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Floristic Studies of Diatom Communities and Habitat Characteristics of Some Inland Waters of Libya

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ABSTRACT. Floristic studies of 17 diatom samples, collected from 6 various localities of Libya in the altitudinal range of 10 m (Dernah) to 697 m (Jadu), yielded a total of 71 taxa (17 are new records for Libya).

Species richness was shown by *Navicula* (12 taxa) followed by *Nitzschia* (11 taxa). Diatom composition indicated that a sample from Ain-ul-Zarga, Jadu, had maximum number of taxa (26) with *Cocconeis placentula* var. *euglypta* dominating. *Amphora veneta* was well represented taxon in all the samples from Wadi el Majanin (near Aziziyah), whilst *Nitzachia denticula* dominated the sample from Dernah and Al-Khums. Two other samples from Al-Khums and a sample from Tripoli had, however, dominance of *Navicula halophila.*

Variability in diatom species composition and their relative abundance was pronounced in the samples from Ghadamis. Thus, *Stauroneis pachycephala* dominated in Ain-ul-Taliat, followed by *Diploneis ovalis* as very common taxon, whilst *Achnanthes brevipes* was dominant in Ain-ul-Deban. Relatively diverse epiphytic diatom growth (11 taxa) was observed on filamentous algae in Ain-ul-Faras, *Biddulphia regina* dominating the community.

The majority of taxa are shown to be alkaliphilous and indicative of oligohalobe status.

Libyan phycological studies witnessed initiation during the last quarter of 19^{th} century when some workers (*e.g.* Ascherson 1878, 1879; Castracane 1889) gave few fresh

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water algal records. Further impetus was received in the beginning of present century with work of Muschler (1910), De Toni and Forti (1913, 1914) and Forti (1927, 1928, 1932). Later, no notable contribution seems to have come forth, and a considerable gap prevailed in our knowledge of algal flora until Nizamuddin and Gerloff (1982) and Nizamuddin (1984) collated earlier information of Libyan algae into two check-lists which serve as helpful reference sources. Wood and Ghannudi (1985) mentioned few algae in their research studies on a shallow artificial fish pond, Tripoli. However, recent contribution to freshwater Libyan algal flora by Foged and Khan (1988) deals with the ecological interpretation and morphological notes of diatoms. Another publication by Khan (1989) describes the development of algal growth in a hot spring at Tajura along its thermal gradient. Khan and Zarmouh (1989) included algal records in their ecological studies on a man-made lake in Wadi el Majanin, Libya. Very recently, Khan (1994) studied species composition of diatom communities in a perennial stream in Ain-Scersciara, Tarhunah from northwest Libya.

The present communication provides the results of additional diatom material collected from 17 sites located in various parts of Libya (Fig. 1). An attempt has been made, wherever possible, to mention some principal ecological characteristics of the habitats studied.

Study Sites and Methods

Libya, though predominantly arid and desertic country, is not uniformly arid (Le Houerou 1984). Instead, substantial differences exist in aridity and other bioclimatic factors from one area to the other. Thus, the northern half (N. of the 29° parallel) is a part of the mediterranean isoclimatic zone with sub-humid (pin-point) to desertic bioclimatic types, while the southern half is a true desert without any well defined precipitation regime submitted to confronting and alternating, damped and degraded mediterranean and tropical influence (cf. Le Houerou 1984). Table 1 presents the localities from where the samples have been collected. All the sites studied (except Jadu, Ghadamis) are situated along the flat plain of Mediterranean Coast (Fig. 1). Jadu and Ghadamis are in the west of Libya. The samples collected are listed below and information is given against each sample about the locality and habitat.

T 58 = Agriculture Faculty, Univ. Campus, Tripoli, Small pond I; scrapings from submerged rooted part of *Typha*.
T 74 = Science Faculty, Univ. Campus, Tripoli. Small water pool; scrapings from the leaves of aquatic plants.
W 59 = Wadi el Majanin, Aziziyah. Flat seepage region of water reservoir; macroalgae.
W 60 = Wadi el Majanin, Aziziyah. Net plankton (mesh size, 64 µm) sample from the main reservoir.

