl. 25, Fig. 2.

Photographed from material collected at site A but never occurred in counts from any of the sites.

PLATE XXIV
(Scale is 10 μ long)

Fig. 1-2. _Navicula radiosa_ var. _tenella_

Fig. 3. _Navicula semen_ var. _semen_

Fig. 4. _Navicula simplex_ var. _simplex_

Fig. 5-7. _Navicula_ sp. #1

Fig. 8. _Navicula_ sp. #2

Fig. 9-12. _Navicula_ sp. #3

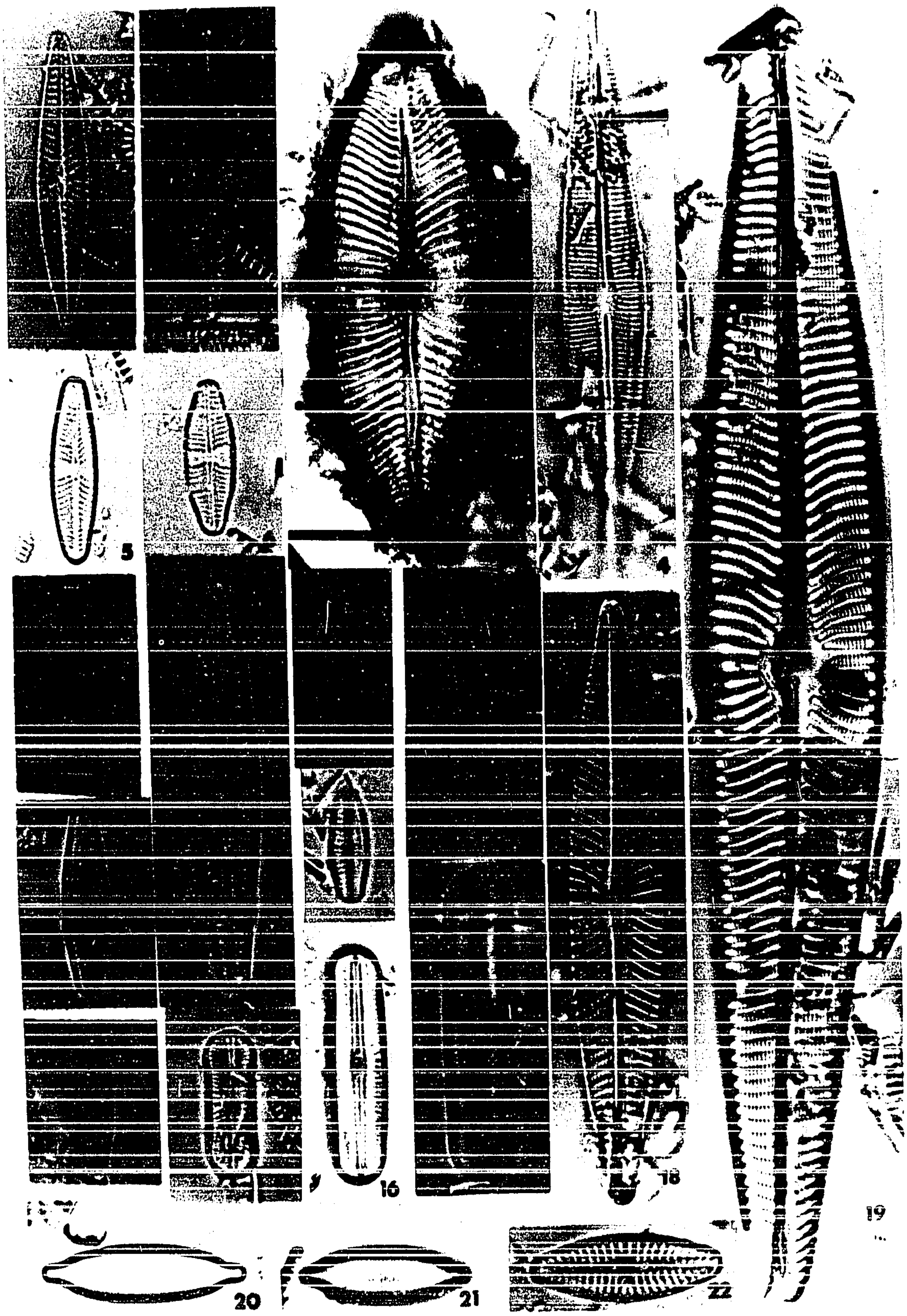
Fig. 13-14. _Navicula_ sp. #4

Fig. 15-17. _Navicula_ sp. #5

Fig. 18-19. _Navicula vulpina_ var. _vulpina_

Fig. 20-21. _Navicula_ sp. #6

Fig. 22. _Navicula_ sp. #11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Navicula sp. #9. Pl. 25, Fig. 3.

Photographed from material collected at site F but never occurred in counts from any of the sites.

Navicula sp. #10. Pl. 25, Fig. 4.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Navicula sp. #11. Pl. 24, Fig. 22.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Neidium Pfitzer

Neidium affine (Ehr.) Pfitz. var. affine, Bot. Abh. Geb. Morph. Physiol., 1(2):39. 1871. Pl. 25, Fig. 7-9.

This taxon was recorded once at A000, G070, and G150.

An alkaliphilous to pH indifferent form most common in quiet waters of pH 5.5-8.3 (with an optimum around 6). It is periphytic, rheophilous, and salt indifferent to oligohalobous (to halophobous?).

Neidium affine var. amphirhynchus (Ehr.) Cl., K. Svenska Vet.-Akad. Handl., Ny Foljd, 26(2):68. 1894 (pro parte). Pl. 25, Fig. 10.

Photographed from material collected at site F but never occurred in counts from any of the sites.

An alkaliphilous to pH indifferent form, apparently of the bottom and littoral zones of lakes but also found in small numbers in rivers and streams. Halophobous?

Neidium affine var. longiceps (Greg.) Cl., K. Svenska Vet.-Akad. Handl., Ny Foljd, 26(2):68. 1894. Pl. 25, Fig. 12.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Apparently an acidophilous species of lakes and rivers.

Neidium decens (Pant.) Stoermer var. decens, Not. Nat., 358:1-9, pl. 1, fig. 8-9. 1963. Pl. 25, Fig. 13.

Photographed from material collected at site A but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Neidium distincte-punctatum Hust. var. distincte-punctatum, in Pasch., Sussw.-Fl. Mitteleuropas, Heft 10, Aufl. 2, p. 247, fig. 386. 1930. Pl. 25, Fig. 6.

Photographed from material collected at site I but never occurred in counts from any of the sites.

This species is known from lakes, rivers, and pools.

Neidium kozlowii var. amphicephala Meresch., Meist Asien, pl. 11, fig. 14-17. 1906. Pl. 25, Fig. 11.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An alkaliphilous form of lakes, rivers, pools, springs, and moss.

Neidium munckii Foged var. munckii, Medd. Gronland, Bd. 128, Nr. 7, p. 45, pl. 5, fig. 7. 19 ?. Pl. 25, Fig. 5.

Photographed from material collected at sites G and H but never occurred in counts from any of the sites.

The ecology of this taxon is insufficiently known.

Neidium productum (Wm. Sm.) Cl. var. productum, K. Svenska Vet.-Akad. Handl., Ny Foljd, 26(2):69. 1894. Pl. 26, Fig. 1.

PLATE XXV
(Scale is 10 u long)

Fig. 1. Navicula sp. #7

Fig. 2. Navicula sp. #8.

Fig. 3. Navicula sp. #9

Fig. 4. Navicula sp. #10

Fig. 5. Neidium munckii var. munckii

Fig. 6. Neidium distincte-punctatum var. distincte-punctatum

Fig. 7-9. Neidium affine var. affine

Fig. 10. Neidium affine var. amphirhynchus

Fig. 11. Neidium kozlowii var. amphicephala

Fig. 12. Neidium affine var. longiceps

Fig. 13. Neidium decens var. decens

Fig. 14-15. Nitzschia amphibia f. rostrata

Fig. 16. Nitzschia amphibia var. amphibia


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Photographed from material collected at site A but never occurred in counts from any of the sites.

A pH indifferent form of lakes and streams that is considered salt indifferent to halophobous.

Nitzschia Hassall

Nitzschia amphibia Grun. var. amphibia, Oestr. D., p. 574, pl. 12, fig. 23. 1862. Pl. 25, Fig. 16; Pl. 26, Fig. 2-3.

This taxon was found at all levels of site D and the upper three of four levels of site F. It was recorded in numbers less than 10.

An alkaliphilous to alkalibiontic form that has been found in lakes, ponds, and streams through a pH range of 4.0-9.3 (with an optimum slightly over 8.5). It is periphytic, current indifferent, and salt indifferent.

Nitzschia amphibia f. rostrata Hust., F. Oesterr. Akad. Wiss., Abt. 1, Biol. 169:436, fig. 26-27. 1959. Pl. 25, Fig. 14-15.

Six specimens of this taxon were found at F010 and one at A000.

The ecology of this taxon is insufficiently known.

Nitzschia angustata (Wm. Sm.) Grun. var. angustata, Arct. D., p. 70. 1880. Pl. 26, Fig. 4-5.

This taxon was found twice at G160, and once at G170 and G190.

An alkaliphilous form in waters of pH between 6.4-8.5 (with an optimum around 8.5). It is limnophilous and salt indifferent to olibohalobous.

Nitzschia dubia Wm. Sm. var. dubia, Syn. British Diat., 1:41, pl. 13, fig. 112. 1853. Pl. 26, Fig. 10.

This taxon was found once at H020 and H030.

An alkaliphilous to pH indifferent form that has been found in fresh and brackish water streams and bogs. It is also considered halophilous to indifferent.

Nitzschia fonticola Grun. var. fonticola, in V.H. Syn. Diat. Belgique, pl. 69, fig. 15-20. 1881. Pl. 26, Fig. 6-9.

This taxon was distributed consistently through sites A, D, and F and distributed randomly through sites G, H, and I. The number of taxa at any level was less than 5, except at F010 where 21 specimens were recorded.

An alkaliphilous to alkalibiontic form that has been found in lakes, ponds, springs, and streams through a pH range of 6.0-9.0 (with an optimum between 8.2-8.6). It is planktonic and periphytic, current indifferent, and salt indifferent to oligohalobous.

Nitzschia subregula Hust. var. subregula, in A.S., Atlas Diat., pl. 351, fig. 16-17. 1924. Pl. 26, Fig. 18.

This taxon was recorded once at A020, D020, and F020.

The ecology of this taxon is insufficiently known.

Nitzschia subregula var. ? Pl. 26, Fig. 16-17.

This taxon was recorded twice at F000.

Nitzschia tropica Hust. var. tropica, Expl. Parc. Nat. Albert, p. 147, pl. 11, fig. 34-48. 1949. Pl. 26, Fig. 11-15.

This taxon was recorded at every level of sites A, D, F, and G and was distributed randomly through sites H and I. From 10-40 specimens were recorded at the levels of sites A, D, F, and G, with no more than two specimens recorded per sample at sites H and I.

The ecology of this taxon is insufficiently known.

Nitzschia sp. #1. Pl. 26, Fig. 19.

This taxon was recorded twice at A020.

Nitzschia sp. #3. Pl. 27, Fig. 3.

Photographed from material collected at site F but never occurred in counts from any of the sites.

Nitzschia sp. #4. Pl. 27, Fig. 4.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Opephora Petit

Opephora martyi Herib. var. martyi, Diat. Foss. Auv., vol. 1, p. 43, pl. 8, fig. 20. 1902. Pl. 27, Fig. 5-6.

This taxon had a very limited distribution through all of the six sites. Numbers of specimens at any level never reached more than two and only one specimen was recorded at H000 and I050.

An alkaliphilous to alkalibiontic form that has been found in shallow water lakes and rivers through a pH range of 6.4-9.0 (with an optimum between 7.8-8.2). It is planktonic and periphytic, limnophilous, and salt indifferent to oligohalobous.

Pinnularia Ehrenberg

Pinnularia acrosphaeria Wm. Sm. var. acrosphaeria, Syn. British Diat., vol. 1, p. 58, pl. 19, fig. 183. 1853. Pl. 27, Fig. 12-14.

This taxon was recorded twice at D020 and once at A010.

An alkaliphilous form that seems to prefer littoral areas of lakes and ponds. It is also considered oligohalobous.

PLATE XXVI
(Scale is 10 μ long)

Fig. 1. Neidium productum var. productum

Fig. 2-3. Nitzschia amphibia var. amphibia

Fig. 4-5. Nitzschia angustata var. angustata

Fig. 6-9. Nitzschia fonticola var. fonticola

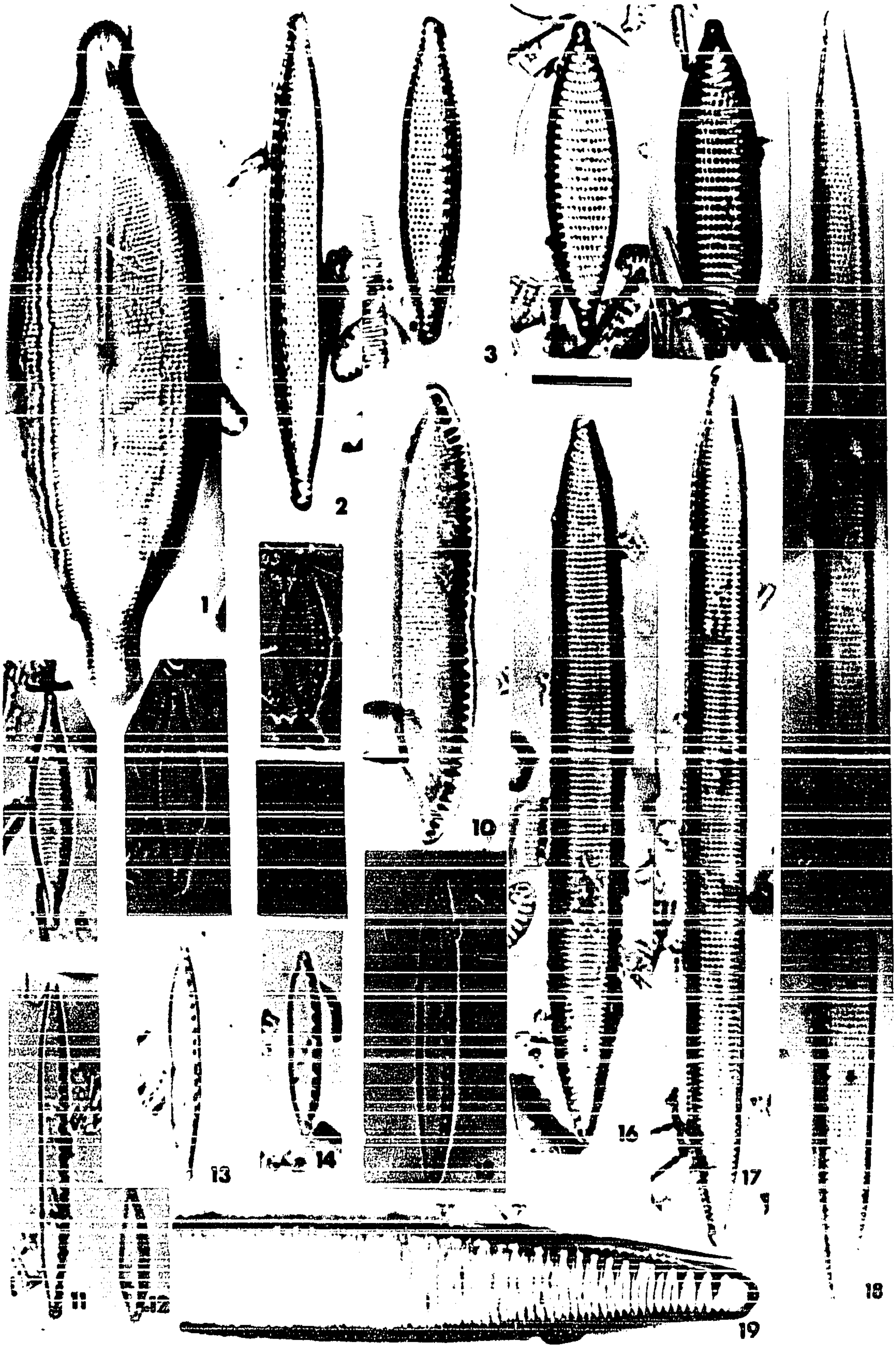
Fig. 10. Nitzschia dubia var. dubia

Fig. 11-15. Nitzschia tropica var. tropica

Fig. 16-17. Nitzschia subregula var. ?

