Records of Free-living Ciliates in Saudi Arabia.
III. Marine Interstitial Ciliates of the Arabian Gulf Island of Tarut*

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ABSTRACT. Sediment samples were collected at low tide from six stations around the coastline of the Saudi Arabian Gulf Island of Tarut on five occasions during 1995 for the study of the marine interstitial ciliate fauna of the Island. Temperature, salinity and pH of the sediments were measured at the time of collection. The interstitial water, total organic matter and the granulometric properties of the sediment samples were analyzed. The interstitial ciliates were identified and enumerated and the seasonal fluctuation in their number of species and density throughout the year were discussed. Fifty eight species belonging to 39 genera and 27 families of marine interstitial ciliates were identified, 43 of which represent new records of the fauna of the Arabian Gulf and Saudi Arabia and five of them were present at all collection sites. Loxophyllum pseudosetigerum, Frontonia marina, Protocruzia depressa, Pleuronema coronatum, Diophrys appendiculata and Uronychia setigera were recorded from all sampling stations throughout the year. The ciliate abundance ranged from 170 to 8,500 cells cm⁻³ of sediment. The distribution of each species around the island was recorded and compared to those in similar habitats worldwide.

Great attention has been paid to the distribution of interstitial ciliates in sediments of coastal and estuarine localities and many surveys have been undertaken worldwide (Faure-Fremiet 1950, Dragesco 1960, 1963 a,b, Fenchel 1969, Wilbert and Kahan

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1981, Ricci et al. 1982, AL-Rasheid 1992, Santangelo and Lucchesi 1992, El-Serehy 1993, and AL-Rasheid and Sleigh 1995). The present paper is the third in the series (AL-Rasheid 1996, 1997) and it presents seasonal data on the abundance of the interstitial ciliate fauna in the Saudi Arabian offshore Gulf Island of Tarut. Tarut Bay is unique in the high productivity of its tidal flats and grassbeds, which make it a major shrimp nursery (Basson et al. 1977), and together with Tarut Island, it has been a center of human activity and a site of major ports, oil facilities and residential communities, as well as the outlet of the long standing irrigated agriculture of Al Qatif Oasis.

Materials and Methods

Field work

Samples were collected in February, May, July, September and December 1995 from six localities on Tarut Island (Fig. 1). Undisturbed samples were obtained at low tide from the topmost 1-3 cm of submerged areas of the sites between high and low tide marks by the sediment core method of Fenchel (1969, 1987). Using a plastic spatula, 50-100 g of surface sediments were skimmed from the topmost centimeter of each sediment and were transferred into a pre-labeled polyethylene bag for granulometric analysis and measurements of sediment total organic matter. Cores were taken as well by the method outlined in AL-Rasheid (1996). Only the top 10 mm of each sediment were searched for benthic ciliates, since they are known to be concentrated in the topmost layers of the sediments (Fenchel 1969).

Sediment total organic matter and grain size distribution: The standard grain size distribution, median grain diameter, and the difference between the interstitial water volume and the volume of interstitial water were determined.

Laboratory methods

The standard acid-base buffer method was used to determine the pH. The sediment pH was determined in a standard buffer solution at the interstitial water.

To measure the grain size distribution, the sediment was sieved through a 1-mm screen, then the grains were combined and sieved through a 0.2-mm screen. The samples were rinsed in a 70°C water bath, air-dried, and combusted to determine the total weight.

The enumerations of live (live) counts of ciliates were accomplished by sieving the sediment through a 10-μm screen with membrane filters. Using a Gilson pipette, 100 μl of drops on a glass slide, the membranes were dried, then the ciliates were blocked, then the ciliates were counted. To count smaller ciliates, the live (live) counts were multiplied by 200 individuals. The relationship between the two was determined using Jaccard's similarity index.

Live organisms were sampled using an active, study of movement was accomplished by placing the samples under cover and observing that surface tension movement was registered.
Sediment temperature was measured on site with a mercury thermometer, while pH was determined with a portable pH meter, previously calibrated on site with standard buffer solutions, and water drained off each sample was used to measure the interstitial water salinity with the aid of a refractometer.

**Laboratory methods**

The standard dry sieving method of Morgans (1956) was used to determine the grain size distribution at each sampling station. Data from the statistical analysis of size distribution by Krumbein and Sloss (1963) was employed to calculate the median grain diameters and to calculate the degree of the sorting index ($S_o$). The difference between wet and dry weight of the sediment was calculated to estimate the interstitial water content of sediments at each sampling station, and hence the volume of interstitial space.

To measure the sediment total organic matter, sediment samples were first sieved through a 2 mm sieve to remove plant fragments, large macrofauna and shells. A small quantity of surface sediment was oven-dried to a constant weight at 70° C and combusted in a muffle furnace at 550° C for 24 hours. After cooling, the samples were reweighed and the loss of weight was taken to be due to the combustion of all organic materials from the sediment.

The enumeration method of Finaly *et al.* (1979) was employed for the direct (live) counts of ciliates from fresh sediment. A sample was diluted 10x, 25x, or 50x with membrane-filtered (0.22 µm Millipore) seawater collected from the same site. Using a Gilson pipette, 5 µl sub-samples of diluted sediment were spotted as a series of drops on a glass slide, and the sediment in each drop was disturbed with a needle to observe attached or temporarily motionless ciliates. If the Gilson pipette was blocked, then the subsample was discarded. At first, fast swimming and large ciliates were counted. Then, at higher magnification, the drop was scanned carefully to count smaller ciliates. Further sub-samples were examined until between 150 and 200 individuals had been counted with satisfactory identification. To study the relationship between the sampling stations in terms of ciliate species composition, Jaccard’s similarity index (J) (Jaccard 1912) was calculated.

Live organisms were studied *in vivo* in hanging drops over depression slides, and under cover slips supported by vaseline rings. Since some ciliates are extremely active, study of the live organisms requires movement to be retarded. This was accomplished by reducing the amount of water in the hanging drop to such an extent that surface tension held the organism in place. With the organisms under coverslips, movement was retarded by slowing agents such as methyl cellulose, or simply by...
keeping the organisms stationary by applying the coverslip closely to the slide. They were then identified and photomicrographed using high power bright field and phase-contrast light microscopy. Intravital and specific stains were employed to observe the structure of organisms (Foissner 1991). On several occasions, the ciliates were fixed, stained with Protargol stains (Wilbert 1975, Lynn 1992) and examined. The characteristics of each organism were then compared to its description in the publications of Carey (1992), Corliss (1979), Kahl (1930-5), Patterson et al. (1989) and Small and Lynn (1985).

