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Records of Marine Interstitial Heterotrichida (Ciliata) from the Saudi Arabian Jubail Marine Wildlife Sanctuary in the Arabian Gulf

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ABSTRACT. Sediment samples were collected at low tide from various localities of Jubail Marine Wildlife Sanctuary in the Arabian Gulf during 1996-1997 for the study of the marine interstitial ciliate fauna of the Sanctuary. Nineteen species belonging to the order Heterotrichida were identified, eleven of these represent new records for the fauna of the Arabian Gulf and Saudi Arabia: *Blepharisma seculum, B. hyalinum, Gruberia beninensis, Pseudoblepharisma tenue, Spirostomum teres, Metopus contortus, Condylostoma acuta, C. longicaudata, C. tardum, Linostoma vorticella,* and *Stentor niger.* The distribution and main taxonomic characters of each species were compared to those in similar habitats worldwide.

At the end of the 1991 Gulf War, an environmental rehabilitation plan, together with the establishment of the Jubail Marine Wildlife Sanctuary (JMWS) north of Jubail city were proposed by the concerned agencies in Saudi Arabia in conjunction with a Task Force from the European Union (Krupp and Khushaim 1996). One of the aims of the project, besides assessing ecological effects of oil spill, is to assess and document biological diversity of the various fauna and flora in order to generate baseline information on species and species assemblages, and to monitor the rehabilitation of coastal and marine habitats (Abuzinadah and Krupp 1994).

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 (Hartwig 1980, Patterson *et al.* 1989, Carey 1992). However, the marine interstitial ciliates of Saudi Arabia have long been neglected. Recently, some studies were undertaken on the ciliate fauna of Saudi Arabia (AL-Rasheid 1996, 1997a, b, 1998), nevertheless, the ciliates of Arabia remain poorly known. In conjunction with the establishment of JMWS several studies are being undertaken on the ciliate fauna of the Sanctuary. The current paper reports on the ciliates of the order Heterotrichida.

Materials and Methods

Samples were collected from August 1996 till December 1997 from coastlines of Jubail Marine Wildlife Sanctuary (JMWS) - (temperature ranged from 16 to 37 °C and salinity ranged from 34-61‰, see AL-Rasheid 1998 for complete description, map of the study area and outlined methodology). Undisturbed sediment samples were collected from the topmost 1-3 cm of submerged areas of the Sanctuary, between high and low tide marks and transferred to the laboratory in thermal containers. In the laboratory, ciliate samples were removed from the sand grains as described by Fauré-Fremiet (1951), studied *in vivo* in hanging drops over depression slides, and under cover slips supported by Vaseline rings. Intravital and specific stains were employed to observe the structure of the organisms (Foissner 1991). The infraciliature was revealed by Wilbert's (1975) method of protargol impregnation. Stained cells were studied, measured and photographed with a Nikon® Photomicrographic System attached to Nikon Alphaphot® microscope. The characteristics of each organism were then compared to descriptions in Carey (1992), Foissner *et al.* (1992) and Kahl (1932).

Results and Discussion

The present study revealed the presence of 19 species of heterotrich ciliates, 11 of which are new (marked by asterisks) to the fauna of Saudi Arabia, and of the Arabian Gulf at large. Specimens as slides of protargol impregnated cells of each species have been deposited in the Museum of Zoology Department, College of Science, King Saud University, Riyadh, Saudi Arabia. The following is a checklist of the recorded species arranged systematically according to Corliss (1979), each species is followed by a brief description. All data of the Saudi populations are based on measurements of at least 10 protargol impregnated specimens. Micrographs of each species are presented in Figs. 1-23.

Family: Spirostomidae Stein 1867

1. *Blepharisma melana* Borror 1963 (Fig. 1).

Elongate, cylindrical, 330-450 × 42-73 µm in length. Adoral zone of

membranelles (AZM) occupies one-third to one-half of body length. Thirty longitudinal somatic kineties. Undulating membrance (UM) well-developed, running from cytostome to apex of cell. Macronucleus moniliform. Contractile vacuole terminal. This species resembles the original description in shape of body and AZM, the number of somatic kineties, and moniliform macronucleus, but smaller in size (450-640 × 64-100 μm).

Distribution: Alligator Harbour in USA (Borror 1963), Caspian Sea (Agamaliev 1983), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

2. *Blepharisma seculum** Isquith *et al.* 1965 (Fig. 2, 3).

