Arab Gulf J. Scient. Res., **15** (3), pp. 733-766 (1997)

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 desnity 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 (Fauré-Fremiet 1950, Dragesco 1960, 1963 a,b, Fenchel 1969, Wilbert and Kahan

*From a Research Project sponsored by the National Commission for Wildlife Conservation and Development, Riyadh, Saudi Arabia.

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).

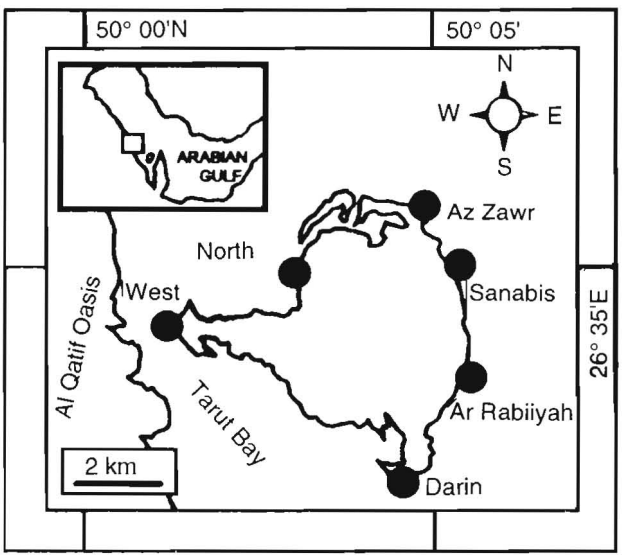

Fig. 1. Map of the Arabian Gulf showing Tarut Island and the sampling sites 1-6.

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 ‰ 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 outputsof 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 sediment. The total organic matter was moderate (17.4%).

Station 3 (Ar Rabiiyah) 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. The size of the interstitial spaces was fairly large (34.3% water content) and the sediment was well sorted (degree of sorting 0.51), while the total organic matter was fairly low (9.8%).

Station 4 (Sanabis) is on the eastern side of the island and its sediment consisted mainly of fine coarse and (46.1%) and medium sand (21.8%), poor in silt and clay (1.2%), with a mean grain size of 608 μm, a moderately sorted sediment (S_o = 1.22), with the lowest interstitial water content of any station (15.5%). The total organic matter was fairly low (7.1%).

Station 5 (Az Zawr) is on the northern side of the island and its sediment consisted of 37.2% fine medium sand, 28.9% of fine sand, and was low in silts and clays (1.7%); its mean grain size was 343 μm. However, the sediment was quite well sorted (S_o = 1.65) and the water content was 25.4%. The total organic matter was the lowest of all stations (3.5%).

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 μm. The size of the interstitial space 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%).

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 sies 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 Bütschli 1889

