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Fresh and brackish water algae new for Israel found in Nahal Qishon (N-Israel)

Abstract

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We studied algal assemblages from the Nahal Qishon, northern Israel, to assess the biodiversity of an aquatic ecosystem under strong anthropogenic impact. In 59 samples of periphyton and phytoplankton collected during 2002-2003, we found 154 species from seven algal divisions. About 17% of the species (26) are new for the algoflora of continental Israel and five of them represent the first record for a genus: *Crinalium endophyticum* Crow (Cyanoprokaryota), *Actinocyclus normanii* (Gregory) Hustedt (Bacillariophyta), *Rhizoclonium hieroglyphicum* (Agardh) Kütz. (Chlorophyta), *Lagynion janei* Bourelly, and *Stylococcus aureus* Chodat (Chrysophyta). Most species new for Israel came from the estuarine assemblage. They are widespread outside Israel, except *Lagynion janei* (Chrysophyta), endemic in the Mediterranean realm.

Introduction

Algoflora of continental Israel presently comprises 1357 species of 11 algal divisions (Nevo & Wasser 2000; Vinogradova & al. 2000 a, b; 2001; Masjuk & al. 2001; Mihailuk & al. 2001 a, b; Tsarenko & al. 2001; Kovalenko & al. 2002 a, b). Taxonomic contributions to this algal diversity are due to our studies of coastal rivers of northern Israel. The coastal rivers of northern Israel have been the least studied. We sampled both relatively clear sources from natural preserves, such as Nahal Oren (Barinova & al. 2004), as well as highly polluted rivers, the most representative of which is the Nahal Qishon.

Nahal Qishon (Figs 1, 2) is the second largest river among the coastal rivers draining an area of 1100 square kilometers from Jenin in Samaria through the Jezreel Valley, the Qishon Water Gap (the narrow pass between Mount Carmel and the Shefar'am Allonim Hills) and the Zevulun Valley to the Mediterranean Sea near Haifa. It is permanent for about 43.6 km of the flow (Qishon River Authority, http://www.kishon.org.il/; Kadmon, 1994). Brackish marshes are patchily preserved over the coastal plain near the Nahal Qishon mouth. The lower reaches are the most heavily polluted with industrial effluents and municipal wastewater adversely impacting the Haifa Bay and surroundings.

Up to now, algae from Nahal Qishon were never systematically studied. Fragmentary

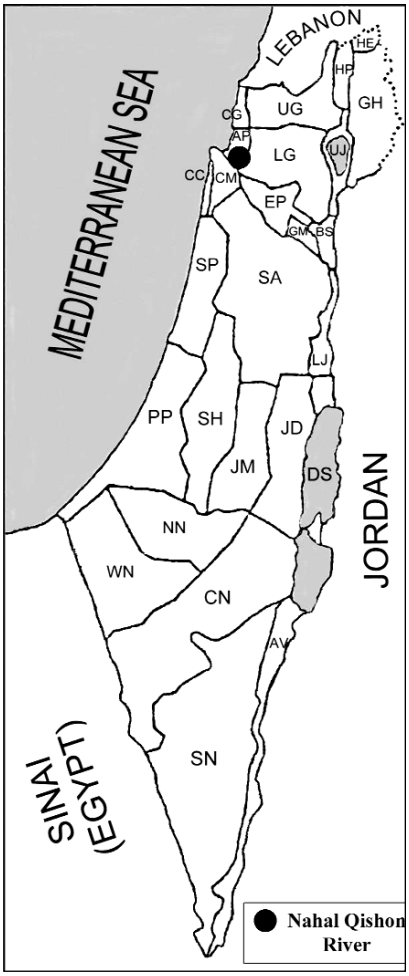

Fig. 1. Site of Nahal Qishon (black spot) in the map of natural regions of Israel: AP - Akko Plane; AV - Arava Valley; BS - Bet Shean Valley; CC - Carmel Coast; CM - Mount Carmel; CN - Central Negev; DS - Dead Sea Area; EP - Esdraelon Plain; GC - Galilee Coast; GH - Golan Heights; GM - Gilboa Mountains; HE - Hermon; HP - Hula Plain; JD - Judean Desert; JM - Judean Mountains; LG - Lower Galilee; LJ - Lower Jordan Valley; NN - Northern Negev; PP - Philistine Plain; SA - Samaria; SH - Shefela; SN - Southern Negev; SP - Sharon Plain; UG - Upper Galilee; UJ - Upper Jordan Valley; WN - Western Negev.

studies exist for a few brackish fishponds and artificial reservoirs in the lower Nahal Qishon basin (Ehrlich 1995; Hisoriev & al. 1996 a, b; Masjuk & al., 1999; Oron & al., 1981; Palamar-Mordvintseva & al. 1996; Rayss 1944; Shilo 1962; Tsarenko & al. 1997). The list of algae obtained from these limited sources, includes 86 species only.

Table 1. Environmental conditions and index of saprobity revealed on the stations of Nahal Qishon.

No. of Station	pH	Conductivity mS/cm	$N\text{-}NO_3$, mg/l	Chloride, mg/l (Qishon River...)	Total P, mg/l (Qishon River...)	Saprobity Index S
1	8.1	35-9.97	3.9	11663	2.3	2.31-2.65
2	7.9	29.6-9.42	10.5	10263	1.9	2.33-2.65
3	7.7	3.35-4.93	2.4	-	0.6	2.59
4	7.7	4.98	3.0	-	-	2.31
5	7.9	5.06	2.6	-	-	2.13-2.2
6	7.8	3.06-5.04	2.8	773	0.7	2.2-2.6
7	7.9	5.01	5.6	-	-	2.39
8	7.9	4.89	7.6	-	-	2.31
9	7.7	2.67-4.87	8.1	-	-	2.33
10	7.6	2.95-5.11	3.9	-	0.9	2.15-2.53
11	7.7	4.88-5.50	3.9	1306	0.5	2.5
12	7.6	5.21	5.5	-	-	2.35-2.38
13	7.7	5.23-6.05	4.3	-	0.6	2.2-2.6
14	7.5	6.26	-	-	-	2.05-2.37
15	8.6	1.66	0.6	-	-	2.1-2.5
16	7.7	3.63	4.6	-	-	2.5-2.76
17	7.7	3.42-3.56	-	-	0.5	2.55-2.56
18	9.1	4.05	-	-	-	2.4-2,52

Material and methods

Material for this study came from 59 samples of phytoplankton and periphyton from Nahal Qishon (Fig. 2). Samples were collected during the winter and summer seasons, from February 2002 to August 2003. The samples were obtained by scooping up for phytoplankton and scratching for periphyton and then fixed in 3% formaldehyde (Whitton & al. 1991). Algae were studied with the Swift dissecting microscope under magnifications of 740-1850 and were photographed with an Inspector 1 digital camera. The diatoms were prepared by the peroxide technique (Swift 1967) modified for glass slides (Barinova 1988). The diatoms were studied both under light microscope and scanning electron microscope JEOL JSM 35C.

The taxonomy of this study mainly follows the systems adopted in the "Süswasserflora von Mitteleuropa" (Komarek & Anagnostidis 1998; Krammer & Lange-Bertalot 1991 a, b; Starmach 1985) and Green Algae (Mattox & Stewart 1984), with additions for individual taxa (Barber & Carter 1996; Ettl & Gartner 1988; Gollerbah & al. 1953; Komárek & Lund 1990; Krammer 2000; Meffert 1988; Palamar-Mordvintseva 1982).

Simultaneously with sampling, we measured conductivity, pH with HANNA HI 9813, and nitrate concentration with HANNA HI 93728.

