A COMPARISON OF EPIPHYTIC DIATOM ASSEMBLAGES ON LIVING AND DEAD STEMS OF THE COMMON GRASS *PHRAGMITES AUSTRALIS*

Judith A. Grimes', Larry L. St. Clair', and Samuel R. Rushforth'

ABSTRACT.— Diatoms epiphytic on *Phragmites australis* (Cav.) Trin. ex Steaded stems were collected from a single clone at the southern end of Provo Bay, Utah Lake, Utah. Diatom populations from both living and dead stem sections were analyzed. Species diversity in each sample was high, indicating that the stems provide a relatively stable habitat for diatom epiphytes. Of the 23 genera found, only *Gomphonema* and *Navicula* showed significant trends toward stem preference. The diatoms in this study support the current view that Utah Lake is a slightly saline, eutrophic system.

The occurrence of diatom assemblages as epiphytes on littoral, emergent macrophytes is well documented (Godward 1934, 1937, Knudson 1957, Prowse 1959). Likewise, the impact of such epiphytes on primary productivity and community trophic structure has been examined in several estuarine environments (McIntire et al. 1971, Stowe et al. 1971, and Main et al. 1974), but has been largely ignored in freshwater systems (Wetzel 1964). The epiphytic diatom communities attached to emergents inevitably play a role in the overall productivity of lakes and estuaries. They also contribute to regulation of the overall metabolism of such waters by altering the amount and quality of allochthonous organics entering the lake by acting as physical and metabolic traps or filters. The attached diatom flora also serves as an autochthonous source of particulate organic and dissolved organic matter that is readily available to pelagic animals. The degree of influence of these epiphytic organisms on the productivity of standing waters has rarely been determined. However, Allen (1971) estimated that up to 31.3 percent of the total littoral production could be attributed to epiphtyic algae, with up to 21.4 percent of the total lake production being attributable to such attached communities. In addition, a comparison between phytoplankton and epiphyte production demonstrated that the latter was equivalent to 75 percent of the phytoplankton production over the annual period (Allen 1971).

Even though epiphytic communities have been demonstrated to be important, the distribution patterns of such assemblages on the basis of variation in host species and host substrate conditions have received little attention. Likewise, the complex physiological relationship between the host macrophyte and the attached diatom species has received less attention than warranted (Wetzel 1964, 1965, 1969b, Allen 1971, Hough et al. 1975). The impact of this relationship is fundamental to understanding the basic distribution patterns of epiphytes not only on different macrophyte host species but also on members of the same species at different levels of senescence.

The purpose of this study is to illuminate distribution patterns of diatom epiphytes on living and dead specimens of a single macrophyte host (*Phragmites australis* (Cav.) Trin. ex Steaded) in Utah Lake, Utah. The data from this study will be used as a baseline for extended research in Utah Lake on epiphyte distribution patterns and epiphyte impact on lake productivity and trophic structure.

Methods

Samples were collected 20 September 1978 from a single clone of *Phragmites australis* located at the southern end of the mouth of Provo Bay in Utah Lake. Five samples of living and five of dead *Phragmites australis* stems were collected as cut 10 cm sections, measured from the water level

Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

down. Samples were prepared according to standard acid-oxidation methods, and permanent diatom slides were made using Naphrax diatom mountant (St. Clair and Rushforth 1977). Slides were examined and diatom species were identified at 1000X with a Ziess RA research microscope with bright field and Nomarski interference phase-contrast accessories.

Quantitative data on the diatom assemblages were recorded by counting 250-400 diatoms for each sample. Previous studies have shown that a statistically valid count can be obtained within this range (Squires 1977). Each slide was then thoroughly scanned to record the rare species. The results were converted into percent relative density values for all species for each site. Shannon-Wiener diversity indices were calculated for individual samples (Shannon and Wiener 1963).

The relative density figures for each sample were compared to all other samples and similarity indices were calculated (Ruzicka 1958). These indices were clustered (Sneath and Sokal 1973) to identify unique community associations within and between the living and dead *Phragmites australis* stem sections.

The most prevalent diatoms encountered in the study and the diatoms that significantly differed between the living and the dead specimens of *Phragmites australis* were determined.

Results

Twenty-three genera and 114 diatom species were found on the 10 Phragmites australis stem sections (Table 1). The most prevalent diatoms throughout the study were Navicula graciloides, Nitzschia inconspicua, and Nitzschia filiformis (Table 2). Nitzschia dissipata, Stephanodiscus astrea var. minutula, and Nitzschia palea were also common. Among the prevalent species, Amphora veneta was found to occur only on the living stems, whereas Navicula schroeteri var. escambia was essentially restricted to the dead stems. TABLE 1. Alphabetical list of the diatom taxa found on living and dead *Phragmites australis* stem sections from Provo Bay, Utah Lake, and their average relative density.