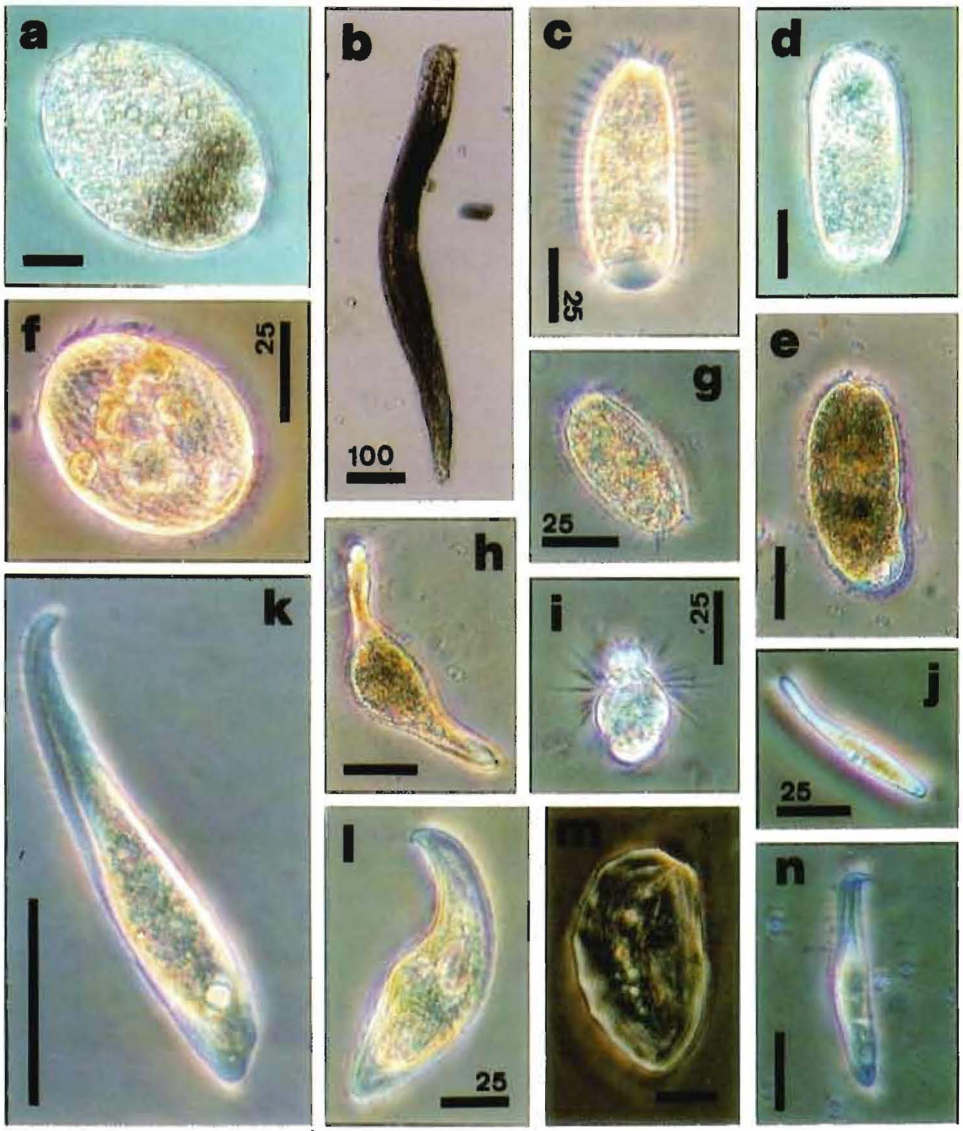

Fig. 2. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Holophrya africana*; b, *Holophrya coronata,* bright-field photomicrograph; c, *Metacystis striata;* d, *Prorodon deflandrei*; e, *Pseudoprorodon halophilus*; f, *Spathidiopsis striatus*; g, *Coleps spiralis*; h, *Lacrymaria acuta*; i, *Mesodinium cinctum*; j, *Litonotus fasciola*; k, *Loxophyllum helus*; l, *Loxophyllum multinucleatum*; m, *Loxophyllum pseudosetigerum*; n, *Loxophyllum rostratum.* All bars = 50 µm unless otherwise indicated.

Order: Prostomatida Schewiakoff 1896

Family: Holophrydiae Perty 1852

1. ***Holophrya africana*** Dragesco 1965 (Fig. 2a)

Spherical, 215-230 μm in diameter. Cytostome circular, slightly raised on a buccal plateau. Nematodesmata of rhabdos basket clearly visible. Macronucleus spherical, contractile vacuole terminal. Cytoplasm filled with inclusions.

Distribution: East African Coast (Dragesco 1965).

2. ***Holophrya coronata*** de Morgan 1925 (Fig. 2b)

Trachelocerca coronata Kahl 1930

Vermiform, 350-800 μm in length. Sluggish swimmer, cotnractile. Body uniformly ciliated; apical region characterized by series of concentric ciliated circles. Cytostome apical. Cytopharyngeal apparatus equipped with long, fine nematodesmata. Trichocysts at anterior and posterior. Many, spindle-shaped macronucleus. Numerous, rounded micronuclei. Contractile vacuole terminal.

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.

Distribution: New Hampshire coast of the United States (Borror 1972).

Suborder: Porodontina Corliss 1974

Family: Prorodontidae Kent 1880-1882

4. ***Prorodon deflandrei*** Dragesco 1960 (Fig. 2d)

Cylindrical, rather ovoid in rear, 120-160 μm in length. Body covered with irregular protuberances, with swollen appearance. Somatic ciliation uniform; mucocysts present inerkinetally. Cytostome apical with distinct buccal plateau. Cytopharyngeal apparatus large with trichocysts. Macronucleus large. Contractile vacuole terminal.

Distribution: Atlantic Coast at Roscoff (Dragesco 1960).

5. ***Pseudoprorodon halophilus*** Kahl 1930 (Fig. 2e)

Oval, elongated, 130-150 μm in length, streaked appearance. Anterior, small cytostome. Small trichocysts, nematodesmata of rhabdos basket long. Body filled with dark granules.

Distribution: Caspian Sea (Agamaliev 1971).

6. ***Spathidiopsis striatus*** (Cohn 1866) Corliss 1979 (Fig. 2f)

Placus striatus Cohn 1866

Placus sulcatus (Mansfeld 1923) Kahl 1930

Cylindrical, 55-60 μm in length. Body dominated by kineties 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), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

Family: Colepidae Ehrenberg 1838

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 (Varma 1985).

Suborder: Haptorina Corliss 1974

Family: Enchelyidae 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.

Distribution: Atlantic Coast at Roscoff (Dragesco 1960), German coast of the English Channel (Hartwig 1974), East African Coast of Somalia (Ricci *et al.* 1982), South Wales in the U.K. (Wright 1982, 1983), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986), Mediterranian Sea (Santangelo and Lucchesi 1992).

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 grove, 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. ***Litonotus fasciola*** (Ehrenberg 1838) Wrzesniowski 1870 (Fig. 2j)
Amphileptus fasciola Ehrenberg 1838
Litonotus duplostriatus (Maupas 1883) Kahl 1931
Loxophyllum duplostriatus Maupas 1883

Elongate, laterally flattened, 60-90 µm in length, with curving neck and rounded posterior. Oral area slit-like. Contractile vacuole, single, posteriorly placed. Two, spherical macronuclei.

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), Mediterranian 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.

Distribution: Dee Estuary in the U.K. (Webb 1956), Gulf of Napoli (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), West Coast of the Caspian Sea (Agamaliev 1967, 1986), Black Sea (Bacescu *et al.* 1967 and Petran 1971), Island of Sylt in the German Bight (Hartwig 1973), Baltic Sea (Hartwig 1974), Louisiana salt marshes (Elliott and Bamforth 1975), East African Coast of Somalia (Ricci *et al.* 1982), Cotonou in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986), Suez Canal in Egypt (El-Serehy 1992).

12. ***Loxophyllum multinucleatum*** Kahl 1928 (Fig. 2-l)

Elongate, 100 µm long. Neck area well-defined; posterior rounded. Flattened band runs around periphery, trichites conspicuous. Macronuclei, many. Contractile vacuole ventral.

Distribution: Baltic Sea (Czapik 1952 and Czapik and Jordan 1976), brackish water lake in Poland (Wiackowski 1981), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

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. Sevral 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: Trachelocercide 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*** Queenerstedt 1867 (Fig. 3a)
Loxophyllum setigerum var. *armartum* (Claparède and Lachmann 1858) Calkins 1902
Litoselenus 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.

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 Caspian Sea (Agamaliev 1967), Black Sea (Bacescu *et al.* 1967 and Petran 1971), White Sea (Burkovsky 1970), Brazilian Coast (Kattar 1970), New Hampshire coast of the United States (Borror 1972), German North Sea Coast (Hartwig 1973 and Berninger and Epstein 1995), Black Sea (Petran 1975), Louisiana salt marshes (Elliott and Bamforth 1975), Baltic Sea (Czapik 1952, Hartwig 1974 and Czapik and Jordan 1976), North Yorkshire in the U.K. (Hartwig and Parker 1977), Tees Estuary in England (Parker 1981), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

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-Rasheid 1997).