Small, pink color *in vivo,* 70-90 μm in length. Dorsal border curved. Somatic kineties 12-20, longitudinally arranged, narrow-spaced on one side, widely-spaced on the other side of the cell. AZM occupies one-half length of body. Macronucleus glabular to reniform, 10-14 × 4-8 μm. Contractile vacuole terminal. This species corresponds in size, shape, macronucleus and infraciliature with the original description.

Distribution: Maryland in USA (Isquith *et al.* 1965).

3. *Blepharisma hyalinum** Perty 1849 (Fig. 4).

Elongate, ca. 70 μm in length. Anterior curves over peristome. AZM occupies one-half to one-third of body length. UM present. Somatic kineties longitudinal, number 12-14. Macronucleus ellipsoidal, 15 × 10 μm. Contractile vacuole terminal. Although this is a freshwater and soil species, the Saudi population agrees with the redescription by Foissner (1989).

Distribution: Eutrophic pond in the Danish Island of Funen (Larsen and Nilsson 1983), Ivory Coast in West Africa (Dragesco and Dragesco-Kernéis 1986), soil samples from Austria (Foissner 1989), freshwater from Greenland (Larsen 1992).

4. *Gruberia aculeata* Ozaki and Yagiu 1941 (Fig. 5).

Elongate, lanceolate, 350 μm in length. Anterior does not curve over peristome. AZM occupies one-third of body length. UM well developed, consists of many dikinetidal fragments. Somatic kineties number 24-30. Macronucleus large, moniliform, consists of 10-15 ellipsoidal beads, each 15-25 × 7-21 μm. Twenty to thirty four micronuclei, 2-3 μm in diameter. No information of protargol-impregnated specimens was found in the available literature.

Distribution: Japan Sea (Ozaki and Yagiu 1941), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

5. *Gruberia beninensis** Dragesco and Dragesco-Kernéis 1986 (Fig. 6).

Lanceolate, orange in color, 200-300 μm in length, anterior curve over peristome, sharply-pointed posteriorly. AZM occupies one-half length of body. UM well developed, consists of many small, dikinetidal fragments. Somatic kineties

number 38-50. Macronucleus moniliforme, consists of 18-27 ellipsoidal beads, 9-12 × 4-6 μm. Micronuclei 40-50, 2-3 μm in diameter. Agrees with the original description by Dragesco and Dragesco-Kernéis (1986).

Distribution: Atlantic West African coast (Dragesco and Dragesco-Kernéis 1986).

6. *Pseudoblepharisma tenue** (Kahl 1926) Kahl 1927 (Fig. 7).

Elongate, 160 μm in length. Anterior part bluntly truncated, posterior rounded. UM and AZM extends one-quarter length of body. Somatic kineties longitudinal, number 9-12. Appeared rose in color due to many rod-shape symbiotic bacteria. Macronucleus ellipsoidal, 35 × 25 μm. Resembles the description in Foissner *et al.* (1992).

Distribution: Southern Louisiana (Bamforth 1963), Latvian rivers (Liepa 1978).

7. *Spirostomum teres** Claparède and Lachmann 1858 (Fig. 8).

Elongate, vermiform, cylindrical, contractile, 300 μm, 560 μm *in vivo* in length. Peristome occupies one-half of body length. Somatic kineties spiraling when contracted, numbered 20-27. Macronucleus ellipsoidal, 31-54 × 10-17 μm. Contractile vacuole terminal, with canal to anterior. Resembles the description of Foissner *et al.* (1992).

Distribution: Dee Estuary in UK (Webb 1956), French Atlantic coast (Dragesco 1960), Gulf of Mexico (Borror 1962), Mobile Bay in USA (Jones 1974), Mediterranean Po Delta (Ghidoni 1975), Hamburg Harbour in German Bight (Bartsch and Hartwig 1984), Shediac Harbor in Canada (Varma 1985), Caspian Sea (Agamaliev 1986), West African Ivory Coast and Cameroon (Dragesco and Dragesco-Kernéis 1986).

Family: Metopidae Kahl 1927

8. *Metopus contortus** (Quennerstdt 1867) Kahl 1932 (Fig. 9).

Ovoid, 100 μm in length. Anterior, rounded, twisted, posterior rounded. AZM long, curving down to two-third length of body. Somatic kineties 27-33. Tuft of caudal cilia present. Macronucleus ovoid, 10-15 μm. Contractile vacuole terminal. The Saudi population match well the redescription by Dragesco (1996).