Results and Discussion

Physico-chemical factors

The Arabian Gulf is an extremely shallow sea, with an average depth of only 35 m and a maximum reaching only 100 m. It is nearly a closed body of water connected with the adjacent India Ocean only by a narrow passage at the Strait of Hormuz. The land masses surrounding the Gulf are very arid. Rainfall is low throughout the region, and as a result the loss of water from the gulf by evaporation far exceeds the input from rivers and run-off. The coastal shallows undergo wide rapid temperature and salinity changes in response to daily and seasonal cycles of heating and cooling (Basson et al. 1977). The Gulf, therefore, is considerably more saline than other seas. The salinity of the study sites was found to be between 34 and 61%o at the height of summer and their surface temperature was 16-37°C. The pH in sediments around the island ranged from 7.5 to 8.1. The highest pH measurements were recorded in the first station (1 West), where the output of ground-water origin irrigation waters from Al Qatif Oasis drain. It is located at the western entrance of the island and its sediment contained the highest silt and clay fraction (29.2%), but the other grain size categories were nearly evenly distributed, giving a mean grain size of 156 µm. Therefore, the sediment sample was poorly sorted, with a degree of sorting of 2.62, which led to the highest percentage of water content at any station (42.2%). The total organic matter was also the highest of all stations (31.3%), probably due to the same reason as high pH observed in this station.

Station 2 (Darin) is on the southern side of the island and its sediment consisted nearly equally of 15.5% medium sand and 11.7% fine medium sand, and had a mean grain size of 281 µm. The size of the interstitial spaces was large (32.5% water content), and the degree of sorting, at 2.34, indicated a poorly sorted sedimen. The total organic matter was moderate (17.4%).

Station 3 (Ar Rabiyah) is on the south west of the island and its sediment consisted of 31.8% medium sand and 25.5% fine medium sand, and had a mean grain size of 524 µm (water content) and the organic matter was fairly high.

Station 4 (Safran) consisted of mainly of fine c (1.2%), with a mean grain size of 436 µm, with the lowest percentage of water content and organic matter was fairly high.

Station 5 (Al Sawadi) consisted of 37.3% coarse sand (17.7%), with a mean grain size of 653 µm, with the lowest degree of sorting (So = 1.65), the lowest of all stations.

Station 6 (Al Fath) side and its sediment consisted of mainly of coarse sand (17.7%), with a mean grain size of 653 µm, with the lowest degree of sorting (So = 1.65), the lowest of all stations.

Systematic Ace

The present study is followed by a worldwide inter is indicated. The checklist of the faun is presented in Table 1.

Phylum: Ciliophora
Class: Kinetozoa
Subclass: Didinozoa
Analysis of interstitial ciliates

To the slide. They bright field and were employed to the ciliates (2) and examined. Description in the person et al. (1989)

The mean grain diameter of the sediment was found to be negatively correlated with the increase in silt and clay fractions (Correlation Coefficient Test, \( p < 0.05^* \)). On the other hand, total organic matter increased significantly with the presence of large amounts of silt and clays \( (p < 0.001^{**}) \).

Systematic Account

The present study revealed the presence of 58 taxa of ciliates, 43 of which are new to the fauna of Saudi Arabia and of the Arabian Gulf at large. The following is a checklist of the recorded species arranged according to Corliss (1979), each species is followed by a brief description according to Carey (1992) and some previous worldwide interstitial records extracted from the literature. Species present at all sites are indicated. The distribution and abundance of the species in the study area are presented in Table 1. Photomicrographs of each species are presented in Figs. 2-7.

Phylum: Ciliophora Doflein 1901
Class: Kinetofragminophorea de Puytorac et al. 1974
Subclass: Gymnostomatida Butschli 1889

Station 6 (North) is situated near the entrance of the island towards the northern side and its sediment consisted of the highest amounts of granules (11.9%) and very coarse sand (17.1%), with a mean grain size of 312 \( \mu \text{m} \). The size of the interstitial spaces was medium, indicated by 28.2% water content. The sediment was poorly sorted (degree of sorting, \( S_o = 3.33 \)), and was found to be high in silt and clay particles (19.0%). The total organic matter was fairly high (21.5%).
Fig. 2. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a. Holophrya africana; b. Holophrya coronata, bright-field photomicrograph; c. Metacystis striata; d. Prorodon deflandrei; e. Pseudoprorodon halophilus; f. Spalhidiopsis striatus; g. Coleps spiralis; h. Lacrymaria acuta; i. Mesodinium cinctum; j. Loxonotus fasciolis; k. Loxophyllum helus; l. Loxophyllum multinucleatum; m. Loxophyllum pseudosegigerum; n. Loxophyllum rostratum. All bars = 50 μm unless otherwise indicated.
Order: Prostomatida Schewiakoff 1896
Family: Holophryidae Perty 1852

1. Holophrya africana Dragesco 1965 (Fig. 2a)
Distribution: East African Coast (Dragesco 1965).

2. Holophrya coronata de Morgan 1925 (Fig. 2b)
Trachelocerca coronata Kahl 1930
Distribution: Plymouth in England (de Morgan 1925), Baltic Sea (Czapik 1952), East Coast of the United States (Borror 1963).

Family: Metacystidae Kahl 1926

3. Metacystis striata Stokes 1893 (Fig. 2c)
Cylindrical, slightly curved, 100 μm in length. Transversely striated, not deeply annulated, terminal cilium absent. Posterior region with characteristic terminal vacuole. Macronucleus, contractile vacuole central.