Order: Karyorelictida Corliss 1974
Family: Trachelocercidae Kent 1880-2

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

Vermiform to flask-shaped, ca. 350 µm at full extension. Posterior rounded. Head region not expanded conspicuously, cytostome ovoid. Buccal region with long, forward pointing cilia. Cytopharyngeal rods short. Large ovoid macronucleus. Contractile vacuole single, posteriorly located.

Distribution: German Bight (Kahl 1933).

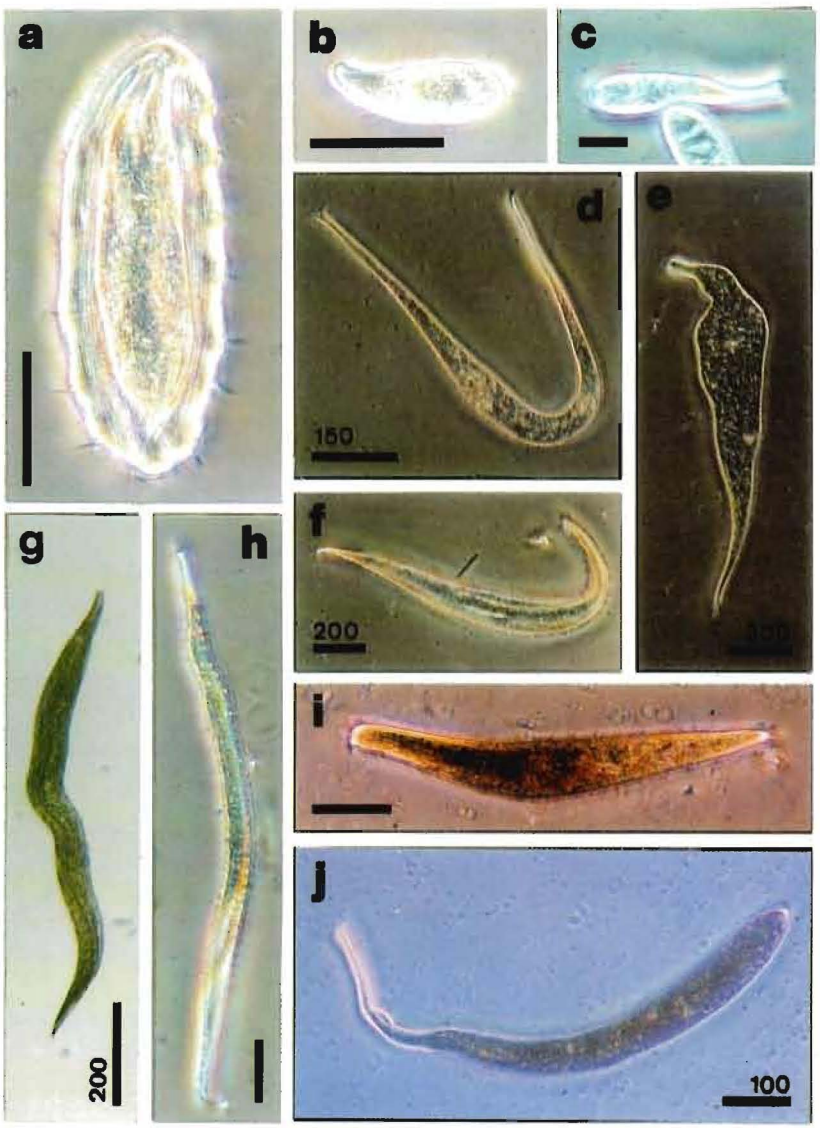

Fig. 3. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Loxophyllum setigerum;* b, *Loxophyllum uninucleatum*; c, *Trachelocerca laevis*; d, *Tracheloraphis aragoi*; e, *Tracheloraphis discolor*; f, *Tracheloraphis hyalinum*; g, *Tracheloraphis indistinctus,* bright-field photomicrograph; h, *Tracheloraphis swedmarki*; i, *Remanella granulosa*; j, *Avelia 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 vacoular 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 stripe 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 stripe 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 stripe 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)

Vermiform, thin with pointed tail, 280-600 μm in length. Head region expanded with funnel-shaped cytostome. Glabrous stripe wide. Four macronuclei.

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)

Elongate, 250-300 µm in length. Body rather crescentic with pointed tail. Pigmentation around buccal region and cytoplasm. Müller's bodies 2-4. Two spherical macronuclei, Micronucleus intercalated.

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*** (Dagesco 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. Multimacronucleated.

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 Fauré-Fremiet in Corliss 1956

Suborder: Chlamydodontina Deroux 1976

Family: Chlamydodotidae Stein 1859

26. ***Chlamydodon mnemosine*** Ehrenberg 1835 (Fig. 4b)

Chlamydodon 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 (Agamaliev 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