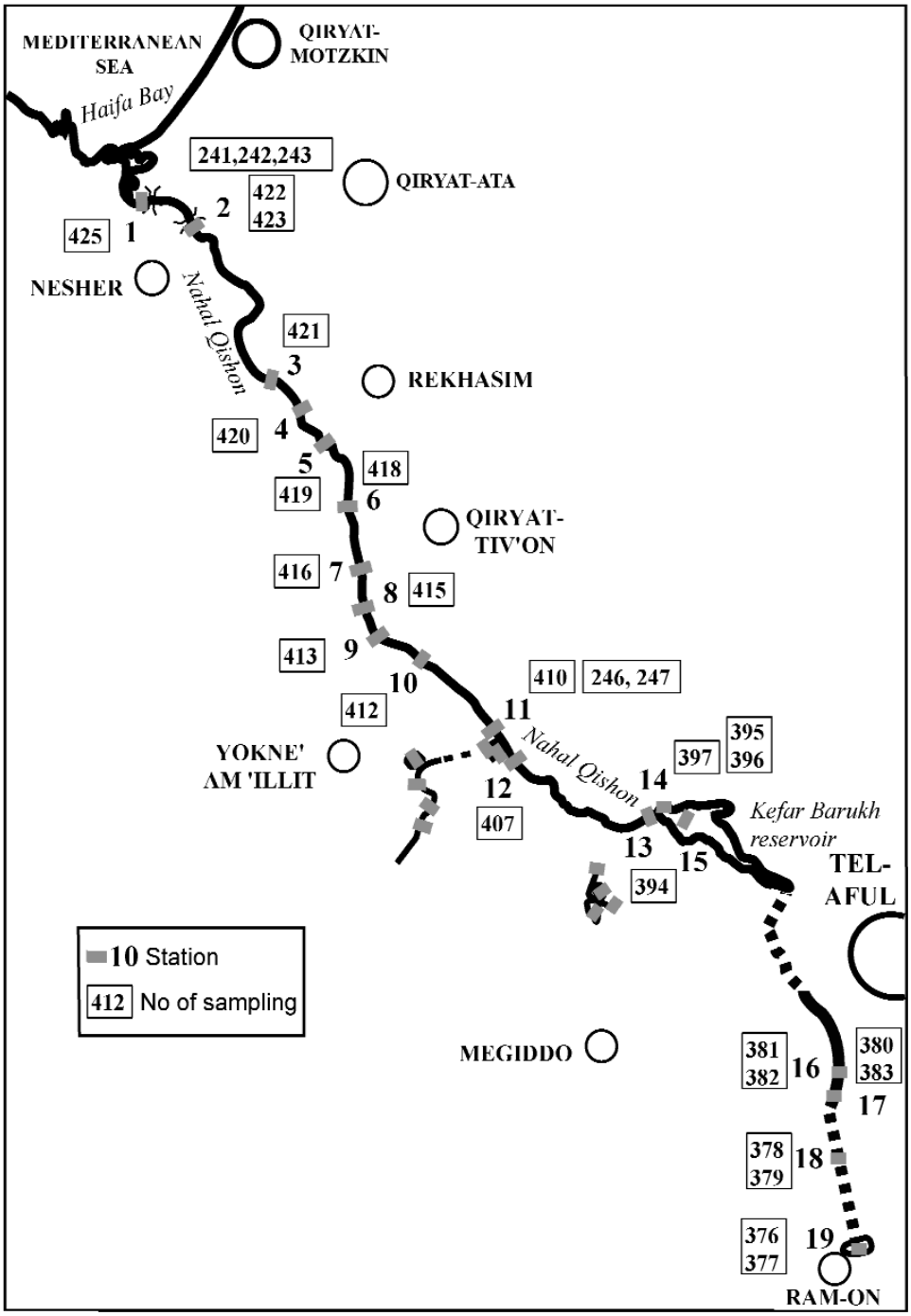

Fig. 2. Map of stations on the Nahal Qishon basin with numbers of algal samples.

Table 2. Major chemical, physical and biological variables ranging on the water quality classes (Romanenko & al. 1990).

Variable	Class of water quality					
	I	II	III	IV	V	VI
Conductivity, mS/cm	<0.4	0.4-0.7	0.7-1.1	1.1-1.3	1.3-1.6	>1.6
TDS, mg/l	<300	500	800	1000	1200	>1200
Chlorides, mg/l	<50	150	200	300	500	>500
Sulphates, mg/l	<50	150	200	300	400	>400
$N\text{-}NO_3^-$, mg/l	<1	3	5	10	20	>20
PO_4^{3-}, mg/l	<0.025	0.2	0.5	1.0	2.0	>2.0
P total, mg/l	< 0.5	0.4	1.0	2.0	3.0	>3.0
Saprobity Index S	0-0.5	0.5-1.5	1.5-2.5	2.5-3.5	3.5-4.0	>4.0

The algal abundances were assessed on the basis of the 5-score scale (Whitton & al. 1991). Saprobity indices were obtained for each algal community (Sládeček 1986) and then used for an integral assessment of the species habitats.

For phytogeographic analysis, the species ranges were plotted against the phytogeographic divisions of the global (Takhtajan 1978), Mediterranean (Zohary & Feinbrun-Dothan 1966) and regional Israeli (Zohary 1966) classifications.

Results and discussion

The physico-chemical environmental variables and their dynamics over the Nahal Qishon stations are indicated in Table 1. The pH and conductivity show that Nahal Qishon is fresh water in the upper and middle reaches, is influenced by sea tides in the lower reaches (Chloride fluctuated from 773 mg per liter to 11663 mg per liter, Qishon River Authority, http://www.kishon.org.il/) and remains alkaline all year-round. The concentration of $N\text{-}NO_3$ is 0.6-10.5 mg per liter. The concentration of P-total is 0.2-7.93 mg per liter (Qishon River Authority, http://www.kishon.org.il/). In winter, conductivity tends to increase from station 10 to the mouth, while pH tends to decrease in the same direction. Connection between conductivity and salinity levels as well as other chemical variables and Index of saprobity S indicated in the Table 2 (Romanenko & al. 1990).

In general, pH is relatively constant fluctuating between 9.1 and 7.5 down the river channel corresponding to the regional norm for carbonate provinces (Meybeck & Helmer 1989).

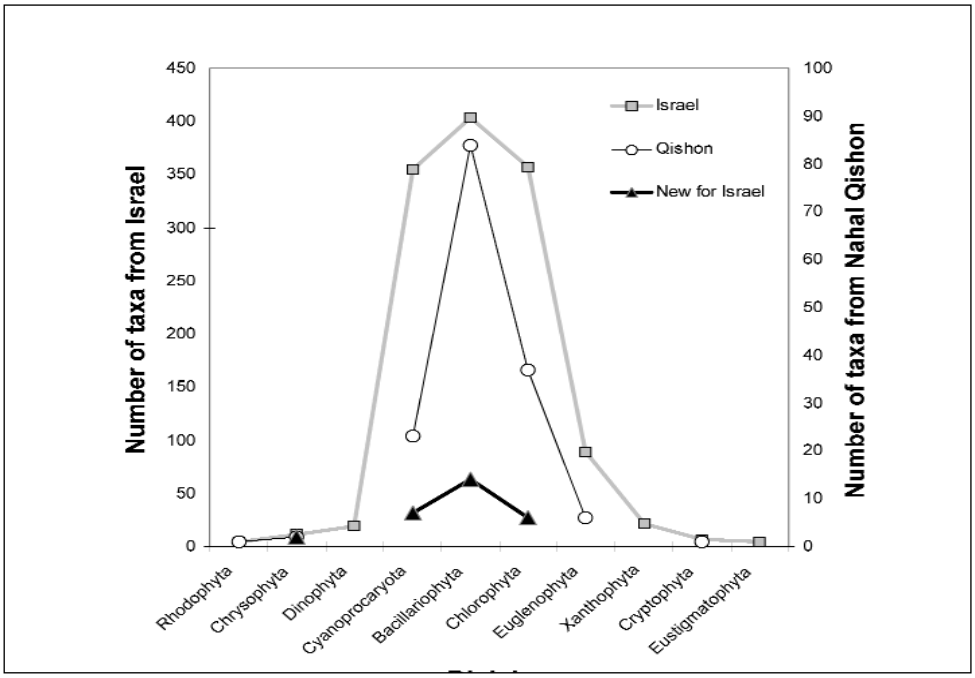

Fig. 3. Distribution of algal species over systematic Divisions.

In samples from Nahal Qishon we found 154 species of algae from 7 divisions (Barinova & al. 2004). Among them, 26 species are recorded for the first time in continental Israel. These species are briefly described in the next section. Among 86 algal species from brackish fishponds and artificial reservoirs in the lower Nahal Qishon basin (Ehrlich 1995; Hisoriev & al. 1996 a, b; Masjuk & al. 1999; Oron & al. 1981; Palamar-Mordvintseva & al. 1996; Rayss 1944; Shilo 1962; Tsarenko & al. 1997), 35 species were found only in fishponds of Akko Plain. They are mostly euglenoids different from those we found in Nahal Qishon.

Species new for Israel constitute about 17% of algal diversity in Nahal Qishon. Five of them represent the first record of a genus: *Crinalium endophyticum* Crow (Cyanoprokaryota), *Actinocyclus normanii* (Gregory) Hustedt (Bacillariophyta), *Rhizoclonium hieroglyphicum* (Agardh) Kütz. (Chlorophyta), *Lagynion janei* Bourelly, and *Stylococcus aureus* Chodat (Chrysophyta).

Curves showing distribution of species over systematic divisions (Fig. 3) are symmetrical for Israel as a whole, for Nahal Qishon as a whole and for new species for Israel found in Nahal Qishon. Therefore, the newly found species add to the algal divisions proportionally to their taxonomic diversity in the regional algoflora.

Most species new for Israel came from the estuarine assemblage. They are widespread outside Israel except *Lagynion janei* (Chrysophyta), endemic in the Mediterranean realm.

The taxonomic list (below) shows that our findings have added, to the diversity of

diatoms (13 species). These are mainly benthic species inhabiting brackish and saline waters. We found them in the lower reaches of Nahal Qishon draining the Akko Plain where marine tides inundate the channel. Most remarkable is *Cylindrotheca gracilis* (Brebisson) Grunow, the shell of which is poorly silicified and usually does not withstand the standard treatment. The blue-greens (cyanoprokaryotes) are second in species richness - six species, three of which are epiphytic. They are also found in lower Nahal Qishon preferring brackish marine waters. Only *Chamaesiphon amethystinus* (Rostaf.) Lemm. occurs in the algal assemblage of the middle reaches dominated by a red alga *Audouinella pygmea* (Kütz.) Weber-van Bosse and its epiphytes.

The green algae are third in species richness, only five species belonging to three orders: Chlorococcales, Desmidiales and Siphonocladales. They occur in both planktonic and benthic assemblages inhabiting waters of low salinity. Most remarkable among them is *Actinastrum hantzschii* var. *subtile* Wołoszyńska, found in the pond on middle reaches of Nahal Qishon in association with the type variety, but fairly distinct from it.