Suborder: Porodontina Corliss 1974
Family: Prorodontidae Kent 1880-1882

4. Prorodon deflandrei Dragesco 1960 (Fig. 2d)
Distribution: Atlantic Coast at Roscoff (Dragesco 1960).

5. Pseudoprorodon halophilus Kahl 1930 (Fig. 2e)
Distribution: Caspian Sea (Agamaliev 1971).
6. *Spathidiopsis striatus* (Cohn 1866) Corliss 1979 (Fig. 2f)

*Cylindrical, 55-60 µm in length. Body dominated by kinetics spiraling in one direction, cross-striated in opposite direction, giving a reticulate pattern. Macronucleus spherical.*

**Distribution:** French Coast (Dragesco 1963a), Plymouth in the U.K. (Lackey and Lackey 1963), Baltic Sea (Czapik and Jordan 1976), White Sea (Burkovsky 1970). Island of Sylt in the German Bight (Hartwig 1973), West Coast of the Caspian Sea (Agamaliev 1986), Benin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).


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7. *Coleps spiralis* Noland 1937 (Fig. 2g)

*Ovoid, 50 µm in length, truncate anteriorly, divided into two by equatorial cleft, cytostome anterior. Body covered with regularly arranged ectoplasmic plates composed of calcium carbonate with 5-8 lateral teeth on each plate. Distinct spiral torsion. Single caudal cilium. Contractile vacuole posterior, macronucleus central.*

**Distribution:** Gulf Coast of Florida (Noland 1937), East Coast of the United States (Borror 1963), White Sea (Burkovsky 1970). Island of Sylt in the German Bight (Hartwig 1973), Shediac Harbour in Canada (Yarma 1985).

8. *Lacrymaria acuta* Kahl 1933 (Fig. 2h)

*Spindle-shaped with pointed tail, 330 µm in length (contracted). Large, sausage-shaped macronucleus. Contractile vacuole posteriorly located.*


Family: Colepidae Ehrenberg 1838

8. *Lacrymaria acuta* Kahl 1933 (Fig. 2h)

*Spindle-shaped with pointed tail, 330 µm in length (contracted). Large, sausage-shaped macronucleus. Contractile vacuole posteriorly located.*


Family: Didiniidae Poche 1913

9. *Mesodinium cinctum* Calkins 1902 (Fig. 2i)

*Anteriorly conical, 35-40 µm in length, cytostome invaginated. Nematodesmata projected clear of body. Macronucleus large, ovoid. Two bands of cilia emerge from anterior groove, some cilia emerge radially.*

**Distribution:** Woods Hole in the U.S.A. (Lackey 1936), Plymouth in the U.K. (Lackey and Lackey 1963).

Order: Pleurostomatida Schewiakoff 1896

Family: Amphileptidae Bütschli 1889

10. *Litonotu*

9. *Lacrymaria acuta* Kahl 1933 (Fig. 2h)

*Spindle-shaped with pointed tail, 330 µm in length (contracted). Large, sausage-shaped macronucleus. Contractile vacuole posteriorly located.*


Family: Didiniidae Poche 1913

10. *Litonotu* Schewiakoff 1896


**Distribution:** Baltic Sea (Czapik and Jordan 1976), White Sea (Burkovsky 1970), Island of Sylt in the German Bight (Hartwig 1973), Shediac Harbour in Canada (Yarma 1985).

11. *Laxophy*

10. *Litonotu* Schewiakoff 1896


**Distribution:** Baltic Sea (Czapik and Jordan 1976), White Sea (Burkovsky 1970), Island of Sylt in the German Bight (Hartwig 1973), Shediac Harbour in Canada (Yarma 1985).

12. *Loxophy*

10. *Litonotu* Schewiakoff 1896


**Distribution:** Baltic Sea (Czapik and Jordan 1976), White Sea (Burkovsky 1970), Island of Sylt in the German Bight (Hartwig 1973), Shediac Harbour in Canada (Yarma 1985).

13. *Loxophy*

10. *Litonotu* Schewiakoff 1896


**Distribution:** Baltic Sea (Czapik and Jordan 1976), White Sea (Burkovsky 1970), Island of Sylt in the German Bight (Hartwig 1973), Shediac Harbour in Canada (Yarma 1985).

14. *Loxophy*
10. *Litonotus fasciola* (Ehrenberg 1838) Wrzesniowski 1870 (Fig. 2j)
   *Amphileptus fasciola* Ehrenberg 1838
   *Litonotus duplostriatus* (Maupas 1883) Kahl 1931
   *Loxophyllum duplostriatus* Maupas 1883
   **Distribution:** Plymouth in the U.K. (de Morgan 1925 and Lackey and Lackey 1963), Dee Estuary in the U.K. (Webb 1956), Baltic Sea (Hartwig 1974), Mediterranean Sea (Ghidoni 1975), Chichester Harbour on the English Channel (Carey and Maeda 1985).

11. *Loxophyllum helus* Stokes 1884 (Fig. 2k)
    *Litonotus helus* Stokes 1884
    Elongate, with distinct neck region, rounded tail, 150 μm in length. Flattened band runs along ventral edge. Large trichocyst warts line dorsal edge. Two ovoid macronuclei. Single contractile vacuole.

12. *Loxophyllum multinucleatum* Kahl 1928 (Fig. 2-1)
   Elongate, 100 μm long. Neck area well-defined; posterior rounded. Flattened band runs around periphery, trichites conspicuous. Macronuclei, many. Contractile vacuole ventral.

13. *Loxophyllum pseudosetigerum* Dragesco 1954 (Fig. 2m)
   Broad, 175-200 μm in length, almost oval with wide flattened band and trichocysts on both sides. Peribuccal papillae present. Several sharply pointed bristles fused with normal ciliature. Many spherical macronuclei, single contractile vacuole (present at all sites).
   **Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

Order: Karyorelictida Corliss 1974
Family: Trachelocercida Kent 1880-2
14. *Loxophyllum rostratum* Cohn 1866 (Fig. 2n)
**Loxophyllum quadricostatum** Vacelet 1961

**Loxophyllum serratum** Kahl 1933

Elongate, 130-180 μm in length. Neck area well-defined; posterior rounded; ventral edge sinuous. Flattened band on both sides. Two ovoid macronuclei, single contractile vacuole.

**Distribution:** Bight (Kahl 1933), the Caspian Sea (Agamaliev 1971), Baltic Sea (Hartwig 1974).

15. **Loxophyllum setigerum** Quennerstedt 1867 (Fig. 3a)

**Loxophyllum setigerum** var. *armatum* (Claparède and Lachmann 1858)

**Calkins 1902**

**Litoscelis armatus** Stokes 1893

Elongate, 150-200 μm in length. Flattened band and trichocysts around periphery. Prebuccal papillae present. Large trichites present in anterior. Several sharply pointed bristles emerge all around body. Macronuclei four, spherical. Contractile vacuoles, many; arranged in a row near dorsal edge.