Fig. 18. Nitzschia subregula var. subregula

Fig. 19. Nitzschia sp. #1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<u>Pinnularia</u> <u>aestaurii</u> Cl. var. <u>aestuarii</u>, K. Svenska Vet.-Akad. Handl., Ny Foljd, 27(3):93, 94, pl. 1, fig. 16. 1895. Pl. 27, Fig. 1-2.

This taxon was recorded once at F000 and F020.

A form that seems to prefer water of high mineral content.

<u>Pinnularia</u> <u>biceps</u> f. <u>petersenii</u> Ross, Natl. Mus. Canada Bull., No. 97, pt. 2, p. 201, pl. 9, fig. 11? 1947. Pl. 27, Fig. 11.

This taxon was recorded once at A000, F000, F030, and G070.

A widely distributed species of circumneutral water.

<u>Pinnularia</u> <u>brebissonii</u> (Kutz.) Rabh. var. <u>brebissonii</u>, Fl. Europaea Alg., sect. 1, p. 222. 1864. Pl. 27, Fig. 9-10.

This taxon was recorded once at G020 and G060.

A salt indifferent form that seems to prefer cool water of low mineral content.

<u>Pinnularia</u> <u>mesolepta</u> (Ehr.) Wm. Sm. var. <u>mesolepta</u>, Syn. British Diat., vol. 1, p. 58, pl. 19, fig. 182. 1853. Pl. 28, Fig. 1.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An alkaliphilous form of the littoral zone of lakes that seems to prefer fresh water of low mineral content. It is salt indifferent to halophobous.

<u>Pinnularia</u> <u>microstauron</u> (Ehr.) Cl. var. <u>microstauron</u>, Acta Soc. Fauna Fl. Fennica, 8(2):28. 1891. Pl. 28, Fig. 2-6.

This taxon was recorded at all levels of site A and was distributed randomly through sites D, F, and G in numbers of no more than four specimens per sample. One specimen was recorded at H010 and I290.

PLATE XXVII
(Scale is 10 µ long)

Fig. 1-2. Pinnularia aestuarii var. aestuarii

Fig. 3. Nitzschia sp. #3

Fig. 4. Nitzschia sp. #4

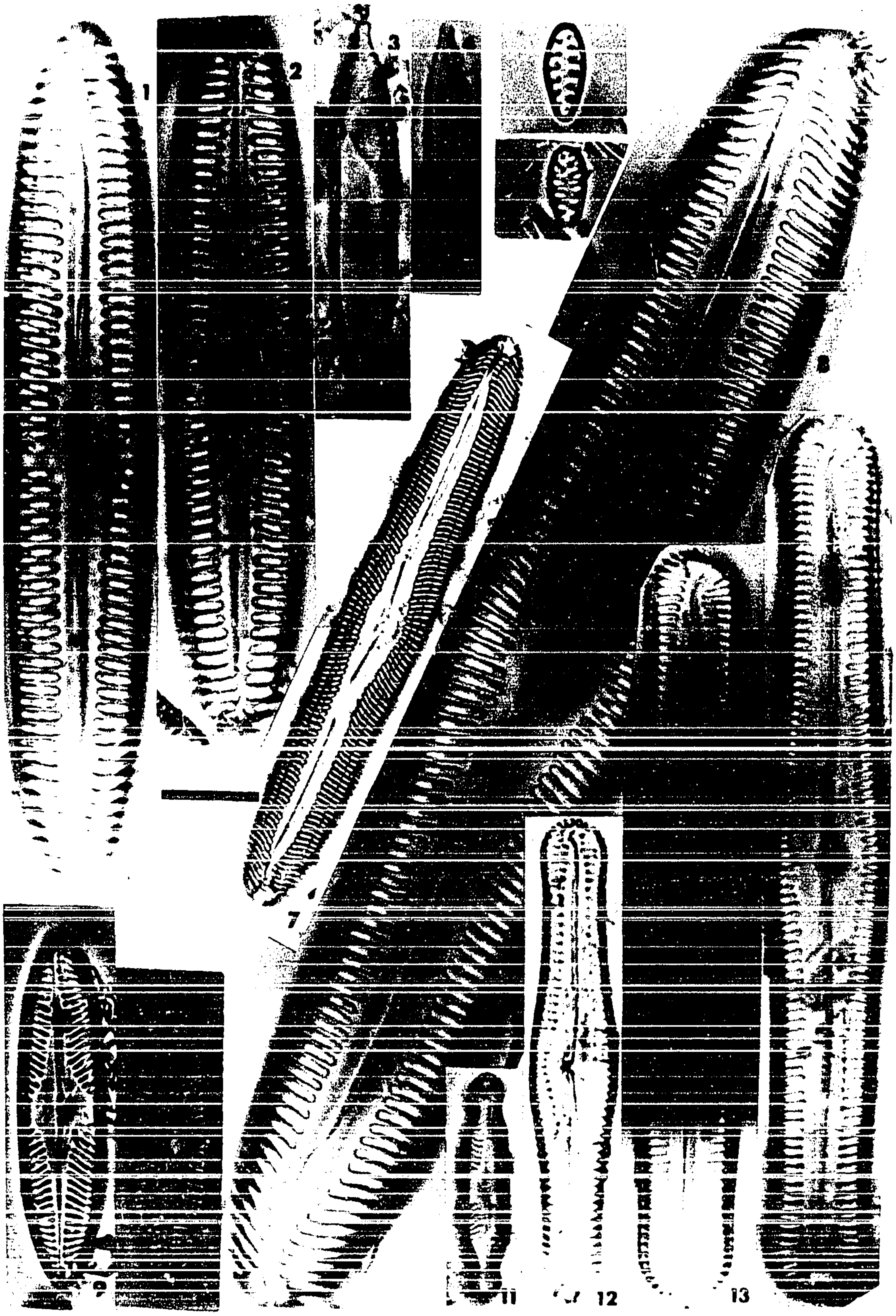
Fig. 5-6. Opephora martyi var. martyi

Fig. 7-8. Pinnularia viridis var. minor

Fig. 9-10. Pinnularia brebissonii var. brebissonii

Fig. 11. Pinnularia biceps f. petersenii

Fig. 12-14. Pinnularia acrosphaeria var. acrosphaeria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An acidophilous form that is able to tolerate a wide range of pH and mineral conditions, but seems to prefer slightly acid freshwater lakes. It is also known to be salt indifferent.

Pinnularia nodosa (Ehr.) Wm. Sm. var. nodosa, Syn. British Diat., vol. 2, p. 96. 1856. Pl. 28, Fig. 7.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An acidophilous to pH indifferent form that seems to prefer cool water and water of low mineral content (although it is sometimes found in other types of water). It has been found in springs and stagnant water areas, and is salt indifferent to halophobous.

Pinnularia viridis var. minor Cl., Acta Soc. Fauna Fl. Fennica, 8(2):22, pl. 1, fig. 2. 1891. Pl. 27, Fig. 7-8.

This taxon was recorded twice at F000 and once at G070.

A pH indifferent to acidophilous form that has been found in the littoral zone of lakes as well as in swamps and wells. It is found in water of higher mineral content than many of the species belonging to this genus and is considered oligohalobous.

Pinnularia sp. #1. Pl. 28, Fig. 8.

This taxon was recorded once at A020, D000, and D010.

This taxon might be related to Pinnularia obscura Krasske.

Rhoicosphenia Grunow

Rhoicosphenia curvata (Kütz.) Grun. ex Rabh. var. curvata, Fl. Europaea Alg., pp. 112, 342. 1864. Pl. 28, Fig. 9.

Photographed from material collected at site A but never occurred in counts from any of the sites.

A widespread alkaliphilous form that has been found in streams, lakes, and bogs (etc.) through a pH range of 5.4-9.0 (with an optimum somewhat over 8). It is epiphytic (and epilithic?), current indifferent to rheophilous, salt indifferent to oligohalobous, and seems to live optimally in oxygen rich waters.

Rhopalodia O. Muller

Rhapalodia gibba (Ehr.) O. Mull. var. gibba, Bot. Jahrb., 22:65, pl. 1, fig. 15-17. 1895. Pl. 28, Fig. 12.

This taxon was distributed randomly through site G with numbers of specimens at any level never above 4.

An alkaliphilous to alkalibiontic form that has been found in springs and streams through a pH range of 6.4-9.0 (with an optimum around 7.8). It is periphytic (and epiphytic), current indifferent, salt indifferent, and usually found in water with moderate to fairly high conductivity.

Rhopalodia gibberula var. vanheurckii O. Mull., Hedwigia, 38:292, pl. 10, fig. 11, pl. 11, fig. 6-7. 1900. Pl. 28, Fig. 10-11.

This taxon was recorded at each level of sites A and D, at three of four levels at site F, and once at G110, G120, I080, and I250.

An alkaliphilous form (6.8-7.8) that seems to prefer water of moderately high conductivity. It is also known to be aerophilous and salt indifferent to oligohalobous (to halophilous).

Stauroneis Ehrenberg

Stauroneis kriegeri Patr. var. kriegeri, Farlowia, 2(2):175. 1945.

Pl. 28, Fig. 13.

This taxon was recorded three times at D010 and once at A000.

An oligohalobous, pH indifferent form that appears to be more characteristic of headwater areas.

Stauroneis lauenburgiana Hust. var. lauenburgiana, Diat. nordd. Seen, IV, S. 405, T. 37, fig. 15. 1950. Pl. 28, Fig. 14-17.

This taxon was recorded once at A010 and once at I060.

The ecology of this taxon is insufficiently known.

Stauroneis phoenicenteron (Nitz.) Ehr. var. phcenicenteron, Phys. Abh. Akad. Wiss. Berlin, for 1841:387, pl. 2(5), fig. 1, pl. 3(1), fig. 17. 1843. Pl. 29, Fig. 1-2.

This taxon was recorded once at F020, I050, and I070.

A pH indifferent (to alkaliphilous?) form that has a wide range of ecological tolerance. It is locally widespread, periphytic, current indifferent, salt indifferent to oligohalobous, and calcium indifferent.

Stauroneis smithii Grun. var. smithii, Verh. Zool.-Bot. Ges. Wien, 10:564, pl. 6, fig. 16. 1860. Pl. 29, Fig. 3, 5.

This taxon was recorded once at A010.

A pH indifferent to alkaliphilous form that seems always to occur in small numbers in the waters of springs, bogs, and stagnant acid waters poor in salts. It is a littoral form in all kinds of oxygen rich water, rheophilous, and salt indifferent to oligohalobous.

Stauroneis sp. #1. Pl. 29, Fig. 4.

Photographed from material collected at site A but never occurred

PLATE XXVIII
(Scale is 10 μ long)

Fig. 1. Pinnularia mesolepta var. mesolepta

Fig. 2-6. Pinnularia microstauron var. microstauron

Fig. 7. Pinnularia nodosa var. nodosa

Fig. 8. Pinnularia sp. #1

Fig. 9. Rhoicosphenia curvata var. curvata

Fig. 10-11. Rhopalodia gibberula var. vanheurckii

Fig. 12. Rhopalodia gibba var. gibba

Fig. 13. Stauroneis kriegeri var. kriegeri

Fig. 14-17. Stauroneis lauenburgiana var. lauenburgiana


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14

in counts from any of the sites.

Surirella Turpin

Surirella striatula Turp. var. striatula, Mem. Mus. d'Hist. Nat. XVI, 51:4108. 1816-1829. Pl. 29, Fig. 6: Pl. 30, Fig. 1.

Photographed from material collected at site A but never occurred in counts from any of the sites.

A pH indifferent form (6.7-7.8) known as a marine or brackish water species. (Mesohalobous?)

Surirella sp. #1. Pl. 29, Fig. 7; Pl. 30, Fig. 2.

This taxon was recorded once at G050, G080, G090, G130, and twice at G180.

Surirella sp. #2. Pl. 29, Fig. 8; Pl. 30, Fig. 3.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Synedra Ehrenberg

One of the demands placed upon my sampling procedure was that only those forms with at least half a valve would be counted. This demand was particularly disastrous to the distribution of those taxa in the genus Synedra. As a result of my preliminary investigations, 13 taxa were present in this Ogallala material. As a consequence of the sampling demands, specimens representing only three of the thirteen taxa were counted. Synedra delicatissima var. angustissima Grun. was particularly hard hit and I am confident that its true distribution through site G in particular is really very extensive.

PLATE XXIX
(Scale is 10 µ long)

Fig. 1-2. *Stauroneis phoenicenteron* var. *phoenicenteron*

Fig. 3. *Stauroneis smithii* var. *smithii*

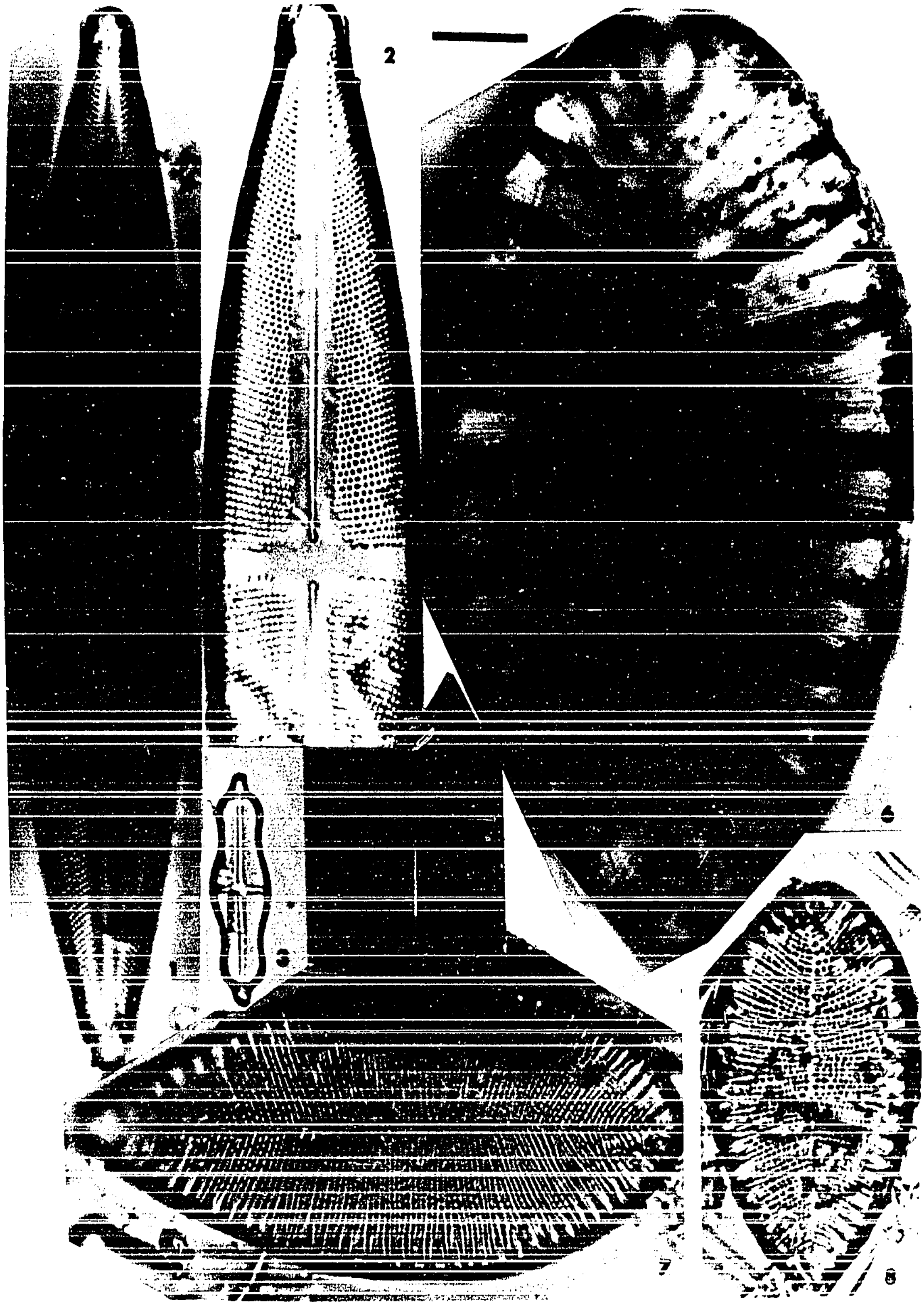
Fig. 4. *Stauroneis* sp. #1

Fig. 5. *Stauroneis smithii* var. *smithii*

Fig. 6. *Surirella striatula* var. *striatula*

Fig. 7. *Surirella* sp. #1

Fig. 8. *Surirella* sp. #2



Synedra acus Kütz. var. acus, Bacill., p. 68, pl. 15, fig. 7. 1844.