New finds include two species of Chrysophyta occurring in epiphytic assemblages on *Cladophora* in the moderately salinity waters of the Akko Plain. *Lagynion janei* Bour. is endemic for the Mediterranean realm, representing a genus that was not previously found in Israel. *Stylococcus aureus* Chod., also belonging to the genus new for Israel, is known from both Mediterranean and Boreal provinces (Starmach 1985).

Ecologically, the newly found species all prefer mesotrophic to eutrophic alkaline waters of moderate to high salinity, which is confirmed by measurements of conductivity (1.66-9.98 mS/cm), pH (7.6-9.1), and nitrate nitrogen (0.6-10.5 mg/l) as well as the calculated indices of saprobity (2.05-2.76).

Taxonomic synonyms, diagnostic features, ecological characteristics, geographical distribution, habitats, and environmental conditions are indicated for each of the species. The distribution and habitats in Israel are given, followed by the frequency estimates by the 5-score system (Whitton & al. 1991). Symbols in the habitat characteristics are: pH - water acidity, C - conductivity, mS/cm, S - index of saprobity (Sládeček 1986), and $N\text{-}NO_3$ - concentration of nitrate nitrogen, mg/l. The samples are deposited in the Institute of Evolution, University of Haifa (IEUH), under no. 245-425.

Description of new for Israel taxa

CYANOPROKARYOTA

Aphanothece Nägeli 1849

1. ***Aphanothece elabens*** (Brébisson et Meneghini) Elenkin 1938: Acta Inst. Bot. Acad. Sci. USSR 2 (1): 279. - **Pl. 3, Fig. 1**.

Synonyms: *Micraloa elabens* Bréb. in Menegh.; *Microcystis elabens* (Bréb.) Kütz.; *Polycystis elabens* (Bréb.) Kütz.; *M. elabens* var. *maior* Bachmann, incl.; *M. aphanothecoides* Zalessky; *Aphanothece elabens* var. *minor* Nyg., incl.; *Coccochloris elabens* (Bréb.) Drouet et Daily.

Description: Colonies microscopic, spherical or flat, aggregate colonies macroscopic,

blue-green or olive-green. Mucilaginous envelopes homogeneous or slightly concentrically lamellate, usually distinctly delimited, rarely diffluent. Cells oval to cylindrical, olive-green, facultatively (in plankton) with aerotopes, 2.8-6.5 x 1-2(3) μm.

Occurrence: Freshwater, periphytic, later in development partly free-floating in clear lakes.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of Kefar-Barukh reservoir - 2; pH - 7.5; C - 6.26 mS/cm; S - 2.05; $N\text{-}NO_3$ - 1.2 mg/l. IEUH-397.

General distribution: Apparently cosmopolitan.

Arthrospira Stizenberger ex Gomont, 1892

2. ***Arthrospira*** ex gr. ***fusiformis*** (Woronich.) Komárek et Lund 1990: Arch. Hydrobiol. Suppl. 85: 11, Figs 3: 4,5. - **Pl. 3, Fig. 2.**

Synonym: Spirulina fusiformis Woronich.

Description: Trichomes 8.2-10.8 μm wide, 100-325 μm long, at cross partitions not constricted, spirally coiled, narrowed to the ends. Diameter of coils in the middle part of the colony about 50-65 μm, the distance between coils 1.8-24 μm, decreasing towards both ends to 3.6-20 μm and 23-24 μm, respectively. Cells 2-3 times wide than long.

Occurrence: In salty waters.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on limestone - 1; pH - 7.9; C - 5.06 mS/cm; S - 2.13; $N\text{-}NO_3$ - 2.6 mg/l. IEUH-419.

General distribution: Asia (Russia, Israel).

Note: Scheldeman & al. (1999) showed that *Arthrospira* ('Spirulina') *fusiformis* is genetically heterogeneous perhaps comprising more than one biological species that are not readily distinguishable at the morphological level; since we did not make the genetic analysis, we prefer to apply open nomenclature (ex gr.) assigning our material to the group of species constituting the original morphospecies *A. fusiformis*.

Chamaesiphon A. Braun et Grunow in Rabenhorst 1865

3. ***Chamaesiphon amethystinus*** (Rostafinski) Lemmermann 1910: Arch. Hydrobiol. Planktonk. 5: 291-338. - **Pl. 2, Figs. 1, 2, 3.**

Synonym: *Sphaerogonium amethystinum* Rostafinski

Description: Cells solitary or arranged in dense groups of parallel cells, attached individually, but often in masses, covering the substrate, cylindrical or slightly expanded towards the ends, broadly rounded at the apex (sometimes with a thickened apical sheath), blunt at the base, straight or rarely very slightly curved, with distinct, gelatinous pad (or adhering discs sometimes combined with a short stipe, or at least with the pseudovagina distinctly separated from the basal part by a constriction); cell content pale blue-green or gray-blue, pinkish, brownish, or violet (all transitions of color change in cells from the same colony), finely and regularly granular; cell dimensions (with pseudovagina) 7-16.5 (20) x (2.5)3.5-4.5(6.5) μm (very rarely longer). Pseudovagina distinct, colorless.

Occurrence: Freshwater, epiphytic, mainly on red filamentous algae and cyanoprokaryotes in clear streams of temperate zone.

Distribution and habitat in Israel: AP: Nahal Qishon, epiphytic on the *Audouinella pyg-*

mea - 1-4; pH - 7.6-7.9; C - 5.01-5.11 mS/cm; S - 2.39; N-NO_3 - 3.9-5.6 mg/l. IEUH-411, 416.
General distribution: Europe, C. America, Asia (Israel).

Crinalium Crow 1927

4. ***Crinalium endophyticum*** Crow 1927. In Gollerbah & al. 1953: Blue-green algae. Guide to Freshwater Algae of the USSR 2: 619, Fig. 321. - **Pl. 2, Fig. 10**.
Description: Trichomes flattened ribbon-shaped, hair-pin-like curved and slightly spirally coiled. Sheath thin or lacking. Transverse partitions slender, scarcely distinguishable. Cells 3-4 x 3.5-6 µm.
Occurrence: In slime of blue-green algae (*Aphanocapsa*).
Distribution and habitat in Israel: AP: Nahal Qishon, on a mass of filamentous algae in water - 1; pH - 7.7; C - 3.63 mS/cm; S - 2.44; N-NO_3 - 4.6 mg/l. IEUH-382.
General distribution: Europe (England, Romania), Asia (Israel).

Limnothrix Meffert 1987

5. ***Limnothrix amphigranulata*** (Van Goore) Meffert 1987: Arch. Hydrobiol./Suppl. 76: 315-346; Meffert, 1988: Arch. Hydrobiol./Suppl. 80, Algological Studies 50-53: 269-276. In Van Goore 1918: Zur Kenntnis der Oscillatoriaceen. Rec. Trav. Bot. Néerland. 15: 257, Pl. 2, Fig. 2. - Pl. 3, Fig. 7 - **Pl. 5, Fig. 7.**
Synonym: *Oscillatoria amphigranulata* Van Goore
Description: Trichomes pale blue-green, straight, linear, 1.8-1.9 µm wide, at cross partitions clearly constricted, ends not narrowed, not capitate, with gas vesicles localized near the cell poles. Cells sometimes slightly expanded around the aerotopes. Cells square or 2-3.5 longer than wide, length 2.1-7.0 µm. Terminal cells rounded, without calyptra.
Occurrence: In saprobic silt of stagnant waters.
Distribution and habitat in Israel: AP: Nahal Qishon, periphyton on the limestone - 5; pH - 7.7-7.9; C - 4.87-5.06 mS/cm; S - 2.13-2.39; N-NO_3 - 2.6-8.1 mg/l. IEUH-413, 418, 419.
General distribution: Europe (Estonia), Asia (Israel).

Xenococcus Thuret in Bornet et Thuret 1880

6. ***Xenococcus pallidus*** (Hansgirg) Komarek et Anagnostidis 1995: Preslia (Praha) 67: 15-23. - **Pl. 3, Figs. 3, 4, 6.**
Synonym: *Xenococcus schousboei* var. *pallidus* Hansg.
Description: Cells more or less spherical or rounded, flattened, usually densely and irregularly aggregated on the surface of other filamentous algae, in one-layered, irregular colonies, pale blue-green or yellow-green, 3-5 µm in diameter.
Occurrence: Marine, epiphytic on seaweeds.
Distribution and habitat in Israel: AP: Nahal Qishon, among the floating masses of filamentous algae - 1-2; pH - 7.6-7.7; C - 3.63-5.11 mS/cm; S - 2.19-2.44; N-NO_3 - 3.9-4.6 mg/l. IEUH-381, 412.