16. **Loxophyllum uninucleatum** Kahl 1928 (Fig. 3b)

Elongate, broad on contraction, 65 μm in length. Anterior on expansion seem to be obliquely truncated. Upper surface domed, lower surface pleated. Flattened band present on both sides of body. Oral region contains long trichocysts. Macronucleus single, ovoid. Contractile vacuole single, terminally located.

**Distribution:** Caspian Sea (Agamaliev 1967), Mobile Bay in the US (Jones 1974), Al-Hassa Oasis in Saudi Arabia (Al-Rashid 1997).

**Order:** Karyorelictiida Corliss 1974

**Family:** Trachelocercidae Kent 1880-2

17. **Trachelocerca laevis** (Quennerstedt 1867) Kahl 1930 (Fig. 3c)


**Distribution:** German Bight (Kahl 1933).
Fig. 3. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Loxophyllum setigerum*; b, *Loxophyllum uninucleatum*; c, *Trachelocerca laevis*; d, *Tracheloraphis aragoi*; e, *Tracheloraphis discolor*; f, *Tracheloraphis hyalinum*; g, *Tracheloraphis indistinctus*, bright-field photomicrograph; h, *Tracheloraphis swedmarki*; i, *Remanella granulosa*; j, *Avetia gigas*. All bars = 50 μm unless otherwise indicated.
18. *Tracheloraphis aragoi* (Dragesco 1953) Dragesco 1960 (Fig. 3d)  
*Trachelocerca aragoi* Dragesco 1953  
Vermiform, thread-like, 1.5 mm in length. Head region slightly expanded, tail region pointed. Cytostome simple, with terminal cleft. Glabrous stipe thin, surrounded with large discoidal vacuolar elements. Small bumps present on body; carry large trichocysts or mucocysts. Six macronuclei, associated with curious large geometric crystalloid structures.  
**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), Al-Hassa Oasis in Saudi Arabia (AL-Rasheid 1997).

19. *Tracheloraphis discolor* Raikov 1962 (Fig. 3e)  
Vermiform, thin, 1.5-1.8 mm in length. Neck region long, contractile, tail finely pointed. Head region slightly expanded, cytostome simple funnel. Glabrous stipe thin. Nuclear apparatus consists of 6-17 bodies, each consisting of four macronuclei and two micronuclei.  
**Distribution:** Black Sea (Kovaleva 1966 and Kovaleva and Golemansky 1979), White Sea (Burkovsky 1970), Island of Sylt in the German Bight (Hartwig 1973).

20. *Tracheloraphis hyalinum* Dragesco 1960 (Fig. 3f)  
Vermiform, thin, with pointed tail, 1.5 mm in length. Head region slightly expanded. Cytostome funnel-shaped and lip with prominent cleft. Glabrous stipe very wide in mid-body region. Interkinetal mucocysts small. Nuclear apparatus consists of five macronuclei and two micronuclei, not surrounded by capsule.  
**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960).

21. *Tracheloraphis indistinctus* Wright 1982 (Fig. 3g)  
Vermiform, rather broad, 0.5-1 mm long. Tail region pointed. Anterior expanded slightly. Cytostome simple. Glabrous stipe very thin, occupying only one kinety. Interkinetal inclusions absent. Nuclear apparatus consists of only four macronuclei.  
**Distribution:** Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), West coast of the Caspian Sea (Agamaliev 1967), Baltic Sea (Czapik and Jordan 1976), South Wales in the U.K. (Wright 1982, 1983).

22. *Tracheloraphis swedmarki* Dragesco 1960 (Fig. 3h)  
**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), Black Sea (Kovaleva 1966), West Coast of Caspian Sea (Agamaliev 1967), Sea of Japan at Posjet Gulf (Raikov and Kovaleva 1968), Black Sea (Petran 1971), German coast of the English Channel (Hartwig 1974 and Berninger and Epstein 1995).
Family: Loxodidae Bütschli 1889
23. *Remanella granulosa* (Kahl 1933) Dragesco 1960 (Fig. 3i)
**Distribution:** Gulf of Napoli (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Black Sea (Kovaleva 1966, Petran 1968 and 1971), West Coast of the Caspian Sea (Agamaliev 1967, 1971), White Sea (Burkovsky 1968), Bay of Bengal (Rao and Ganapati 1968), Coast of Brazil (Kattar 1970), Baltic Sea (Hartwig 1974), South Wales in the U.K. (Wright 1982, 1983).

Family: Geleiidae Kahl 1933
24. *Avelia gigas* (Dragesco 1954) Nouzarède 1975 (Fig. 3j)
*Geleia gigas* Dragesco 1954
Vermiform, 1-2 mm in length. Neck region present, anterior apex curved over to form a hook. Buccal opening furnished with long cilia. Tail rounded. Mucocysts fine, coloured brown, lying interkinetally, together with other inclusions. Multimacronucleate.
**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), Arcachon in France (Swedmark 1964).

25. *Avelia martinicense* Nouzarède 1975 (Fig. 4a)
Large, vermiform, ca. 2.7 mm in length, highly contractile, coloured brown. Buccal opening flat. Two macronuclei. Micronucleus intercalated.
**Distribution:** Arcachon in France (Nouzarède 1975).

Superorder: Phyllopharyngidea de Puytorac et al. 1974
Order: Cyrtophorida Faure-Fremiet in Corliss 1956
Suborder: Chlamydodontina Deroux 1976
26. *Chlamydon mnemosine* Ehrenberg 1835 (Fig. 4b)
*Chlamydon rectus* Ozaki and Yagiu 1941
Ovoid to reniform, 80-100 μm long. Dorsum overhanging ventrum, band of trichites continuous. Oral aperture oval, supported by long thin nematodesmata. Macronucleus ovoid, 4-5 contractile vacuoles.
**Distribution:** Woods Hole in the U.S.A. (Lackey 1936), Dee Estuary (Webb 1956), Atlantic Coast at Roscoff (Dragesco 1960), Romanian Sea (Lepsi 1962), West coast of Caspian Sea (Agamalev 1967), White Sea (Burkovsky 1970), Brazilian Coast (Kattar 1970), Bermuda (Hartwig 1980), Bénin and Mauretania in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986), Baltic Sea (Czapik and Fyda 1992).