Pl. 30, Fig. 12.

Photographed from material collected at site A but never occurred in counts from any of the sites.

A widely distributed alkaliphilous form that has been found in all stagnant and running waters (including lakes and ponds) through a pH range of 6.2-9.0 (with an optimum between 7.4-7.6). It is periphytic or tycho-planktonic, limnophilous, and salt indifferent. It seems to prefer water which does not have a very low conductivity.

Synedra delicatissima var. angustissima Grun. in V.H., Syn. Diat. Belgique, pl. 39, fig. 10. 1881. Pl. 30, Fig. 11.

Photographed from material collected at site G but never occurred in counts from any of the sites.

Entire specimens of this taxon were photographed several times from material collected at site G but never occurred in counts from any of the sites. As indicated above, it was, in reality, quite predominant at site G but as a consequence of the sampling procedure was never counted.

A pH indifferent form that has been found in springs, bogs, rivers, and especially ponds. It appears to favor water of medium hardness, is limnophilous, salt indifferent, and planktonic.

Synedra fasciculata var. truncata (Grev.) Patr., Diat. U.S., p. 142, pl. 5, fig. 16. 1966. Pl. 30, Fig. 9-10.

Photographed from material collected at site I but never occurred in counts from any of the sites.

This taxon has been found in fresh water of high conductivity or somewhat brackish water.

PLATE XXX
(Scale is 10 μ long)

Fig. 1. Surirella striatula var. striatula

Fig. 2. Surirella sp. #1

Fig. 3. Surirella sp. #2

Fig. 4. Synedra parasitica var. parasitica

Fig. 5. Synedra rumpens var. rumpens

Fig. 6. Synedra sp. #2

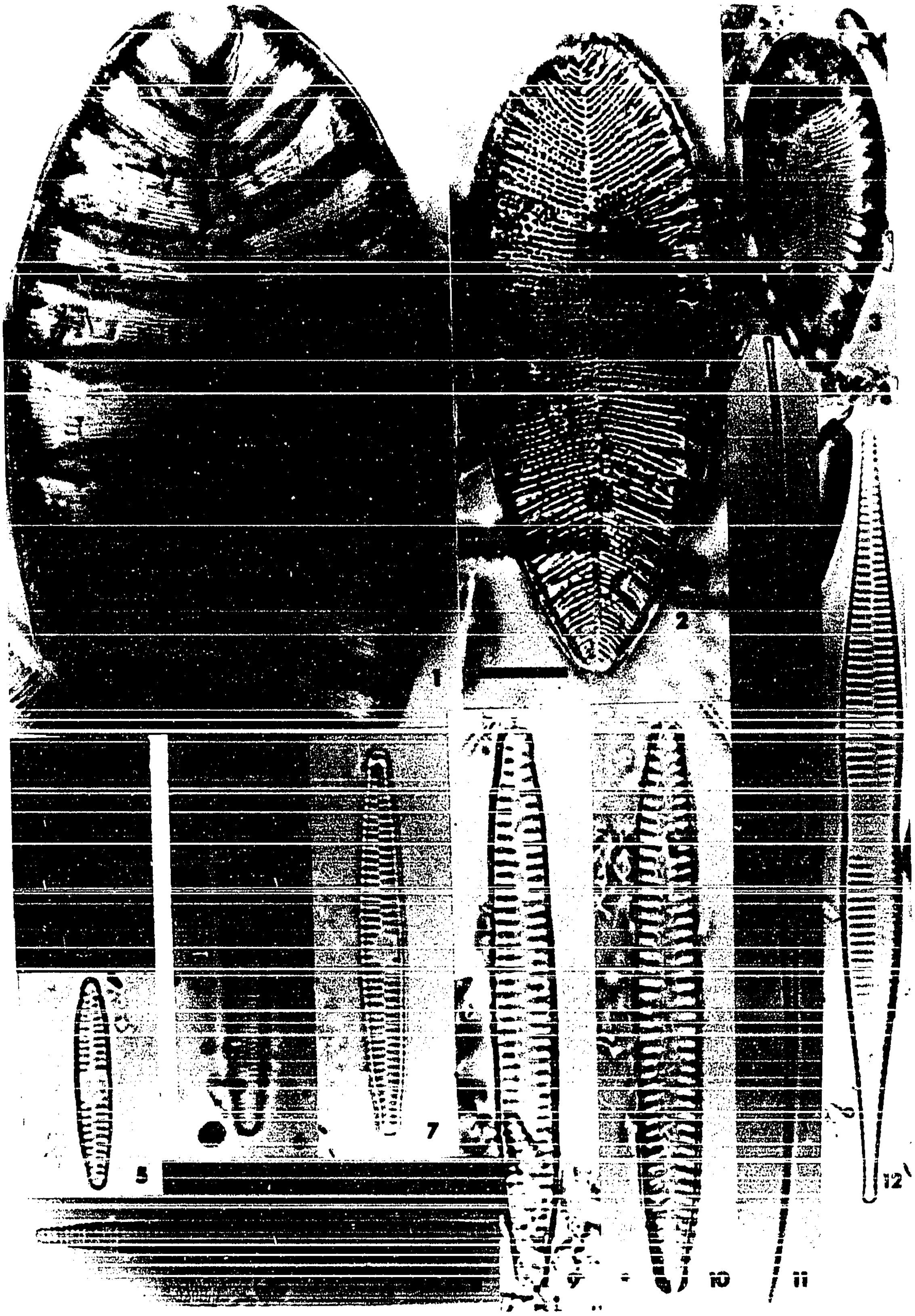
Fig. 7. Synedra sp. #3

Fig. 8. Synedra ulna var. #3

Fig. 9-10. Synedra fasciculata var. truncata

Fig. 11. Synedra delicatissima var. angustissima

Fig. 12. Synedra acus var. acus



Synedra monodi Guermeur var. monodi, Catalogues Inst. Francais d'Afr. Noire, No. 12, p. 27-28, pl. 2, fig. 1. 1954. Pl. 31, Fig. 1-2.

Photographed from material collected at sites A and G but never occurred in counts from any of the sites.

This taxon represents a form that has been considered by many authors as nothing more than an "erstlingszelle" of Synedra ulna. During my preliminary investigations, I came across too many of these forms to believe they were merely the "erstlingszelle" of that species.

The ecology of this species is insufficiently known.

Synedra parasitica (Wm. Sm.) Hust. var. parasitica, in Pasch., Sussw.-Fl. Mitteleuropas, Heft 10, Aufl. 2, p. 161, fig. 195. 1930. Pl. 30, Fig. 4.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An alkaliphilous form of the littoral zone that is usually epiphytic on other diatoms. It is oligohalobous to salt indifferent.

Synedra radians Kütz. var. radians, Bacill., p. 64, pl. 14, fig. 7. 1844. Pl. 31, Fig. 3.

Photographed from material collected at site A but never occurred in counts from any of the sites.

An alkaliphilous planktonic form that is limnophilous, salt indifferent, and is often found in waters with a fairly high conductivity.

Synedra rumpens Kütz. var. rumpens, Bacill., p. 69, pl. 16, fig. 6(6), fig. 4-5. 1844. Pl. 30, Fig. 5.

This taxon was recorded three times at G070 and once at I280.

According to Patrick and Reimer (1966), and confirmed by my own difficulty in differentiating between the two, "this species seems to be related to Fragilaria vaucheriae (Kütz.) Peters."

A widely distributed pH indifferent form that has been found in freshwater lakes and ponds or slow-flowing streams through a pH range of 6.0-9.0 (with an optimum between 6.4-6.8). It is periphytic, current indifferent, and salt indifferent.

Synedra ulna var. aequalis (Kutz.) Hust., Arch f. Hydrobiol., Bd. 10, S. 45. 1914. Pl. 31, Fig. 4.

Photographed from material collected at sites A and G but never occurred in counts from any of the sites.

This taxon may be the same as Synedra ulna var. obtusa V.H.

This is a taxon that seems to prefer water of low mineral content.

Synedra ulna var. spathulata Hust., Die Kieselalgen 2, Tiel 1, Lieferung fig. 691k-p. 1962. Pl. 31, Fig. 5.

Photographed from material collected at site A but never occurred in counts from any of the sites.

A widely distributed littoral form that prefers water of every kind. Tychoplanktonic?

Synedra ulna var. #3. Pl. 30, Fig. 6; Pl. 31, Fig. 8.

This taxon was recorded once at D010.

Synedra ulna var. #4. Pl. 31, Fig. 7-8.

This taxon was recorded once at I050.

Synedra sp. #2. Pl. 30, Fig. 6.

Photographed from material collected at site A but never occurred in counts from any of the sites.

Synedra sp. #3. Pl. 30, Fig. 7.

Photographed from material collected at site I but never occurred in counts from any of the sites.

Tabellaria Ehrenberg

Tabellaria flocculosa (Roth) Kütz. var. flocculosa, Bacill., p. 127, pl. 17, fig. 21. 1844. Pl. 31, Fig. 12.

This taxon was recorded twice at A010 and once at D010.

A very peculiar acidophilous form that has been found in ponds and bogs through a pH range of 4.2-9.0 (with an optimum between 5.0-5.3). It is periphytic and tychoplanktonic, limnobiontic, and halophobous. It also seems to have a wide tolerance for different types of water and is considered calcium indifferent.

Tabellaria sp. #1. Pl. 31, Fig. 9-11.

This taxon was recorded once at D010.

The genus Tabellaria appears to be the only genus into which the fragments seen in figures 9, 10, and 11 of plate 31 can most confidently be placed.

PLATE XXXI

(Scale is 10 μ long)