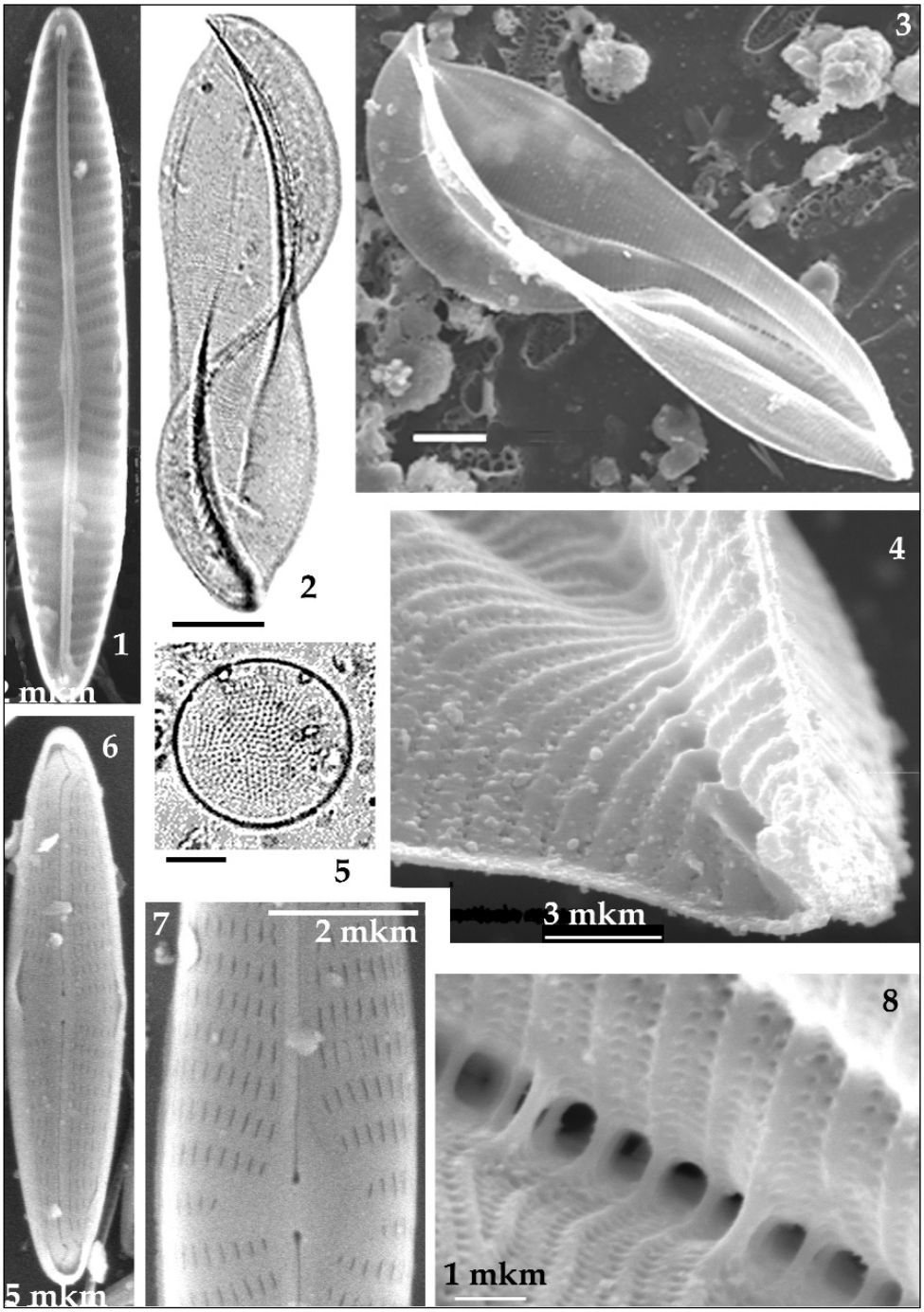

Plate 1. New taxa of algae from Nahal Qishon. *Navicula perminuta* - 1,6,7; *Entomoneis alata* - 2, 3, 4, 8; *Actinocyclus normanii* - 5. Scale bar 2, 3, 5 - 10 µm; 1, 7 - 2 µm; 4 - 3 µm; 6 - 5 µm; 8 - 1 µm.

General distribution: Europe, N. America, Asia (Israel).

BACILLARIOPHYTA

Actinocyclus Ehrenberg 1837

7. ***Actinocyclus normanii*** (Gregory) Hustedt 1957: Abhandl. Naturw. Ver. Bremen 34: 218. - **Pl. 1, Fig. 5.**

Synonyms: *Coscinodiscus normanii* Greg. ex Grev.; *Actinocyclus normanii* var. *subsalsus* (Juhlin-Dannf.) Hust.

Description: Cells drum-shaped with concentrically thickened valves, either convex or concave in the middle, diameter 25-110 µm, cell height/diameter ratio 0.4 to more than 1. Valve surface with polygonal or rounded areoles that in the larger forms are arranged in distinctly clustered radial files, 10-13 /10 µm, in smaller forms irregularly disposed. Cingulum finely areolate, the areoles extend to the margin of valve and are visible in surface view as narrow ring. Labiate processes occur on the valve margin, often one in each cluster of areoles. Pseudonodule discernible in the larger forms only on the border of valve and cingulum, 1 - 2 µm in diameter.

Occurrence: Planktonic, in eutrophic freshwaters on seacoast.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on limestone - 1; pH - 7.9; C - 4.89 mS/cm; S - 2.31; N-NO_3 - 7.6 mg/l. IEUH-415.

General distribution: Cosmopolitan.

Anomoeoneis Pfitzer 1871

8. ***Anomoeoneis sphaerophora*** (Ehrenberg) Pfitzer f. ***sculpta*** Krammer 1985: Mikrokosmos 74: 105-109. Hustedt, 1959: Die Kieselalgen Deutschlands, Osterreichs und der Schweiz. 1-3. In Rabenhorst's Kryptogamenflora. Leipzig, 2: 741. - **Pl. 4, Fig. 5.**

Synonyms: *Navicula rostrata* Ehrb.; *N. tumens* W. Sm.; *N. sculpta* Ehrb.; *Anomoeoneis sculpta* (Ehrb.) Cleve; *A. sphaerophora* f. *sculpta* (Ehrb.) O. Müll.

Description: Valves elliptical-lanceolate with protracted, subrostrate to rostrate-apiculate ends; margins regularly convex throughout the main portion of the valve. Axial area narrow, linear, bordered by a single row of puncta. Central area united with elongate lateral areas forming lyrate area; sometimes with median expansion on one side, which extends to the margin. Striae slightly radiate throughout the valve except at the ends where they are often parallel. Puncta arranged in longitudinally undulating rows. Individual puncta more dispersed near lateral clear areas than at the valve margins. Length, 65-200 µm; breadth, 25-36 µm; striae, 10-16/10 µm.

Occurrence: In brackish water.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on limestone - 1; pH - 7.9; C - 4.89; mS/cm; S - 2.31; N-NO_3 - 7.6 mg/l. IEUH-415.

General distribution: Cosmopolitan.