Achnanthes hauckiana**.07-Achnanthes lauceolata var. dubia*-PAchnanthes lauceolata var. dubia*-PAchnanthes minutissima2.2057Achnanthes minutissima2.2057Achnanthes minutissima2.2057Achnanthes sp.**P-Amphora ovalis31PAmphora perpusilla.761.79Amphora perpusilla.761.79Amphora veneta8.781.26Amphora sp.*.19-Asterionella formosa.09.08Caloneis sphaerophora*P-Cocconeis placentula var. euglypta*-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana*13Cyclotella mengliniana1.871.80Cymbella affinis*-PCymbella fifnis*-PDiatoma tenue var. elongatum.13.23Diploneis oblongella**.02-Epithemia adnata var. proboscidea*-PFragilaria construens var. orelusPPFragilaria construens var. unflata.06.17Fragilaria construens var. venter.65.11Fragilaria lapponica**.19-Fragilaria apinnata**.31-Gomphonema grile**.02-Cymbolnema grile**.02-Gomphonema subclavatum.07.13F	Species	Living	Dead
Achnanthes lanceolata var. dubia*-PAchnanthes lanceolata var. dubia*.06PAchnanthes minutissima2.20.57Achnanthes sp.**P-Amphora ovalis var. pediculus*.10Amphora ovalis var. pediculus*-Amphora ovalis var. englypta*-Anomoeoneis sphaerophora**PAcconceis flacentula var. lineata.07Coscinodiscus sp06Cyclotella kutzinghiana*-13.13Cyclotella meneghiniana1.87Cymbella affinis*-P-Cymbella mueller**.14Cymbella sp.**PP-Diatoma tenue var. elongatum.13Diploneis oblongella**.02P-Fragilaria brevistriata*-P-Fragilaria construens var. binodis.06PPFragilaria construens var. unflata.06.15.15Fragilaria construens var. venter.65.11.13Fragilaria pinnata*.13.12.14.14.17Fragilaria pinnata*.17Fragilaria similis.19.17.17<	Achnanthes hauckiana°°	.07	_
Achnanthes lewisiana.06PAchnanthes minutissima2.20.57Achnanthes sp.**PAmphora ovalis.31PAmphora ovalis var. pediculus*Amphora ovalis var. pediculus*Amphora ovalis var. pediculus*Amphora perpusillaAmphora sp.**Anomoeoneis sphaerophora**PAsterionella formosaCocconeis placentula var. euglypta*PCocconeis placentula var. lineataCyclotella kutzinghiana*Cyclotella meneghiniana1.871.80Cymbella affinis*Cymbella minuta*Cymbella minuta*Cymbella sp.**PDialoma tenue var. elongatumDiploneis oblongella**Pragilaria construens var. binodisFragilaria construens var. venterFragilaria construens var. venterFragilaria iapponica**Actina indita var. angustissimaActina donata var. necturaFragilaria construens var. venterFragilaria construens *Fragi	Achnanthes lanceolata var. dubia°	_	Р
Achnanthes minutissima2.20.57Achnanthes sp.°°P-Amphora ovalis.31PAmphora ovalis var. pediculus°08Amphora perpusilla.761.79Amphora veneta8.781.26Anomoeoneis sphaerophora°°P-Asterionella formosa.09.08Caloneis fenzlioides°°.02-Cocconeis placentula var. euglypta°-PCocconeis placentula var. euglypta°-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°13Cyclotella filmis°-PCymbella affinis°-PCymbella affinis°-PCymbella affinis°-PCymbella nuelleri°°.14-Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella solongella°°.02-Epithemia adnata var. porcellusPPFragilaria construens°-PFragilaria construens °17Fragilaria construens var. binodis.06PFragilaria construens var. binodis.06PFragilaria virescens*17Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13 <td>Achnanthes lewisiana</td> <td>.06</td> <td>Р</td>	Achnanthes lewisiana	.06	Р
Achnanthes sp.°°P-Amphora ocalis.31PAmphora ocalis var. pediculus°08Amphora veneta8.781.26Amphora veneta8.781.26Amphora veneta8.781.26Amphora sp.°°.19-Anomoeoneis sphaerophora°°P-Asterionella formosa.09.08Caloneis fenzlioides°.02-Cocconeis placentula var. euglypta°-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°13Cyclotella meneghiniana1.871.80Cymbella affinis°-PCymbella muelleri°.14-Cymbella mostrata.07.05Cymbella sp.°°P-Diatoma tenue var. elongatum.13.23Diploneis oblongella°°.02-Fragilaria brevistriata°-PFragilaria construens var. porcellusPPFragilaria construens var. inflata.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria alponoica°.19-Fragilaria pinnata°*.37-Fragilaria pinnata°*.02-Comphonema affine°*.03.05Gomphonema affine°*.02-Comphonema subclavatum.08PVar. commutatum	Achnanthes minutissima	2.20	.57
Amphora ovalis.31PAmphora ocalis var. pediculus°08Amphora perpusilla.761.79Amphora sp.°*.19-Anonoeoneis sphaerophora°°P-Asterionella formosa.09.08Caloneis fenzlioides°*.02-Cocconeis placentula var. euglypta°-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°13Cyclotella meneghiniana1.871.80Cymbella affinis°-PCymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella sp.°*P-Piatoma tenue var. elongatum.13.23Diploneis oblongella°*.02-Fragilaria construens°-PFragilaria construens °-PFragilaria construens °-PFragilaria construens var. inflata.06PFragilaria construens var. venter.65.11Fragilaria pinnata**.37-Fragilaria pinnata**.90.63Comphonema affine**.13-Comphonema fifine**.13-Gomphonema affine**.13-Gomphonema affine**.13-Gomphonema subclavatum.08PVar. commutatum.08PGomphonema tencllum**.02 <t< td=""><td>Achnanthes sp. °°</td><td>Р</td><td>-</td></t<>	Achnanthes sp. °°	Р	-
Amphora ovalis var. pediculus° – .08 Amphora perpusilla .76 1.79 Amphora veneta 8.78 1.26 Amphora veneta 8.78 1.9 Anomoconcis sphaerophora°° P – Anomoconcis sphaerophora°° P – Asterionella formosa .09 .08 Cocconcis placentula var. euglypta° – P Cyclotella kutzinghiana° – .13 Cyclotella muelleri° – P Cymbella affinis° – P Cymbella prostrata .07 .05 Cymbella prostrata .07 .05 Diploneis oblongella°° .02 – Fragilaria brevistriata var. porcellus P P Fragilaria construens var. binodis .06 P	Amphora ovalis	.31	Р
Amphora perpusilla.761.79Amphora veneta8.781.26Amphora sp.**.19-Anomoeoneis sphaerophora**P-Asterionella formosa.09.08Caloneis fenzlioides**.02-Cocconeis placentula var. euglypta*-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana*13Cyclotella meneghiniana1.871.80Cymbella affinis*-PCymbella minuta*06Cymbella prostrata.07.05Cymbella sp.**P-Diatoma tenue var. elongatum.13.23Diploneis oblongella**.02-Epithemia adnata var. protoscidea*-PFragilaria brevistriata*.76.17Fragilaria construens*-PFragilaria construens var. inflata.06PFragilaria construens var. binodis.06PFragilaria pinnata**.37-Fragilaria pinnata**.37-Fragilaria pinnata**.37-Fragilaria pinnata**.13-Gomphonema affine**.02-Gomphonema affine**.02-Gomphonema affine**.02-Gomphonema subclavatum.38.05Gomphonema subclavatum.38.05Matta arenaria*29Gomphonema subclavatum <td< td=""><td>Amphora ovalis var. pediculus°</td><td>_</td><td>.08</td></td<>	Amphora ovalis var. pediculus°	_	.08
Amphora veneta8.781.26Amphora sp.**.19-Anomoeoneis sphaerophora**PAsterionella formosa.09Caloneis fenzlioides**.02Cocconeis placentula var. euglypta*-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06Cyclotella kutzinghiana*08Cyclotella meneghiniana.09.18Cymbella minuta*09.14.09.15Cymbella prostrata.07.05Cymbella prostrata.06.13.23Diploneis oblongella**.04.02.05.02.06.13.07.05Cymbella sp.**P.08.02.09.13.23Diploneis oblongella**.0203.06.04.13.05.02.05.02.06.15Fragilaria construens*06.15Fragilaria construens*06.16Fragilaria construens var. binodis.06.06PFragilaria construens var. binodis.06.17Fragilaria ipinnata**.17Fragilaria ipinnata**.13.17.17Fragilaria ipinnata var. lancettula.07.13.26.20.20.20.20.21 </td <td>Amphora perpusilla</td> <td>.76</td> <td>1.79</td>	Amphora perpusilla	.76	1.79
Amphora sp.°°.19-Anomoeoneis sphaerophora°°P-Asterionella formosa.09.08Caloneis fenzlioides°°.02-Cocconeis placentula var. euglypta°-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°13Cyclotella meneghiniana1.871.80Cymbella affinis°-PCymbella affinis°06Cymbella moulleri°*.14-Cymbella sp.°°P-Diatoma tenue var. elongatum.13.23Diploneis oblongella°°.02-Epithemia adnata var. porcellusPPFragilaria brevistriata°-PFragilaria construens°-PFragilaria construens°17Fragilaria construens var. inflata.06.15Fragilaria construens var. venter.65.11Fragilaria pinnata°*.37-Fragilaria pinnata°*.37-Gomphonema affine°*.13-Gomphonema affine°*.13-Gomphonema affine°*.13-Gomphonema tenellum°*.02-Gomphonema tenellum°*.02-Gomphonema tenellum°*.02-Gomphonema tenellum°*.02-Gomphonema tenellum°*.02-Gomphonema tenellum°*.02-Gomphonema tenellum°* <t< td=""><td>Amphora veneta</td><td>8.78</td><td>1.26</td></t<>	Amphora veneta	8.78	1.26