Fig. 1-2. Synedra monodi var. monodi

Fig. 3. Synedra radians var. radians

Fig. 4. Synedra ulna var. aequalis

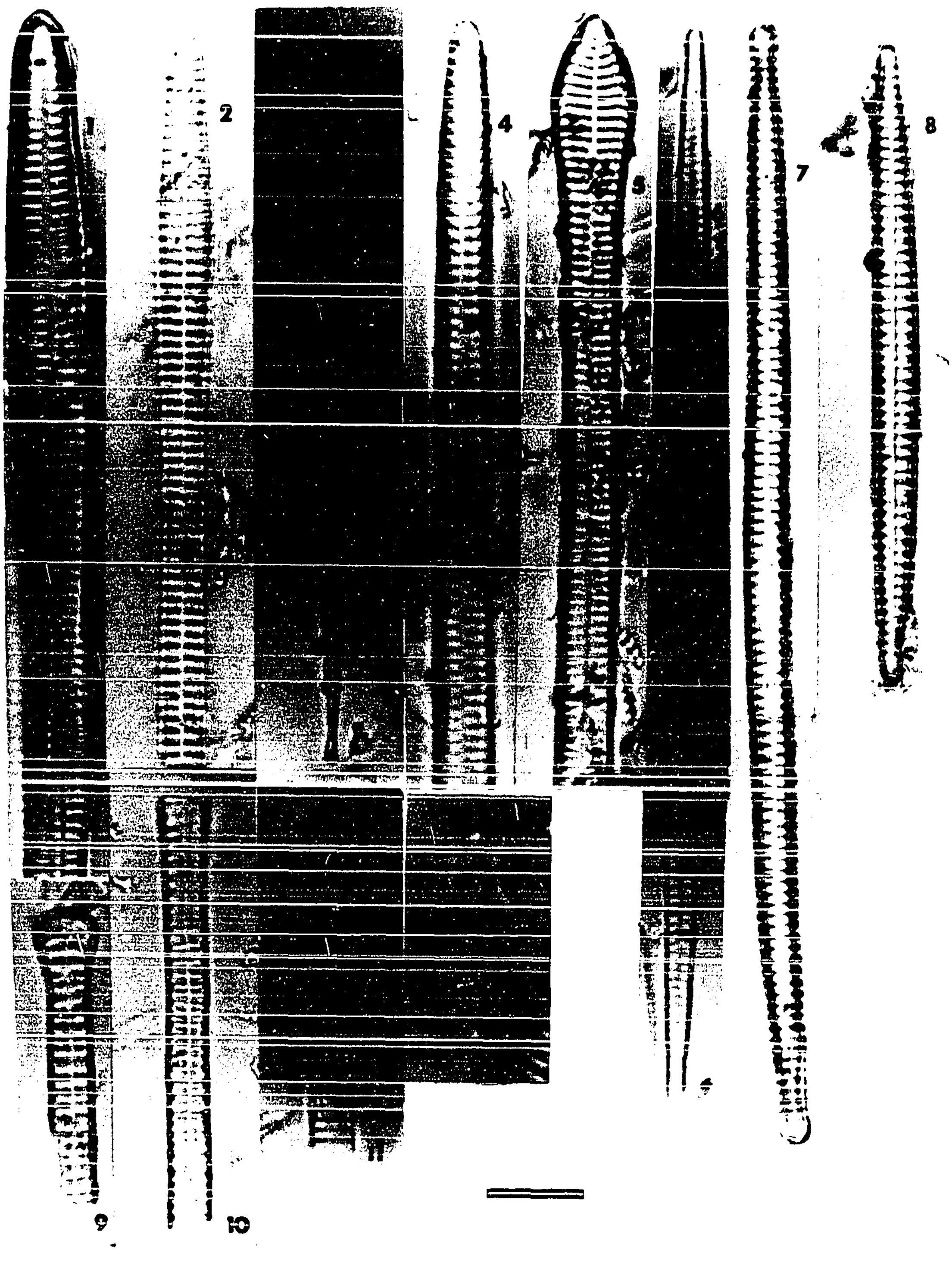
Fig. 5. Synedra ulna var. spathulata

Fig. 6. Synedra ulna var. #3

Fig. 7-8. Synedra ulna var. #4

Fig. 9-11. Tabellaria sp. #1

Fig. 12. Tabellaria flocculosa var. flocculosa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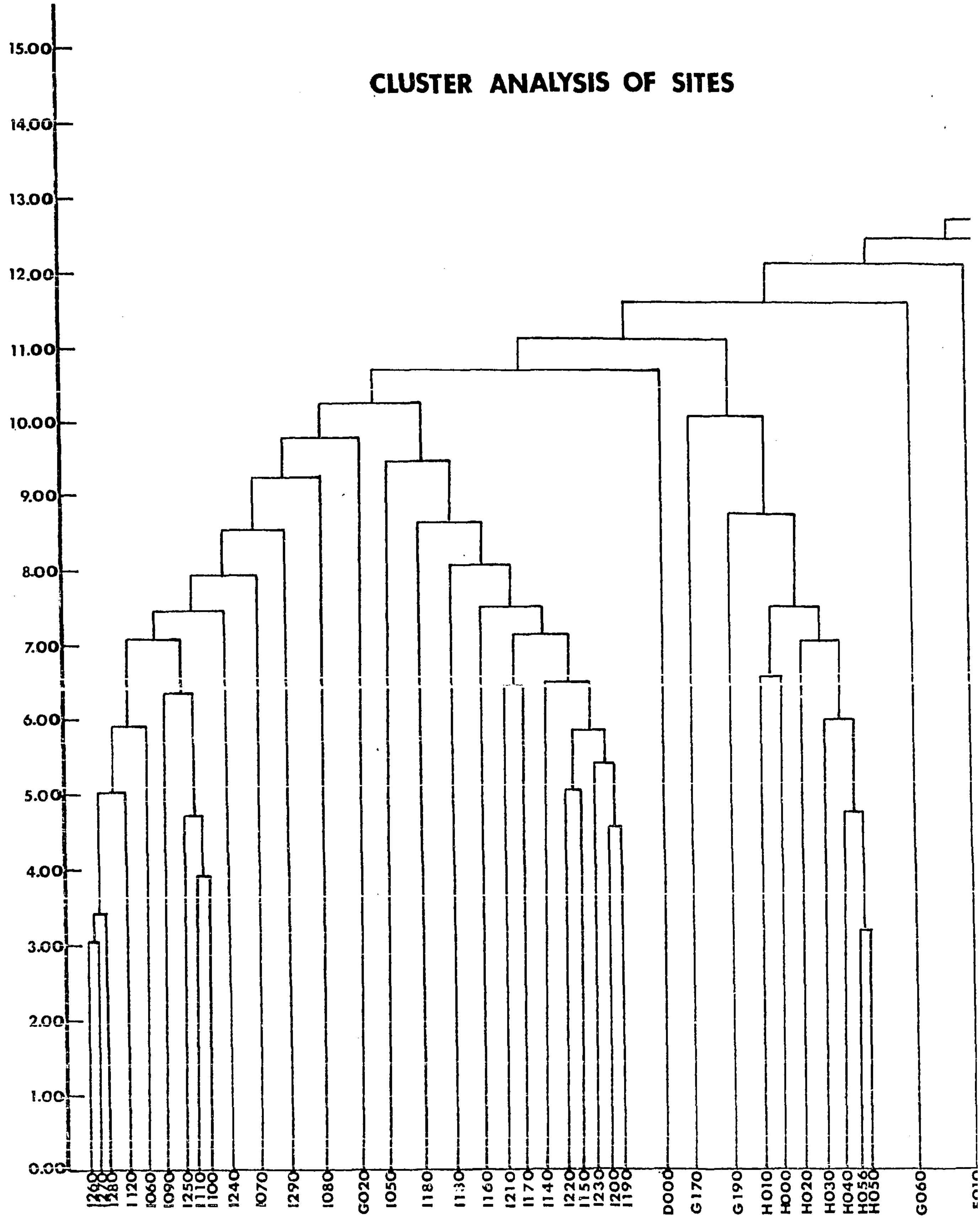
Interpretation of the Data

The results of the cluster analysis (Fig. 3) are inconsistent with data presented in Tables 3 and 5 as well as with the data from Fig. 4. As it, likewise, does not agree with my own intuitive interpretation of the data presented in this investigation, I have chosen to disregard the cluster analysis altogether.

The physical characteristics of these marl deposits are fairly constant from one site to the next, although a distinction can be made between the Wallace County sites (G, H, and I) and the Ellis and Phillips Counties sites (A, D, and F) based on the diatom associations to be found at each. When measured in terms of the mutual presence or absence of taxa between sites, the consimilarity of taxa found at sites A, D, and F and those found at sites G, H, and I is seen. In Table 3, the mutual presence and mutual absence of the 139 recorded taxa is given for six pairwise site comparisons. The measured comparison between sites A-D, A-F, G-I, and H-I were found to be considerably higher than those measured between sites A-G and F-H. Of the 139 recorded taxa, 49 were unique to sites A, D, or F, and 27 were found only at sites G, H, or I (which means that 63 taxa were common to both of these site complexes). The following taxa occurred in at least one sample at each of the six sites: Achnanthes minutissima var. minutissima, Anomoeoneis sphaerophora var. sphaerophora, Cocconeis placentula var. placentula, Cymbella cesatii var. cesatii, Cymbella cistula var. cistula, Cymbella minuta var. silesiaca, Cymbella muelleri var. muelleri, Fragilaria brevistriata var. brevistriata, Fagilaria brevistriata var. inflata, Fragilaria construens var. venter, Fragilaria lapponica var. lapponica,

Fig. 3. Cluster analysis dendrogram with the degree of sample association measured in Euclidean distance units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I240
I070
I290
I080
G020
I05G
I180
I130
I160
I210
I170
I140
I220
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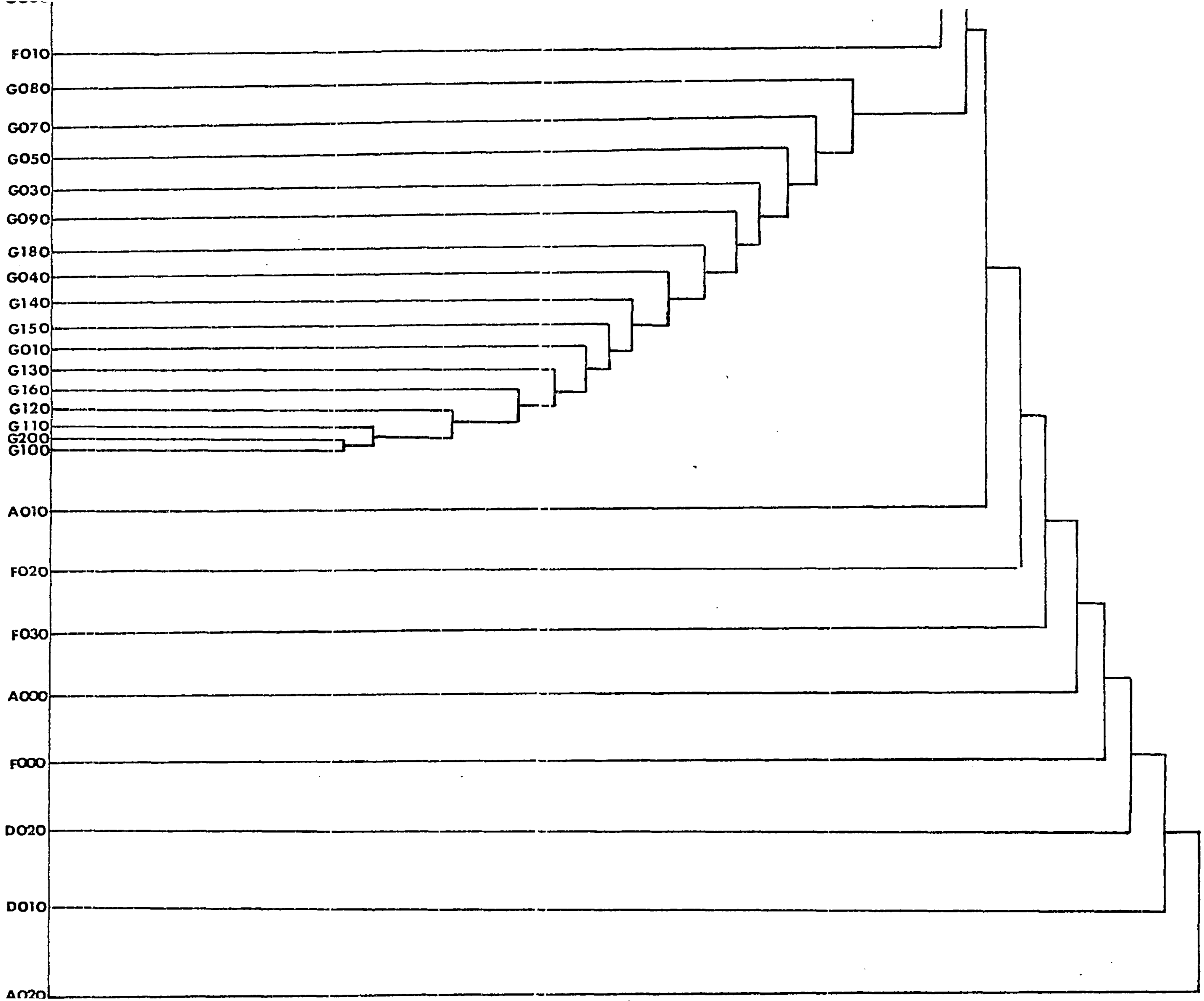

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G070
G050
G030
G090
G180
G040
G140
G150
G010
G130
G160
G120
G110
G200
G100
A010
F020
F030
A000
F000
D020
D010
A020

Table 3. Mutual presence (x) and mutual absence (o) of the 139 recorded taxa for each of six pairwise site comparisons

	A-D	A-F	A-G	F-H	G-I	H-I
Achnanthes exigua	x	x	x		x	
Achnanthes felxella	o	o			x	x
Achnanthes grimmei	x	x	x	x		
Achnanthes hungarica	x	x				
Achnanthes lanceolata	x	x			o	o
Achnanthes minutissima	x	x	x	x	x	x
Achnanthes sp. #1	x	x			o	o
Achnanthes sp. #2	x	x			o	o
Achnanthes sp. #3			o		o	o
Achnanthes sp. #5	o	o		o		o
Amphora ovalis v. ovalis	o	o		o		o
Amphora ovalis v. affinis	o	o			x	x
Amphora reinholdi	o	o				
Amphora sp. #1	x	x		x	o	
Amphora sp. #2	o	o	o	o		
Amphora sp. #3	x	x			o	o
Amphora sp. #4	o	o			x	x
Amphora sp. #5		x	x			o
Amphora sp. #6		x			o	o
Amphora sp. #7		x			o	o
Amphora sp. #8	x	x	x	x		
Amphora sp. #9		o		o		o
Anomoeoneis costata				o	o	o
Anomoeoneis exilis v. lanceolata	o	o			x	x
Anomoeoneis sphaerophora	x	x	x	x	x	x
Caloneis bacillum						o
Caloneis clevei v. tugelae	o		o		o	o
Caloneis clevei v. ?		x			o	o
Caloneis limosa	o	o			x	x
Caloneis westii		x			o	o

Table 3. (Continued)

	A-D	A-F	A-G	F-H	G-I	H-I
Cocconeis placentula	x	x	x	x	x	x
Cyclotella kansensis	o	o			x	x
Cymatopleura cochlea				o	o	o
Cymbella acutiuscula		o			x	x
Cymbella aspera v. aspera				o	o	o
Cymbella austriaca	o	o	o		o	
Cymbella cesatii v. cesatii	x	x	x	x	x	x
Cymbella cesatii v. ?	x	x		x	o	
Cymbella cistula	x	x	x	x	x	x
Cymbella hauckii	o	o			x	
Cymbella laevis	o	o			x	x
Cymbella mexicana	x	x	x		x	
Cymbella microcephala			x		x	x
Cymbella minuta v. silesiaca	x	x	x	x	x	x
Cymbella muelleri	x	x	x	x	x	x
Cymbella pusilla	o	o				o
Cymbella sp. #1	o		o		o	o
Cymbella sp. #2	o					x
Cymbella sp. #5	o	o	o	o		
Denticula elegans v. kittoniana	o	o			x	x
Diploneis oblongella	x	x				
Epithemia adnata v. proboscidea	o	o	o	o		
Epithemia sp. #1	x	x			o	o
Eunotia curvata	x	x	x			o
Eunotia glacialis				o	o	o
Eunotia praerupta	x	x			o	o
Eunotia sp. #2		o	o	o	o	o
Eunotia sp. #3	o		o		o	o
Fragilaria brevistriata v. brevistriata	x	x	x	x	x	x
Fragilaria brevistriata v. inflata	x	x	x	x	x	x

Table 3. (Continued)

	A-D	A-F	A-G	F-H	G-I	H-I
Fragilaria construens v. construens				o	o	o
Fragilaria construens v. binodis				o	o	o
Fragilaria construens v. exigua				o	o	o
Fragilaria construens v. venter	x	x	x	x	x	x
Fragilaria construens v. ?	x	x		x	o	
Fragilaria lapponica	x	x	x	x	x	x
Fragilaria pinnata v. lancettula	x	x	x	x	x	x
Fragilaria vaucheriae		x	x	x	x	x
Fragilaria virescens	o	o	o	o		
Fragilaria sp. #1	x	x			o	o
Gomphonema acuminatum	o	o	o			x
Gomphonema affine v. insigne	x	x	x	x	x	x
Gomphonema angustatum v. angustatum			o			
Gomphonema angustatum v. ?	x	x				
Gomphonema dichotomum	x	x	x	x	x	x
Gomphonema gracile	o		o		o	o
Gomphonema subclavatum		o	o	o	o	o
Gomphonema tackei	x	x			o	o
Hantzschia amphioxys v. amphioxys	o		o		o	o
Hantzschia uticensis	o	o		o		o
Hantzschia vivax	x	x			o	o
Mastogloia elliptica v. dansei	o	o				
Melosira distans v. distans				o		
Melosira distans v. decipiens	x	x		x		x
Melosira italica v. italica	x	x				
Melosira italica v. ?			o		o	o
Melosira sp. #1	x	x				
Meridion circulare			o		o	o
Navicula absoluta	x			o		
Navicula amphibola			o		o	o

Table 3. (Continued)

	A-D	A-F	A-G	F-H	G-I	H-I
Navicula anglica v. subsalsa		o		o		o
Navicula cincta	x	x	x	x	x	x
Navicula confervacea v. peregrina		o	o	o	o	o
Navicula cryptocephala				o	o	o
Navicula cuspidata v. cuspidata	x		x	o		o
Navicula dicephala v. abiskoensis	x	x	x		x	
Navicula gregaria	x	x	x	x		
Navicula lanceolata v. lanceolata	x			o	o	o
Navicula mediocris	x	x				
Navicula platensis			o		o	o
Navicula pupula v. rectangularis	x	x	x		x	
Navicula pygmaea	x	x	x			o
Navicula radiosa v. radiosa	x	x	x	x		
Navicula radiosa v. tenella	x	x	x	x	x	x
Navicula simplex		x		x		x
Navicula vulpina	o	o			x	x
Navicula sp. #1			x		x	x
Navicula sp. #5	o			x	x	x
Navicula sp. #6		x			o	o
Neidium affine v. affine			x	o		o
Nitzschia amphibia v. amphibia			o		o	o
Nitzschia amphibia v. rostrata		x			o	o
Nitzschia angustata			x	o		o
Nitzschia dubia	o	o	o		o	
Nitzschia fonticola	x	x	x	x	x	x
Nitzschia subregula v. subregula	x	x			o	o
Nitzschia subregula v. ?	o		o		o	o
Nitzschia tropica	x	x	x	x	x	x
Nitzschia sp. #1				o	o	o
Opephora martyi	x	x	x	x	x	x

Table 3. (Continued)

	A-D	A-F	A-G	F-H	G-I	H-I
Pinnularia acrosphaeria	x			o	o	o
Pinnularia aestuarii	o		o		o	o
Pinnularia biceps f. petersenii		x	x			o
Pinnularia brebissonii	o	o		o		o
Pinnularia microstauron	x	x	x	x	x	x
Pinnularia viridis v. minor	o					o
Pinnularia sp. #1	x			o	o	o
Rhopalodia gibba	o	o		o		o
Rhopalodia gibberula v. vanheurckii	x	x	x		x	
Stauroneis kriegeri	x			o	o	o
Stauroneis lauenburgiana				o		
Stauroneis phoenicenteron	o	o				
Stauroneis smithii				o	o	o
Surirella sp. #1	o	o		o		o
Synedra rumpens	o	o		o	x	
Synedra ulna v. #3		o	o	o	o	o
Synedra ulna v. #4	o	o	o	o		
Tabellaria flocculosa	x			o	o	o
Tabellaria sp. #1		o	o	o	o	o
Totals	58x 39o	61x 36o	39x 28o	31x 40o	41x 54o	38x 67o
	97	97	67	71	95	105

Fragilaria pinnata var. lancettula, Gomphonema affine var. insigne, Gomphonema dichotomum var. dichotomum, Navicula cincta var. cincta, Navicula radiosa var. tennella, Nitzschia fonticola var. fonticola, Nitzschia tropica var. tropica, Opephora martyi var. martyi, and Pinnularia microstauron var. microstauron. Only two of these, Cymbella cesatii var. cesatii and Cymbella minuta var. silesiaca occurred at every level at each of the six sites.