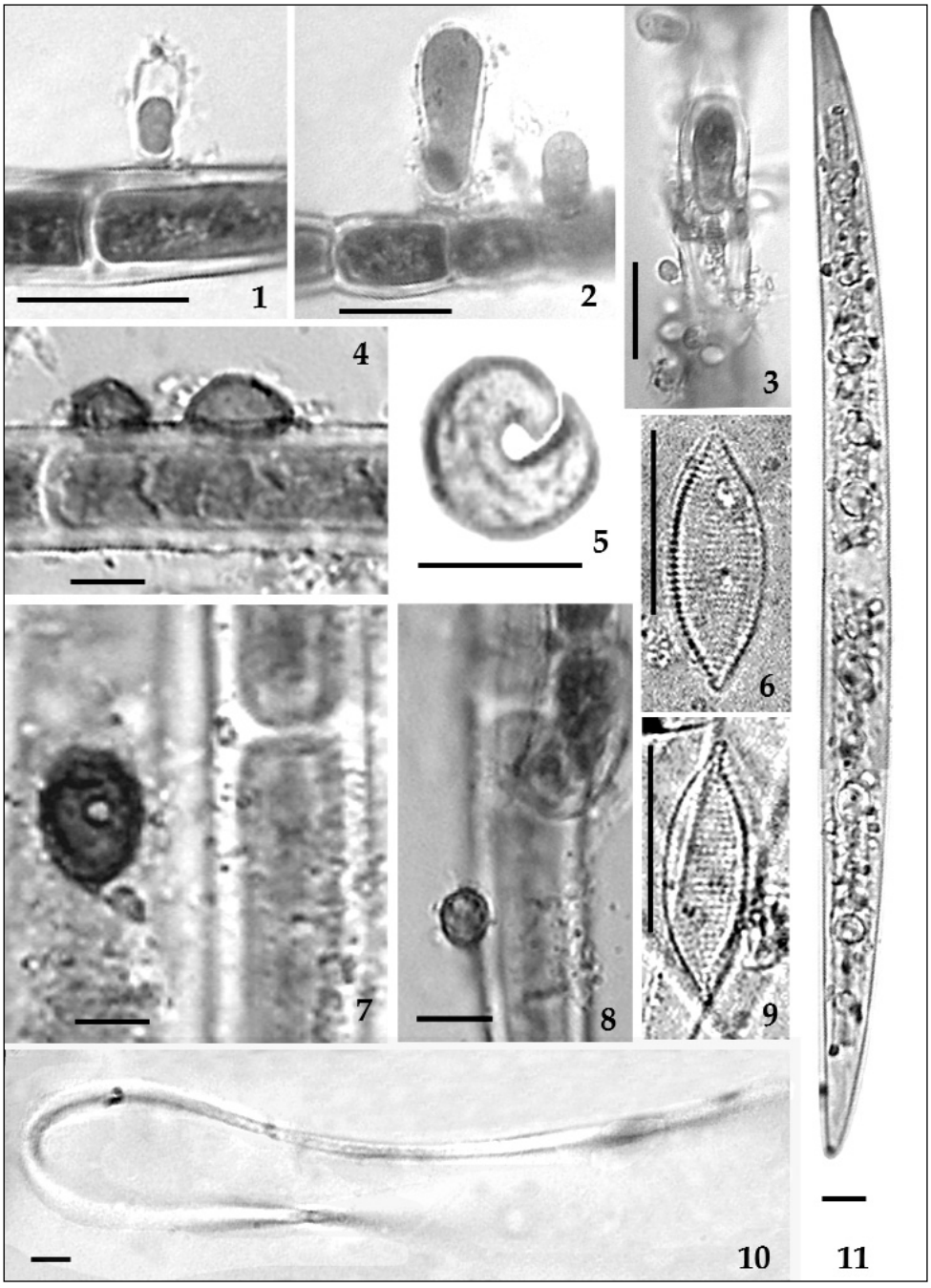

Plate 2. New taxa of algae from Nahal Qishon. *Chamaesiphon amethystinus* - 1, 2, 3; *Lagynion janei* - 4, 7, 8; *Nitzschia compressa* var. *balatonis* - 6, 9; *Closterium strigosum* - 11; *Crinalium endophyticum* - 10; R*aphidocelis sigmoidea* - 5. Scale bar - 10 µm.

Cocconeis Ehrenberg 1838

9. ***Cocconeis placentula*** Ehrenberg var. ***pseudolineata*** Geitler 1927: Arch. Protistenk. 59: 512, Pl. 12, Fig. 5; text-fig. 2 e, f. - **Pl. 5, Fig. 2**.

Description: Valve nearly flat, widely elliptic, elliptic, and linear-elliptic up to lanceolate-elliptic, length, 7.5-38 µm, width 8-40 µm; R-valve of variable width, valvocopula fimbriate, always with fimbria of first order, less often also with fimbria of second order. Valvocopula hyaline, separated by a concentric hyaline ring from the plane part of the valve. Axial field very narrow, near the central knot suddenly expanded, rounded or rhombic-elliptical. Raphe filiform, central branches closely approaching each other, terminating into small drop-like pores, distal branches extending up to the marginal hyaline ring. Striae 14-23, typically 20-23/10 µm, gently punctate, puncta 15-20/10 µm. Valve RL with simple valvocopula without fimbria, with well expressed fine structure and with axial field. Striae on large valves 13-18 (20)/10 µm, on small valves 16-20 (22)/10 µm.

Occurrence: Periphytic on woody stems and limestone in temperate still and running water. Saproxenic, oligohalobic-indifferent, alkaliphilic.

Distribution and habitat in Israel: AP: Nahal Qishon, in tributary - 1; pH - 7.7; C - 3.63 mS/cm; S - 2.76; N-NO_3 - 4.6 mg/l. IEUH-382.

General distribution: Cosmopolitan.

Craticula Grunow 1868

10. ***Craticula accomoda*** (Hustedt) D. G. Mann in Round & al. 1990: The Diatoms. Biology and morphology of the genera. Camb. Univ. Press, Cambridge: 666. - **Pl. 5, Fig. 4.**

Synonyms: *Navicula accomoda* Hust., *Navicula minusculoides* Hust.; *N. molesta* var. *subdiversa* Messikommer.

Description: Valves elliptic to elliptic-lanceolate, ends protracted, rostrate, length 17-25 µm more commonly about 20 µm, breadth 5-8 µm. Raphe filiform, central pores somewhat distant, terminal fissures barely visible. Axial area very narrow, linear; central area indistinct, ± elliptic. Striae almost parallel throughout or slightly convergent towards the ends, 17-25/10 µm in the middle, denser at the poles, 20-28/10 µm. Areoles ± rounded to almost rectangular, in central part often longitudinally expanded.

Occurrence: Periphytic, indicating a high level of organic pollution, saprophilic, polysaprobic.

Distribution and habitat in Israel: AP: Nahal Qishon, periphyton on limestone and woody stems in a tributary of Nahal Qishon - 1; pH - 9.1; C - 4.05 mS/cm; S - 2.52; N-NO_3 - 0.1 mg/l. IEUH-378.

General distribution: Cosmopolitan.

Cyclotella Kützing 1833

11. ***Cyclotella tuberculata*** Makarova et Loginova. In Loginova, 1990: Reports of Russian Academy of Sciences 34 (9): 847, Pl. 2, Fig. 1-10. - **Pl. 4, Fig. 4.**

Synonyms: *Cyclotella affinis* (Pr.-Lavr. & Makar.) Makar. & Genkal, *C. caspia* var. *affinis*

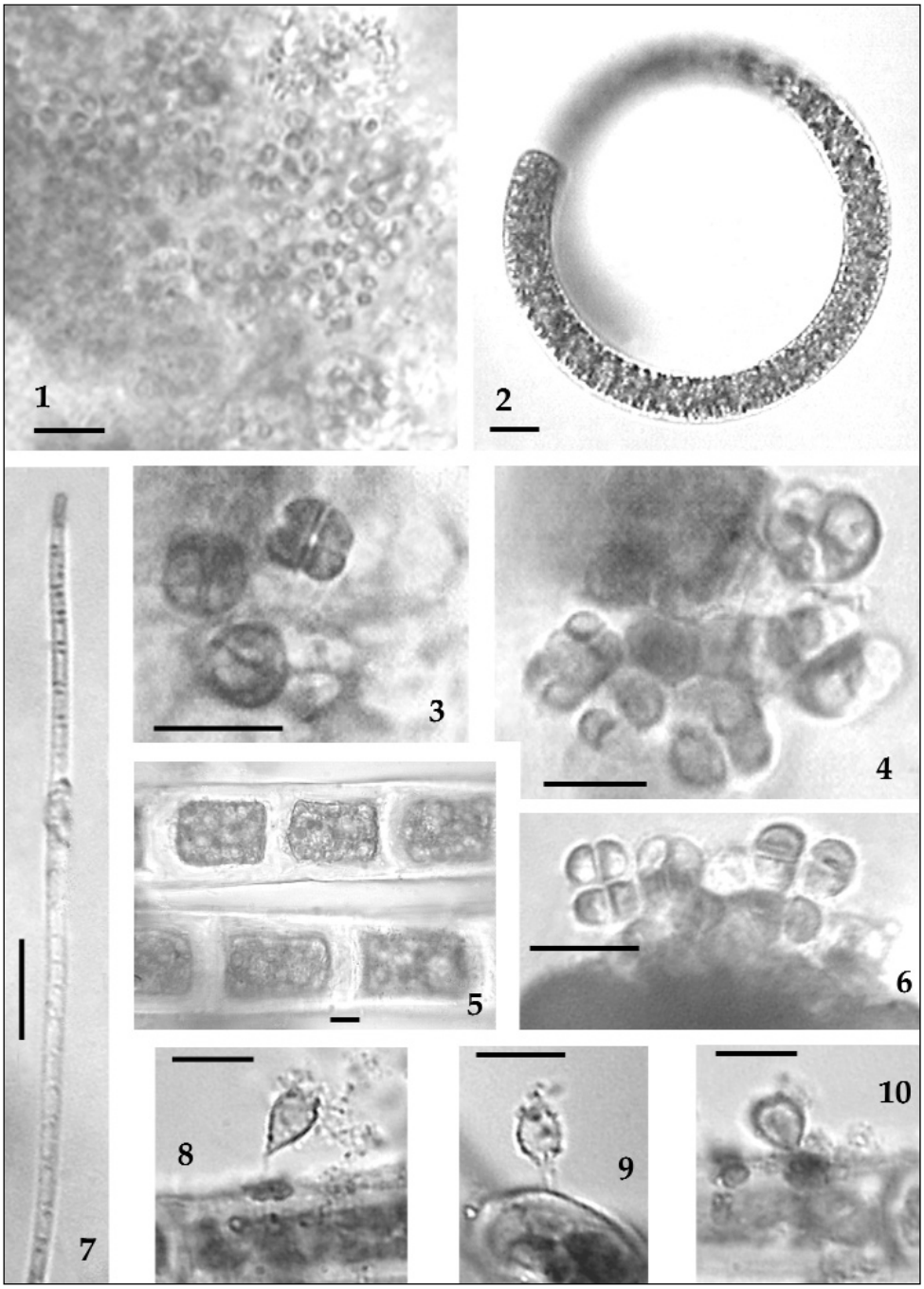

Plate 3. New taxa of algae from Nahal Qishon. *Aphanothece elabens* - 1; *Arthrospira exgr. fusiformis* - 2; *Xenococcus pallidus* - 3, 4, 6; *Rhizoclonium hieroglyphicum* - 5; *Limnothrix amphigranulata* - 7; *Stylococcus aureus* - 8, 9, 10. Scale bar -10 μm

Pr.-Lavr. & Makar.