Anomoeone is sphaerophora \circ PAsterionella formosa.09.08Caloneis fenzlioides \circ .02-Cocconeis placentula var. euglypta \circ -PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana \circ 13Cyclotella meneghiniana1.871.80Cymbella affinis \circ -PCymbella minuta \circ 06Cymbella minuta \circ 06Cymbella sp. \circ P-Diatoma tenue var. elongatum.13.23Diploneis oblongella \circ .02-Epithemia adnata var. porcellusPPFragilaria brevistriata \circ -PFragilaria construens \circ -PFragilaria construens \circ -PFragilaria construens \circ 17Fragilaria pinnata \circ .37-Fragilaria pinnata \circ .37-Fragilaria pinnata \circ .37-Fragilaria pinnata \circ .33-Gomphonema affine \circ .13-Gomphonema affine \circ .13-Gomphonema tenellum \circ .02-Gomphonema tenellum \circ .02- <td>Amphora sp.°°</td> <td>.19</td> <td>-</td>	Amphora sp.°°	.19	-
Asterionella formosa.09.08Caloneis fenzlioides**.02-Cocconeis placentula var. euglypta*-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana*13Cyclotella meneghiniana1.871.80Cymbella affinis*-PCymbella minuta*06Cymbella muelleri**.14-Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.02-Epithemia adnata var. porcellusPPEpithemia adnata var. porcellusPPFragilaria brevistriata*-PFragilaria construens var. binodis.06.06Fragilaria construens var. binodis.06PFragilaria construens var. binodis.06PFragilaria construens var. binodis.06.11Fragilaria i apinnata**.37-Fragilaria pinnata**.37-Fragilaria pinnata**.33-Gomphonema affine**.02-Gomphonema subclavatum.44.21Gomphonema subclavatum.44.21Gomphonema subclavatum.44.21Gomphonema ventricosum**.44.21Gomphonema subclavatum.44.21Comphonema subclavatum.44.21Comphonema subclavatum	Anomoeoneis sphaerophora°°	Р	_
Caloneis fenzlioides**.02-Cocconeis placentula var. euglypta*-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana*13Cyclotella meneghiniana1.871.80Cymbella affinis*-PCymbella affinis*-PCymbella minuta*.07.05Cymbella minuta*.07.05Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella sp.*P-Diatoma tenue var. elongatum.13.23Diploneis oblongella*.02-Epithemia adnata var. porcellusPPFragilaria brevistriata*-PFragilaria construens var. porcellusPPFragilaria construens var. binodis.06PFragilaria construens var. binodis.06PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria dipponica**.19-Fragilaria inpinata**.37-Fragilaria pinnata var. lancettula.07.13Fragilaria similis.19.17Fragilaria viescens**P-Comphonema affine**.02-Comphonema affine**.02-Comphonema subclavatum.44.21Comphonema subclavatum.44.21Comphonema subclavatum.29<	Asterionella formosa	.09	.08
Cocconeis placentula var. euglypta°-PCocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°13Cyclotella kutzinghiana°13Cymbella affinis°-PCymbella affinis°06Cymbella finis°06Cymbella muelleri°*.14-Cymbella postrata.07.05Cymbella sp.*°P-Diatoma tenue var. elongatum.13.23Diploneis oblongella°.02-Epithemia adnata var. porcellusPPFragilaria brevistriata°-PFragilaria construens var. porcellusPPFragilaria construens var. inflata.06PFragilaria construens var. inflata.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata°*.19-Fragilaria pinnata°*.19.17Fragilaria pinnata var. lancettula.07.13Fragilaria virescens**P-Comphonema affine**.13-Comphonema subclavatum.08PComphonema subclavatum.08PComphonema subclavatum.08PComphonema subclavatum.21PMatou arensis*15Navicula arensis*15Navicula arensis*15 <td>Caloneis fenzlioides°°</td> <td>.02</td> <td>_</td>	Caloneis fenzlioides°°	.02	_
Cocconeis placentula var. lineata.07.07Coscinodiscus sp06.06Cyclotella kutzinghiana°Cyclotella meneghiniana1.871.80Cymbella affinis°PCymbella minuta°Cymbella muelleri°°Cymbella muelleri°°Cymbella prostrata.07.05Cymbella prostrataCymbella sp.°°PDiatoma tenue var. elongatumJialonai tenue var. elongatumDiponeis oblongella°°PEpithemia adnata var. procellusPPFragilaria brevistriata var. inflataFragilaria construens var. binodisFragilaria construens var. venterFragilaria construens var. venterFragilaria pinnata var. lancettula <td>Cocconeis placentula var. euglypta°</td> <td>_</td> <td>Р</td>	Cocconeis placentula var. euglypta°	_	Р
Coscinadiscus sp06.06Cyclotella kutzinghiana $-$.13Cyclotella meneghiniana 1.87 1.80 Cymbella affinis $-$ PCymbella minuta $-$.06Cymbella muelleri $-$.07Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.07.05Cymbella prostrata.07.02Diatoma tenue var. elongatum.13.23Diploneis oblongella $-$ PFragilaria brevistriata $-$ PFragilaria brevistriata $-$ PFragilaria brevistriata var. porcellusPPFragilaria construens $-$ PFragilaria construens var. proboscidea $-$ PFragilaria construens var. inflata.06.15Fragilaria construens var. binodis.06PFragilaria construens var. binodis.06PFragilaria pinnata *.17.17Fragilaria pinnata *.19.17Fragilaria pinnata *.13-Gomphonema affine*.13-Gomphonema gracile*.02-Gomphonema gracile*.02-Gomphonema parculum.44.21Gomphonema parculum.44.21Gomphonema sp.*.06-Melosira granulata.55.65Melosira granulata.21PNavicula arvensis*15Navicula arven	Cocconeis placentula var. lineata	.07	.07
Cyclotella kutzinghiana13Cyclotella meneghiniana1.871.80Cymbella affinis-PCymbella minuta06Cymbella minuta.07.05Cymbella prostrata.07.05Cymbella sp."P-Diatoma tenue var. elongatum.13.23Diploneis oblongella".02-Epithemia adnata var. porcellusPPFragilaria brevistriata-PFragilaria brevistriata var. inflata.06.15Fragilaria construens-PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria pinnata °*.37-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens °P-Comphonema affine °.13-Gomphonema affine °.02-Gomphonema subclavatum.30.05Gomphonema subclavatum.08PVar. commutatum.08PGomphonema sp. °.06-Melosira italica.21PNavicula arvensis.15.15Navicula arvensis.15.15Navicula arvensis.21PNavicula arvensis.21PNavicula arvensis <td>Coscinodiscus sp.</td> <td>.06</td> <td>.06</td>	Coscinodiscus sp.	.06	.06
Cyclotella meneghiniana1.871.80Cymbella affinis°–PCymbella minuta°–.06Cymbella muelleri°°.14–Cymbella postrata.07.05Cymbella sp.°°P–Diatoma tenue var. elongatum.13.23Diploneis oblongella°°.02–Epithemia adnata var. porcellusPPFragilaria brevistriata°–PFragilaria brevistriata°–PFragilaria construens°–PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata°°.37–Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens°P–Gomphonema affine°°.13–Gomphonema affine°°.02–Gomphonema autoclavatum.44.21Var. commutatum.08PGomphonema subclavatum.55.65Melosira italica.21PNavicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15Navicula arvensis°–.15	Cuclotella kutzinghiana°	_	.13
Cymbella affinis-PCymbella minuta06Cymbella muelleri.14-Cymbella prostrata.07.05Cymbella sp.°P-Diatoma tenue var. elongatum.13.23Diploneis oblongella°.02-Epithemia adnata var. porcellusPPEpithemia adnata var. proboscidea°-PFragilaria brevistriata.06.15Fragilaria brevistriata var. inflata.06.15Fragilaria construens-PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata°.19-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria virescens°P-Gomphonema affine°.13-Gomphonema affine°.02-Gomphonema abclavatum.08PVar. commutatum.08PGomphonema subclavatum.02-Var. commutatum.08PGomphonema sp.°.06-Melosira granulata.55.65Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15 <td>Cuclotella meneghiniana</td> <td>1.87</td> <td>1.80</td>	Cuclotella meneghiniana	1.87	1.80
Cymbella minuta*066Cymbella muelleri**.14-Cymbella prostrata.07.055Cymbella sp.**P-Diatoma tenue var. elongatum.13.233Diploneis oblongella**.02-Epithemia adnata var. porcellusPPEpithemia adnata var. proboscidea*-PFragilaria brevistriata*-PFragilaria brevistriata var. inflata.066.155Fragilaria construens*-PFragilaria construens var. binodis.066PFragilaria construens var. venter.655.11Fragilaria construens var. venter.655.11Fragilaria pinnata**.37-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens**P-Gomphonema affine**.13-Gomphonema affine**.02-Gomphonema antricatum*.08PGomphonema ventricosum**.44.21Gomphonema sp.**.06-Melosira granulata.55.65Melosira granulata.58.05Melosira italica.21PNavicula arvensis*15Navicula arvensis*15Navicula arvensis*59Navicula arvensis*59Navicula cincta*59<	Cumbella affinis°	_	Р