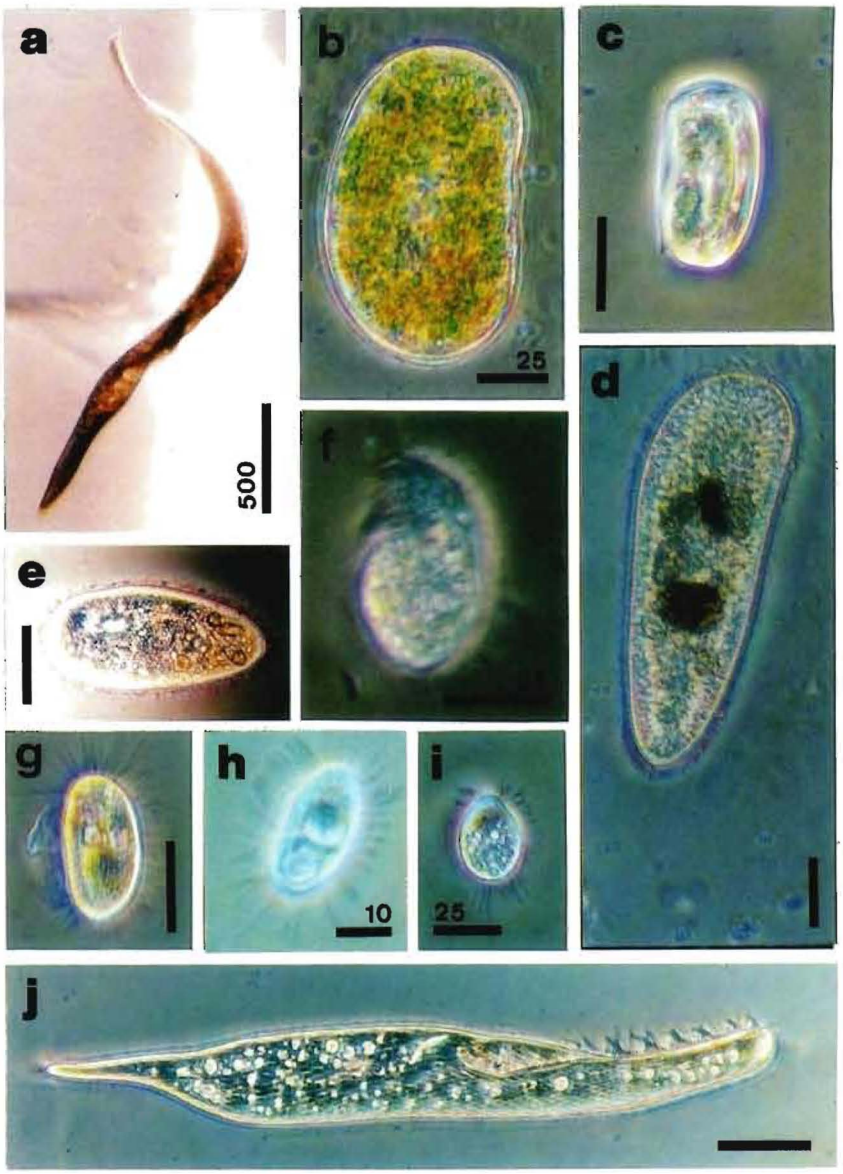

Fig. 4. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Avelia martinicense,* bright-field photomicrograph; b, *Chlamydodon mnemosine*; c, *Dysteria monostyla*; d, *Frontonia marina*; e, *Frontonia vacuolata*; f, *Protocruzia depressa*; g, *Pleuronema coronatum*; h, *Cyclidium citrullus*; 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.

Distribution: Plymouth in the U.K. (Lackey and Lackey 1963), White Sea (Burkovsky 1970), New Hampshire in the US (Borror 1972), Caspian Sea (Agamaliev 1974), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

Class: Oligohymenophorea de Puytorac *et al.* 1974

Subclass: Hymenostomatida Delage and Hérouard 1896

Order: Hymenostomatida Delage and Hérouard 1896

Suborder: Peniculina Fauré-Fremiet in Corliss 1956

Family: Frontoniidae Kahl 1926

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

Elongate, 300-350 µm long. Anterior wider than posterior, dorso-ventrally flattened. Oral aperture small. Macronucleus large, two micronuclei. Single, small, centrally-located contractile vacuole. Trichocysts numerous, fine. (present at all sites).

Distribution: Dee Estuary (Webb 1956), Gulf of Napoli (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), East Coast of the US (Borror 1963), Plymouth in the U.K. (Lackey and Lackey 1963), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), West Coast of the Caspian Sea (Agamaliev 1967, 1986), Black Sea (Petran 1968, 1971), Brazilian Coast (Kattar 1970), New Hampshire coast of the United States (Borror 1972), Island of Sylt in the German Bight (Hartwig 1973), Louisiana salt marshes (Elliott and Bamforth 1975), Norfolk Saltmarshes (Barnes *et al.* 1976), Baltic Sea (Fenchel 1969, Hartwig 1974 and Czapik and Jordan 1976), Bermuda (Hartwig 1980, 1986), East African Coast of Somalia (Ricci *et al.* 1982), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

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

Ovoid, 150-160 µm long. Oral aperture small, well-dfeined. Macronucleus large, irregularly-shaped, contractile vacuole terminal. Trichocysts numerous, fine.

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 kineies 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-Rasheid 1996).

Suborder: Pleuronematina Fauré-Fremiet in Corliss 1956

Family: Pleuronematidae Kent 1880-1882

31. ***Pleuronema coronatum*** Kent 1880-1882 (Fig. 4g)

Pleuronema coronata var. *marina* Kahl 1928

Ovoid, slightly reniform, 85-90 µm long. Undulating membrane very large, almost encircling cytostome posteriorly. Caudal cilia present. Macronucleus large, ovoid; contractile vacuole large; trichocysts large, few.
Distribution: Gulf Coast of Florida (Noland 1937), French Coast (Fauré-Frémiet 1950 and Dragesco 1963 a,b) Dee Estuary (Webb 1956), Gulf of Napoli (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), East Coast of the US (Borror 1963), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Western Norway (Reuter 1963), Coast of Cameroun (Dragesco 1965), Black Sea (Kovaleva 1966, Bacescu *et al.* 1967 and Petran 1971, 1975), West Coast of the Caspian Sea (Agamaliev 1967, 1986), Bay of Bengal (Rao and Ganapati 1968), White Sea (Burkovsky 1968), Coast of Brazil (Kattar 1970), New Hampshire coast of the United States (Borror 1972), Louisiana salt marshes (Elliott and Bamforth 1975), Baltic Sea (Fenchel 1969, Czapik and Jordan 1976 and Czapik and Fyda 1992), Bermuda (Hartwig 1977, 1980), North Yorkshire in the U.K. (Hartwig and Parker 1977), Tees Estuary in England (Parker 1981), East African Coast of Somalia (Ricci *et al.* 1982), Suez Canal in Egypt (El-Serehy 1992), Mediterranian Sea (Ghidoni 1975, Santangelo and Lucchesi 1992), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rashied 1996).