Distribution: Gulf of Mexico (Borror 1962), New Hampshire coast in USA (Borror 1972), Baltic Sea (Czapik and Jordan 1976, Czapik and Fyda 1992), British Isles and North Sea (Wright and Knight-Jones 1990), Mediterranean French coast (Dragesco 1996).

Family: Condylostomatidae Kahl in Doflein and Reichenow 1927-9

9. *Condylostoma acuta** Dragesco 1960 (Fig. 10).

Elongate, cylindrical, 170-220 μm in length. Tail needle-like. Peristome short, wide, with UM and AZM, occupy one-fifth length of body. Pellicle pleated on contraction. Somatic kineties number 19-22. Macronucleus vermiform, 80-110 μm in length, 10-15 μm across. Matching the original description, except for the kineties number (14).

Distribution: French Atlantic coast (Dragesco 1960).

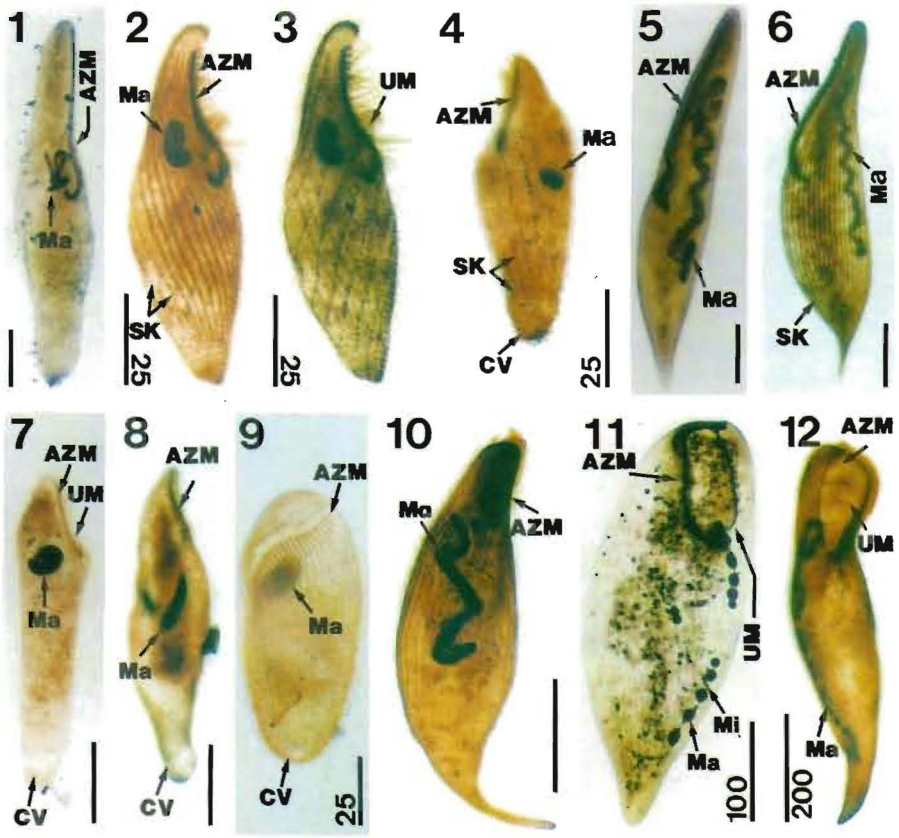

Fig. 1-12. Micrographs of protargol-impregnated ciliate species found in the Jubail Marine Wildlife Sanctuary. 1) *Blepharisma melana;* 2,3) *Blepharisma seculum;* 4) *Blepharisma hyalinum;* 5) *Gruberia aculeata;* 6) *Gruberia beninensis;* 7) *Pseudoblepharisma tenue;* 8) *Spirostomum teres;* 9) *Metopus contortus;* 10) *Condylostoma acuta;* 11) *Condylostoma arenarium;* 12) *Condylostoma magnum.* AZM, adoral zone of membranelles; CV, contractile vacuole; Ma, macronucleus; Mi, micronucleus; SK, somatic kineties; UM, undulating membrane. Bars = 50 μm, unless otherwise indicated.

10. *Condylostoma arenarium* Spiegel 1926 (Fig. 11).