Cymbella muelleri.14Cymbella prostrata.07Cymbella prostrata.07Cymbella prostrata.07Diatoma tenue var. elongatum.13Jiploneis oblongella.02Epithemia adnata var. porcellusPPPEpithemia adnata var. proboscidea-PPFragilaria brevistriata.06Sragilaria construens-PPFragilaria construens var. binodis.06PPFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata.37Fragilaria pinnata.37Fragilaria var. lancettula.07.13-Fragilaria var. lancettula.07.13-Fragilaria varcheriae.90.63-Fragilaria varcheriae	Cumbella minuta°	_	.06
Symoothe11Cymbella prostrata.07Cymbella sp.°°PDiatoma tenue var. elongatum.13.23Diploneis oblongella°°.02Epithemia adnata var. porcellusPPEpithemia adnata var. proboscidea°-PFragilaria brevistriata°-PFragilaria brevistriata var. inflata.06.15Fragilaria construens°-PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.12Fragilaria pinnata°.37PFragilaria pinnata°.37Fragilaria pinnata°.13Gomphonema affine°*.13Gomphonema affine°*.02Gomphonema affine°*.02Gomphonema subclavatum.44.21Gomphonema ventricosum°*.44-Gomphonema subclavatum.08var. commutatum.08var. commutatum.08PNavicula arensis°15Navicula arensis°15Navicula arensis°15Navicula arensis°55.65Melosira granulata.55.65Melosira italica.21 <td>Cumbella muelleri°°</td> <td>.14</td> <td>_</td>	Cumbella muelleri°°	.14	_
Cymbella sp. **P-Diatoma tenue var. elongatum.13.23Diploneis oblongella **.02-Epithemia adnata var. porcellusPPEpithemia adnata var. proboscidea *-PFragilaria brevistriata *-PFragilaria brevistriata var. inflata.06.15Fragilaria construens *-PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata **.37-Fragilaria pinnata **.37-Fragilaria pinnata **.13-Gomphonema affine **.13-Gomphonema affine **.02-Gomphonema affine **.02-Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema subclavatum.02-Var. commutatum.08PGomphonema sp. **.06-Melosira granulata.55.65Melosira italica.21PNavicula arvensis *15Navicula arvensis *15Navicula arvensis *59Navicula circut *59Navicula circut *59Navicula circut *59	Cumbella prostrata	.07	.05
Diatoma tenue var. elongatum.13.23Diploneis oblongella°°.02-Epithemia adnata var. porcellusPPEpithemia adnata var. proboscidea°-PFragilaria brevistriata°-PFragilaria brevistriata var. inflata.06.15Fragilaria construens°-PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata°°.37-Fragilaria pinnata°°.37-Fragilaria var. lancettula.07.13Fragilaria vinilis.19.17Fragilaria virescens°°P-Gomphonema affine°°.02-Gomphonema affine°°.02-Gomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema subclavatum.21PNavicula arvensis°15Navicula arvensis°15Navicula arvensis°15Navicula arvensis°15Navicula arvensis°15Navicula arvensis°15Navicula arvensis°55Matoria farance15Navicula arvensis°15Navicula arvensis°15Navicula arv	Cumbella sn °°	P	.00
Diabona tente van etonganan1.00Diploneis oblongella°°.02Epithemia adnata var. porcellusPPPEpithemia adnata var. proboscidea°-PPFragilaria brevistriata var. inflata.06.15Fragilaria construens°-PPFragilaria construens var. binodis.06PPFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.19-Fragilaria pinnata°.37Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria vaucheriae.90.63Fragilaria virescens°P-Gomphonema affine°°.13Gomphonema olivaceum.30.05Gomphonema subclavatumvar. commutatum.08var. commutatum.08PGomphonema subclavatumvar. commutatum.08PMelosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arvensis°15Navicula arenaria°21PNavicula arenaria°22.02.35Navicula arenaria°- <tr< td=""><td>Diatoma tenue var elongatum</td><td>13</td><td>23</td></tr<>	Diatoma tenue var elongatum	13	23
Epithemia adnata var. porcellusPEpithemia adnata var. proboscidea°–PFragilaria brevistriata°–PFragilaria brevistriata var. inflata.06.15Fragilaria construens°–PFragilaria construens°–PFragilaria construens var. binodis.06PPFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.12Fragilaria pinnata°.37PFragilaria pinnata°.19.17Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens°P-Comphonema affine°°.02-Gomphonema filne°°.02-Gomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema subclavatum.21-var. commutatum.05.65Melosira granulata.55.65Melosira italica.21PNavicula arvensis°15Navicula arvensis°15Navicula arvensis°15Navicula conta°.02-Melosira italica.21PNavicula arvensis°15Navicula arvensis°15Navicula arvensis°15	Dinloneis oblongella°°	.10	.20
Epithemia adnata var. proboscidea*PEpithemia adnata var. proboscidea*PFragilaria brevistriata*PFragilaria brevistriata var. inflata.06.15Fragilaria construens*PFragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria pinnata**.37-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens**P-Gomphonema affine**.13-Gomphonema intricatum*-PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.02-var. commutatum.08PGomphonema subclavatum.21PMelosira granulata.55.65Melosira italica.21PNavicula arvensis*15Navicula arvensis*15Navicula conta*92Navicula cincta*92Navicula cincta*59Navicula cincta*59Navicula cincta*59	Enithemia adnata var norcellus	.02 P	Р
Implementa tanta var. probostateaImplementa tanta var. probostateaFragilaria brevistriata var. inflata.06.15Fragilaria brevistriata var. inflata.06.15Fragilaria construens var. binodis.06PFragilaria construens var. venter.65.11Fragilaria contonensis°17Fragilaria pinnata °.37-Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens°P-Gomphonema affine°.13-Gomphonema gracile°.02-Gomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema tenellum°°.02-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arenaria°-PNavicula conta*59Navicula cincta*59Navicula cincta*59Navicula circumtexta*59	Epithemia adnata var. porcettus	1	p
Fragilaria brevistriataImagilariaFragilaria brevistriatavar. inflata.06.15Fragilaria construensvar. binodis.06PFragilaria construens var. venter.65.11Fragilaria construens var. lancettula.07.13Fragilaria pinnata °.37Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria vaucheriae.90.63Fragilaria virescens °PGomphonema affine °.13Gomphonema gracile °.02Gomphonema olivaceum.30.05Gomphonema subclavatumvar. commutatum.08PGomphonema tenellum °.02Quaphonema sp. °Melosira granulataAlesira granulataNavicula arenaria °Navicula arenaria °Navicula conta °Navicula conta °Navicula cincut °Navicula cincut °Navicula cincut °<	Eragilaria hrenistriata°		P
Fragilaria corectstriata var. infatta	Fragilaria brevistriata vor inflata	06	15
Fragilaria construents var. binodis $ 1$ $Fragilaria construens var. venter.65.11Fragilaria construens var. venter.37 Fragilaria pinnata °°.37 Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria vaucheriae.90.63Fragilaria virescens °°P Gomphonema affine °°.13 Gomphonema gracile °°.02 Gomphonema nutricatum °-PGomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema ventricosum °°.44 Gomphonema sp. °°.06 Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arenaria °-PNavicula arenaria °-.15Navicula cincta °-.59Navicula cincta °-.59Navicula cincta °-.59Navicula cincta °-.59$	Fragilaria construens°	.00	.15 P
Fragilaria construens var. venter.00IFragilaria construens var. venter.65.11Fragilaria construens var. venter.65.11Fragilaria construens var. venter.19-Fragilaria lapponica°°.19-Fragilaria pinnata°°.37-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria vaucheriae.90.63Fragilaria virescens°°P-Comphonema affine°°.13-Gomphonema gracile°.02-Gomphonema intricatum°-PGomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arvensis°15Navicula capitata var. hungarica°15Navicula cincta°59Navicula cincta°59Navicula circumtexta°59	Fragilaria construens var binodis	06	P
Fragilaria construents var. center.05.11Fragilaria cotonensis°17Fragilaria lapponica°°.19-Fragilaria pinnata °°.37-Fragilaria pinnata var. lancettula.07.13Fragilaria similis.19.17Fragilaria vaucheriae.90.63Fragilaria virescens°°P-Comphonema affine°°.13-Gomphonema gracile°°.02-Gomphonema olivaceum.30.05Gomphonema olivaceum.30.05Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema tenellum°°.02-Gomphonema sp.°°.66-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula capitata var. hungarica°15Navicula cincta°59Navicula circumtexta°59Navicula cryptocephala.29.35	Fragilaria construens var. venter	.00	- 11