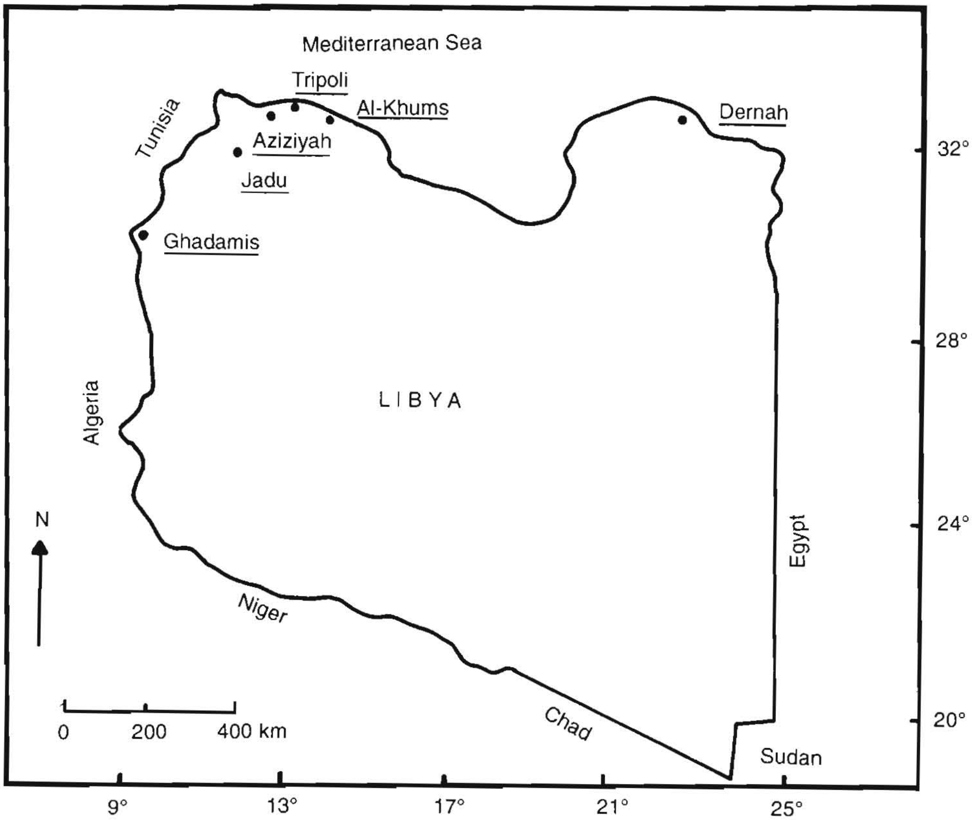

Fig. 1. Map of Libya showing sampling localities (underlined).

W 61, W 62 {= Wadi el Majanin, Aziziyah. Wide seepage region of the reservoir; thick algal mats.

J 52 = Ain-ul-Zarga, Jadu. Macroalgae (*Chara*).

G 53 = Ain-ul-Deban, Ghadamis. Filamentous algae.

G 67 = Ain-ul-Faras, Ghadamis. Filamentous algae and plant debris.

G 68 = Sondha, Ghadamis. Water tank; filamentous algae.

G 69 = Ain-ul-Taliat, Ghadamis. Pond; filamentous algae.

G 70 = Ain-ul-Faras, Ghadamis. Stream; filamentous algae.

K 48 = Al-Huleus, Al-Khums. Pond I; filamentous algae.

K 49 = Al-Kasir, Al-Kair, Al-Khums. Pond; filamentous algae.

K 50 = Al-Huleus, Al-Khums. Pond II; filamentous algae.

K 73 = Wadi Ain-Qam, Al-Khums. Pond water sedimented for algae.

D 66 = Dernah, water-fall site; dried algal sample.

Table 1. Geographical co-ordinates and altitude of localities surveyed. The number of diatom taxa found in each locality also given

Locality	Latitude 0'	Longitude 0'	Altitude m	Tot. sample collected	Tot. diatoms identified
Tripoli	32 54	13 11	22	2	8
Aziziyah	32 32	13 01	116	4	29
Jadu	31 57	12 01	697	1	26
Ghadamis	30 08	09 30	326	5	33
Al-Khums	32 39	14 16	18	4	31
Dernah	32 47	22 39	10	1	13