Elongate, cylindrical, 300-400 μm in length. Peristome wide, occupies one-third of body length. AZM consists of 70-80 membranelles. Tail rounded. Somatic kineties number 40. Macronucleus moniliform, consists of 10-17 parts each about 11-15 μm across. Agrees with the redescription by (Dragesco and Dragesco-Kernéis 1986).

Distribution: Gulf of Naples (Nobili 1957), Atlantic Coast at Roscoff (Dragesco 1960), Barents Sea (Raikov 1960, Kovaleva 1967), Gulf of Mexico (Borror 1962), Alligator Harbour in Florida (Borror 1963), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Coast of Mauritania (Dragesco 1965), Black Sea (Kovaleva 1966, Bacescu *et al.* 1967, Petran 1975), Bay of Bengal (Rao 1969), White Sea (Burkovsky 1970), Coast of Brazil (Kattar 1970), New Hampshire coast (Borror 1972), Baltic Sea and German coast of the English Channel (Bock 1952, Czapik 1952, 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), Caspian Sea (Agamaliev 1986), West African coast of Benin (Dragesco and Dragesco-Kernéis 1986), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

11. *Condylostoma magnum* Spiegel 1926 (Fig. 12).

Elongate, highly contractile, ca 500-850 µm in length. Head region spatulate. Tail long, tapering. Peristome deep, wide, equipped with UM and AZM (90 membranelles), occupies one-forth to one-third of body length. Somatic kineties

Fig. 13-16. Micrographs of protargol-impregnated *Condylostoma longicaudata* found in the Jubail Marine Wildlife Sanctuary, showing various shapes of the nuclear apparatus from specimens of one site. Arrows indicate macronuclei. Bar = 200 µm.

numbered 80-90. Macronucleus moniliform, consists of 30-45 globular beads each 10-18 µm across. Agrees with the redescription by Dragesco and Dragesco-Kernéis (1986).

Distribution: Gulf of Florida (Bullington 1940), Gulf of Mexico (Borror 1962), Mobile Bay in the USA (Jones 1974), Mediterranean Sea (Ghidoni 1975), Caspian Sea (Agamaliev 1983), Cotonou at the Eastern African coast (Dragesco and Dragesco-Kernéis 1986), Al-Hassa Oasis in Saudi Arabia (AL-Rasheid 1997a), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

12. *Condylostoma longicaudata** Dragesco 1996 (Figs. 13-16).

Elongate, transparent, ca 400-600 µm in length. Tail long, pointed. Peristome small, equipped with UM and AZM (76-86 membranelles). Somatic kineties 30-36 (32 in Fig. 13; 30 in Fig. 14; 36 in Fig. 15; 34 in Fig. 16). Macronuclear apparatus nodular to moniliform (highly variable in shapes and numbers; (Figs. 13-16). Despite the macronucleus variability, the Saudi population agrees in size and somatic kineties with the original description.

Distribution: Mediterranean French coast (Dragesco 1996).

13. *Condylostoma patens* Dujardin 1841 (Fig. 17).

Elongate, 500 µm in length. Posterior broad, rounded. Peristome, UM and AZM occupy one-fifth of body length. AZM consists of 50-64 membranelles. Somatic kineties number 60-73. Macronucleus moniliform, consists of 7-12 globular beads each 20-30 µm across. No information of protargol-impregnated specimens was found in the available literature.

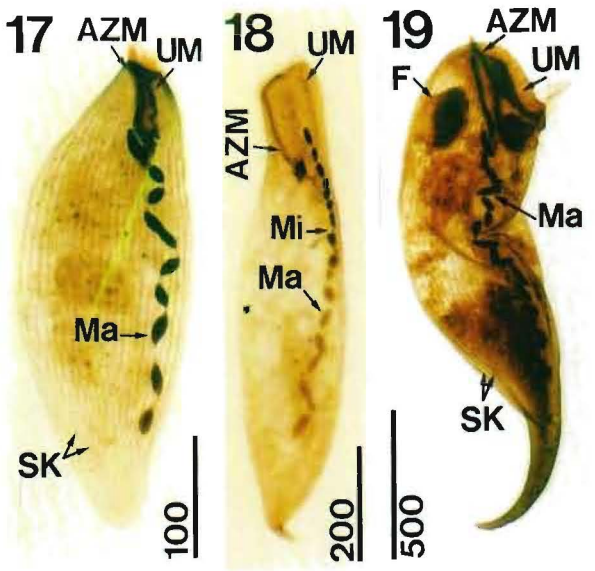

Fig. 17-19. Micrographs of protargol-impregnated ciliate species found in the Jubail Marine Wildlife Sanctuary. 17) *Condylostoma patents;* 18) *Condylostoma remanei;* 19) *Condylostoma reichi.* AZM, adoral zone of membranelles; F, food vacuole; Ma, macronucleus; Mi, micronucleus; SK, somatic kineties; UM, undulating membrane.