Pragilaria crotonensis $.11$ Fragilaria lapponica°° $.19$ $-$ Fragilaria pinnata °° $.37$ $-$ Fragilaria pinnata var. lancettula $.07$ $.13$ Fragilaria similis $.19$ $.17$ Fragilaria vaucheriae $.90$ $.63$ Fragilaria virescens°°P $-$ Gomphonema affine°° $.13$ $-$ Gomphonema gracile°° $.02$ $-$ Gomphonema intricatum° $-$ PGomphonema olivaceum $.30$ $.05$ Gomphonema parvulum $.44$ $.21$ Gomphonema subclavatum $.44$ $.21$ Var. commutatum $.08$ PGomphonema tenellum°° $.02$ $-$ Gomphonema sp.°° $.06$ $-$ Melosira granulata $.55$ $.65$ Melosira granulata var. angustissima 1.58 1.05 Melosira italica $.21$ PNavicula arenaria° $-$ PNavicula capitata var. hungarica° $.15$ Navicula cincta° $.59$ Navicula cincta° $.59$ Navicula circumtexta° $.59$	Fragilaria crotononoio°	.00	.11
Fragilaria inpuncta.19-Fragilaria pinnata °°.37-Fragilaria pinnata var. lancettula.07.13Fragilaria similis.19.17Fragilaria vaucheriae.90.63Fragilaria virescens °°P-Comphonema affine °°.13-Gomphonema gracile °°.02-Gomphonema intricatum °-PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Comphonema subclavatum.08PVar. commutatum.08PGomphonema tenellum °°.02-Gomphonema sp. °°.06-Melosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arenaria °-PNavicula capitata var. hungarica °02-Navicula cincta °05Navicula cincta °.02-Savicula cryptocephala.29.35	Fragilaria lapponica ^{°°}	10	.17
Fragilaria pinnata.57-Fragilaria pinnata var. lancettula.07.13Fragilaria pinnata var. lancettula.07.13Fragilaria similis.19.17Fragilaria vaucheriae.90.63Fragilaria virescens°P-Comphonema affine°°.13-Comphonema gracile°°.02-Comphonema intricatum°-PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Comphonema subclavatum.08PVar. commutatum.08PGomphonema tenellum°°.02-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arenaria°-PNavicula capitata var. hungarica°15Navicula cincta°59Navicula circumtexta°55Navicula circumtexta°15Navicula cryptocephala.29.35	Fragilaria ninpata ^{°°}	.15	
Fragilaria pinnata val. tancettuta.07.13Fragilaria similis.19.17Fragilaria vaucheriae.90.63Fragilaria virescens°°P-Gomphonema affine°°.13-Gomphonema gracile°°.02-Gomphonema intricatum°-PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.02-var. commutatum.08PGomphonema tenellum°°.02-Gomphonema subclavatum.06-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arenaria°-PNavicula arenaria°-PNavicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula circumtexta°15Navicula cryptocephala.29.35	Fragilaria pinnata vor Janosttula	.57	12
Fragilaria similas.19.11Fragilaria vaucheriae.90.63Fragilaria virescens°°P $-$ Gomphonema affine°°.13 $-$ Gomphonema gracile°°.02 $-$ Gomphonema intricatum° $-$ PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.08PVar. commutatum.08PGomphonema tenellum°°.02 $-$ Gomphonema sp.°°.06 $-$ Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis° $-$.15Navicula capitata var. hungarica° $-$.15Navicula cincta° $-$.59Navicula circumtexta° $-$.15Navicula cryptocephala.29.35	Fragilaria cimilio	.07	.15
Inaguaria vaucheriae.90.03Fragilaria virescens°°P-Gomphonema affine°°.13-Gomphonema gracile°°.02-Gomphonema intricatum°-PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Comphonema subclavatum.44.21Var. commutatum.08PGomphonema tenellum°°.02-Gomphonema ventricosum°°.44-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°59Navicula cryptocephala.29.35	Fragilaria similis	.19	.17
Indiana UnescensIGomphonema affine °.13Gomphonema gracile °.02Gomphonema intricatum °.02Gomphonema olivaceum.30Jopphonema olivaceum.30Gomphonema parvulum.44Comphonema subclavatumvar. commutatum.08Comphonema tenellum °°.02Gomphonema ventricosum °°.44Gomphonema sp. °°.06Melosira granulata.55Melosira granulata var. angustissima1.58I.581.05Melosira italica.21Navicula arenaria °-PNavicula capitata var. hungarica °Navicula cincta °-Navicula circumtexta °-Navicula cryptocephala.29.35	Fragilaria viressens ^o	.90 D	.05
Gomphonema ajracile °.13–Gomphonema gracile °.02–Gomphonema intricatum °–PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.44.21var. commutatum.08PGomphonema tenellum °°.02–Gomphonema ventricosum °°.44–Gomphonema sp. °°.06–Melosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arvensis °–.15Navicula arenaria °–PNavicula capitata var. hungarica °–.1Navicula cincta °–.59Navicula circumtexta °–.15Navicula cryptocephala.29.35	Comphonema affine °°	12	_
Gomphonema gracue.02–Gomphonema intricatum°–PGomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.44.21Var. commutatum.08PGomphonema tenellum°°.02–Gomphonema ventricosum°°.44–Gomphonema sp.°°.06–Melosira granulata.55.65Melosira granulata.55.65Melosira italica.21PNavicula arvensis°–.15Navicula arenaria°–PNavicula capitata var. hungarica°–.1Navicula cincta°–.59Navicula circumtexta°–.15Navicula cryptocephala.29.35	Comphonema gracile [°]	.13	
Gomphonema intricatum-1Gomphonema olivaceum.30.05Gomphonema parvulum.44.21Gomphonema subclavatum.44.21var. commutatum.08PGomphonema tenellum°°.02-Gomphonema ventricosum°°.44-Gomphonema ventricosum°°.44-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Comphonema intricatum ^o	.02	P
Gomphonema buddeeum.50.50Gomphonema parvulum.44.21Gomphonema subclavatum.08PVar. commutatum.02-Gomphonema tenellum°°.02-Gomphonema ventricosum°°.44-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Comphonema olivaceum	30	05
Gomphonema purcutum.44Gomphonema subclavatumvar. commutatum.08PGomphonema tenellum°°.02Gomphonema ventricosum°°.44Gomphonema ventricosum°°.44Gomphonema sp.°°.06Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21Navicula arvensis°-Navicula arenaria°-PNavicula aurora°°Navicula capitata var. hungarica°-1Navicula cincta°-Navicula circumtexta°-15Navicula cryptocephala.29.35	Comphonema parvulum	.50	.00
Var. commutatum.08PGomphonema tenellum°°.02-Gomphonema ventricosum°°.44-Gomphonema ventricosum°°.44-Gomphonema sp.°°.06-Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Comphonema subclavatum	.11	.21
Gomphonema tenellum°°.00Gomphonema tenellum°°.02Gomphonema ventricosum°°.44Gomphonema sp.°°.06Melosira granulata.55.65Melosira granulata var. angustissima1.581.581.05Melosira italica.21Navicula arvensis°15Navicula arenaria°Navicula aurora°°.02Navicula capitata var. hungarica°1Navicula cincta°Navicula circumtexta°15Navicula cryptocephala.29.35	var commutatum	08	Р
Gomphonema ventricosum°.02Gomphonema ventricosum°.44Gomphonema sp.°.06Melosira granulata.55Sologira granulata var. angustissima1.581.581.05Melosira italica.21Navicula arvensis°-Navicula arenaria°-Navicula capitata var. hungarica°-Navicula cincta°-Navicula cincta°-Navicula circumtexta°-Navicula cryptocephala.29.35	Comphonema tenellum °°	.00	1
Gomphonema sp. °°.06Melosira granulata.55Melosira granulata var. angustissima1.581.581.05Melosira italica.21Navicula arvensis°-Navicula arenaria°-Navicula aurora°°.02Navicula capitata var. hungarica°-1Navicula cincta°Navicula circumtexta°-15Navicula circumtexta°29.35	Gomphonema ventricosum°°	44	
Melosira granulata.55.65Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula aurora°°.02-Navicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Gomphonema sp °°	06	-
Melosira granulata var. angustissima1.581.05Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula aurora°°.02-Navicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula circumtexta29.35.29.35	Melosira granulata	.55	.65
Melosira italica.21PNavicula arvensis°15Navicula arenaria°-PNavicula aurora°°.02-Navicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Melosira granulata var. angustissima	1.58	1.05
Navicula arvensis°15Navicula arenaria°-PNavicula aurora°°.02-Navicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Melosira italica	.21	P
Navicula arenaria°–PNavicula aurora°°.02–Navicula capitata var. hungarica°–.1Navicula cincta°–.59Navicula circumtexta°–.15Navicula cryptocephala.29.35	Navicula arvensis°	_	.15
Navicula aurora°°.02Navicula capitata var. hungarica°-1Navicula cincta°Navicula cincta°-59Navicula circumtexta°15Navicula cryptocephala.29.35	Navicula arenaria°	_	Р
Navicula capitata var. hungarica°1Navicula cincta°59Navicula circumtexta°15Navicula cryptocephala.29.35	Navicula aurora°°	.02	_
Navicula cincta°–.59Navicula circumtexta°–.15Navicula cryptocephala.29.35	Navicula capitata var. hungarica°	_	.1
Navicula circumtexta°15Navicula cryptocephala.29.35	Navicula cincta°	_	.59
Navicula cryptocephala .29 .35	Navicula circumtexta°	_	.15
	Navicula cryptocephala	.29	.35