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 cilium 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-Rasheid 1996).

Class: Polyhymenophorea Jankowski 1967

Fig. 5. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Blepharisma melana*; b, *Gruberia aculeata*; c, *Parablepharisma pellitum*; d, *Spirostomum loxodes*; e, *Metopus pellitus*; f, *Condylostoma arenarium*; g, *Condylostoma 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.

Distribution: East Coast of Cape Cod in the US (Fauré-Frémiet 1951), Gulf of Naples (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, Bacescu *et al.* 1967 and Petran 1971), West Coast of the Caspian Sea (Agamaliev 1967), White Sea (Burkovsky 1970), Coast of Brazil (Kattar 1970), The Mediterranian Sea (Ghidoni 1975), Baltic Sea (Czapik 1952, Fenchel 1969, Hartwig 1974, Czapik and Jordan 1976 and Czapik and Fyda 1992), North Yorkshire in the U.K. (Hartwig and Parker 1977), Bermuda (Hartwig 1980), Tees Estuary in England (Parker 1981), Gulf of Somalia (Ricci *et al.* 1982), Shediac Harbour in Canada (Varma 1985), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

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 Yagiu 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

Hartwig 1974), Louisiana salt marshes (Elliott and Bamforth 1975), Bermuda (Hartwig 1980).

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).

Family: Metopidae Kahl 1927

39. ***Metopus pellitus*** (Kahl 1930-1935) Carey 1992 (Fig 5e)

Metopus controtus 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 posterioly located.

Distribution: Alligator Harbor in Flordia (Borror 1963), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), West Coast of the Caspian Sea (Agamaliev 1974), Louisiana salt marshes (Elliott and Bamforth 1975), Baltic Sea (Fenchel 1969, Hartwig 1974, Czapik and Jordan 1976 and Czapik and Fyda 1992).

Family: Condylostomatidae Kahl in Doflein and Reichenow 1927-1929

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

Elongate, cylindrical, 300-500 µm in length. Tail rounded. Peristome wide, short. Macronucleus moniliform. Mucocysts present in pellicle. Contractile vacuole single.

Distribution: Gulf of Naples (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), Gulf of Mexico (Borror 1962), Alligator Harbor in Florida (Borror 1963), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Coast of Mauretania (Dragesco 1965), Black Sea (Kovaleva 1966, Bacescu *et al.* 1967 and Petran 1975), West Coast of the Caspian Sea (Agamaliev 1967, 1972 and 1986), Bay of Bengal (Rao and Ganapati 1968), White Sea (Burkovsky 1968), Coast of Brazil (Kattar 1970), New Hampshire coast (Borror 1972), Baltic Sea and the German coast of the English Channel (Czapik 1952 and Hartwig 1974), Louisiana salt marshes (Elliott and Bamforth 1975), Norfolk saltmarshes (Barnes *et al.* 1976), Bermuda (Hartwig 1977, 1986), North Yorkshire in the U.K. (Hartwig and Parker 1977), South Wales in the U.K. (Wright 1982, 1983), Gulf of Somalia (Ricci *et al.* 1982).

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.

Distribution: Mobile Bay in the US (Jones 1974), The Mediterranian Sea (Ghidoni 1975), Cotonou in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986), Al-Hassa Oasis in Saudi Arabia (AL-Rasheid 1997).