Percent occurrence for forty of the most widespread of the 139 taxa recorded in the sample counts are shown in Table 4A. These forty taxa represent 86.9% of all specimens counted at site A; 87.9% of all specimens counted at site D; 88.4% of all specimens counted at site F; 95.7% of all specimens counted at site G; 97.3% of all specimens counted at site H; and 99.1% of all specimens counted at site I. In terms of the 32,984 specimens counted during the course of this investigation, these forty taxa account for 31,897 or 96.7% of all specimens counted. The remaining 99 taxa that were counted at least once account for only 1,087 of the 32,984 specimens counted, or 3.3%. The occurrence of each of these forty taxa at each of the six sites is also given graphically in Fig. 4. Table 5 gives a complete sample by sample distribution for the 139 taxa for which data were recorded in the sample counts as well as lists those additional 64 taxa that were photographed but never occurred in counts from any of the sites.

The distributions of Achnanthes exigua var. exigua (Fig. 4.1), Anomoeoneis sphaerophora var. sphaerophora (Fig. 4.7), Epithemia sp. #1 (Fig. 4.19), Melosira distans var. decipiens (Fig. 4.31), Melosira italica

Fig. 4. Distributions for forty of the most widespread of the 139 recorded taxa. The common log of the number counted is plotted against samples

1. *Achnanthes exigua*
2. *Achnanthes flexella*
3. *Achnanthes grimmei*
4. *Achnanthes minutissima*
5. *Amphora* sp. #4
6. *Anomoeoneis exilis* var. *lanceolata*
7. *Anomoeoneis sphaerophora*
8. *Caloneis limosa*

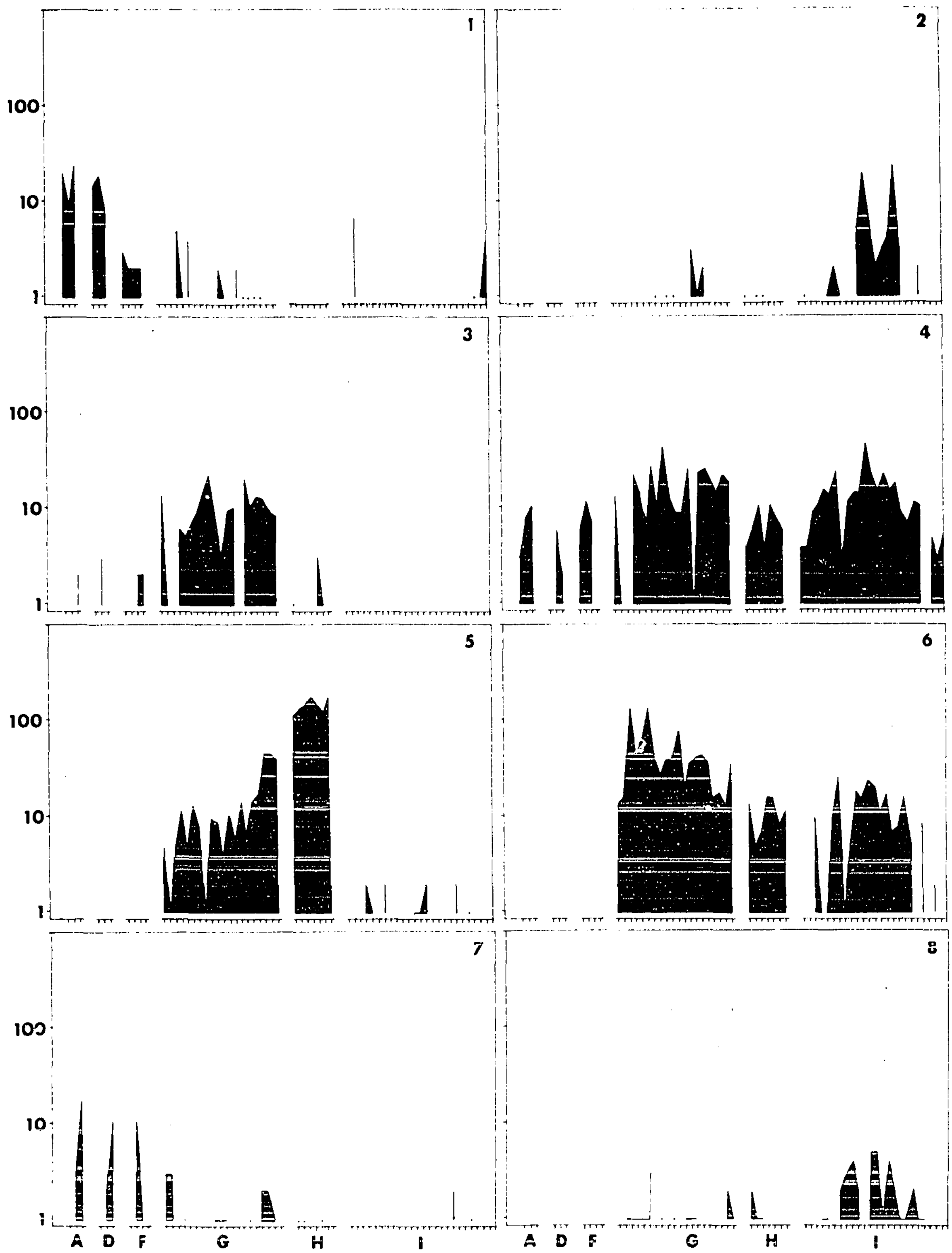

1
2
3
4
5
6
7
8
100
10
1
A D F G H I
A D F G H I

Fig. 4. (Continued)

9. *Cocconeis placentula*
10. *Cyclotella kansensis*
11. *Cymbella cesatii* var. *cesatii*
12. *Cymbella cistula*
13. *Cymbella mexicana*
14. *Cymbella microcephala*
15. *Cymbella muelleri*
16. *Cymbella minuta* var. *silesiaca*

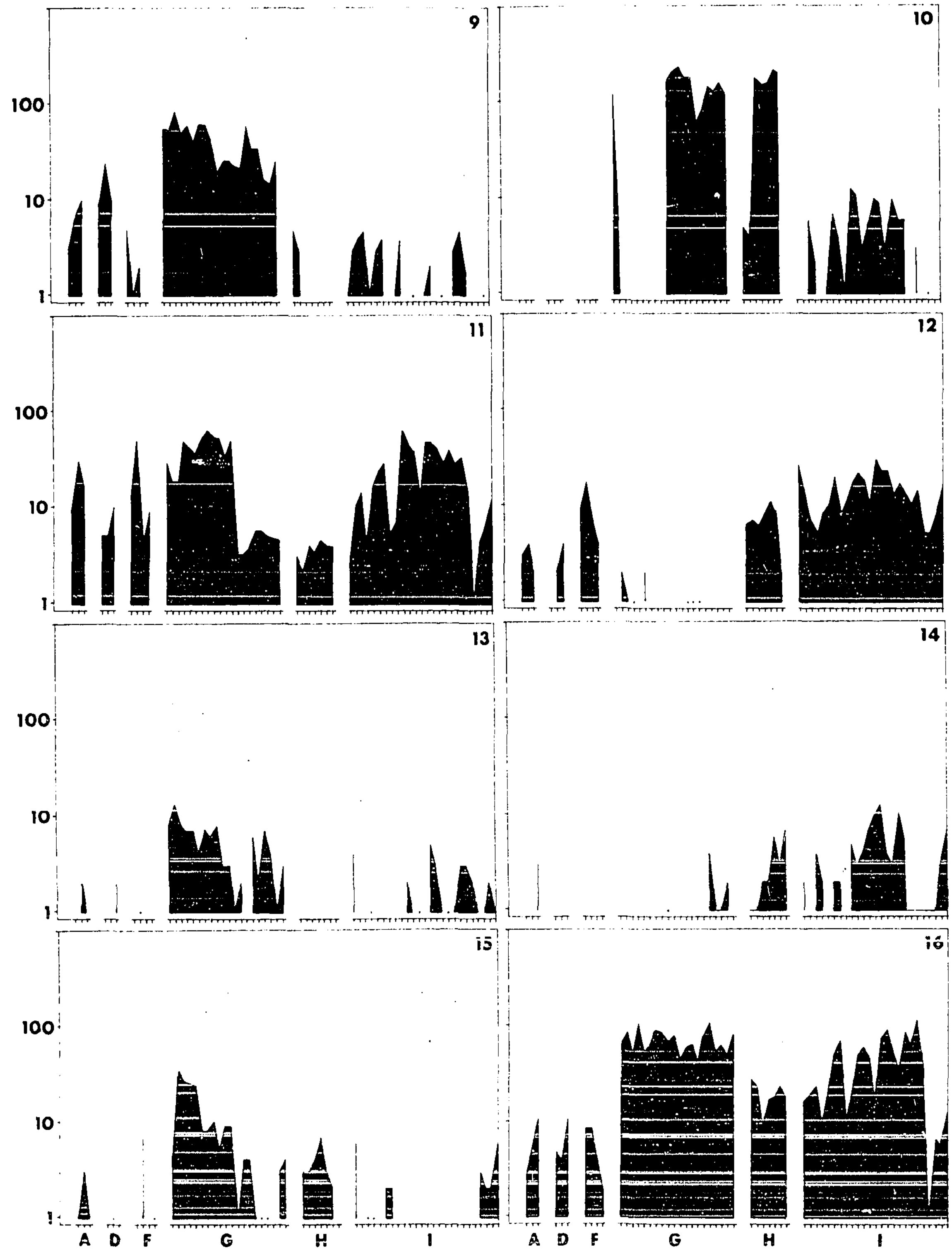

9
10
11
12
13
14
15
16
100
10
1
A
D
F
G
H
I

Fig. 4. (Continued)

17. _Cymbella_ sp. #2

18. _Denticula elegans_ var. _kittoniana_

19. _Epithemia_ sp. #1

20. _Fragilaria brevistriata_ var. _brevistriata_

21. _Fragilaria brevistriata_ var. _inflata_

22. _Fragilaria construens_ var. _venter_

23. _Fragilaria lapponica_

24. _Fragilaria pinnata_ var. _lancettula_

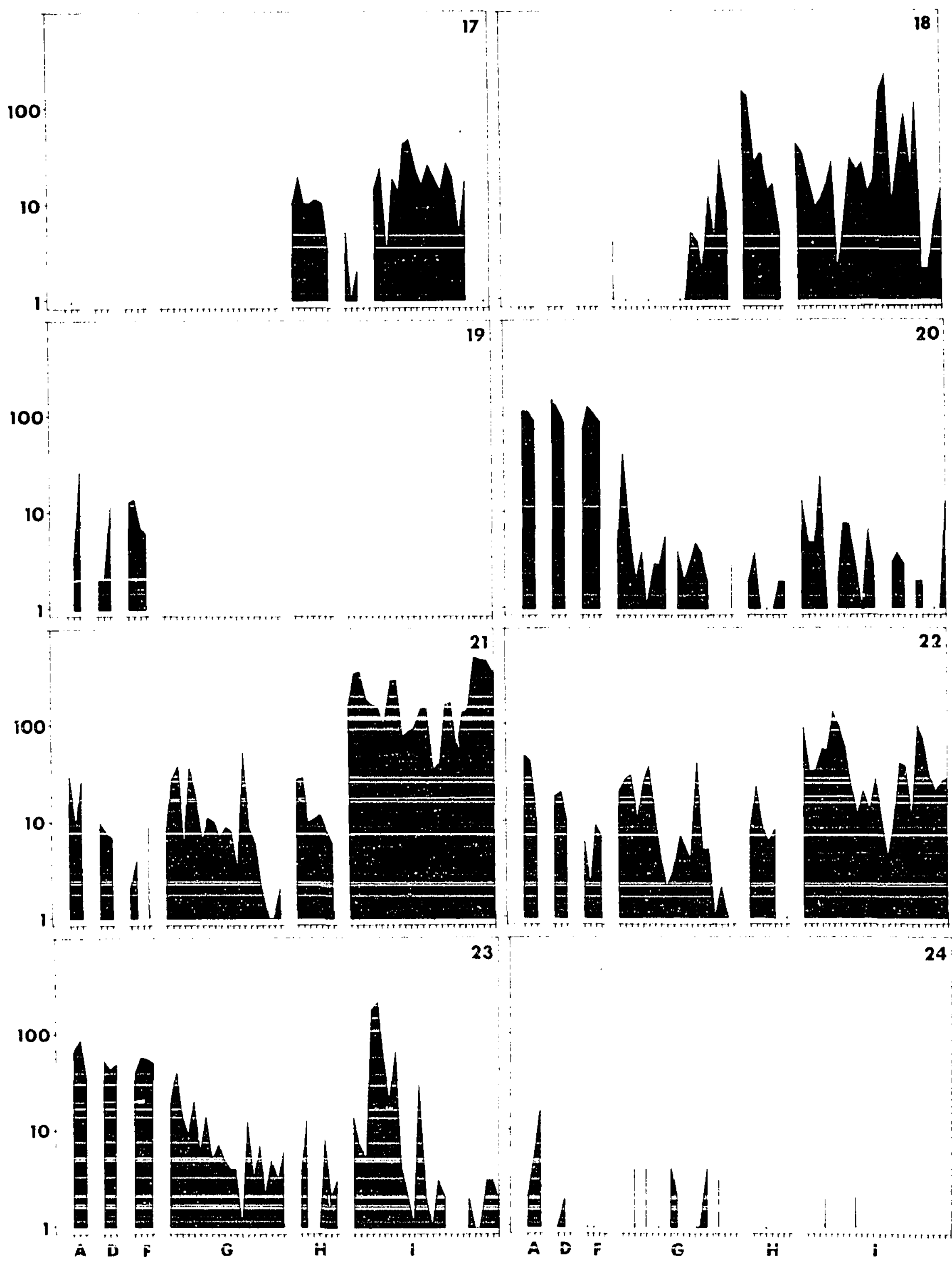

17
18
19
20
21
22
23
24
100
10
1
A D F G H I
A D F G H I

Fig. 4. (Continued)