Description: Cells solitary, low cylindrical. Valves rounded, 5-18 µm in diameter. Peripheral zone about one-third of the valve, in LM appearing separated by a narrow hyaline ring. Striae of uniform length, in 2 - 3 rows, occasionally reduced to a single row towards the center, consisting of small pores, 20-40 per 10 µm. Alveoles simple, small. Fultoportulae with two struts, situated on interalveolar partitions, typically on 3rd to 7th partitions, seldom on 2nd partition at uniform distance from the margin. Bilabiate process on an interalveolar partition at the base of alveole. Central part rounded, tangentially undulate. Central processes (1 - 9) with three struts, in an arched row on convex part of central field near the peripheral zone.

Occurrence: In brackish water.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on limestone and woody stems and wood fragments - 1; pH - 7.7; C - 4.98 mS/cm; S - 2.31; N-NO_3 - 3.0 mg/l. IEUH-420.

General distribution: Europe, Asia (Russia, Turkmenistan, Israel), N. America.

Cylindrotheca Rabenhorst 1859

12. ***Cylindrotheca gracilis*** (Brebisson) Grunow in Van Heurck 1882: Synopsis des diatomées de Belgique. Atlas, Taf. 78-103. - **Pl. 4, Figs. 9, 10**.

Synonyms: *Ceratoneis gracilis* Bréb. ex Kütz.; *Cylindrotheca gersternbergeri* Rabenh.

Description: Theca soft, poorly silicified, coiled several times around longitudinal axis, spindleform, ends beak-like, raphe canals running from pole to pole fortified by fibulae. Valves reduced, mostly consisting of numerous connecting bands on both sides of the raphe. Central knots probably always missing. Dimensions variable, length is 60-240(340) µm, width is 4-6(8-14) µm; Fibulae is 20-24(15-18)/10 µm;

Occurrence: Peripytic in very electrolyte-rich water of inland and coastal reservoirs.

Distribution and habitat in Israel: AP: Nahal Qishon, on woody stems - 1; pH - 7.7; C - 5.51 mS/cm; S - 2.50. IEUH-410.

General distribution: Cosmopolitan.

Cymbopleura (Krammer) Krammer 1999

13. ***Cymbopleura hybrida*** (Grunow) Krammer 2000. Diatoms of Europe. A.R.G. Gantner Verlag, Ruggel. 4: 63, Figs. 86:1-14; 87:1-12; 88:12-14. - **Pl. 4, Fig. 1; Pl. 5, Fig. 5.**

Basionym: *Cymbella hybrida* Grun. ex Cleve

Synonym: Cymbella hybrida Grun. in Cleve & Möller

Description: Valves not, or only very slightly, dorsiventral, linear, dorsal and ventral margins straight to barely convex, ends apiculate, subrostrate or rostrate. Length is 30 - 62 ?m, breadth is 9 - 11 µm, maximum length/breadth ratio is 4.4. Axial area rather narrow, in the median line of the valve. Central area rather large, 1/3-1/2 of the valve breadth, oval, rounded or diamond-shaped, sometimes distinctly asymmetrical. Raphe slightly lateral, narrowing towards the distal ends, appearing filiform near the proximal ends. Proximal raphe ends slightly expanded as central pores and sometimes ventrally tipped; terminal fissures angular and dorsally deflected. The form of the terminal fissures is dependent on the development of the valve ends. Striae slightly radial through-

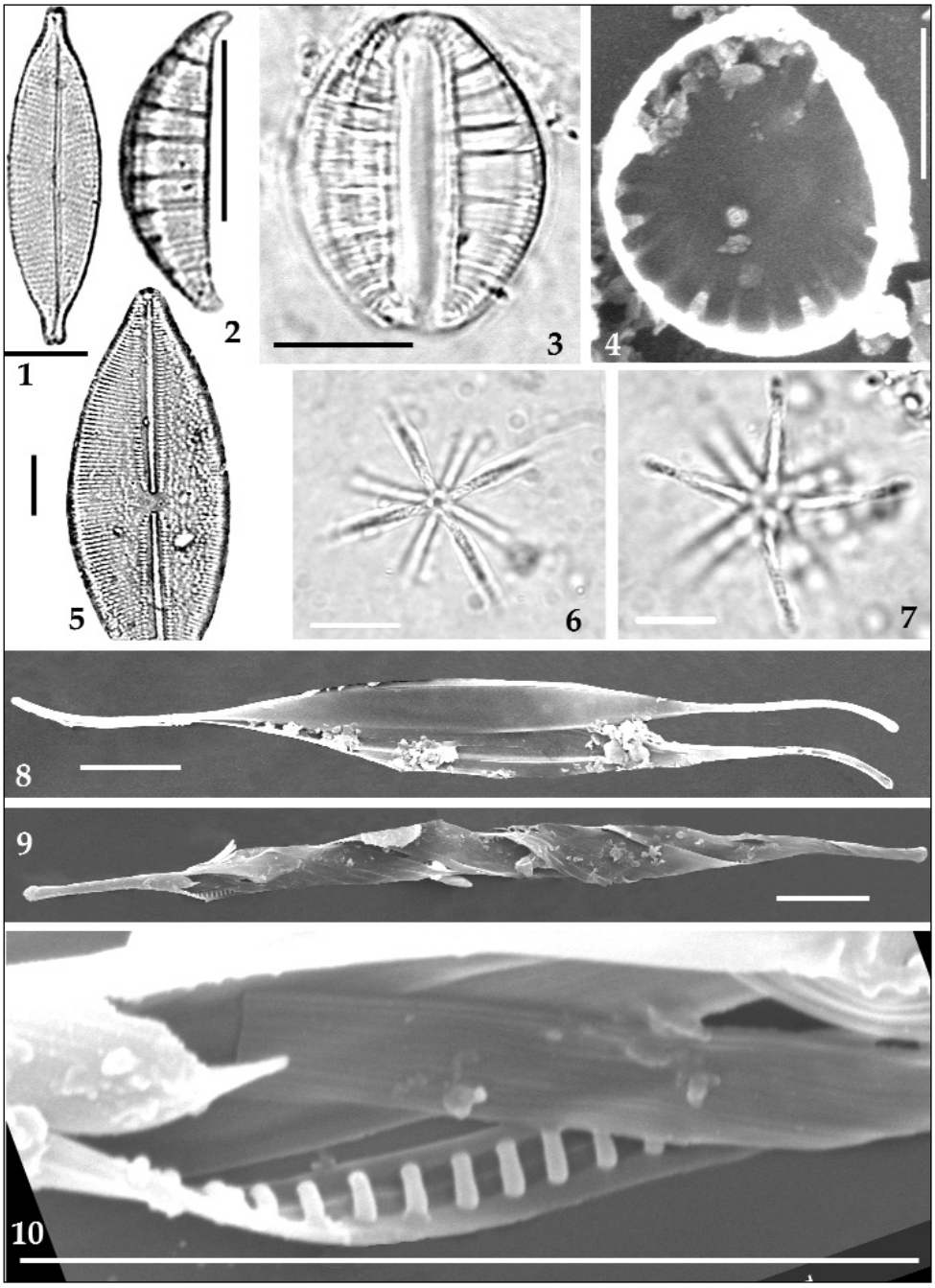

Plate 4. New taxa of algae from Nahal Qishon. *Cymbopleura hybrida* - 1; *Rhopalodia brebissonii* - 2, 3; *Cyclotella tuberculata* - 4; *Anomoeoneis sphaerophora* f. *sculpta* - 5; *Actinastrum hantzschii* var. *subtile* - 6, 7; *Nitzschia reversa* - 8; *Cylindrotheca gracilis* - 9, 10. Scale bar - 10 μm.

out, in the middle part near the cĕntral area usually curved, around the central area frequently irregularly arranged, puncta not visible in LM. Striae in middle part, dorsally 9-13/10 µm, up to 16/10 µm towards the ends, puncta 29-31/10 µm.

Occurrence: Occasionaly in periphyton of slightly brackish water.

Distribution and habitat in Israel: AP: Nahal Qishon, periphyton on stems and wood fragments in Kefar-Barukh Reservoir and Nahal Qishon - 1; pH - 7.6-8.6; C - 1.66-5.5 mS/cm; S - 2.28-2.50; N-NO_3 - 0.6-5.5 mg/l. IEUH-396, 407, 410.

General distribution: Europe, Asia (Russia, Israel).

Entomoneis Ehrenberg 1845

14. ***Entomoneis alata*** (Ehrenberg) Ehrenberg 1845: Ber. Akad. Wiss. Berlin: 54. - **Pl. 1, Figs. 2, 3, 4, 8.**

Synonyms: Navicula alata Ehrb.; *Amphiprora alata* (Ehrb.) Kütz.

Description: Valve linear-elliptic beak-like on ends. Length, 55-160 µm, breadth 30-60 µm. Keel with two wings in LM appearing in one plane though belonging to opposite valves. Intercalary bands with a linear series of short dashes, 20-25/10 µm. Junction line smoothly curving, somewhat angular subterminally. Irregular siliceous thickenings occur along the junction line. Striae on the valve surface very finely punctate, 14-17/10 µm. Wings with distinct pits in linear files.

Occurrence: Alkaliphil, in salty water.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on limestone - 1-3; pH - 7.7-8.1; C - 4.87-9.97 mS/cm; S -2.13-2.59; N-NO_3 -2.4-8.1 mg/l. IEUH-410, 413, 418, 419, 420, 421, 425.

General distribution: Cosmopolitan.

Navicula Bory de St. Vincent 1822.