Suborder: Dysteriina Deroux 1976
Fig. 4. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, Avelia martinicense, bright-field photomicrograph; b, Chlamydonon mnemosine; c, Dysteria monostyla; d, Frontonia marina; e, Frontonia vacuolata; f, Protocruzia depressa; g, Pleuronema coronatum; h, Cyclidium cirrulus; i, Cristigera setosa; j, Anigsteinia clarissimum. All bars = 50 μm unless otherwise indicated.
Family: Dysteriidae Claparède and Lachmann 1858

27. *Dysteria monostyla* (Ehrenberg 1859 (Fig. 4c)

*Ervilia monostyla* (Ehrenberg 1859) Stein 1859

*Aegyria legumen* Dujardin 1841

*Dysteria duplopharynx* Lepsi 1927

Elongate, almost rectangular, rather wider posteriorly with rounded corners, 80 μm in length. Raised longitudinal rib along the lateral edge of dorsal surface. Single dagger-like podite arising from a slight depression at posterior. Cytopharyngeal basket and complex teeth present. Macronucleus single, two contractile vacuoles.


Class: Oligohymenophorea de Puytorac et al. 1974

Subclass: Hymenostomatida Delage and Hérouard 1896

Order: Hymenostomatida Delage and Hérouard 1896

Suborder: Peniculina Faure-Fremiet in Corliss 1956

Family: Frontoniidae Kahl 1926

28. *Frontonia marina* Fabre-Domergue 1891 (Fig. 4d)


29. *Frontonia vacuolata* Dragesco 1960 (Fig. 4e)


**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), Chichester Harbour on the English Channel (Carey and Maeda 1985).

Order: Scuticociliatida Small 1967

Suborder: Philasterina Small 1967

30. *Protocurzia depressa* Ammermann 1968 (Fig. 4f)
Ovoid, 50 µm, apex pointed. Somatic ciliation sparse dorsally, as spiral kineties ventrally. Macronucleus large, micronuclei variable in number. Present at all sites. **Distribution:** New Hampshire in the U.S. (Borror 1972), Saudi Arabia Gulf Islands of Al-Batinah and Abu Ali (AL-Rashid 1996).

Suborder: Pleuronematina Faure-Fremiet in Corliss 1956
Family: Pleuronematidae Kent 1880-1882
31. *Pleuronema coronatum* Kent 1880-1882 (Fig. 4g)

Pleuronema coronatum var. marina Kahl 1928

Family: Cyclidiidae Ehrenberg 1838
32. *Cyclidium citrullus* (Cohn 1866) Kahl 1931 (Fig. 4h)
Pleuronema citrullus Cohn 1866
Ovoid, 30 µm in length. Anterior and posterior raised to form a small bump at either end. Buccal ciliature occupies half length of body. Caudal cillum present. Macronucleus spherical. Contractile vacuole present. **Distribution:** Baltic Sea (Fenchel 1969), West Coast of the Caspian Sea (Agamaliev 1986), Qarun Salt Lake in Egypt (Wilbert 1995).

33. *Cristigera setosa* Kahl 1928 (Fig. 4i)
Ovoid, 30 µm in length. Buccal apparatus very large, extending three-quarters of body. Ciliation dense anteriorly, reduced to few long rigid cilia posteriorly. Macronucleus single. **Distribution:** Atlantic Coast at Roscoff (Dragesco 1960), White Sea (Burkovsky 1970), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rashid 1996).

Class: Polyhymenophorea Jankowski 1967
Fig. 5. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Blepharisma melonae*; b, *Graberia aculeata*; c, *Parablepharisma pelitum*; d, *Spirostomum loxodes*; e, *Metopus pellitus*; f, *Condylotoma arenarium*; g, *Condylotoma magnum*. All bars = 50 μm unless otherwise indicated.
Subclass: Spirotrichia Bütschli 1889
Order: Heterotrichida Stein 1859
Suborder: Heterotrichina Stein 1859
Family: Spirostomidae Stein 1867

34. *Anigsteinia clarissimum* (Anigstein 1912) Isquith 1968 (Fig. 4j)

*Blepharisma clarissimum* Anigstein 1912

Elongate, 380 μm in length. Anterior curving over the buccal area at the apex of cell. Adoral zone of membranelles (AZM) very long; attains at least one-half the length of cell. Undulating membrane small. Contractile vacuole posteriorly placed with a canal running up the right side. Macronucleus moniliform, with 20-30 ovoid units, associated with 10 micronuclei.


35. *Blepharisma melana* Borror 1963 (Fig. 5a)

Elongate, cylindrical, 250-400 μm in length. Neck region present. Peristome occupies one-third of body length. Undulating membrane well-developed, running from cytostome to apex of cell. Macronucleus moniliform; contractile vacuole terminal.

**Distribution:** East Coast of the US (Borror 1963), West Coast of the Caspian Sea (Agamaliev 1967)

36. *Gruberia aculeata* Ozaki and Yagi 1941 (Fig. 5b)

Elongate to lanceolate, highly contractile, 300-600 μm in length. Peristome occupies one-third of body length. Undulating membrane absent. AZM well-developed. Posterior pointed. Macronucleus large, moniliform. Contractile vacuoles large, numerous, distributed throughout body.

**Distribution:** East Coast of the US (Borror 1963).

37. *Parablepharisma pellitum* Kahl 1930-1935 (Fig. 5c)

Elongate, 200 μm in length. Wider in mid-body region than at either end. Kineties run longitudinally without spiralling. Peristome occupies one-half of body length. AZM large. Macronucleus consists of several ovoid bodies. Bacteria cover the pellicle.

**Distribution:** West Coast of the Caspian Sea (Agamaliev 1967), Baltic Sea (Fenchel 1969 and
38. Spirostomum loxodes Stokes 1885 (Fig. 5d)
Elongate, 200-300 μm in length. Anterior curved over peristome, which occupies one-third of body length. Somatic ciliation is uniform. Macronucleus moniliform. Contractile vacuole equipped with canal running to anterior.
**Distribution**: Dee Estuary (Webb 1956).