25. *Fragilaria vaucheriae*

26. *Gomphonema acuminatum*

27. *Gomphonema affine* var. *insigne*

28. *Gomphonema dichotomum*

29. *Mastogloia elliptica* var. *dansei*

30. *Melosira distans* var. *distans*

31. *Melosira distans* var. *decipiens*

32. *Melosira italica* var. *italica*

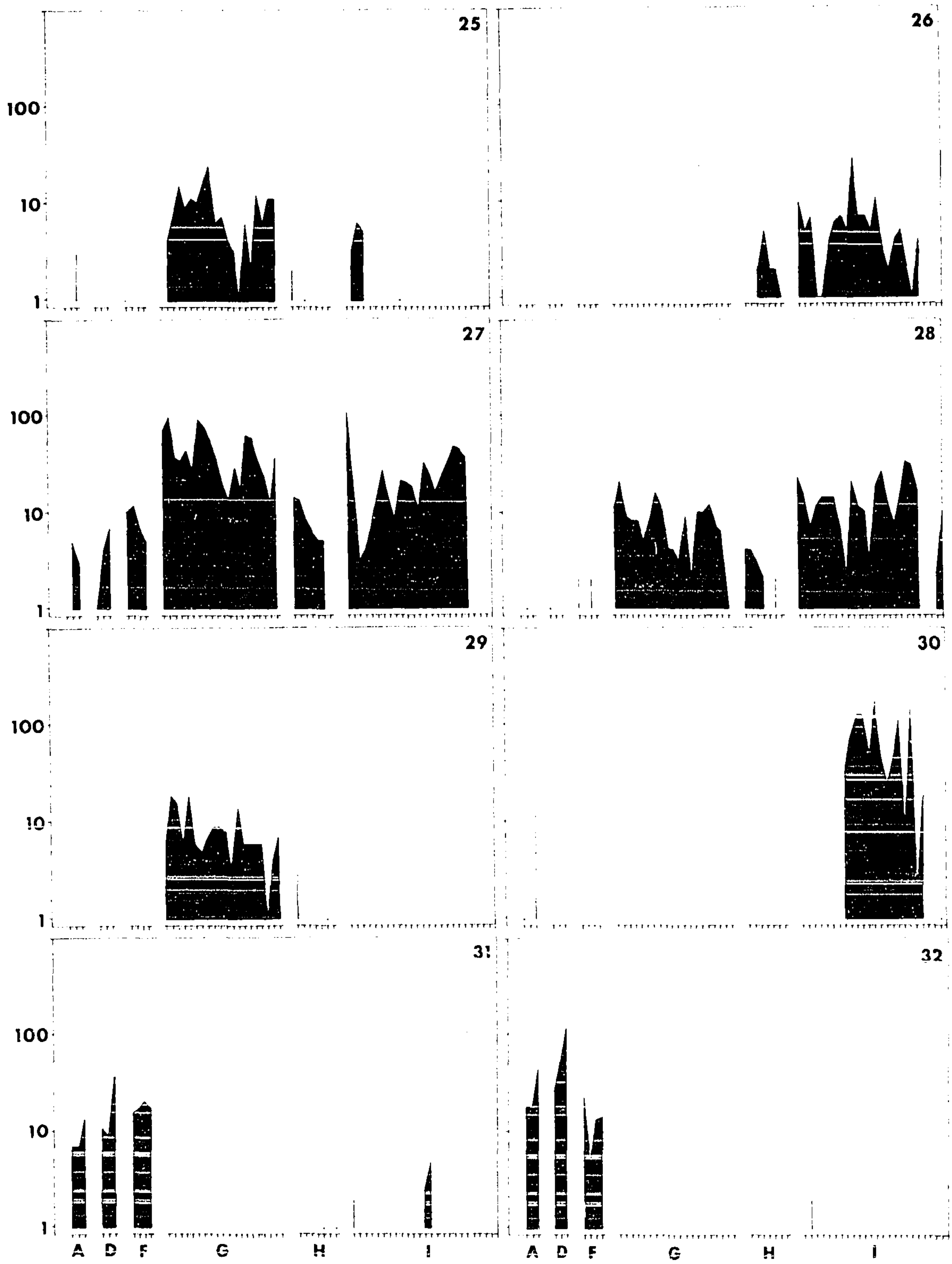

25
26
27
28
29
30
31
32
100
10
1
A
D
F
G
H
I

Fig. 4. (Continued)

33. *Navicula cincta*

34. *Navicula gregaria*

35. *Navicula mediocris*

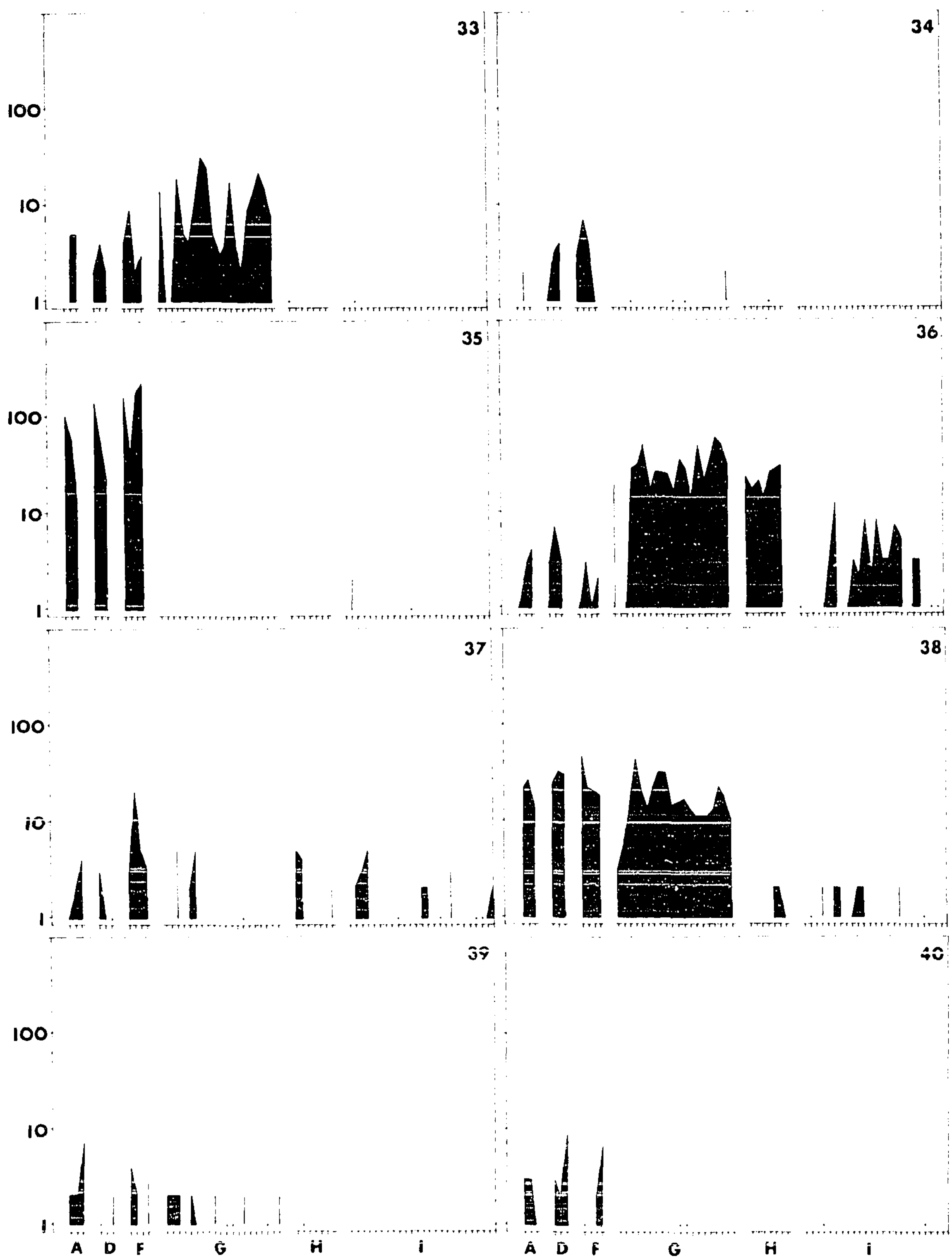
36. *Navicula radiosa* var. *tenella*

37. *Nitzschia fonticola*

38. *Nitzschia tropica*

39. *Pinnularia microstauron*

40. *Rhopalodia gibberula* var. *vanheurckii*


33
34
35
36
37
38
39
40
100
10
1
A D F G H i
A D F G H i

var. italica (Fig. 4.32), Navicula mediocris var. mediocris (Fig. 4.35), and Rhopalodia gibberula var. vanheurckii (Fig. 4.40) represent taxa that were found at sites A, D, and F but which were absent from or had very limited distributions at sites G, H, and I. The distributions of Anomoeoneis exilis var. lanceolata (Fig. 4.6), Cyclotella kansensis var. kansensis (Fig. 4.10), Denticula elegans var. kittoniana (Fig. 4.18), and Gomphonema dichotomum var. dichotomum (Fig. 4.28) represent taxa that were found at sites G, H, and I but which were absent from or had very limited distributions at sites A, D, and F. And the distributions of Cymbella minuta var. silesiaca (Fig. 4.16), Fragilaria brevistriata var. brevistriata (Fig. 4.20), Gomphonema affine var. insigne (Fig. 4.27), and Navicula radiosa var. tenella (Fig. 4.36) point to the differences that exist between these two site complexes in terms of the numbers of specimens of those taxa recorded at each. The particular distributions that have been cited here represent only the most obvious examples. There are other species distributions that suggest similar associations, and there are some that suggest nothing at all.

In spite of the association of certain taxa at each of these site complexes, an interrelationship based on species frequencies is difficult to demonstrate. Since there is no time stratigraphic significance associated with any of the samples, it is not possible to compare specific levels between sites. We can only compare individual patterns of distribution and hope that the same number of specimens of a given taxa at one site follows a similar distributional pattern at some point within another site. Most of the distributions of Fig. 4 indicate that the numbers of specimens at each level and their pattern of distribution through each site are extremely erratic. Few, if any, of the forty species distributions of Fig. 4 seem to follow a similar distributional pattern from one site to another.

Table 4A. Percent occurrence of forty of the most widespread of the 139 taxa for which data were recorded in the sample counts

	Site					
	A	D	F	G	H	I
Achnanthes exigua	3.4	2.6	.4	.2	.0	.1
Achnanthes flexella	.0	.0	.0	.1	.1	.5
Achnanthes grimmei	.1	.2	.2	1.6	.1	.0
Achnanthes minutissima	1.4	.5	1.2	3.1	1.3	2.5
Amphora sp. #4	.0	.0	.0	2.7	28.5	.2
Anomoeoneis exilis v. lanceolata	.0	.0	.0	8.6	2.1	1.6
Anomoeoneis sphaerophora	1.4	.8	.6	.2	.1	.0
Caloneis limosa	.0	.0	.0	.1	.1	.3
Cocconeis placentula	1.3	2.8	.4	7.9	.2	.3
Cyclotella kansensis	.0	.0	.0	17.1	27.2	.8
Cymbella cesatii	3.4	1.3	3.6	7.9	6.6	4.2
Cymbella cistula	.6	.4	1.8	.1	1.3	2.6
Cymbella mexicana	.2	.1	.0	.9	.0	.2
Cymbella microcephala	.2	.0	.0	.1	.6	.7
Cymbella muelleri	.3	.1	.4	1.7	.6	.2
Cymbella minuta v. silesiaca	1.3	1.3	1.1	13.8	3.9	8.0
Cymbella sp. #2	.1	.0	.0	.0	2.0	2.5
Denticula elegans v. kittoniana	.0	.0	.0	.7	10.2	7.1
Epithemia sp. #1	2.0	1.0	1.9	.0	.0	.0
Fragilaria brevistriata	20.9	23.1	19.5	.9	.3	.8
Fragilaria brevistriata v. inflata	4.2	1.6	.7	2.5	2.8	38.3
Fragilaria construens v. venter	6.5	3.0	1.1	2.3	1.5	7.7

Table 4A. (Continued)

	Site					
	A	D	F	G	H	I
Fragilaria lapponica	12.0	9.3	9.7	1.8	.8	4.6
Fragilaria pinnata v. lancettula	1.5	.2	.1	.2	.0	.0
Fragilaria vaucheriae	.2	.0	.0	1.6	.1	.1
Gomphonema accuminatum	.0	.0	.0	.0	.3	.9
Gomphonema affine v. insigne	.5	.8	1.6	8.2	1.4	4.0
Gomphonema dichotomum	.1	.1	.3	1.6	.4	2.4
Mastogloia elliptica v. dansei	.0	.0	.0	1.5	.1	.0
Melosira distans	.8	.0	.0	.0	.0	7.6
Melosira distans v. decipiens	1.8	3.6	3.4	.0	.1	.1
Melosira italica	5.3	12.8	2.8	.0	.0	.0
Navicula cincta	.6	.5	.8	2.0	.0	.0
Navicula gregaria	.1	.5	.7	.0	.0	.0
Navicula mediocris	10.9	13.7	28.4	.0	.0	.0
Navicula radiosa v. tenella	.5	.8	.3	5.2	4.3	.5
Nitzschia fonticola	.4	.3	1.5	.2	.2	.2
Nitzschia tropica	3.8	5.4	5.0	3.2	.1	.1
Pinnularia microstauron	.7	.2	.4	.2	.0	.0
Rhopalodia gibberula v. vanheurckii	.4	.9	.5	.0	.0	.0
Totals	86.9	87.9	88.4	95.7	97.3	99.1

CONCLUSIONS

In view of the lack of similarity between the samples of different sites (even between the samples of those sites with a similar association of species), it is not possible at this time to establish biostratigraphic units based on diatom distributions that could be used in the correlation of one area of the Ogallala with another. Perhaps, after more assemblages have been studied, such correlations will be possible. Presently, however, this is not possible, and I am convinced that future attempts at correlation will be unsuccessful as well. The reason lies in the suspected nature of the Ogallala sediments. As was first pointed out by Hawthorn (1897), there were so many changes in the velocity of the water carrying the Ogallala sediments that lesser local lagoons and marshes existed in different places and for varying lengths of time. In light of the present investigation, this would allow for the general similarity of taxa at certain sites and, more significantly, would account for their very random and noncorrelating distributions. As noted earlier, a vast majority of the taxa found at these sites have very erratic distributions (Fig. 4). At site G, for example, Cyclotella kansensis var. kansensis goes from 124 specimens down to 4 in an interval of just 10 cm.; Denticula elegans var. kittoniana goes from 18 to 148 to 225 specimens, then down to 10 specimens, all in the interval of 30 cm. (site I); and at site I, Melosira distans var. distans goes from 9 specimens up to 146, then back down to 2 specimens in the interval of 20 cm. These represent just a few of the more erratic distributional patterns which tend to support the hypothesis that the deposition at each of these six sites was proceeding at its own rate.

The immediate significance of being able to distinguish two site complexes on the basis of their species assemblages is not yet clear. Perhaps, each of these site complexes represents a distinct cycle of deposition during Ogallala history. An evolutionary reshuffling of taxa may have allowed for replacement of earlier assemblages with ecologically similar ones; of particular interest in this regard is the fact that, of the numerous unnamed taxa recorded or only photographed once and never seen again, the majority are known from sites A, D, and/or F. Some or all of these may represent taxa that had become extinct before the second depositional cycle had begun, but other explanations such as their having been introduced into habitats of marginal compatibility may also apply.

On the basis of ecological parameters associated with living taxa, there is nothing that would suggest separate depositional histories for either of these two species assemblages. Physico-chemical spectra analyses of 91 taxa are given in Table 4B. Twenty of these taxa are unique to sites A, D, and/or F; 17 are unique to sites G, H, and/or I; and 54 are common to both of these site complexes. The analysis suggests that these diatoms were all deposited in shallow alkaliphilous fresh water. The samples contain a considerable number of periphytic forms and only a very few planktonic or benthic diatoms [According to Abbott and Vanlandingham (1972), muddy or cloudy water could prevent the growth of benthic forms.]. Several taxa characteristic of waters of high conductivity were also found as were a number of calciphilous forms.