All the samples (except Numbers, T 58, T 74, and W 60) were collected directly by hand and preserved in 4% formalin in the field. The samples (T 58, T 74) were obtained by gently scraping the substrata. The sample (W 60) was collected by towing plankton net (mesh size, 64 µm) in water followed by centrifugation in the laboratory for obtaining concentrated sample. The samples for diatom analysis were air-dried and stored in separate small polyethylene bags. Identification was carried out by Dr N. Foged at the Danish Diatom Research Laboratory. The identification is based primarily on Hustedt (1930), Huber-Pestalozzi (1942), Patrick and Reimer (1966, 1975), and several publications of N. Foged (*e.g.* Foged 1979, 1980, 1982, 1985 a,b) and Foged and Khan (1988). Water samples for pH and conductivity were collected simultaneously as well, except for Jadu and Al-Khums. A battery-operated pH-meter "Schott, Mainz Cg 717" was used for pH estimations whilst the conductivity measurements were recorded with a digital-type conductivity meter WTW (Wissenschaftl. Technische Werkstatten Weilheim).

Results

The taxa identified in the samples are arranged in alphabetical order, and information is also included about their pH-relation and halobion status as gleaned from literature. The sample number(s) mentioned against each taxon indicate(s) the mere presence of the taxon unless stated otherwise in parenthesis.

Achnanthes

Achnanthes brevipes Ag.
W 59, W 60, W 61, J 52, G 53 (dominant), G 67 G 70, K 48, K 49, K 50; polyhalobe

A. brevipes var. *intermedia* (Kütz.) Cleve
J 52, G 70, K 48, K 73; polyphalobe (mesohalobe?)

**A. brevipes* var. *parvula* (Kütz)
W 61, W 62, G 53, G 67, G 69, G 70; polyphalobe

A. coarctata (Bréb) Grun.
W 59, W 61, W 62; oligohalobe, pH-indifferent

A. exigua Grun.
G 70: oligohalobe, alkaiphil

**A. grimmei* Krasske
J 52 (common); oligohalobe (halophil?) alkaliphil

A. lanceolata (Bréb.) Grun
J 52; oligohalobe, alkaliphil

A. minutissima Kütz.
W 61, J 52, G 67, G 68, K 48, K 73, D 66 (common); oligohalobe, alkaliphil

Amphora

Amphora ovalis Kütz
J 52; oligohalobe, alkaliphil

A. ovalis var. *libyca* (EHR.) Cleve
J 52, K 73, D 66; oligohalobe, alkaliphil

A. ovalis var. *pediculus* (Kütz.) V. Heurck
W 60; oligohalobe, alkaliphil

**A. montane* Krasske
G 67 (fairly common), G 68 (very common), K 73; oligohalobe, alkaliphil

A. veneta Kütz.
W 59 (dominant), W 60 (fairly common), W 61 (dominant), W 62 (dominant), K 48; oligohalobe, pH-circumneutral

Anomoeoneis

Anomoeoneis exilis (Kütz) Cleve
G 53, K 48; oligohalobe, alkalibiontic

**A. exilis* var. *lanceolata* A. Mayer
G 53; oligohalobe, alkalibiontic

A. sphaerophora (Kütz.) Pfitzer
J 52; oligohalobe (halophil), alkalibiontic

Biddulphia

Biddulphia regina W. Smith
J 52, G 69 (fairly common), G 70 (dominant), K 73; polyhalobe

Cocconeis

Cocconeis pediculus Ehr.
T 58, G 53 (fairly common); oligohalobe, alkaliphil

C. placentula Ehr.
W 62; oligohalobe, alkaliphil

C. placentula var. *euglypta* (Ehr.) Cleve
W 59, J 52 (dominant); oligohalobe, alkaliphil

Cyclotella

Cyclotella meneghiniana Kütz.
G 68, D 66; oligohalobe (halophil), alkaliphil

Cymatopleura

Cymatopleura elliptica (Bréb.) W. Smith
J 52 (common); oligohalobe, alkaliphil

Cymbella

Cymbella affinis Kütz.
W 59, W 61, K 48; oligohalobe, alkaliphil

C. helvetica Kütz.
T 58, W 61, G 67, K 48; oligohalobe, alkaliphil

C. microcephala Grun.
G 67, G 68, K 48, K 49 (common), K 50, K 73, D 66 (common); oligohalobe, pH-circumneutral

C. pusilla Grun.
G 67, G 70, K 73, D 66; mesohalobe

Diploneis

**Diploneis didyma* Ehr.
G 53; polyhalobe

**D. oculata* (Ehr.) Cleve
J 52; oligohalobe, alkaliphil

D. ovalis (Hilse) Cleve
J 52, G 67, G 68, G 69 (very common), G 70, D 66 (fairly common); oligohalobe, alkaliphil

Epithemia

Epithemia mulleri Fricke
J 52; oligohalobe, alkaliphil

Eunotia

**Eunotia pectinalis (Kütz.)* Rabh.
G 67, D 66 (fairly common); oligohalobe (halophobe), acidophil

E. sudetica (O. Muller) Hust.
W 61, K 73, D 66; oligohalobe (halophobe), acidophil

Frustulia

Frustulia vulgaris Thwaites
J 52; oligohalobe, alkaliphil

Gomphonema

Gomphonema gracile Ehr.
T 74, W 60, W 61, W 62, J 52, G 69, G 70, K 49, D 66; oligohalobe, alkaliphil