Distribution: Plymouth (de Morgan 1925, Lackey and Lackey 1963), Yellow Sea (Wang and Nie 1932), Woods Hole in USA (Lackey 1936), French Atlantic coast (Fauré-Fremiet 1948, Dragesco 1954), Cape Cod in east USA (Fauré-Fremiet 1951), Dee Estuary in the U.K. (Webb 1956), Whitstable in England (Maghraby and Perkins 1956), Gulf of Mexico (Borror 1962), Bay of Bengal (Rao 1969), Baltic Sea (Hartwig 1974), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

14. *Condylostoma remanei* Spiegel 1928 (Fig. 18).

Elongate, broad, anterior spatulate, terminating in sharply pointed tail. Attains 1 mm in length. Peristome wide, occupies one-quarter of body length. AZM consists of 95-125 membranelles. Somatic kineties number 30-34. Macronucleus moniliform, consists of 13-20 beads, each 20-30 μm in length. Agrees with the original description.

Distribution: Mediterranean and Atlantic Coasts of France (Fauré-Fremiet 1950, Dragesco 1960, 1963, Ghidoni 1975), Cape Cod in east USA (Fauré-Fremiet 1951), Gulf of Naples (Nobili 1957), Barents Sea (Raikov 1960, Kovaleva 1967), Marseille Bay in Monaco (Vacelet 1961), Gulf of Mexico (Borror 1962), Japan Sea at Ussuri (Raikov 1963) and at Posjet Gulf (Raikov and Kovaleva 1968), Black Sea (Kovaleva 1966, Bacescu *et al.* 1967, Petran 1975), Caspian Sea (Agamaliev 1983), Baltic Sea (Bock 1952, Czapik 1952, Fenchel 1969, Hartwig 1974), Brazilian Coast (Kattar 1970), Island of Sylt in the German Bight (Hartwig 1973), 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), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

15. *Condylostoma reichi* Wilbert and Kahan 1981 (Fig. 19).

Elongate, 1.5-2.5 mm in length. Head region and peristome greatly enlarged. Body flattened ventrally. Highly contractile. AZM consists of more than 200 membranelles. Somatic kineties number 72-98. Macronucleus moniliform, 15-22 beads each 30-35 μm in length. Contractile vacuole large, posteriorly located. Agrees with the original description from the Red Sea and with the recent redescription by Dragesco and Dragesco-Kernéis (1986).

Distribution: Red Sea (Wilbert and Kahan 1981), Cotonou at the Eastern African coast (Dragesco and Dragesco-Kernéis 1986), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

16. *Condylostoma nigra* Dragesco 1960 (Fig. 20).

Ovoid, 150-200 μm in length. UM large, peristome occupies one-third of body length. AZM consists of 61-80 membranelles. Somatic kineties number 20-32. Macronucleus moniliform, consists of 10-13 beads, each 20-24 μm in length. Agrees with the original description.

Distribution: French Atlantic coast (Dragesco 1960), Saudi Arabian Gulf Islands of Al-Batinah and Abu Ali (AL-Rasheid 1996), Saudi Arabian Gulf Island of Tarut (AL-Rasheid 1997b).

17. *Condylostoma tardum** Penard 1922 (Fig. 21).

Ovoid, 200-250 μm in length. Peristome small, curving, occupies one-quarter length of body. AZM consists of 33-52 membranelles. Somatic kineties number 30-35. Macronuclei consists of three large ovoid beads each, 27-38 μm in size. Micronuclei three, 8-12 μm in diameter. The size, shape of cells, and numbers of

macro and micronuclei conform with the original description.

Distribution: French Atlantic coast (Dragesco 1960), Baltic Sea (Czapik and Jordan 1976).

18. *Linostoma vorticella** (Ehrenberg 1833) Jankowski 1978 (Fig. 22).