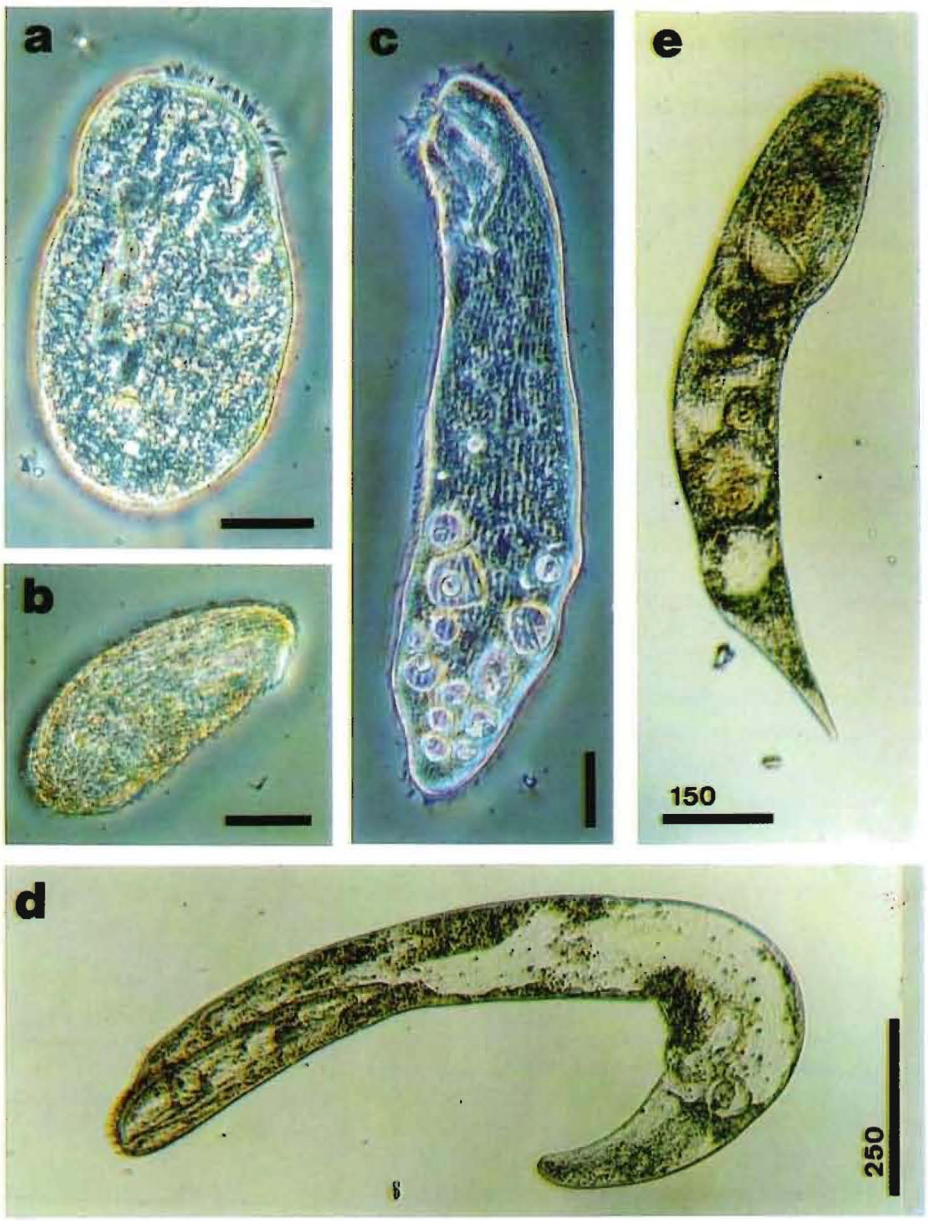

Fig. 6. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Condylostoma minima*; b, *Condylostoma nigra*; c, *Condylostoma patens*; d, *Condylostoma reichi*, bright-field photomicrograph; e, *Condylostoma remanei*, bright-field photomicrograph. 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.

Distribution: Plymouth (de Morgan 1925 and Lackey and Lackey 1963), Woods Hole in the US (Lackey 1936), East Coast of Cape Cod in the US (Fauré-Frémiet 1951), Dee Estuary in the U.K. (Webb 1956), Whitstable in England (Maghraby and Perkins 1956), Bay of Bengal (Rao and Ganapati 1968 and Rao 1969), Baltic Sea (Hartwig 1974), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

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.

Distribution: Found in Solar Lake on the Red Sea (Wilbert and Kahan 1981), Cotonou in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986).

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-Frémiet 1950 and Dragesco 1960, 1963b, Ghidoni 1975), East Coast of Cape Cod in the US (Fauré-Frémiet 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

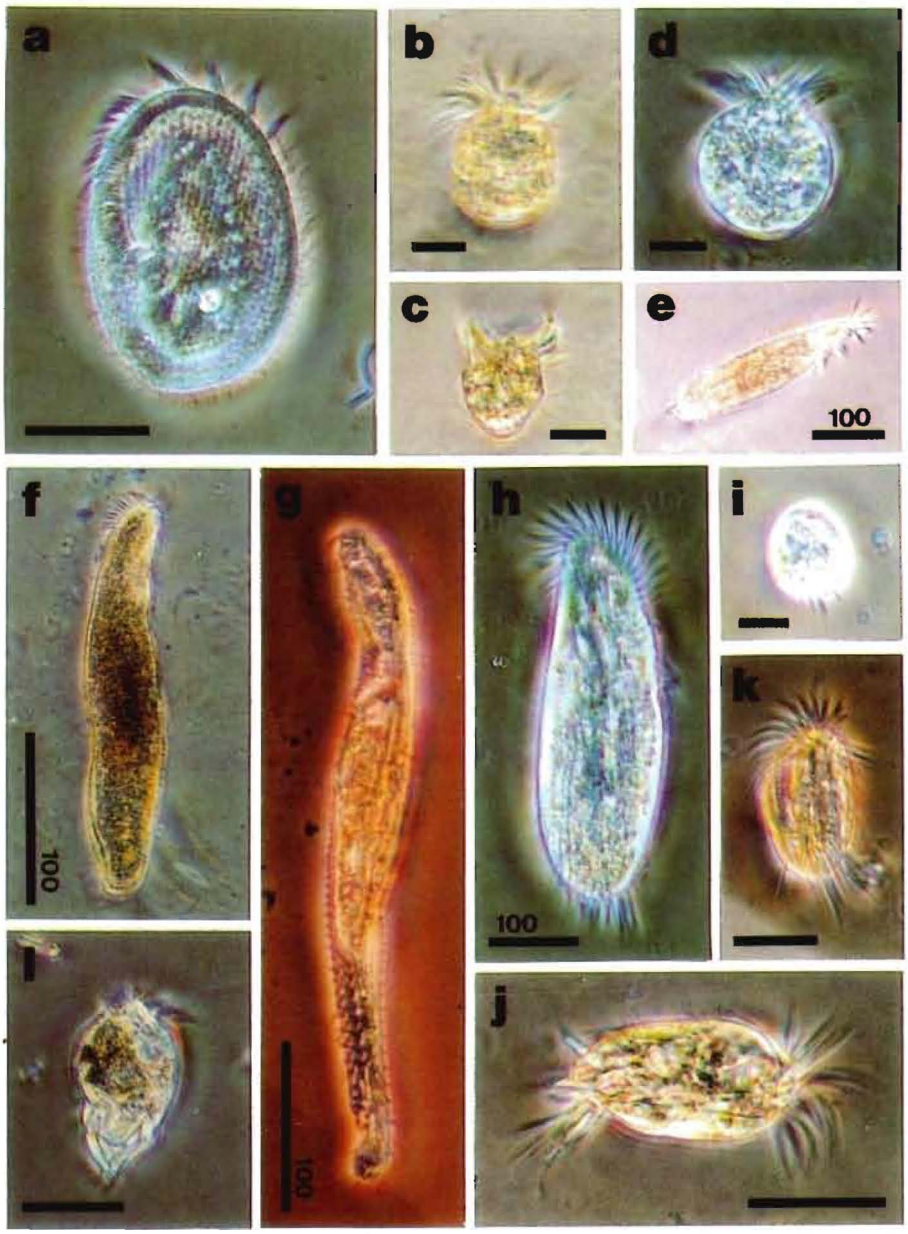

Fig. 7. Phase-contrast (unless otherwise indicated) photomicrographs of live ciliate species reported from Tarut Island. a, *Peritromus montanus*; b, *Strombidium langenula*; c, *Strombidium purpureum*; d, *Strobilidium elegans*; e, *Strongylidium maritimum*; f, *Keronopsis rubra*; g, *Epiclintes felis*; h, *Oxytricha marina*; i, *Aspidisca turrita*; j, *Diophrys appendiculata*; k, *Euplotes cristatus*; l, *Uronychia setigera*. All bars = 50 µm unless otherwise indicated.