G. lanceolatum Ehr.
T 74, W 60, W 61, J 52, G 69, G 70, K 49, D 66; oligohalobe, alkaliphil

**G. longiceps* Ehr. var. *subclavata* Grun.
J 52; oligohalobe, alkaliphil

G. parvulum Kütz.
T 74, W 59, W 61, W 62, J 52, G 68, G 69, G 70, K 48; oligohalobe, pH-circumneutral

G. parvulum var. micropus (Kütz.) Cleve
W 59, W 61, W 62, G 69, G 70, K 48; oligohalobe, pH-circunnuetral

Hantzschia

Hantzschia amphioxys (Ehr.) Grun.
W 59, W 61, W 62; oligohalobe, ph-indifferent

Melosira

Melosira arenaria Moore
J 52 (common); oligohalobe, alkaliphil

Navicula

Navicula cincta (Ehr.) Kütz.
G 67; oligohalobe (halophil), alkaliphil

N. crytocephala Kütz.
G 67, G 68, G 70, K 73; oligohalobe, alkaliphil

N. cryptocephala var. *veneta* (Kütz.) Grun.
W 62; oligohalobe, alkaliphil

**N. cuspidata* var. *ambigua* (Ehr.) Cleve
W 62; oligohalobe, alkaliphil

N. halophila (Grun.) Cleve
T 58 (dominant), W 59 (common), W 60, W 61, W 62, J 52, G 67, K 48 (dominant), K 49 (dominant), K 50 (common), K 73, D 66; mesohalobe, alkaliphil

N. mutica Kütz.
W 59, W 60, W 61, W 62, K 73; oligohalobe, pH-circumneutral

**N. mutica* var. *binodis* Hust.
W 59; oligohalobe, pH-circumneutral

**N. mutica* var. *cohnii* (Hilse) Cleve
W 62; oligohalobe, pH-circumneutral

**N. mutica* var. *nivalis* (Ehr.) Hust.
W 62; oligohalobe, circum-neutral

N. pygmaea Kütz.
K 70; mesohalobe

**N. rhynchocephala* Kütz.
G 67; oligohalobe (indifferent – halophil), alkaliphil

N. tenella Bréb.
J 52, G 67, G 70, K 48, K 49, K 50, D 66 (very common); oligohalobe, pH-circumneutral

Nitzschia

Nitzschia (unidentified)
T 74 (dominant)

N. amphibia Grun.
G 67, K 48 (common), K 49, K 73, D 66 (very common); oligohalobe, alkaliphil

N. apiculata (Greg.) Grun.
G 70, K 73; mesohalobe, alkaliphil

N. denticulata Grun.
W 61, J 52 (common), G 67 (common), G 68 (very common), G 69, K 48 (very common), K 49 (dominant), K 50 (dominant), D 66 (dominant); oligohalobe, alkaliphil