Table 1 continued.

Species	Living	Dead
Navicula cryptocephala var. veneta	3.45	4.38
Navicula exigua°	_	Р
Navicula graciloides	12.35	9.17
Navicula heufleri var. leptocephala	.08	Р
Navicula lanceolata°	_	.08
Navicula minima	.07	.84
Navicula oblonga	Р	.08
Navicula peregrina°	_	.08
Navicula pupula	Р	.08
Navicula radiosa var. tenella	1.13	2.42
Navicula rhuncocephala°	_	Р
Navicula salinarum°	_	.13
Navicula salinarum yar, intermedia	.08	.05
Navicula schroeteri var. escambia	3.06	6.23
Navicula tenelloides	.15	1.27
Navicula tripunctata	P	.33
Navicula tripunctata var. schizonemoid	es 44	1.51
Navicula sn °		63
Nitzschia acicularis	51	.00
Nitzschia amphibia	.01	25
Nitzschia aniculata	.06	18
Nitzschia dissinata	6.00	4 95
Nitzschia filiformis	7.10	6.83
Nitzschia frustulum	80	53
Nitzschia gracilis°°	.00	.00
Nitzschia hantzschiana	4 94	4 40
Nitzschia holsatica	1.67	2.35
Nitzschia inconspicua	12.40	13.25
Nitzschia linearis	06	08
Nitzschia longissima var. closterium	.00	.00
Nitzschia ovalis	.18	.00
Nitzschia palea	6.90	13.50
Nitzschia paleaceae	4.63	3.92
Nitzschia punctata°	_	P
Nitzschia sigmoidea [°]	_	P
Nitzschia stagnorum [°]	Р	_
Nitzschia sp. 1	P	42
Nitzschia sp. 2°°	.21	
Ophephora martui°	_	Р
Rhoicosphenia curvata	3.96	6.32
Rhopalodia gibba°	_	.05
Rhopalodia gibberula var. vanheurekii	.10	Р
Stephanodiscus astrea°°	.06	_
Stephanodiscus astrea var. minutula	5.15	4.34
Stephanodiscus niagarae°	_	.08
Surirella angustata	Р	Р
Surirella ovalis var. brightwellii°	_	.15
Surirella ovata°°	.08	-
Synedra acus	.08	1.60
Synedra delicatissima var. angustissima	.15	.02
Synedra fasciculata var. trunctata°	-	.08
Synedra mazamaensis	.15	.08
Synedra socia	Р	.08
Synedra ulna	Р	.11
Synedra ulna var. contracta	.81	.02