15. ***Navicula angusta*** Grunow 1860: Verh. Kais.-Königl. Zool.-Bot. Ges. Wien 10: 528, fig. 3: 19. - **Pl. 5, Fig. 6.**

Synonyms: Navicula cari var. *angusta* Grun. in Van Heurk; *N. cincta* var. *angusta* (Grun.) Cl.; *N. cincta* var. *linearis* Østr.; *N. pseudocari* Krasske; *N. lobeliae* Jørg.

Description: Valves linear, ends wedge-shaped, obtuse to broadly rounded, sometimes slightly protracted, 30 - 78 µm long, 5 - 8 µm wide. Raphe lateral, fissure of outer raphe running close to the margin of the axial area from poles to central area, then curving back towards the mid-line. Axial area very narrow, linear, central area variably expanded, distinctly asymmetric. Striae radial, convergent towards the ends, 11-12/10 µm, lineolae 30/10 µm.

Occurrence: Periphytic in brackish, slightly acidic, slightly humic water, saproxenic, acidophilic.

Distribution and habitat in Israel: AP: Nahal Qishon, periphyton on plants - 1; pH - 7.7; C - 4.21 mS/cm; S - 2.59; N-NO_3 - 2.4 mg/l. IEUH-421.

General distribution: Cosmopolitan.

16. ***Navicula perminuta*** Grunow in Van Heurck 1880: Synopsis des diatomées de Belgique. Atlas. Pl. 1-30. - **Pl. 1, Figs. 1, 6, 7.**

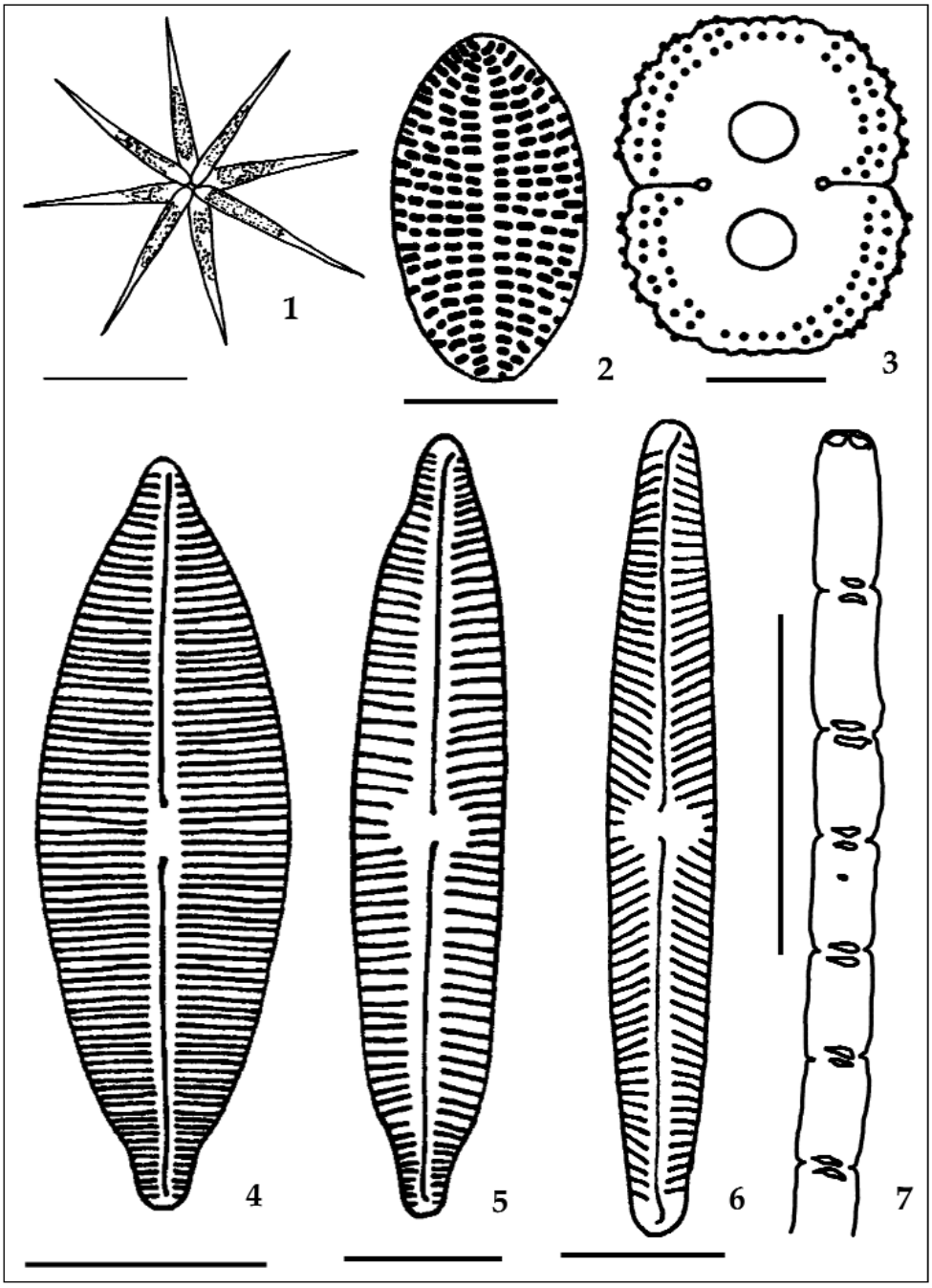

Plate 5. New taxa of algae from Nahal Qishon. *Actinastrum hantzschi*i var. *subt*ile - 1; *Cocconeis placentula* var. *pseudolineata* - 2; *Cosmarium subprotumidum* - 3; *Craticula accomoda* - 4; *Cymbopleura hybrida* - 5; *Navicula angusta* - 6; *Limnothrix amphigranulata* - 7. Scale bar - 10 μm.

Synonyms: *Navicula cryptocephala* var. *perminuta* (Grun.) Cl.; *N. diserta* Hust.; *N. dulcis* Patr. non Krasske; *N. mendotia* Van Landingham.

Description: Valves lanceolate to linear-lanceolate, ends not protracted, obtusely rounded, with median costa visible under SEM, length 5.5-20 µm, wide 2-4 µm. Raphe filiform, axial area very narrow, central area almost reaching valve margins on both sides due to the shortening of two middle striae. Striae only slightly radially divergent, slightly convergent towards the ends, 14-20/10 µm; lineolae recognisable in LM, 33/10 µm.

Occurrence: Periphytic in brackish water, eurysaprobic, halophilic.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton of limestone and woods - 1-5; pH - 7.8-7.9; C - 5.04-9.42 mS/cm; S -2.13-2.65; N-NO_3 - 2.6-10.5 mg/l. IEUH-245, 418, 419, 422.

General distribution: Cosmopolitan.

Nitzschia Hassall 1845

17. ***Nitzschia compressa*** (Bailey) Boyer var. ***balatonis*** (Grunow) Lange-Bertalot 1987: Bibl. Diatom. 15: 12. - **Pl. 2, Figs. 6, 9.**

Synonyms: *Nitzschia balatonis* Grun. in Cl. & Grun.; *N. punctata* Hust.; *N. hustedtiana* Salah; *N. hustedtiana* Choln.; *N. subpunctata* Choln.; *N. chutteri* Arch.

Description: Valve widely elliptic to elliptic-lanceolate, length 12.5-30 µm, width 3.5-8 µm. Raphe keel strongly eccentric, in LM indistinct. Fibulae as numerous as striae, concealing the central knot. Striae formed of fine puncta, 16-21/10 µm, in the central part relatively distant.

Occurrence: Periphytic in brackish waters and in seas, halophilic.

Distribution and habitat in Israel: AP: Nahal Qishon, periphyton on woody stems in Nahal Qishon and its tributary - 1; pH - 7.7; C - 3.56-6.05 mS/cm; S - 2.55-2.76; N-NO_3 - 4.1-4.3 mg/l. IEUH-380, 382, 383, 394.

General distribution: Cosmopolitan.

18. ***Nitzschia reversa*** W. Smith 1853: A synopsis of the British Diatomaceae. With remarks on their structure, functions and distribution; and instructions for collecting and preserving specimens. 1. John van Voorstn, London: 43, Pl. 15, Fig. 121. - **Pl. 4, Fig. 8.**

Synonyms: Nitzscha longissima var. *reversa* Grun. in Cl. & Grun.; *N. closterium* sensu auct. nonnull; *N. longissima* sensu auct. nonnull.

Description: Theca spindleform with longly protracted ends formed by keels of the raphe, sigmoid, never terminating with a hair. Length up to 180 µm. Width is 3-5 µm. Raphe keel with about 18-21 fibulae /10 µm, the middle ones more distant from each other. The central knot between the two distant middle fibulae. Striae 55-64/10 µm.

Occurrence: Planktonic in brackish water and in seas, halophilic.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of Kefar-Barukh Reservoir and periphyton on limestone - 1-3; pH - 7.5-7.9; C - 4.87-9.42 mS/cm; S - 2.05-2.65; N-NO_3 - 1.2-10.5 mg/l. IEUH-397, 413, 421, 422, 423.

General distribution: Cosmopolitan.