N. frustulum (Kütz.) Grun.
W 61, G 69, G 70; oligohalobe (indifferent – halophil), alkaliphil

**N. frustulum* var. *subsalina* Hust.
G 68: oligohalobe (halophil), alkaliphil

N. gandersheimiensis Krasske
W 61, K 48; mesohalobe, alkaliphil

N. hungarica Grun.
W 61, W 62, K 73; oligohalobe (mesohalobe ?), alkaliphil

N. linearis W. Smith
J 52; oligohalobe, alkaliphil

N. paleacea Grun.
G 68 (common), G 70; oligohalobe, alkaliphil

**N. vitrea* Norman
K 73; mesohalobe

Pinnularia

Pinnularia borealis Ehr.
W 59; oligohalobe, pH-circumneutral

Stauroneis

**Stauroneis pachycephala* Cleve
G 67, G 69 (dominant), G 70; oligohalobe – mesohalobe ?, alkaliphil

Surirella

Surirella ovalis (Bréb.) Grun.
J 52, G 70, K 48, K 73; mesohalobe, alkaliphil

S. ovata Kütz.
J 52; oligohalobe, alkaliphil

**S. peisoneis* Pant.
K 73 (common); mesohalobe

Synedra

Synedra acus Kütz.
W 61; oligohalobe, alkaliphil

S. ulna (Nitzsch) Ehr.
T 58 (fairly common), W 59, K 48; oligohalobe, pH-circumneutral

Tabellaria

Tabellaria flocculosa (Roth) Kütz.
K 48; oligohalobe (halophobe), acidophil

*new records for Libya

Table 2. Some chemical characteristics of habitats from where the samples were collected. Number of diatom taxa identified for each sample also given

Locality	Sample No.	Date of collection	pH	Conductivity µS	Totl. diatoms identified
Tripoli	T 58	31.1.1987	7.2	8763	5
Tripoli	T 74	26.6.1987	7.2	1824	3
Wadi el Majanin	W 59	6.2.1987	7.8	513	13
Wadi el Majanin	W 60	6.2.1987	7.6	272	6
Wadi el Majanin	W 61	6.2.1987	7.8	512	20
Wadi el Majanin	W 62	6.2.1987	7.8	513	14
Jadu	J 52	11.1.1987	ND	ND	26
Ghadamis	G 53	14.1.1987	6.9	32725	6
Ghadamis	G 67	12.3.1987	6.7	3404	17
Ghadamis	G 68	12.3.1987	6.2	3960	10
Ghadamis	G 69	12.3.1987	6.8	3147	9
Ghadamis	G 70	12.3.1987	7.2	3248	17
Al-Khums	K 48	12.12.1986	ND	ND	18
Al-Khums	K 49	19.12.1986	ND	ND	7
Al-Khums	K 50	19.12.1986	ND	ND	5
Al-Khums	K 73	25.5.1987	ND	ND	18
Dernah	D 66	4.3.1986	7.5	1478	13

ND = Not determined

Discussion

Despite significant regional differences in aridity influencing the distinct bioclimatic zones (cf. Le Houerou 1984), Libya is widely considered to be predominantly desertic, covering a great portion of the Sahara Desert. The scanty taxanomic literature on diatoms is largely based on short visits or expeditions and restricted to check-lists. Earlier studies, with the exception of recent contributions by Foged and Khan (1988) and Khan (1994), on freshwater diatom assemblages and their corresponding environments are lacking, thus limiting the interpretation of the present research findings. However, the present investigations indicate that the diatom flora of the sites is characterized by wide heterogeneity in relation to species composition and degree of abundance. Thus, in a hypersaline habitat (K_{20} > 6000 µS; Beadle 1981) from Tripoli (Sample No. T 58), only few diatoms occurred with *Navicula halophila* as a dominant taxon. Several workers (Hustedt 1957, Foged 1982) identified the taxon as mesohalobe (having optimum in fairly brackish waters). According to Beadle (1981), relatively only few species of plants and animals can live in hypersaline waters, and possession of an appropriate regulatory mechanism is certainly required.

Diatom analysis of all the samples from Wadi el Majanin (conductivity; 272-513 µS) revealed the presence of *Amphora veneta* as an important taxon, in terms of its relative abundance. The thick algal mats collected from the wide seepage region (W 61) had rich epiphytic growth of diatoms (20 taxa), whilst a sample (W 60) obtained using plankton net from the water reservoir recorded poor composition (6 taxa) of diatom species. This variation in population densities of the sites is obviously attributable to different sampling methodology used for diatom collections, though habitat characteristics may be also implicated, as ionic content (cf. Tab. 2) of the seepage region was nearly two-fold (512-513 µS) as compared to the main water reservoir (272 µS). A solitary sample from Ain-ul-Zarga, Jadu, had rich diatom (26 taxa) population with *Cocconeis placentula* var. *euglypta* dominating, whilst *Achnanthes grimmei, Cymatopleura elliptica, Nitzschia denticula, Melosira arenaria* were observed as common taxa – all reported (Foged 1980, Khan 1994) as oligohalobe (proper freshwater species) and alkaliphil (pH > 7). Each of the five samples collected from different sites of Ghadamis had variable diatom species composition and diversity. Thus, Ain-ul-Deban, a high salinity biotope (32.7%) had only 6 taxa (*Achnanthes brevipes* dominating) which indicates that in hypersaline waters only few organisms live. *Achnanthes brevipes* recorded as polyhalobe (Foged 1980, 1985 a,b) dominated this sample. *Stauroneis pachycephala* was dominant taxon in Ain-ul-Taliat (Sample No. G 69) whilst in a sample (G 68) from Sondha, *Amphora montana*, and *Nitzschia denticula* constituted important diatoms, recorded as very common taxa. The epiphytic diatom community, though rich (17 taxa) in a freshwater stream (conductivity; 3248 µS) of Ain-ul-Faras (Sample No. G 70), revealed *Biddulphia regina* as dominant taxon. Quoting a personal communication of Reynolds (cf. Khan 1994), there are only few species of Biddulphia (2 or 3) present in freshwaters and said to be uncommon. DeToni and Forti (1914) and Pampanini (1914) documented *Biddulphia regina* as a marine diatom from Tripoli. Khan (1994) evaluating the ecological distribution of diatom communities, found *B. regina* growing as a freshwater taxon in a lotic environment (Ain-Seerseiara stream), Tarhunāh, Libya.