** Species unique to living Phragmites australis stems.

*Species unique to dead Phragmites australis stems.

P Species not recorded on the transects taken for relative density figures but found on other sections of the diatom slide. Species diversity according to number of species encountered was high, averaging 48 species per sample. However, there were generally 2 to 4 dominant species ranging between 10–18 percent relative density in each sample, which allowed for only moderately high Shannon-Wiener diversity values (Table 3). Forty-nine percent of the diatom species was found in 30 percent of all samples, and 34 percent of the diatom species was found in 50 percent of all samples.

The results of the cluster analysis (Fig. 1) demonstrate the high degree of similarity encountered for all ten samples. Even so, marginal separation into samples from living and dead stems was obtained.

A similarity matrix comparing all 10 samples was constructed.

Means of similarity indices for living stems, dead stems, and between living and dead stems were computed. T-tests were performed and it was determined that there was no significant difference in similarity within or between these samples sets.

DISCUSSION

Each of our 10 samples consistently contained approximately 50 identifiable species. In general, no one species represented more than 18 percent of the total population of any sample. These conditions are indicative of a diverse flora that is further supported by our Shannon-Wiener diversity values and the average number of species per substrate (Table 3). Such conditions indicate that the epiphyte flora in Utah Lake is more diverse than we previously believed. T-tests were computed comparing the means of the Shannon-Wiener diversity indices of both substrates as well as the average number of species from both living and dead stems. No significant differences between the values in either comparison existed.

A total of 23 diatom genera were encountered during this study. The number of species included in these genera was nearly equally distributed between living and dead stems (Table 4). However, substratum preferences were noted in the genera *Navicula* and *Gomphonema* and in individual species within several other genera. Of the 114 species found in the study, 22 were unique to living and 29 were unique to dead stems.

Dead stems Living stems 2 4 5 6 7 8 9 10 1 Species 3.1 Achnanthes minutissima 3.3 3.2 Amphora perpusilla 7.2 11.2 5.6 17.3 Amphora veneta 3.0 Cyclotella meneghiniana Melosira granulata 3.9 var. angustissima Navicula cryptocephala 4.9 4.2 3.7 5.4 3.3 6.1 3.5 34 var. veneta 13.213.5 14.0 11.2 5.5 13.4 14.98.5 13.6 Navicula graciloides 9.9 Navicula radiosa 3.2 3.3 6.2 var. tenella Navicula schroeteri 5.7 6.3 6.2 6.2 10.6 var. escambia Navicula tripunctata 3.3 var. schizonemoides 6.8 8.7 3.6 7.8 3.1 4.1 4.67.9 3.6 4.7 Nitzschia dissipata 12.5 5.4 11.1 3.5 6.6 3.2 7.0 5.2 12.2 3.1 Nitzschia filiformis 23.4 9.5 7.3 12.2 25.7 6.2 12.1 10.1 15.5Nitzschia inconspicua 12.3 8.7 4.6 5.4 3.1 Nitzschia hanztschiana 3.1 3.3 Nitzschia holsatica 3.7 5.4 3.9 7.8 Nitzschia palea 5.0 5.7 5.7 10.4 17.7 9.4 12.4 16.1 12.0 Nitzschia paleacea 10.6 4.5 6.8 5.0 3.3 7.7 7.4 Rhoicosphenia curvata 7.7 6.2 6.6 9.4 12.2 Stephanodiscus astrea var. minutula 3.4 5.3 5:2 6.2 5.5 4.6 4.1 3.2 4.3

TABLE 2. Important species encountered on *Phragmites australis* stem sections from Provo Bay, Utah Lake, with their percent relative densities. Important species are those species with a percent relative density greater than 3 percent in any one sample.

The most important species in each sample are indicated by boldface type.

TABLE 3. Shannon-Wiener diversity values for the five living and five dead *Phragmites australis* stem sections from Provo Bay, Utah Lake.

			S°		
Sample No.	Living	Dead	Living	Dead	
1	2.96	3.12	48	52	
2	2.96	2.98	50	47	
3	2.86	3.09	33	50	
4	2.96	2.85	44	38	
5	3.07	3.15	47	51	
x	2.962	3.038	44.4	47.6	

*Average number of species/substrate.

An analysis of the diatom types unique to the living stems reveals that most were periphytic stalk formers, whereas those unique to the dead stems were mostly periphytic mobile forms.

The distribution of species of Gomphonema and Navicula on Phragmites stems showed significant deviation from random. Thus, of a total of nine Gomphonema species encountered during this study, eight of these occurred on living stems, five of which were restricted to living stems. Conversely, of four species that occurred on dead stems, only one was restricted to that habitat. These data suggest that the living stems provide a more suitable substrate for several *Gomphonema* species. Such species tend to be strictly epiphytic in distribution, usually being attached by a gelatinous jelly stipe (Patrick and Reimer 1966). Whether the preference of these species for living stems is relative to the availability of nutrients or the physical condition of the substrate is yet to be determined.

Some interesting distribution patterns were also observed in the 26 species of *Navicula*. Twenty-five of these were found on the dead stems, of which 11 were restricted to that substrate. On the other hand, only 15 *Nav*-



Fig. 1. Cluster dendrogram showing similarities of diatoms on living and dead *Phragmites australis* stem sections from Provo Bay, Utah Lake.

icula species were observed on the living stems and only one taxon was restricted to living stems.

We believe the high number of *Navicula* species in our samples can be accounted for, at least in part, by the fact that many are opportunistic, occurring on a wide variety of substrates. These opportunistic *Navicula* species occurred primarily on dead *Phragmites* stems except for one or two species that dominated both living and dead stems. The reason for this is open to speculation, but it is probably related to nutrient interaction, the physical condition of the substrate, or reduced competition on the dead stems.

The hypothesis that condition of the *Phrag*mites stems had no effect on the presence or absence of *Gomphonema* and *Navicula* was tested by chi-square analysis using a 2 X 2 contingency table. The results departed significantly from random. This supported the concept that *Gomphonema* and *Navicula* were separated on the basis of habitat type.

Consistent with other Utah Lake studies, the diatoms in this study reflect the condition of the lake waters. Most of the prevalent diatoms were either alkaphilous or alkabiontic forms and also indicators of eutrophy. Additionally, many are known to have the ability to withstand elevated levels of dissolved salts. These data, together with the elevated diversity found at Utah Lake, support the current view that Utah Lake is a saline-eutrophic ecosystem.

We recognize the preliminary nature of the present study. Even so, we believe the differences shown in communities on the living versus the dead stems are significant. Future studies are planned to expand our data TABLE 4. Alphabetical list of diatom genera found on *Phragmites australis* stem sections from Provo Bay, Utah Lake, and the occurrence of species from those genera on living and dead substrates.

Genus	Living	Dead	
Achnanthes	4	3	
Amphora	4	5	
Anomoeneis	1	0	
Asterionella	1	1	
Caloneis	1	0	
Cocconeis	1	2	
Coscinodiscus	1	1	
Cuclotella	1	2	
Cumbella	3	3	
Diatoma	1	1	
Diploneis	1	0	
Epithemia	1	2	
Fragilaria	9	9	
Gomphonema	8	4	
Melosira	3	3	
Navicula	15	25	
Nitzschia	18	17	
Ophephora	0	1	
Rhocosphenia	1	1	
Rhoipalodia	1	2	
Stephanodiscus	2	2	
Surirella	2	2	
Synedra	6	7	

base to the other species of emergent macrophytes in Utah Lake. Furthermore, we plan studies to answer the following questions: (1) Are some epiphytes host specific? (2) What patterns of seasonal succession are evident in the epiphytic flora? (3) What impact does the epiphytic flora have on productivity and trophic structure of the lake? These questions take on added significance for future resource management in light of proposed large-scale changes in Utah Lake, such as the diking of Provo and Goshen bays.

LITERATURE CITED

- ALLEN, H. L. 1971. Primary productivity, chemo-organotrophy, and nutritional interactions of epiphytic algae and bacteria on macrophytes in the littoral of a lake. Ecol. Monogr. 41(2):97-127.
- GODWARD, M. B. 1934. An investigation of the causal distribution of algal epiphytes. Beih. Bot. Centralbl. 52A:506-539.
- _____. 1937. An ecological and taxonomic investigation of the littoral algal flora of Lake Windermere. J. Ecology 25:496-568.
- HOUGH, R. A., AND R. G. WETZEL. 1975. The release of dissolved organic carbon from submersed aquatic

macrophytes: diel, seasonal, and community relationships. Verh. Int. Ver. Limnol. 19:939-948.