Hartwig 1974), Brazilian Coast (Kattar 1970), North Yorkshire in the U.K. (Hartwig and Parker 1977), South Wales in the U.K. (Wright 1982, 1983), Chichester Harbour on the English Channel (Carey and Maeda 1985), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

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 Hamsphire 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.

Distribution: Norfolk saltmarshes in the U.K. (Barnes *et al.* 1976).

Family: Holostichidae Fauré-Fremiet 1961

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

Oxytricha rubra Ehrenberg 1838

Holosticha flavorubra Entz 1884

Elongate, 250-300 µm in length, rounded anteriorly, blunt posteriorly. Peristome occupies quarter of body. True frontal cirri absent. Many small, ovoid macronuclei. Red to orange in colour.

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 Mediterranian Sea (Ghidoni 1975), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

Family: Keronidae Dujardin 1840

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

Epiclintes 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.

Distribution: French Mediterranean and Atlantic Coasts (Fauré-Frémiet 1950 and Dragesco 1960), East Coast of Cape Cod in the US (Fauré-Frémiet 1951), Gulf of Naples (Nobili 1957), Marseille Bay in Monaco (Vacelet 1961), Plymouth in the U.K. (Lackey and Lackey 1963), East Coast of the US (Borror 1963), Japan Sea at Ussuri (Raikov 1963), Coast of Mauretania (Dragesco 1965), Black Sea (Kovaleva 1966 and Petran 1968), Bay of Bengal (Rao and Ganapati 1968 and Rao 1969), White Sea (Burkovsky 1968, 1970), Coast of Brazil (Kattar 1970), Island of Sylt in the German Bight (Hartwig 1973), Baltic Sea (Hartwig 1974 and Czapik and Jordan 1976), North Yorkshire in the U.K. (Hartwig and Parker 1977), Bermuda (Hartwig 1980, 1986), Thames estuary (Carey and Tatchell 1983), Chichester Harbour on the English Channel (Carey and Maeda 1985), West Coast of the Caspian Sea (Agamaliev 1986).

Suborder: Sporadotrichina Fauré-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

and Dragesco-Kerneis 1986), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

Family: Aspidiscidae Ehrenberg 1838

55. ***Aspidisca turrita*** (Ehrenberg 1838) Claparède and Lachmann 1858 (Fig. 7i)
Euplotes turritus Ehrenberg 1838

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)
Stylonychia appendiculata Ehrenberg 1838

Ovoid, ca 100 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).

Distribution: Dee Estuary in the U.K. (Webb 1956), Marseille Bay in Monaco (Vacelet 1961), East Coast of the US (Borror 1963), Baltic Sea (Fenchel 1969, Hartwig 1974, Czapik and Jordan 1967 and Czapik and Fyda 1992), West Coast of Caspian Sea (Agamaliev 1967), Bay of Bengal (Rao and Ganapati 1968 and Rao 1969), Brazilian Coast (Kattar 1970), Island of Sylt in the German Bight (Hartwig 1973), Chichester Harbour on the English Channel (Carey and Maeda 1985), Bénin in the Eastern African coast (Dragesco and Dragesco-Kerneis 1986), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996).

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-l)

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),

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

Species	Station																											
	1					2					3					4					5					6				
Month	F	M	J	S	D	F	M	J	S	D	F	M	J	S	D	F	M	J	S	D	F	M	J	S	D	F	M	J	S	D
1. *Holophrya africana*								●	•	•																				
2. *Holophrya coronata*																						•	•							
3. *Metacystis striata*	•		●																											
4. *Prorodon deflandrei*												•	●	•				•					•							
5. *Pseudoprorodon halophilus*											•	●	•	•	•															
6. *Spathidiopsis striatus*																											•	●		
7. *Coleps spiralis*	●	•	●	•																						•	●	●	•	●
8. *Lacrymaria acuta*						•		•	•	•	•	●	•	•	•		•	•					•							
9. *Mesodinium cinctum*		•	•								●		•	●	•														•	
10. *Litonotus fasciola*								•	•		•	•	●					•												
11. *Loxophyllum helus*													●									•								
12. *Loxophyllum multinucleatum*												•	●	•																
13. *Loxophyllum pseudosetigerum*				•			•	•	●		•	●	●		•	•	●	•		●		•			•	•		•		
14. *Loxophyllum rostratum*							•					•	•																	
15. *Loxophyllum setigerum*												●	●	•	•		•	●	•			•	•	•			•			
16. *Loxophyllum uninucleatum*			•	•										•			•													
17. *Trachelocerca laevis*							●	•	•	•			•	•							•									
18. *Tracheloraphis aragoi*												•	•	•	•															
19. *Tracheloraphis discolor*								•			•		•	•	•			●					•							
20. *Tracheloraphis hyalinum*											•	•	●									•								
21. *Tracheloraphis indistinctus*													•	•																
22. *Tracheloraphis swedmarki*																•	•	•	•											
23. *Remanella granulosa*											•	•	•	•			•			•										
24. *Avelia gigas*												•	●																	
25. *Avelia martinicense*											•		•																	
26. *Chlamydodon mnemosine*						•	•	•	•	•		•	●	•	•	•														
27. *Dysteria monostyla*							•	●	●																					
28. *Frontonia marina*	•	•	●	•	•	•	•	•	•	•	•	●	●	•	•	•	•	•	•	•	•	•	•	•	•	•	●	•	•	•