39. Metopuspellitus (Kahl 1930-1935) Carey 1992 (Fig 5e)
*Metopus contortus* var. *pellitus* Kahl 1930-5
Ovoid to elongate, 100 μm in length. Anterior twisted to left but not greatly projected beyond body. Pellicle ornamented by attached bacteria. AZM large; extending to equatorial region. Posterior rounded with caudal cilia. Macronucleus ovoid, anteriorly placed. Contractile vacuole posteriorly located.

40. Condylostoma arenarium Spiegel 1926 (Fig. 5f)

41. Condylostoma magnum Spiegel 1926 (Fig. 5g)
Elongate, highly contractile, ca. 1 mm in length. Head region spatula-shaped. Tail long, tapering. Peristome deep, wide. Macronucleus moniliform.
Fig. 6. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, Condyllostoma minima; b, Condyllostoma nigra; c, Condyllostoma patens; d, Condyllostoma reichii, bright-field photomicrograph; e, Condyllostoma remanei, bright-field photomicrograph. All bars = 50 μm unless otherwise indicated.
42. *Condylostoma minima* (Dragesco 1954) Dragesco 1960 (Fig. 6a)

*Condylostoma minuta* (Dragesco 1954)

Ovoid, ca. 100-200 μm in length. Mucocysts line the pellicle. Peristome wide, deep and almost ovoid, with large membranelles. Macronucleus moniliform, consisting of 6 elements. Contractile vacuole with satellites.

**Distribution:** Atlantic Coast at Roscoff (Dragesco 1960).

43. *Condylostoma nigra* Dragesco 1960 (Fig. 6b)

Distinctly ovoid, both ends rounded, 250 μm in length. Undulating membrane large, peristome small. Macronucleus moniliform; contractile vacuoles present. Abundant mucocysts, pigmented dark blue; dark coloured.

**Distribution:** Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

44. *Condylostoma patens* Dujardin 1841 (Fig. 6c)

Elongate, 500 μm in length (200 μm contracted), spatulate anteriorly, broad and rounded posteriorly. Peristome wide, macronucleus moniliform. Contractile vacuole present with long canal running forward to equatorial region.


45. *Condylostoma reichi* Wilbert and Kahan 1981 (Fig. 6d)

Elongate, 1.5-2.5 mm in length. Head region and peristome greatly enlarged. Body flattened ventrally. Highly contractile. Cytoplasm colourless. Macronucleus like a string of beads. Contractile vacuole large, posteriorly located.


46. *Condylostoma remanei* Spiegel 1928 (Fig. 6e)

*Condylostoma caudatum* Spiegel 1928

*Condylostoma remanei* var. *oxyoura* Dragesco 1960

Elongate, broad, anterior spatulate, expanding to mid-body, terminating in sharp pointed tail. Attains 1 mm in length. Peristome wide, deep. Macronucleus moniliform. Contractile vacuole absent.

**Distribution:** Mediterranean and Atlantic Coasts of France (Fauré-Fremiet 1950 and Dragesco 1960, 1963b, Ghidoni 1975), East Coast of Cape Cod in the US (Fauré-Fremiet 1951), Gulf of Naples (Nobili 1957), Marseille Bay in Monaco (Vacelet 1961), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Black Sea (Kovaleva 1966, Bacescu et al. 1967 and Petran 1975), Caspian Sea (Agamaliev 1967), Baltic Sea (Czapik 1952, Fenchel 1969 and...
Fig. 7. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, Peritremus montanus; b, Strombidium langenula; c, Strombidium purpureum; d, Strombilidium elegans; e, Strongylidium maritimum; f, Keronop/sis rubra; g, Epiclotes felis; h, Oxytricha marina; i, Aspidisca turrita; j, Diophrys appendiculata; k, Euplotes cristatus; l, Uronychia setigera. All bars = 50 μm unless otherwise indicated.
Family: Peritromidae Stein 1867  
47. *Peritromus montanus* Kahl 1928 (Fig. 7a)  
Ovoid, 90 μm in length. Buccal ciliature runs from left to right anteriorly.  
Dorsum ornamentated with many warts and spines. Protuberance prominent,  
well-developed. Somatic ciliation without spines. Two ovoid macronuclei.  
**Distribution:** Mobile Bay in the US (Jones 1974).

Order: Oligotrichida Bütschli 1887  
Suborder: Oligotrichina Bütschli 1887  
Family: Strombidiidae Fauré-Fremiet 1970  
48. *Strombidium langenula* Fauré-Fremiet 1924 (Fig. 7b)  
Ovoid, 50 μm in length. Peristomial collar large; AZM deep, extending  
two-thirds of body length. Posterior contains cortical plates. Trichites band in a  
funnel-shape arrangement present posteriorly.  
**Distribution:** Dee Estuary in the U.K. (Webb 1956).

49. *Strombidium purpureum* Kahl 1930-1935 (Fig. 7c)  
Ovoid, almost cylindrical, 40-50 μm long. Peristomial collar short, blunt.  
Posterior rounded, distinct equatorial cleft. AZM poorly developed. Single, ovoid  
macronucleus.  
**Distribution:** New Hampshire coast of the United States (Borror 1972).

Family: Strobilidiidae Kahl in Doflein and Reichenow 1927-1929  
50. *Strobilidium elegans* (Kahl 1930-1935) Maeda and Carey 1985 (Fig. 7d)  
*Lohmanniella elegans* Kahl 1930-1935  
Spherical, 40 μm in length. Peristome not raised. AZM extensive with large  
membranelles of a single type in the closed formation. Macronucleus large, ovoid.  
**Distribution:** Caspian Sea (Agamaliev 1971).

Order: Hypotrichida Stein 1859  
Suborder: Stichotrichina Fauré-Fremiet 1961  
Family: Strongylidiidae Fauré-Fremiet 1961  
51. *Strongylidium maritimum* Wang and Nie 1932 (Fig. 7e)  
Elongate, cylindrical, both ends rounded, 80-120 μm in length. Peristome long,  
extending along one edge of anterior. Three long, stiff frontal cirri at apex of cell.  
Somatic cirri spiral down body. Two ovoid macronuclei.