Table 4B. Physico-chemical spectra analyses of the 91 taxa for which ecological data is known

	pH spectrum					Halobion spectrum						Current spectrum					"Habitat" spectrum			
	Acidobiontic	Acidophilous	Indifferent	Alkaliphilous	Alkalibiontic	Oligohalobous	Halophobous	Indifferent	Halophilous	Mesohalobous	Euhalobous	Limnobiontic	Limnophilous	Indifferent	Rheophilous	Rheobiontic	Planktonic	Tychoplanktonic	Benthic	Periphytic
Achnanthes exigua				x		x		x						x						x
Achnanthes flexella		x	x				x						x				x			x
Achnanthes hungarica				x		x		x					x	x						x
Achnanthes lanceolata				x				x							x	x				x
Achnanthes minutissima			x					x						x						x
Amphora ovalis v. ovalis				x				x					x	x						x
Amphora ovalis v. affinis				x				x					x	x						x
Anomoeoneis costata									x											
Anomoeoneis exilis v. lanceolata				x		x	x	x												
Anomoeoneis sphaerophora					x				x						x					x
Caloneis bacillum				x				x							x					x
Caloneis limosa				x		x		x				x								x
Cocconeis placentula				x				x						x						x
Cymbella aspera v. aspera				x		x		x						x						x
Cymbella austriaca		x						x					x							
Cymbella cistula v. cistula				x		x		x				x	x							x
Cymbella mexicana				x																
Cymbella microcephala				x		x		x						x						x
Cymbella muelleri				x																
Cymbella pusilla			x			x				x										
Denticula elegans v. kittoniana				x																
Diatoma vulgare v. grande					x		x													
Diploneis oblongella				x		x		x						x						x
Epithemia adnata v. proboscidea				x																x
Eunotia curvata		x	x				x	x						x				x		x
Eunotia glacialis		x																		
Eunotia major var. ?		x																		
Eunotia praerupta		x				x														
Fragilaria brevistriata v. brevistriata				x				x	x					x						x

Table 4B. (Continued)

	pH spectrum					Halobion spectrum						Current spectrum					"Habitat" spectrum			
	Acidobiontic	Acidophilous	Indifferent	Alkaliphilous	Alkalibiontic	Oligohalobous	Halophobous	Indifferent	Halophilous	Mesohalobous	Euhalobous	Limnobiontic	Limnophilous	Indifferent	Rheophilous	Rheobiontic	Planktonic	Tychoplanktonic	Benthic	Periphytic
Fragilaria brevistriata v. inflata				x																
Fragilaria construens v. construens				x				x						x				x		x
Fragilaria construens v. binodis								x												
Fragilaria construens v. venter				x				x				x						x		x
Fragilaria lapponica			x					x												
Fragilaria pinnata v. lancettula																				
Fragilaria vaucheriae				x		x		x						x	x					x
Frgailaria virescens			x				x	x						x						
Gomphonema acuminatum				x		x		x					x							x
Gomphonema angustatum v. angustatum				x				x						x						x
Gomphonema gracile			x	x		x		x				x	x							x
Gomphonema subclavatum						x			x											x
Hantzschia amphioxys v. amphioxys				x		x		x						x						x
Mastogloia elliptica v. dansei									x	x										x
Melosira distans v. distans		x					x							x			x			x
Melosira italica v. italica			x	x			x	x						x			x	x		x
Meridion circulare				x			x	x							x	x		x		x
Navicula amphibola			x	x		x		x						x						
Navicula anglica v. subsalsa				x		x		x							x				x	x
Navicula cincta				x					x											
Navicula confervacea v. peregrina			x	x				x												x
Navicula cryptocephala				x				x	x					x						
Navicula cuspidata v. cuspidata				x		x		x						x						x
Navicula cuspidata v. heribaudi				x				x												

Table 4B. (Continued)

	pH spectrum					Halobion spectrum						Current spectrum					"Habitat" spectrum			
	Acidobiontic	Acidophilous	Indifferent	Alkaliphilous	Alkalibiontic	Oligohalobous	Halophobous	Indifferent	Halophilous	Mesohalobous	Euhalobous	Limnobiontic	Limnophilous	Indifferent	Rheophilous	Rheobiontic	Planktonic	Tychoplanktonic	Benthic	Periphytic
Navicula dicephala v. abiskoensis				x		x		x											x	x
Navicula lanceolata v. lanceolata				x		x		x					x							x
Navicula pupula v. rectangularis			x	x		x		x						x					x	x
Navicula pygmaea				x	x					x										
Navicula radiosa v. radiosa			x	x		x		x						x						x
Navicula radiosa v. tenella			x	x																x
Navicula semen							x	x												x
Navicula vulpina				x		x														
Neidium affine v. affine			x	x		x		x							x					x
Neidium affine v. amphirhynchus				x															x	x
Neidium affine v. longiceps		x																		
Neidium kozlowii v. amphicephala				x																
Neidium productum							x	x												
Nitzschia amphibia v. amphibia				x	x			x						x						x
Nitzschia angustatum				x		x		x					x							
Nitzschia dubia			x	x				x	x											
Nitzschia fonticola				x	x	x		x						x			x			x
Opephora martyi				x	x	x		x					x				x			x
Pinnularia acrosphaeria				x		x														x
Pinnularia brebissonii								x												
Pinnularia mesolepta				x			x	x												
Pinnularia microstauron		x						x												
Pinnularia nodosa		x					x	x												
Pinnularia viridis v. minor		x	x			x														x
Rhoicosphenia curvata				x		x		x						x	x					x
Rhopalodia gibba v. gibba				x	x			x						x						x
Rhopalodia gibberula v. vanheurckii				x		x		x												
Stauroneis kriegeri			x			x														

Table 4B. (Continued)

	pH spectrum					Halobion spectrum						Current spectrum					"Habitat" spectrum			
	Acidobiontic	Acidophilous	Indifferent	Alkaliphilous	Alkalibiontic	Oligohalobous	Halophobous	Indifferent	Halophilous	Mesohalobous	Euhalobous	Limnobiontic	Limnophilous	Indifferent	Rheophilous	Rheobiontic	Planktonic	Tychoplanktonic	Benthic	Periphytic
Stauroneis phoenicenteron			x			x		x						x						x
Stauroneis smithii			x	x		x		x							x					x
Surirella striatula			x							x										
Synedra acus				x				x					x					x		x
Synedra delicatissima v. angustissima			x					x					x				x			
Synedra fasciculata v. truncata																				
Synedra parasitica						x		x												x
Synedra radians													x							
Synedra rumpens			x					x						x						x
Tabellaria flocculosa		x					x					x						x		x
Totals	0	12	26	59	7	35	13	61	7	5	0	5	14	29	9	2	6	7	4	55

The taxa that make up these assemblages were overwhelmingly current "indifferent" to limnophilous indicating that these bodies of water were standing. It was fresh water as evidenced by the halobien spectrum since the majority of taxa fall in the "indifferent" category, indicative of fresh water. The rheophilous to rheobiontic forms (associated with running water) make up about 20% of the deposits and suggest that streams feeding these depositional waters were substantial. According to Vanlandingham (California Academy of Sciences, San Francisco, CA; personal communication; 1976), "one of the most striking things about the Wallace County diatomite is that is has a strikingly high rheophilous element in the community and suggests deposition on a river flood plain. This and one of the deposits in Nevada are the only significant diatomites that I know of in the world that have had a possible river flood plain deposition."

The suggestion of a marshy sort of flood plain environment is substantiated by information provided by several other students of the Ogallala. Thomasson (Div. of Science and Math, Black Hills State College, Spearfish, SD; personal communication; 1976) working with fossil angiosperm seeds, and Zehr (1974) working with fossil vertebrates have concluded that the depositional environment in the vicinity of sites A and D was a subhumid, subtropical, savanna or savanna parkland. Zehr's Hamburg Fauna represents "a community occupying the floodplain of a large permanent river." The presence of large land tortoises suggests a frost-free climate of wet and dry seasons but no winter. Another of the inhabitants of this fauna, Teleoceras sp., was a short-legged rhinoceras which, because of its physical build (massive body and short legs) is thought to have occupied areas around pools and swamps. In addition to the freshwater mollusks which were found associated with these diatomaceous marls, nucules from the alga Chara globularis were collected by Joseph Thomasson from the marl at the Ellis County sites (Joseph Thomasson; Div. of Science and Math, Black Hills State College, Spearfish, SD; personal communication; 1976). According to Fay K. Daily (Research Associate, Butler University, Indianapolis, IN; personal communication to Joseph Thomasson; 1975), Chara globularis is an extant species with a cosmopolitan distribution and is found "in my experience . . . in the black mucky substrata of lakes and lagoons."

Biostratigraphically, this investigation presents a preliminary look at the similarities and differences between six diatomaceous marl deposits of the Ogallala in western Kansas. There are many more diatomaceous marl outcrops in Kansas and Nebraska that await similar study. One of the best methods of obtaining age determination information would be to collect diatomaceous sediments associated with well-authenticated vertebrate fossils so that the stratigraphic relations of the diatomaceous beds and those carrying vertebrate fossils could be established unequivocally. Preliminary work of this sort has been carried out by a few people, including S. L. Vanlandingham (California Academy of Sciences, San Francisco, CA; personal communication; 1976) who suggests that "the diatomaceous marl from Ellis County is the equivalent of the diatomaceous marl of Wallace and Logan Counties, Kansas, which is Ogallala age (early Pliocene); however, on the basis of the new radiometric geologic dating, I would suspect that the age is possibly close to latest Miocene or early Pliocene." According to G. W. Andrews (U.S. Geol. Survey, Washington, D.C.; personal communication; 1976), "I doubt that you will find Epithemia in deposits of greater age than Middle Pliocene. Rhopalodia appears about the same time, perhaps a bit later. Both are common in later sediments of the Great Plains area." According to Zehr (1974), there have been increasing discussions in recent years "centering on the problematic Mio-Pliocene boundary, and the establishing of a new mammal age term for this transition, the Valentinian. The problem revolves around trying to zone recognizable stages of evolution in mammals with time transgressive stratigraphic units. It is possible that this cannot be done outside the type localities. Although the Hamburg local fauna does contain Valentinian forms, I shall consider it to be an early Clarendonian (early Pliocene) vertebrate fauna."

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And now if you'll excuse me, I'm off to Maine.

APPENDIX

Table 5. Master table of six fossil diatom populations from the Ogallala Formation of western Kansas

Taxon / Sample	A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160
	Ellis County						Phillips County																			
Achnanthes exigua Grun. v. exigua	20	9	25	15	19	8	3	2	2	2				5	1	4					2	1		2	1	1
Achnanthes flexella (Kütz.) Brun. v. flexella																		1		1	1			3	1	2
Achnanthes grimmei Krasske v. grimmei			2		3				2	2	13	1		6	5		9	14	22	8	3	9	10		20	10
Achnanthes hungarica (Grun.) Grun. var. hungarica	2			3	19	7	1																			
Achnanthes lanceolata (Bréb. in Kütz.) Grun. in Cl. & Grun. v. lanceolata	2	2		4		1	4		2	2																
Achnanthes minutissima Kütz. v. minutissima	3	8	11		6	2	6	12	7		14	1		23	15	6	28	10	48	13	9	9	26	1	24	26
Achnanthes sp. #1	3	1		2	2	1	4	3	1	3																
Achnanthes sp. #2	2	1			2				1																	
Achnanthes sp. #3						1				1																
Achnanthes sp. #4[a]																										
Achnanthes sp. #5																1										
Achnanthes sp. #6[a]																										
Amphora ovalis (Kütz.)Kütz. var. ovalis																										
Amphora ovalis v. affinis (Kütz.) V.H. ex DeT.																1						3		1		
Amphora reinholdi Hanna v. reinholdi											2		7	2	1	5	2	1	1		3	3		1		
Amphora sp. #1	1				2		4	1	2	4																
Amphora sp. #2																										
Amphora sp. #3	1	4	4	2	2	2		2	1																	
Amphora sp. #4											5	1	5	12	5	14	8	1	10	9	4	11	6	15	7	1
Amphora sp. #5	1		2					1	1					2												
Amphora sp. #6		1	3					1																		
Amphora sp. #7		2	1				1		2																	
Amphora sp. #8		5	2	3		1	2	6	3	2				3			1	1		1	2	1	1			
Amphora sp. #9					3						2															
Amphora sp. #10[a]																										
Amphora sp. #11[a]																										
Anomoeneis costata (Kütz.) Hust. v. costata		1	6																							
Anomoeneis exilis v. lanceolata Mayer											14	16	135	46	69	138	43	28	40	42	80	21	37	41	45	3
Anomoeneis sphaerophora (Ehr.) Pfitz. v. sphaerophora		4	18		2	11		11	1		3	3		1					1	1	1				1	
Anomoeneis sp. #1[a]																										
Caloneis bacillum (Grun.) Cl. v. bacillum					3		1		3	3												1				
Caloneis clevei v. tugelae (Cholnoky) Cholnoky										1																
Caloneis clevei v. ?		3								3																
Caloneis limosa (Kütz.) Patr. v. limosa												1	1	1	1	3		1		1		1	1	1		
Caloneis westii (Wm. Sm.) Hendey v. westii			1					1																		
Caloneis sp. #1[a]																										
Caloneis sp. #2[a]																										

[a]Taxa that were photographed but never counted.

Wallace County

G160	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
1	1	1												3																				1	1	4
2				1	1		1	1					1				1	2	1	1		5	19	6	2	3	4	23	3			2				
10	13	12	9	8	1				3	1																										
														1																						
26	21	15	23	19	4	6	11	4	11	8	6	4	4	9	11	16	14	25	3	12	15	15	49	24	16	24	16	19	9	7	12	11		5	3	6
			1																																	
	1	1							1						3				2	2																
		2	1	1		2																														
										1																										
																																		1		3
15	18	48	47	42	117	144	150	183	154	130	183	1			2	1		2					1	1	2					2		1				10
	1																																			
		3		1			1	1	2																											
38	16	18	13	37	14	6	8	16	16	8	12			10	1	1	10	27	1	5	19	16	25	21	11	18	7	8	17	5		9		2		
	2	2	1		1	1			1																				2			1				
	1	1																																		
			2	1	2	1	1								1	1		2	3	4	2		5	5	1	4	2	1	1	2	1	1				1

Table 5. (Continued)

Taxon	Sample A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160	G170
	Ellis County						Phillips County																				
Cocconeis placentula Ehr. v. placentula	3	7	10	9	25	10	5	1	2		57	56	87	51	62	41	65	63	45	20	27	27	24	23	62	36	36
Cyclotella kansensis Hanna v. kansensis											124	4								171	210	231	185	182	64	82	149
Cymatopleura cochlea Brun. v. cochlea			2																								
Cymbella acutiuscula Cl. v. acutiuscula						1										1											
Cymbella aspera (Ehr.) H. Perag. v. aspera			1																								
Cymbella aspera v. ?[a]																											
Cymbella austriaca Grun. v. austriaca																											
Cymbella cesatii (Rabh.) Grun. ex A.S. v. cesatii	9	30	16	5	5	10	13	50	4	9	29	18	18	48	42	35	53	63	54	52	33	48	31	31	36	55	55
Cymbella cesatii v. ?	1	4	1			2	12	14	5	5																	
Cymbella cistula (Ehr. in Hempr. & Ehr.) Kirchn. v. cistula	3	4	2		2	4	9	18	7	4		2	1	1		2							1	1	1		
Cymbella hauckii V.H. v. hauckii														1													
Cymbella inaequalis (Ehr.) Rabh. v. v. inaequalis[a]																											
Cymbella laevis Naeg. ex Kütz. v. laevis															2	4		2				1		3			
Cymbella mexicana (Ehr.) Cl. v. mexicana		2	1			2		1			8	13	8	7	7	4	7	6	8	3	3	1	2		6	2	7
Cymbella microcephala Grun. v. microcephala			3																1							4	1
Cymbella minuta v. pseudogracilis (Choln.) Reim.[a]																											
Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	6	11	5	4	11	9	9	4	2	70	90	52	111	56	68	95	87	73	83	46	62	67	43	81	116	56
Cymbella muelleri Hust. v. muelleri	1	3	1		1			8		1	4	34	27	25	24	8	8	10	5	3	9	1	4	4	1	1	1
Cymbella pusilla Grun. v. pusilla														1	1	1		6	1							1	1
Cymbella sp. #1									1																		
Cymbella sp. #2		1																									
Cymbella sp. #4[a]																											
Cymbella sp. #5																											
Cymbella sp. #6[a]																											
Cymbella sp. #7[a]																											
Cymbella sp. #9[a]																											
Cymbella sp. #10[a]																											
Cymbella sp. #11[a]																											
Denticula elegans v. kittoniana (Grun.) DeT.											4		1				1					1	1	5	4	2	12
Diatoma vulgare v. grande (Wm. Sm.) Grun.[a]																											
Diploneis oblongella (Naeg. ex Kütz.) Ross v. oblongella	6	1		2	4	3	5		2	4																	
Epithemia adnata v. proboscidea (Kütz.) Patr.																											
Epithemia sp. #1	2	3	27	2	2	12	13	14	7	6																	
Eunotia curvata (Kütz.) Lagerst. v. curvata	2			1	4	7	4	1							1												
Eunotia glacialis Meist. v. glacialis	1																										