Rhopalodia O. Müller 1895

19. ***Rhopalodia brebissonii*** Krammer 1987. In Krammer 1988: Nova Hedwigia 47: 159-205. - **Pl. 4, Figs. 2, 3.**

Synonyms: Rhopalodia musculus var. *succincta* sensu H. & M. Peragallo; *R. gibberula* var. *succincta* sensu Fricke.

Description: Theca broadly elliptic with truncate ends. Valve massive, strongly dorsiventral, dorsal side strongly convex, ventral side straight or somewhat convex, ends bluntly pointed, incurved, length is 15-40 µm, width of theca is 12-20 µm, valvae is 5-8.5 µm. Costae relatively strong, visible in LM, 35-60 /10 µm. Striae 2 - 5 between each pair of costae, 17-22 striae/10 µm. On the striae nearby of the raphe are appropriate otherwise for series of single points 15-18(20)/10 µm.

Occurrence: Occasionaly, peripytic in waters with middle to high electrolyte content and in brackish coastal waters, halophil.

Distribution and habitat in Israel: AP: Nahal Qishon, on floating filamentous algae - 1; pH - 7.6; C - 5.11 mS/cm; S - 2.19; $N\text{-}NO_3$ - 3.9 mg/l. IEUH-412.

General distribution: Cosmopolitan.

CHLOROPHYTA

Actinastrum Lagerheim, 1882

20. ***Actinastrum hantzschii*** Lagerheim var. ***subtile*** Wołoszyńska1911: Wydz. Mat.-przyr. Pol. Akad. Um. Krakow, 51B: 293-305. - **Pl. 4, Figs. 6, 7; Pl. 5, Fig. 1.**

Synonyms: Actinastrum schroeteri var. *subtile* (Wołosz.) Fott; *A. hantzschii* var. *gracile* Roll sensu Korsch.

Description: Coenobia of 4-, 8-, (16) cells. Cells elongated conical to spindleform- cylindrical, sometimes slightly curved, with heteropolar ends, the inner one broadly rounded, the external one bluntly pointed. Chloroplast parietal, with a single not always distinct pyirenoid. Cells more than 6 times longer than wide, (12)24 - 36 x (1.5)2 - 3.5(4.5) µm.

Occurrence: Planktonic or in periphytic algae communities in fresh water, betamesosaprobiont, oligohalobic-indifferent.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of Kefar-Barukh Reservoir - 1; pH - 8.6; C - 1.66 mS/cm; S - 2.28; $N\text{-}NO_3$ - 0.6 mg/l. IEUH-396.

General distribution: Cosmopolitan.

Closterium Nitzsch ex Ralfs 1848

21. ***Closterium strigosum*** (Cleve) Brébisson 1856: Mem. Soc. Imper. Sci. Nat. (Cherbourg) 4: 113-162; 301-304. Pl. 1,2. - **Pl. 2, Fig. 11.**

Basionym: Closterium strigosum Bréb. 1856.

Synonym: Closterium peracerosum Gay

Description: Cells 11-12 times longer than broad, (100) 200 - 300 x (10) 13 - 16 µm; slightly bent, 20-30º of arc; ventral margin straight or very slightly tumid; ends slightly incurved narrowly pointed.

Occurrence: Planktonic and benthic in lakes and rivers.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of a collector basin - 1-

2; pH - 8.5; C - 2.05 mS/cm; S - 2.09-2.21. IEUH-376, 377

General distribution: Europe, Asia (Russia, Uzbekistan, Israel), Africa, S. America.

Cosmarium Corda ex Ralfs 1848

22. ***Cosmarium subprotumidum*** Nordst. In Nordst & Wittrock 1876: Öfv. Kngl. Sven. Vet.-Akad. Förhandl. Stokholm 42(6): 38, Tab. 12, Fig. 14. - **Pl. 5, Fig. 3.**

Description: Cells laterally flattened, nearly rounded, 23-38.4 µm long, 21-33.6 µm wide, 17-18.5 µm thick, deeply constricted in the middle. Isthmus. 6-10.8 µm wide. Sinus narrow linear, slightly expanded at the bottom and distally. Semicells rounded-trapezoid, apex truncate with 2 - 4 undulations, base flat, sides with 3 - 4 undulations increasing towards the apex. Upper ends smooth or obliquely concave, lower ends rectangular or slightly rounded. Lateral view oval with large bulges on both sides at the base. Apical view elliptic with a prominent 3-undulate bulge in the middle of lateral sides. Shell with more or less regular radial granules along the margins, in pairs opposite each undulation. Undulations with a single granule, occasionally bigranulate. Each semicell with a central bulge above the isthmus, with 3 longitudinal rows of larger granules, 3- 5 granules per row, the middle row straight, the lateral ones arched. Chloroplasts with a single central pyrenoid. Zygospores unknown.

Occurrence: At coast of the big lakes and in the big ponds, the rivers, pools, water basins, rice fields.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of Kefar-Barukh Reservoir - 1-2; pH - 8.6; C - 1.66 mS/cm; S - 2.28; $N\text{-}NO_3$ - 0.6 mg/l. IEUH-396.

General distribution: Cosmopolitan.

Raphidocelis Hindak emend. Marvan & al. 1984

23. ***Raphidocelis sigmoidea*** Hindak, 1977. Biol. Pr., Bratislava, 23 (4): 1-190. - **Pl. 2, Fig. 5.**

Description: Solitary cells or colonies of few cells, with poorly appreciable, transparent, unstructured slime. Cells crescent-shaped, slightly braided up to the S-shaped form, with one or both braided ends, sometimes one end rounded or papilla extended into a terminal papilla. Shell rather thick, colorless to brownish, sometimes granulate. Chloroplast parietal, grooved, typically not reaching to the ends of the cell, without pyrenoid. Reproduction by 2-4 autospores released from a shell break. Cells 5 - 11 x 1.5 - 3 µm.

Occurrence: In plankton of eutrophic water, at the bottom of ponds, rivers, and inundated reservoirs.

Distribution and habitat in Israel: AP: Nahal Qishon, in plankton of Kefar-Barukh Reservoir and in periphyton of tributary - 1-4; pH - 8.6-9.1; C - 1.66-4.05 mS/cm; S - 1.70-2.52; $N\text{-}NO_3$ - 0.1-0.6 mg/l. IEUH-378, 379, 395.

General distribution: Europe (Czech Republic, Ukraine), Asia (Israel).

Rhizoclonium Kützing 1843

24. ***Rhizoclonium hieroglyphicum*** (Agardh) Kützing 1843. Phycologia generalis, oder Anatomie, Physiologie und Systemkunde der Tange. Brockhaus, Leipzig: 1-458. - **Pl. 3, Fig. 5.**

Synonyms: Conferva fontinalis Berkeley; *Microspora fontinalis* De Toni; *Rhizoclonium hieroglyphicum* subsp. *longiarticulatum* (Wille) Heering; *Rh. lacustre* Ktitz.; *Rh. macromeres* Wittr.

Description: Filaments loosely interlaced, bright green, straight or slightly arched, free floating or sometimes anchored by the basal rhizoid. Vegetative branches mostly lacking or, if present, short, not separated by a partition, not segmented, typically appearing as papillae or swellings. Cells cylindrical or occasionally expanded in the middle, 2 - 10 times longer than wide, width 10-32 (50) μm, occasionally squarish. Shell delicate, typically no more than 2 μm thick, sometimes with irregular thickenings.

Occurrence: In fresh and brackish waters, hot springs, on damp rocks.

Distribution and habitat in Israel: AP: Nahal Qishon, in floating masses of filamentous algae - 5; pH - 7.6-7.7; C - 3.63-5.11 mS/cm; S - 2.19-2.44; $N\text{-}NO_3$ - 3.6-4.6 mg/l. IEUH-381, 412.

General distribution: Cosmopolitan.

CHRYSOPHYTA

Lagynion Pascher 1912

25. ***Lagynion janei*** Bourelly 1957. Rev. Algol., Mémoire Hors Sér. 1: 1-412. - **Pl. 2, Figs. 4, 7, 8.**

Description: Cases small, rounded, 12-14 μm wide, 6-8 μm height. Walls scabrate, dark yellow or brown, impregnated with ferric compounds. Neck colorless, 3-4 μm long. Cells with 1-2 chromatophores and a solitary pulsing vacuole. Rhizopodia unramified.

Occurrence: Epiphytic on filamentous algae.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton on *Cladophora* - 5; pH - 7.9; C - 5.01 mS/cm; S - 2.39; $N\text{-}NO_3$ - 5.6 mg/l. IEUH-416.

General distribution: Europe (France), Asia (Israel).

Stylococcus Chodat 1898

26. ***Stylococcus aureus*** Chodat 1898. Bull. Herb. Boiss. Geneve VI, 6: 431-475. - **Pl. 3, Figs. 8, 9, 10.**

Description: Cases small broadly spindle-shaped, 8 μm in heigh, 4.5 μm in width, on foot 8-10 μm long. Rhizopodia simple. Chromatophores parietal, 2 pulsing vacuoles at the base or in the central part of the cell.

Occurrence: Epiphytic on algae.

Distribution and habitat in Israel: AP: Nahal Qishon, in periphyton, on *Cladophora* - 4; pH - 7.9; C - 5.01 mS/cm; S - 2.39; $N\text{-}NO_3$ - 5.6 mg/l. IEUH-416.

General distribution: Europe (Switzerland), Asia (Israel).

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