Family: Holostichidae Faure-Fremiet 1961

52. Keronopsis rubra (Ehrenberg 1838) Kahl 1930-1935 (Fig. 7f)

*Oxytricha rubra* Ehrenberg 1838

*Holosticha flavorubra* Entz 1884


Distribution: Dee Estuary in the U.K. (Webb 1956), Atlantic Coast at Roscoff (Dragesco 1960), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), West Coast of the Caspian Sea (Agamaliev 1967), Bay of Bengal (Rao 1969), Baltic Sea (Fenchel 1969), White Sea (Burkovsky 1970), The Mediterranean Sea (Ghidoni 1975), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rashid 1996).

Family: Keronidae Dujardin 1840

53. Epilimnetes felis (Müller 1786) Carey and Tatchell 1983 (Fig. 7g)

*Epilimnetes ambiguus* Kahl 1932

Elongate, flexible, highly contractile, 140-300 μm in length. Body divided into three regions; flattened head, slightly expanded mid-body, long flattened tail. Head region bears buccal cavity and AZM. No true frontal cirri. Two rows of marginal cirri and single long row of transverse cirri at periphery of body. Two-four caudal cirri at tip of tail. Three rows of sensory bristles on dorsum. Many small, ovoid macronuclei.


Suborder: Sporadotrichina Faure-Fremiet 1961

Family: Oxytrichidae Ehrenberg 1838

54. *Oxytricha marina* Kahl 1930-1935 (Fig. 7h)

Elongate, cylindrical, 120 μm long. AZM occupying quarter of body. Anterior and posterior ends rounded. Peristome occupies one-quarter of body length. Two ovoid macronuclei.

Distribution: Gulf of Napoli (Nobili 1957), Baltic Sea (Hartwig 1974), Tchad in Africa (Dragesco...
Family: Aspidiscidae Ehrenberg 1838

55. *Aspidiscus turrita* (Ehrenberg 1838) Claparède and Lachmann 1858 (Fig. 7i)

Ovoid, convex on the right, 35 μm in length. Dorsal surface smooth, with long, backwardly curving thorn. Seven frontoventral cirri, five transverse cirri.

**Distribution:** Plymouth in the U.K. (Lackey and Lackey 1963), West Coast of Caspian Sea (Agamaliev 1986).

Family: Euplotidae Ehrenberg 1838

56. *Diophrys appendiculata* (Ehrenberg 1838) Kahl 1930-1935 (Fig. 7j)

Styloynchia appendiculata Ehrenberg 1838

Ovoid, ca 106 μm long. Anterior rounded with well-developed AZM occupying ca. half of body. Posterior lateral concavity not ornamented. Three caudal cirri, 7-8 frontoventral cirri, 5 transverse, three cirri on left marginal. Two macronuclei. (Present at all sites).


57. *Euplotes cristatus* Kahl 1930-1935 (Fig. 7k)

Ovoid, 50-60 μm long. Dorsum ornamented, ventrum plain. Peristome narrow. AZM just over one-half body length. Ten frontoventral cirri, 5 transverse cirri, 4 caudal cirri. Macronucleus C-shaped.

**Distribution:** Ussuri Gulf on the Japan Sea (Raikov 1963), Gulf of Naples (Wichterman 1967), West Coast of Caspian Sea (Agamaliev 1967), White Sea (Burkovsky 1970), Baltic Sea (Hartwig 1974).

58. *Uronychia setigera* Calkins 1902 (Fig. 7-1)

Ovoid, 50-80 μm long. Peristome large, occupying over half body length; with 2-3 flagella-like cirri and 2 paroral membranes. Undulating membranes wide. Four-five transverse cirri, 2 marginal cirri, 2 curved, dorsally attached right caudal cirri, satellite cirrus thin, long. Three-four dorsal ridges. Single spherical macronucleus. (Present at all sites).

**Distribution:** Woods Hole in the U.S.A. (Lackey 1936), Plymouth in the U.K. (Lackey and Lackey 1963), Brazilian Coast (Kattar 1970), Norfolk saltmarshes in the U.K. (Barnes *et al.* 1976), and Dragesco-Kerneis 1986), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).
Family: Aspidiscidae Ehrenberg 1838
55. Aspidiscus turritus (Ehrenberg 1838) Claparède and Lachmann 1858 (Fig. 7i)

Ovoid, convex on the right, 35 μm in length. Dorsal surface smooth, with long, backwardly curving thorn. Seven frontoventral cirri, five transverse cirri.

**Distribution:** Plymouth in the U.K. (Lackey and Lackey 1963), West Coast of Caspian Sea (Agamaliev 1967).

Family: Euplotidae Ehrenberg 1838
56. Diophrys appendiculata (Ehrenberg 1838) Kahl 1930-1935 (Fig. 7j)

Ovoid, ca 106 μm long. Anterior rounded with well-developed AZM occupying ca. half of body. Posterior lateral concavity not ornamented. Three caudal cirri, 7-transverse, three cirri on left marginal. Two macronuclei.


57. Euplotes cristatus Kahl 1930-1935 (Fig. 7k)

Ovoid, 50-60 μm long. Dorsum ornamented, ventrum plain. Peristome narrow. AZM just over one-half body length. Ten frontoventral cirri, 5 transverse cirri, 4 caudal cirri. Macronucleus C-shaped.

**Distribution:** Ussuri Gulf on the Japan Sea (Raikov 1963), Gulf of Naples (Wichterman 1967), West Coast of Caspian Sea (Agamaliev 1967), White Sea (Burkovsky 1970), Baltic Sea (Hartwig 1974).

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**Distribution:** Woods Hole in the U.S.A. (Lackey 1936), Plymouth in the U.K. (Lackey and Lackey 1963), Brazilian Coast (Kattar 1970), Norfolk saltmarshes in the U.K. (Barnes 1976).
Table 1. The distribution, abundance and total number of ciliate species reported at all stations during the study period. The size of the circle represents ciliate abundance as follows: (•) = 1-100, (••) = 100-200, (•••) = 200-300 (••••) = 300-500, (•••••) = > 500 cell per cm$^{-3}$ of sediment.