Wallace County

	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
16	36	17	15	27	5	3						1	3	4	5	1	3	4		1	4		1		1	2		1		3	5	2			1	
12	149	130	161	125	51	40	181	156	158	219	207			6	2		1	7	4	1	13	11	3	5	10	9	3	10	6	6		3		1		
					1																															2
					1	4	5		1	1																										
5	55	48	46	44	31	21	39	33	44	39	38	3	10	14	4	16	23	28	5	7	62	44	37	13	47	47	40	28	39	27	33	14	1	4	6	11
					4	7	13	13	11	8	3																									
					6	7	6	8	11	8	2	26	14	7	5	8	10	20	8	11	17	22	18	10	30	23	23	13	17	13	10	14	5	5	7	15
			1																2	11		1	1	3				1	1		1			1		1
		1			1		1					2																								
2	7	4	1	3								4			1						2	1	1		5	3	1	1	1	3	3	2	1	1	2	1
4	1	1	2		1	1	2	2	6	3	7	2		4	2		2	2		5	3	4	7	10	13	4	3	11	6		1	1	1	1	3	7
16	56	66	52	89	29	24	10	18	19	25	19	17	19	25	10	20	51	76	11	18	53	66	49	19	78	99	59	38	91	68	123	43	1	7	6	13
1	1		3	4	3	3	4	7	3	2		6		1	1		2	2															3	2	2	6
1	1		1																																	
					10	19	10	10	11	10	3	5	1	2			14	24	3	18	13	41	46	22	15	25	18	13	26	19	5	17			1	
														2																						
2	12	4	29	8	149	135	27	33	14	16	5	43	33	16	9	11	16	28	2	7	30	22	27	13	18	148	225	10	34	87	21	116	2	2	6	13
																						1	1				1		1							
																									1											

Table 5. (Continued)

		Ellis County					Phillips County																				
Taxon	Sample A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160	G170
Eunotia major v. ?[a]																											
Eunotia praerupta Ehr. v. praerupta		1			1		1	1		1																	
Eunotia vanheurckii Patr. v. *vanheurckii*[a]																											
Eunotia sp. #1[a]																											
Eunotia sp. #2					1																						
Eunotia sp. #3									1																		
Eunotia sp. #4[a]																											
Fragilaria brevistriata Grun. v. brevistriata	120	118	96	159	121	89	76	131	116	92	5	41	6	2	4	1	3	3	6		4	2	3	5	4	2	
Fragilaria brevistriata v. inflata (Pant.) Hust.	31	9	27	10	8	7	2	4		9	8	27	39	5	38	18	6	11	10	7	9	8	3	54	9	6	2
Fragilaria construens (Ehr.) Grun. v. construens		1	4																								
Fragilaria construens v. binodis (Ehr.) Grun.	1																										
Fragilaria construens v. exigua (Wm. Sm.) Schulz.			5																								
Fragilaria construens v. venter (Ehr.) Grun. in V.H.	52	42	9	18	20	10	6	2	9	7	20	28	30	10	24	37	13	4	2	3	7	5	4	40	5	5	1
Fragilaria construens v. ?	9	6	1	1	10	2		2	1	3																	
Fragilaria lapponica Grun. v. lapponica	72	87	33	54	44	50	40	59	56	51	20	40	14	9	20	6	14	5	7	5	4	4	1	13	3	7	2
Fragilaria pinnata v. lancettula (Schum.) Hust. in A.S.	2	6	16	1	2		1	1					4		4		1		4	2			1	1	4		3
Fragilaria pinnata v. ?[a]																											
Fragilaria vaucheriae (Kütz.) Peters. v. vaucheriae			3				1					4	7	15	9	11	10	16	24	6	7	4	3	1	6	2	12
Fragilaria virescens Ralfs v. virescens																											
Fragilaria sp. #1	3			1			2	1	1	1																	
Gomphonema acuminatum Ehr. v. acuminatum																											
Gomphonema affine v. insigne (Greg.) Andrews		5	3	1	4	7	10	12	7	5	69	99	37	35	44	27	93	76	56	37	19	13	29	16	62	58	34
Gomphonema angustatum (Kütz.) Rabh. v. angustatum						3	1																				
Gomphonema angustatum v. ?	1				2			1		1																	
Gomphonema dichotomum Kütz. v. dichotomum		1		1			2		2		11	21	9	8	8	5	8	16	11	4	4	3	9	2	10	10	12
Gomphonema gracile Ehr. emend V.H. v. gracile							1																				
Gomphonema martini Fricke v. martini[a]																											
Gomphonema subclavatum (Grun.) Grun. v. subclavatum				1	2																						
Gomphonema tackei Hust. v. tackei		2	1		2	1				1																	
Gomphonema sp. #1[a]																											
Hantzschia amphioxys (Ehr.) Grun. v. amphioxys							1																				
Hantzschia amphioxys f. capitata O. Muller[a]																											
Hantzschia amphioxys v. vivax Grun.[a]																											
Hantzschia uticensis (Grun.) Hust. v. uticensis																											1

Wallace County

	G160	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
	2				3	2	4	1	1	1	2	2	14	5	5	25	1		2	8	8	3	1	7	3			3	4	3		2	2		1	1	12
	6	2	1	1	2	28	29	10	11	12	8	6	150	349	356	186	162	152	102	289	294	76	85	92	144	146	34	39	156	169	53	130	136	489	471	456	373
	5	1	2	1		8	23	9	6	8		1	93	32	33	55	53	136	93	57	22	11	20	12	27	10	4	10	39	36	10	97	70	27	20	25	27
								3																													
	7	2	5	3	6	4	13		1	8	2	3	14	7	5	176	217	53	19	66	4	2	1	30	2	1	3	2				2	1	1	3	3	2
		3						1								2					2																
	2	12	6	11	11	2		1						3	6							1															
																5				2																	
								2	5	2	2	1	10	5	7	1	1	4	6	7	5	29	7	7	5	11	3	2	4	5	2	1	4				
:	58	34	24	12	37	14	13	8	6	5	5		107	22	3	4	7	17	27	14	8	21	20	18	10	32	24	15	23	32	46	44	35				8
															1	1							1														
																																	1				1
)	10	12	7	6	1	4	4	3	2		2		23	15	7	11	14	14	14	6	2	21	11	10	3	16	26	13	7	14	33	31	17			2	10
		1																																			

Table 5. (Continued)

Taxon	Sample A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160	G170
	Ellis County						Phillips County																				
Hantzschia vivax (Wm. Sm.) M. Peragallo v. vivax	1		1		1		1																				
Mastogloia elliptica v. dansei (Thwaites) Cl.											6	19	16	6	19	6	5	7	9	9	8	3	14	6	6	6	6
Melosira distans (Ehr.) Kütz. v. distans	1		12																								
Melosira distans v. decipiens (Grove in A.S.) Cl.-Euler	7	7	14	11	9	38	16	18	21	18																	
Melosira italica (Ehr.) Kütz. v. italica	19	19	46	28	55	121	26	5	14	15																	
Melosira italica v. ?				1	2	10			1																		
Melosira sp. #1	3	1	13	4	3	13	6	3		1																	
Meridion circulare (Grev.) Ag. v. circulare				1			1		1	1																	
Navicula absoluta Hust. v. absoluta	2	2		1	10	1																					
Navicula amphibola Cl. v. amphibola						1			1																		
Navicula anglica v. subsalsa (Grun.) Cl.						1					1						1	1	1				1		1	2	1
Navicula cincta (Ehr.) Ralfs v. cincta		5	5	2	4	2	4	9	2	3	14	1	1	19	5	4	12	32	25	5	3	4	18	3	2	9	13
Navicula confervacea v. peregrina (Wm. Sm.) Grun. in V.H.					7																						
Navicula cryptocephala Kütz. v. cryptocephala			4																								
Navicula cuspidata (Kutz.) Kutz. v. cuspidata		1	1	1																							
Navicula cuspidata v. heribaudi Peragallo in Heribaud.[a]																											
Navicula cuspidata v. major Meist.[a]																											
Navicula dicephala v. abiskoensis (Hust.) A. Cl.	2	1	1			1			1			1				1		1									
Navicula gregaria Donk. v. gregaria		2		1	3	4	3	7	4	1				1							1		1				
Navicula halophila f. tenuirostris Hust.[a]																											
Navicula lanceolata (Ag.) Kütz. v. lanceolata		1	2	1	2	1																					
Navicula lanceolata v. ?[a]																											
Navicula mediocris Krasske v. mediocris	103	58	13	141	56	21	166	40	176	222																	
Navicula platensis (Freng. in Freng. & Cordini) Cholnoky v. platensis					1	1	1			1																	
Navicula pupula v. rectangularis (Greg.) Grun.	2		3	1		3	1	3	4		1		2	2	3	4	1	1	1				2	2			1
Navicula pygmaea Kütz. v. pygmaea	1		3	1	2				1		2			1				1					3		1	1	
Navicula radiosa Kütz. v. radiosa	1	9	37	1	5	7	3	13	11	1	2								1						5	2	
Navicula radiosa v. tenella (Bréb. ex Kütz.) Grun.	1	3	4	3	7	3	1	3	1	2	19		1	28	31	50	17	26	26	25	16	35	28	13	47	20	37
Navicula semen Ehr. emend Donk. v. semen[a]																											
Navicula simplex Krasske v. simplex			1				1																				
Navicula vulpina Kütz. v. vulpina																						1					
Navicula sp. #1		1											2		4	4								1			
Navicula sp. #2[a]																											
Navicula sp. #3[a]																											
Navicula sp. #4[a]																											
Navicula sp. #5									2							1			2	1			1	3			
Navicula sp. #6		1								2																	

Wallace County

	G160	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
	6	6	1	4	7	3					1																										
																				36	80	130	132	51	176	48	25	42	111	9	146	2	19			1	
										1		1	2												3	5											
														2																							
																			1	2			1		2												
														1																						1	1
1	2	1																																			
2	9	13	22	15	8	1									1																						1
			1																																		
																	1										1					2					
					2					1																											
														2										1													
		1		2																	1				1				1	2			1				
1	1		1		1																																
5	2		3			2	1																														
47	20	37	58	50	31	23	17	21	14	25	28	30	1				1	4	12		1	3	2	8	2	8	3	3	7	5		3	3		1	1	
										1																						1					
					1	2	1	2			1				1			3	5					5					1			1	3		1	1	
						1																											1		1	1	
			2	1			1																	1		1											

Table 5. (Continued)

	Ellis County						Phillips County																				
Taxon / Sample	A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160	G170
Navicula sp. #7[a]																											
Navicula sp. #8[a]																											
Navicula sp. #9[a]																											
Navicula sp. #10[a]																											
Navicula sp. #11[a]																											
Neidium affine (Ehr.) Pfitz. v. affine	1																1								1		
Neidium affine v. amphirhynchus (Ehr.) Cl.[a]																											
Neidium affine v. longiceps (Greg.) Cl.[a]																											
Neidium decens (Pant.) Stoermer v. decens[a]																											
Neidium distincte-punctatum Hust. v. distincte-punctatum[a]																											
Neidium kozlowii v. amphicephala Meresch.[a]																											
Neidium munckii Foged v. munckii[a]																											
Neidium productum (Wm. Sm.) Cl. v. productum[a]																											
Nitzschia amphibia Grun. v. amphibia				2	1	5		10	7	5																	
Nitzschia amphibia v. rostrata Grun.	1							6																			
Nitzschia angustata (Wm. Sm.) Grun. v. angustata			1																								2
Nitzschia dubia Wm. Sm. v. dubia																											
Nitzschia fonticola Grun. v. fonticola		2	4	3	1	1	3	21	5	3			5		2	5								1			
Nitzschia subregula Hust. v. subregula			1			1			1																		
Nitzschia subregula v. ?							2																				
Nitzschia tropica Hust. v. tropica	21	26	14	24	32	30	46	22	20	18	3	6	13	44	21	13	22	32	31	14	15	16	13	11	11	11	13
Nitzschia sp. #1			2																								
Nitzschia sp. #3[a]																											
Nitzschia sp. #4[a]																											
Opephora martyii Herib. v. martyii			1		1	1			1	2				1													
Pinnularia acrosphaeria Wm. Sm. v. acrosphaeria		1				2																					
Pinnularia aestuarii Cl. v. aestuarii							1		1																		
Pinnularia biceps f. petersenii Ross	1						1			1							1										
Pinnularia brebissonii (Kütz.) Rabh. v. brebissonii												1				1											
Pinnularia mesolepta (Ehr.) Wm. Sm. v. mesolepta[a]																											
Pinnularia microstauron (Ehr.) Cl. v. microstauron	2	2	7	1		2	4	2		3	2	2	2		2	1			2		1	1		2			
Pinnularia nodosa (Ehr.) Wm. Sm. v. nodosa[a]																											
Pinnularia viridis v. minor Cl.							2										1										
Pinnularia sp. #1			1	1	1																						
Rhoicosphenia curvata (Kütz.) Grun. ex Rabh. v. curvata[a]																											
Rhopalodia gibba (Ehr.) O. Muller v. gibba												2	2					2	4				1	1	1	1	
Rhopalodia gibberula v. vanheurckii O. Muller	3	3	1	3	2	9	1		2	7											1	1					

Wallace County

G160	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
	2		1																																	
							1	1																												
					5	4					2		2	3	5					1				2	2		1		3		1		1	1	1	
11	13	22	17	10					2	2	1		1		2		2	2		1	2	2						2				1				
					1							1																								
		1		2		1																														
1																																				
															1																	1				

Table 5. (Continued)

Taxon	Sample																											
	Ellis County						Phillips County																					
	A000	A010	A020	D000	D010	D020	F000	F010	F020	F030	G010	G020	G030	G040	G050	G060	G070	G080	G090	G100	G110	G120	G130	G140	G150	G160	G170	G180
Stauroneis kriegeri Patr. v. kriegeri	1				3																							
Stauroneis lauenburgiana Hust. v. lauenburgiana		1																										
Stauroneis phoenicenteron (Nitz.) Ehr. v. phoenicenteron									1																			
Stauroneis smithii Grun. v. smithii		1																										
Stauroneis sp. #1[a]																												
Surirella striatula Turp. v. striatula[a]																												
Surirella sp. #1															1			1	1				1					
Surirella sp. #2[a]																												
Synedra acus Kütz. v. acus[a]																												
Synedra delicatissima v. angustissima Grun.[a]																												
Synedra fasciculata v. truncata (Grev.) Patr.[a]																												
Synedra monodi Guermeur v. monodi[a]																												
Synedra parasitica (Wm. Sm.) Hust. v. parasitica[a]																												
Synedra radians Kütz. v. radians[a]																												
Synedra rumpens Kütz. v. rumpens																	3											
Synedra ulna v. aequalis (Kütz.) Hust.[a]																												
Synedra ulna v. spathulata Hust.[a]																												
Synedra ulna v. #3					1																							
Synedra ulna v. #4																												
Synedra sp. #2[a]																												
Synedra sp. #3[a]																												
Tabellaria flocculosa (Roth) Kütz. v. flocculosa		2			1																							
Tabellaria sp. #1					1																							
Number of taxa	47	55	58	43	56	51	51	43	51	45	29	27	28	33	33	36	30	32	32	26	29	32	33	34	32	30	33	

Wallace County

G160	G170	G180	G190	G200	H000	H010	H020	H030	H040	H050	H056	I050	I060	I070	I080	I090	I100	I110	I120	I130	I140	I150	I160	I170	I180	I190	I200	I210	I220	I230	I240	I250	I260	I270	I280	I290
													1																							
												1			1																					
		2																																		
																																			1	
												1																								
30	33	34	31	29	35	29	29	23	28	25	20	24	22	26	28	18	21	25	22	27	23	25	28	26	26	22	23	25	25	18	24	30	11	21	23	26