Condylostoma vorticella (Dujardin 1841) Penard 1922

Ovoid, ca. 100 µm in length. Peristome V-shaped, equipped with UM, occupies

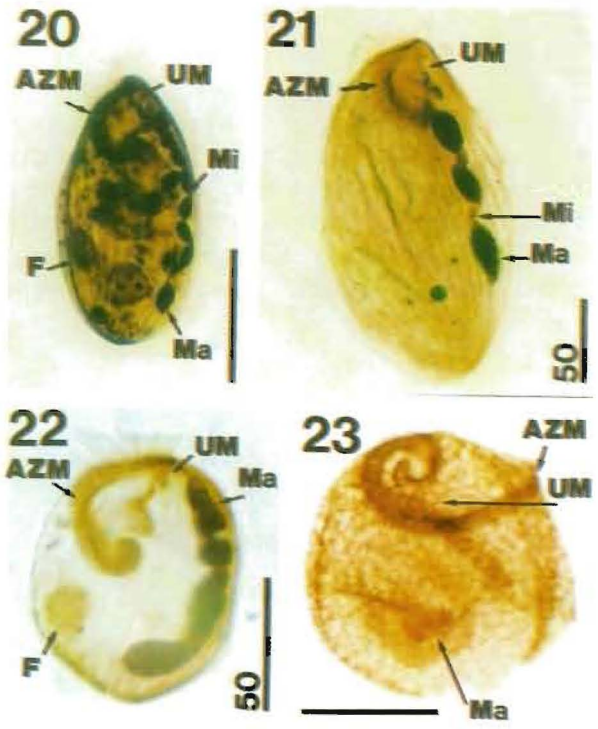

Fig. 20-23. Micrographs of protargol-impregnated ciliate species found in the Jubail Marine Wildlife Sanctuary. 20) *Condylostoma nigra;* 21) *Condylostoma tardum;* 22) *Linostoma vorticella;* 23) *Stentor niger.* AZM, adoral zone of membranelles; F, food vacuole; Ma, macronucleus; Mi, micronucleus; SK, somatic kineties; UM, undulating membrane. Bars = 100 µm, unless otherwise indicated.

one-half of body length. AZM consists of 40 membranelles. Somatic kineties number 30. Macronucleus moniliform, consists of 4-6 beads. Contractile vacuole terminal. The Saudi population agrees with the recent redescription by Foissner *et al.* (1992).

Distribution: Atlantic coast of Cameroon (Dragesco 1970), Mobile Bay in USA (Jones 1974), Hamburg Harbour in German Bight (Bartsch and Hartwig 1984), Caspian Sea (Agamaliev 1986).

19. *Stentor niger** (Müller 1773) Ehrenberg 1831 (Fig. 23).

Trumpet-shaped to avoidal, ca. 200 µm in length. AZM, UM spiraling; AZM consists of 150 membranelles. Somatic kineties spiraling on contraction, number 55-60. Macronucleus ellipsoidal, 30 µm in diameter. Subpellicular granules

yellow-brown in color, which make the cells appear dark *in vivo*. Symbiotic algae absent. This genus have been revised by Foissner and Wölfl (1994).

Distribution: Atlantic coast of Gabon (Dragesco 1966), Cameroon (Dragesco 1970), and Uganda (Dragesco 1972).

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سجل الهدبيات البين رملية البحرية حرة المعيشة من رتبة Heterotrichida من محمية الجبيل البحرية في الخليج العربي بالمملكة العربية السعودية

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تم جمع عينات من الرمال البحرية من مواقع مختلفة أختيرت في المنطقة ما بين المد والجزر على شواطئ محمية الجبيل البحرية في الخليج العربي خلال عامي ١٩٩٦ و ١٩٩٧م ، وتم تعريف الهدبيات القاطنة ، حيث وُصِفَ ١٩ نوعاً من الهدبيات البين رملية البحرية (المتعلقة بالرمال القاعية) التي تنتمي إلى رتبة Heterotrichida ، وتمثل ٨ أجناس في ٣ فصائل من فصائل الهدبيات ، وقد وُجِدَ أن ١١ نوعاً منها تسجل لأول مرة كأنواع ضمن التواجد الحيواني لكل من الخليج العربي والمملكة العربية السعودية . وقد تم مقارنة توزيع كل من الأنواع الموصوفة ضمن المحمية بالتوزيع العالمي لهذا النوع .