29. *Frontonia vacuolata*							●	●																						
30. *Protocruzia depressa*			•		•	●	•	●	●					●	•	•	•	⬤				●	•		•	●				
31. *Pleuronema coronatum*		•	•	•				•	●	•					•	•	•		●		•		•	⬤			•	●		•
32. *Cyclidium citrullus*	•	●	●	⬤	●																									
33. *Cristigera setosa*	•	●	⬤	•	•																									
34. *Anigsteinia clarissimum*		•	•	•																										
35. *Blepharisma melana*											•	•	●	●																
36. *Gruberia aculeata*											•	●	⬤	•	•	•	•	●	⬤	•		•	•							
37. *Parablepharisma pellitum*											●	•	●	⬤	•		●	•	•											
38. *Spirostomum loxodes*											•	•	•	•	•															
39. *Metopus pellitus*						•		•	•	•			●	●	•	•	•	●	•	•										
40. *Condylostoma arenarium*												•	•																	
41. *Condylostoma magnum*													•	•	•															
42. *Condylostoma minima*													●	●																
43. *Condylostoma nigra*								•			●	•	●	●	●														•	
44. *Condylostoma patens*								•	•			●	•	•		•														
45. *Condylostoma reichi*													•	•																
46. *Condylostoma remanei*														•																
47. *Peritromus montanus*	•	•	●	•	•			•	•			•	●	•														•	•	
48. *Strombidium langenula*	●	•	⬤	•			•		•			●	●	•													•	•	●	
49. *Strombidium purpureum*	•	●	●	•	•			•	•			•	•	●														•		
50. *Strobilidium elegans*		•		•		•	•																							
51. *Strongylidium maritimum*										•	●	●	⬤		●	●	⬤	●	•		•	•	●	•						
52. *Keronopsis rubra*						•	•			•	•	•	●	•																
53. *Epiclintes felis*											•																			
54. *Oxytricha marina*											●	•			•	●	•		•	•	•	•	•			•	•	●	•	
55. *Aspidisca turrita*											•	⬤	⬤	⬤	●															
56. *Diophrys appendiculata*	•	•	●			●	•					●	⬤	●						•	•	•	⬤					•	⬤	●
57. *Euplotes cristatus*																						•	•	•						
58. *Uronychia setigera*			●	⬤		●	●			•	●	●	●	●					•	●	•			•	•	•	●	•		•
Abundance of Ciliates (No. x10^3 per cm^{-3} of sediment)	0.92	1.53	3.81	2.13	0.62	1.22	1.85	1.78	2.06	0.67	2.31	5.72	8.50	3.85	1.91	1.06	2.17	2.63	1.19	0.80	0.34	1.11	1.55	0.85	0.17	0.51	0.92	1.49	1.26	0.72
No. of Species	9	12	15	13	6	9	13	17	14	10	21	30	39	33	20	11	14	13	10	8	7	12	13	6	4	6	8	11	8	5
Total No. of Species	17					24					45					21					18					15				

Southampton Water in England (AL-Rasheid 1992, 1995), Suez Canal in Egypt (El-Serehy 1992), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali and Al-Hassa Oasis (AL-Rasheid 1996, 1997).

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) hroughout 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 sand 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 wormest month of July as it is in December (mean temepratures 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 pseudosetigerm, Frontonia marina, Protocruzia 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

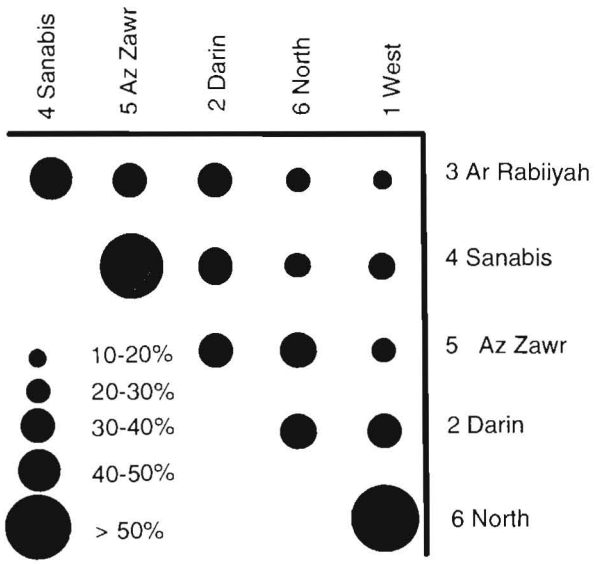

Fig. 8. The percentage similarity values of ciliate species composition between pairs of stations.

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).

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(Received 01/07/1996;
in revised form 07/12/1996)

سجل الأوليات الهدبية حرة المعيشة في المملكة العربية السعودية ٣ . الهدبيات البين رملية في جزيرة تاروت في الخليج العربي

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تم جمع عينات من الرمال البحرية من منطقة ما بين المد والجزر من ستة مواقع مختارة على جزيرة تاروت الواقعة قبالة شاطئ المملكة العربية السعودية شرقي واحة القطيف ، وتم تحليل التربة فيزيائياً لقياس نسب وأحجام حبيبات الرمل ونسبة المياه البين رملية ونسبة المواد العضوية الكلية . وتم عد وتصنيف الهدبيات القاطنة ووصف ٥٨ نوعا من الهدبيات البين رملية البحرية (المتعلقة بالرمال القاعية) من شواطئ جزيرة تاروت . والأنواع التي تم تسجيلها تنتمي إلى ٣٩ جنسا في ٢٧ فصيلة من فصائل الهدبيات ، ٤٣ منها تسجل لأول مرة كأنواع ضمن التواجد الحيواني 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 .