- KNUDSON, B. M. 1957. Ecology of the epiphytic diatom Tabellaria flocculosa (Roth) Kutz. var. flocculosa in three English lakes. J. Ecology 45:93-112.
- MAIN, S. P., AND C. D. MCINTIRE. 1974. The distribution of epiphytic diatoms in Yaquina Estuary, Oregon. Bot. Mar. 17:88-99.
- MCINTIRE, C. D., AND W. S. OVERTON. 1971. Distributional patterns of assemblages of attached diatoms from Yaquina Estuary, Oregon. Ecology 52:758-777.
- PATRICK, R., AND C. REIMER. 1966. The diatoms of the United States. Acad. Nat. Sci. Phil., Monograph 13, v. 1. 688 pp.
- PROWSE, G. A. 1959. Relationship between epiphytic algal species and their macrophytic hosts. Nature 183:1204-1205.
- RUSHFORTH, S. R., L. L. ST. CLAIR, J. A. GRIMES, J. R. JOHANSEN, AND M. WHITING. The phytoplankton of Utah Lake. Great Basin Nat. Mem. 5. In press.
- RUZICKA, M. 1958. Anwendung mathematisch-statisticher methoden in der geobotanik (Synthetische bearbeitung von aufnahmen). Biologia Bratisl. 13:647-661.
- SHANNON, C. E., AND W. WIENER. 1963. The mathematical theory of communication. University of Illinois Press, Urbana.
- SNEATH, R. H. A., AND R. R. SOKAL. 1963. Numerical taxonomy: principles and practice of numerical classification. W. H. Freeman Co., San Francisco. 573 pp.
- SNEDECOR, G. W., AND W. COCHRAN. 1968. Statistical methods. Iowa State Press. 593 pp.
- SQUIRES, L. E., S. R. RUSHFORTH, AND J. D. BROTHERSON. 1979. Algal response to a thermal effluent: study of a power station on the Provo River, Utah, U.S.A. Hydrobiologia 63(1):17-32.
- ST. CLAIR, L. L., AND S. R. RUSHFORTH. 1977. The diatom flora of the Goshen Warm Springs ponds and wet meadows, Goshen, Utah, U.S.A. Nova Hedwigia 28:353-425.
- STOWE, W. C., AND J. C. GOSSELINK. 1971. Community structure and production of the epiphytic algae in the Barataria Bay area of Louisiana. Paper read at the 34th annual meeting of the American Society of Limnology and Oceanography, Winnipeg, June 14–17.
- WETZEL, R. G. 1964. A comparative study of the primary productivity of higher aquatic plants, periphyton, and phytoplankton in a large, shallow lake. Int. Rev. Ges. Hydrobiol. 49:1-61.
- - —. 1969b. Factors influencing photosynthesis and excretion of dissolved organic matter by aquatic macrophytes in hardwater lakes. Verh. Int. Ver. Limnol. 17:72-85.

POISONOUS PLANTS OF UTAH

Jack D. Brotherson, ' Lee A. Szyska,' and William E. Evenson²

ABSTRACT .- A list of the major livestock-poisoning plants has been compiled for the state of Utah. Two hundred fifteen taxa representing 36 families, 119 genera, and 209 species occur within the state. Forty-one percent are from two families, the Asteraceae and the Fabaceae. The remaining families of major importance are: Poaceae, Ranunculaceae, Solanaceae, Chenopodiaceae, Brassicaceae, Ascelpiadaceae, Liliaceae, and Euphorbiaceae. Sixty-nine percent of the genera occur with a single species. Thirty-three percent of the taxa are introduced to the state. Most of the plants are insect pollinated; 57 percent are herbaceous perennials.

Most livestock poisoning occurs during the spring. This is due both to concentration of toxins in emerging vegetation and to the absence of more suitable forage on late winter and spring ranges. Green herbage is poisoning in about 80 percent of all taxa, seeds and fruits in about 15 percent, and the remaining 5 percent have toxic compounds confined to flower heads, sap, tubers, or roots. Disturbed or cultivated habitats and poorly managed range harbor the greatest diversity of poisonous plants. Wetlands contain fewer poisonous taxa than do xeric or mesic areas.

The predominating plant toxins are various alkaloids and glycosides. Sixteen percent of the plants have uncharacterized toxins. Cattle and sheep are more susceptible to poisoning than are horses, swine, or poultry.

Records document man's encounters with poisonous plants since ancient times. They have played both positive and negative roles in human culture (Dayton 1948). This conspicuous duality of poisonous plants remains a major concern for range management. Kingsbury's (1964) manual on the poisonous plants of the United States and Canada was designed to aid veterinarians and ranchers in recognizing poisonous plants and the symptoms they produce in poisoned livestock. Valentine (1978) prepared an extensive bibliography on the poisonous plants of American rangelands, and numerous works have been published dealing with local species lists and descriptions (Evers 1972, Mihalopoulus 1974, Schmutz et al. 1968, Stoddard et al. 1949, USDA 1968).

The scope of this paper is twofold: to provide a list of taxa of the major poisonous plants of Utah, and to present some general patterns observed among poisonous plants within the state. It is hoped that this annotated compilation and discussion will prove useful to range managers and biologists alike.

MATERIALS AND METHODS

Data on poisonous taxa were gleaned from the published literature and by consultation

with specialists in botany and toxicology. Much of the descriptive literature on poisonous plants is redundant, consequently, only the more recent works are cited here.

Criteria used in compiling the list of poisonous plants were:

- 1. The taxon had to be sufficiently abundant (either native or introduced) in natural ecosystems to constitute a legitimate threat to livestock or wildlife. For example, some species of the genus Astragalus are known to be toxic but are not abundant enough within the state to be considered dangerous (Williams and Barneby 1977).
- 2. Ornamentals were included only if they have escaped widely from cultivation. Such plants are frequent along ecotones or in disturbed habitats.
- 3. Suspicions of toxicity had to be reasonably well-founded. The genus Astragalus, for example, is represented by more than 100 species in Utah (Welsh 1978), but only those taxa demonstrably toxic were included in the present listing.

Additional variables considered for each taxon were: life history strategy (annual, biennial, perennial), patchiness of distribu-

¹Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602. ²Department of Physics and Astronomy, Brigham Young University, Provo, Utah 84602.



Grimes, J A, St, Clair L L, and Rushforth, S R. 1980. "A COMPARISON OF EPIPHYTIC DIATOM ASSEMBLAGES ON LIVING AND DEAD STEMS OF THE COMMON GRASS PHRAGMITES-AUSTRALIS." *The Great Basin naturalist* 40, 223–229.

View This Item Online: <u>https://www.biodiversitylibrary.org/item/33900</u> Permalink: <u>https://www.biodiversitylibrary.org/partpdf/91072</u>

Holding Institution Harvard University, Museum of Comparative Zoology, Ernst Mayr Library

Sponsored by Harvard University, Museum of Comparative Zoology, Ernst Mayr Library

Copyright & Reuse

Copyright Status: In copyright. Digitized with the permission of the rights holder. Rights Holder: Brigham Young University License: <u>http://creativecommons.org/licenses/by-nc-sa/3.0/</u> Rights: <u>https://biodiversitylibrary.org/permissions</u>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at https://www.biodiversitylibrary.org.