Navicula halophila and *Nitzschia denticula* were well represented (relative abundance varied from common-very common to dominant) diatoms constituents in all the samples from Al-Khums, except a sedimented pond water sample (K 73) from Wadi Ain-Qam, where *Surirella peosoneis* (mesohalobe; having their optimum in fairly brackish water) was a common diatom among total of 18 taxa recorded from the sample. A solitary sample from a freshwater biotope (conductivity; 1484 µS) from Dernah (Sample No. D 66) in north-east Libya revealed *Nitzschia denticula* as dominant taxon whilst *Nitzschia amphibia, Navicula tenella* were very common followed by *Achnanthes minutissima, Cymbella microcephala,* observed as common taxa.

Concluding, it may be said that the present research studies attempted to document diatom communities from diversified habitats of Libya, and the results, in general, indicate that majority of the taxa are oligohalobe and alkaliphil. However, further ecological observations on species variations and diversity may serve as useful indicators of long-term environmental changes, especially from arid desertic regions.

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دراسات فلورية لمجتمعات دياتومية
والصفات البيئية لبعض المياه الداخلية الليبية

أم .أ .خان *

قسم النبات – جامعة الفاتح – طرابلس – ليبيا

تمت دراسات فلورية ل ١٧ عينة دياتومية جمعت من ٦ مواقع مختلفة من ليبيا عند ارتفاع بلغ معدله مابين ١٠ م (درنة) إلى ٦٩٧ م (جادو) تنتج ما مجموعه ٧١ تاكسون (سجل منها ١٧ نوعًا جديدًا لليبيا) . ظهرت أنواع غنية ب *Navicula* (١٢ تاكسون) يتبعها ال *Nitzschia* (١١ تاكسون) ويتضح من تركيب الدياتومات أن عينة من عين الزرقا والجادو بها عدد أقصى من الدياتومات وصل إلى ٢٦ تاكسون من هذه الانواع *Cocconeis Placentula* var. *englypta* والذي كان مسيطراً ولكن ال *Amphora veneta* كان ممثلا في جميع العينات التي تم جمعها من وادي المجانين (قريبا من العزيزية) بينما ال *Nitzchia denticula* كان سائداً في العينات التي جمعت من درنة والخمس . عينتين اخرتين جمعتا من الخمس وعينة من طرابلس كانت السيادة في تلك العينات ل *Navicula halophila* .

ظهرت الاختلافات في تركيب انواع الدياتومات ووفرتها في العينات التي جمعت من القداميس أما *Stauronesis pachycephala* فكان سائداً في عين الطاليات يتبعها ال *Diploneis ovalis* حيث كان هذا النوع شائعًا بينما ال *Achnanthes brevipes* كان له السيادة في عين الدبان .

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* العنوان الحالي : قسم النبات – جامعة كشمير – ص .ب ٧٢٦ – جي .بي .أو . سريناغار – ١٩٠٠٠١ – كشمير – الهند

كان ملاحظاً في الطحالب الخيطية في عين الفاراس نمو دياتومي هوائي متنوع في حوالي (١١ تاكسون) وكان طحلب ال *Biddulphia regina* سائداً في المجتمع الدياتومي .

أغلب الانواع بدت محبة للقلوية وأعتبرت كمؤشرات على كثرة الملوحة .