<table>
<thead>
<tr>
<th>Species</th>
<th>Station</th>
<th>Month</th>
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<tbody>
<tr>
<td>1. Holophrya africana</td>
<td>1</td>
<td>F</td>
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<td>2. Holophrya coronata</td>
<td>2</td>
<td>M</td>
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<td>3. Metacystis striata</td>
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<td>J</td>
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<td>4. Prorodon deflectrii</td>
<td>4</td>
<td>S</td>
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<td>5. Pseudoprorodon halophilus</td>
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<td>J</td>
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<td>6. Spathidiopsis striatus</td>
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<td>7. Coleps spiralis</td>
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<td>8. Lacrymaria acuta</td>
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<td>9. Metodinium circinum</td>
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<td>10. Litonius fasciola</td>
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<td>11. Loxophyllum helus</td>
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<td>12. Loxophyllum multinucleatum</td>
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<td>13. Loxophyllum pseudosetigerum</td>
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<td>14. Loxophyllum rostratum</td>
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<td>15. Loxophyllum setigerum</td>
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<td>16. Loxophyllum uninucleatum</td>
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<td>17. Trachelocera laevis</td>
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<td>22. Tracheloraphis swedmarkii</td>
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<td>23. Remanella granulosa</td>
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<td>24. Avelia gigas</td>
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<td>25. Avelia martinicense</td>
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<td>28. Frontonia marina</td>
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<td>29. Frontonia vacuolata</td>
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<td>30. Protocruzia depressa</td>
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<td>33. Cristigera setosa</td>
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<td>35. Blepharisma melane</td>
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<td>36. Pleuronema coronatum</td>
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<td><em>Blepharisma melana</em></td>
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<td><em>Parablepharisma pellitum</em></td>
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<td><em>Oxytricha marina</em></td>
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<td>56.</td>
<td><em>Diophrys appendiculata</em></td>
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<td>57.</td>
<td><em>Euplotes cristatus</em></td>
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<tr>
<td>58.</td>
<td><em>Uronychia setigera</em></td>
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Abundance of Ciliates (No. x10^6 per cm^-3 of sediment)

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<th>No. of Species</th>
<th>Total No. of Species</th>
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<td>10</td>
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Ciliate abundance and species composition

The abundance of the ciliate species in each of the five collections in the study area is presented in Table 1. All ciliate species were most abundant at Station No. 3 (Ar Rabiiyah) throughout the year, which may relate to the favorable sediment properties as well as to the environmental conditions prevailing there. It has the best sorted sediment of all stations, together with relatively high interstitial spaces, which provide shelter for both the ciliates and their food organisms (Fenchel 1969). The sands of Station 1 (West) and 6 (North) were the poorest in ciliates, both in species composition and in the number of individuals (see Table 1). This may be due to the high contents of silt and clay fraction and total organic contents, which made the sediments poorly sorted for the ciliates to accommodate.

The present study clearly indicates a seasonality of ciliate abundance. The composition and abundance of ciliate found during the present study differed significantly with seasons (ANOVA Test, $p < 0.05^*$. The ciliate counts were higher during the period of warm months (May through September) than during the colder months (December and February). The average number of species per station were found to be more than twice as high and the average ciliate density was more than four times as high in the warmest month of July as it is in December (mean temperatures of 36.6° C and 16.5° C respectively). This pronounced seasonal change was found to be correlated with the change in temperature ($r = 0.6819, p < 0.01^{**}$ for the ciliate density, $r = 0.6129, p < 0.05^*$ for the average number of species, Correlation Coefficient Test). Temperature may influence the increase in the activity of ciliates and the availability of food organisms in summer more than in winter. A positive correlation between temperature increase and growth rate of ciliates was previously reported (Fenchel 1969). The noticeable change in temperature in the Arabian Gulf may explain the seasonality observed.

Five species were recorded from all sampling stations throughout the year; *Loxophyllum pseudosetiger*, *Frontonia marina*, *Protocrucia depressa*, *Pleuronema coronatum*, *Diophrys appendiculata* and *Uronychia setigera*. *Frontonia marina* was found at all six stations all year round. It was most abundant in July at station 3 (Ar Rabiiyah). Maximum population during that period was 671 ± 165 cells cm$^{-3}$ of sediment. Interestingly, the seven species of *Condylostoma* were recorded mainly from station 3 (Ar Rabiiyah), with some counts at other stations. Only one species of
this genus, Condylostoma nigra was recorded throughout the year with a maximum population density of 354 ± 278 cells cm$^{-3}$. The other species were usually found in low numbers.

The percentage similarity values of the ciliate species composition between the sampling stations, based on Jaccard Index (J) is presented in Figure 8. The two landward stations (1 West and 6 North) are similar in species composition (52.4%), while the other two seaward stations (4 Sanabis and 5 Az Zawr) are highly similar to each other (50.3%). Other stations showed some homogeneity of ciliate communities in Tarut Island. Ar Rabiiyah and West stations were the least similar to one another (19.23%).

Although the Arabian Gulf environment is harsh, characterized by high temperature and salinity fluctuation, the present study indicated that the interstitial ciliate community is considerably richer than was expected, and that many species are able to tolerate remarkable extremes of temperature and salinity. Similar observations have been reported previously (Arar et al. 1986 and Basson et al. 1977).
References


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سجل الأوليات الهدبية حرة المعيشة في المملكة العربية السعودية

3. الهدبيات البنين مؤلفة في جزيرة تاروت في الخليج العربي

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تم جمع عينات من الرمال البحرية من منطقة ما بين المدى والجزر من ستة مواقع مختلفة على جزيرة تاروت الواقعة قبالة شاطئ المملكة العربية السعودية شرقاً واحة القطيف، وتم تحليل الربة فئيئياً لقياس نسب وأحجام حيبات الرمل ونسبة المياه بين رملية ونسبة المواد العضوية الكلية. وتم عدد وتسلسل الهدبيات القاطنة ووصف 8 نوعاً من الهدبيات البنين رملية البحرية (المتعلقة بالرمال القاعية) من شواطئ جزيرة تاروت. والأنواع التي تم تسجيلها تشمل 39 جنساً في 27 فصيلة من فصائل الهدبيات، 43 منها تسجل لأول مرة كأنواع ضمن التواجد الحيوي لكل من الخليج العربي والمملكة العربية السعودية. كما أوضح البحث أن خمسة من تلك الأنواع هي دائمة الإقامة في هذه الجزيرة. هذا وقد تم توضيح التوزيع الجغرافي لكل نوع من الأنواع الموصوفة ضمن الجزيرة ومقارنته بالتوزيع العالمي لها.