ON THE INTERSTITIAL CILIATE FAUNA OF BERMUDA (1)

by

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Résumé

Faune interstitielle des Ciliés des Bermudes.

La présence de onze espèces de Ciliés mésopsammiques récoltés dans les sédiments de deux stations des Bermudes (Tuckers Town Beach: eu littoral; North Reef: sublittoral) est signalée et ces Ciliés sont décrits par leurs caractères morphologiques.

Sept espèces sont déjà connues de la côte orientale des Etats-Unis.

Les possibilités de colonisation («means of dispersal») des Iles sont discutées et l'auteur essaie de montrer les difficultés de révision en ce qui concerne les possibilités de la distribution.

Introduction

The taxonomic studies concerning the interstitial ciliates conducted recently in widely separated parts of the world have shown **a** remarkable degree of identity of species reported from different continents (Agamaliev, **1969;** Burkovsky, **1970** a). This supports the hypothesis of Fauré-Fremiet **(1950),** that the interstitial ciliates **as** well **as** the meiofauna of the lacunar system of marine beaches (Rao, **1974)** have a cosmopolitan distribution. Our knowledge of the geographical distribution of the interstitial ciliates is still incomplete due to lack of sufficient data from many parts of the world. There is a considerable lack of information concerning the coasts of South America, Africa, Australia, the Far East and the islands of the Indo-Pacific region.

From the east coast of the United States faunistic-systematic papers on interstitial ciliates are known from Borror **(1963** a, b), Fauré-Fremiet **(1951)** and Jones **(1974).** The Islands of Bermuda, nearly **800** miles off the east coast of North America, are still protozoologically virgin territory. An intense study of the ciliate fauna of these islands is of special interest and in comparison with the fauna of the atlantic coast of North America means of dispersal **for** the interstitial ciliates could be discussed. The studies shall be a first contribution to the ciliate fauna of Bermuda.

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Material and Methods

The sampling was carried out at Tuckers Town Beach and on the North Reef (Fig. 1) during September 1975.

Tuckers Town Beach is located in a small secluded bay opening to the South-West into Castle Harbor. The bay is well protected and the beach consists of fine calcareous sand with a mean grain size of 250 µm (Farris, 1975). Two sites were chosen, called «flat» and «sandbar».

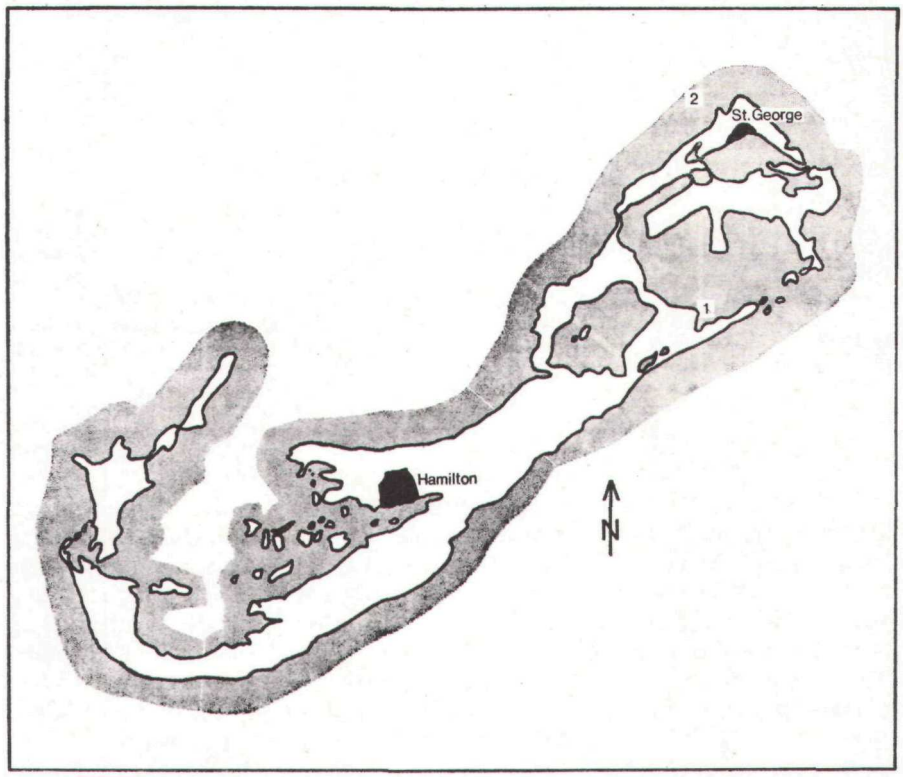

FIG. 1
Location of sampling stations.
1: Tuckers Town Beach; 2: North reef.

The North Reef is located nearly 7 miles off the North coast of Bermuda. The sediment from a depth of 3 to 4 m had a mean grain size of more than 500 µm. It consists of calcareous sand.

The ciliates were extracted from the sediment by the seawater-ice-method (Uhlig, 1968; Uhlig, Thiel and Gray, 1973) and worked out alive. The drawings were made from living material and by known stainings and fixation (see Hartwig, 1973 a).

For the classification of species the scheme proposed by Corliss (1975) was used.

DESCRIPTION OF SPECIES

The 11 species, recorded at the two sampling stations, were described in systematic order.

CLASS KINETOFRAGMINOPHORA

Order Karyorelictida

Family **Geleiidae**

Geleia nigriceps Kahl, 1933 (Fig. 2 A)

Locality:

Tuckers Town Beach (sandbar and flat).

Body length between 500 and 800 µm by a mean width of 42 µm in the anterior and 94 µm in the posterior part of the cell. Anteriorly the clearly pointed beak («bec», Dragesco, 1960) is lacking, which is present at the rest of the *Geleia* species. The anterior margin of the peristome is vaulted forward and clearly rounded. The frontal groove present at the rest of the *Geleia* species is lacking. The posterior end is narrowed and conically rounded. The 25-35 somatic ciliary rows are reaching the anterior end of the complete breadth, but end posteriorly polarly. The length of the somatic cilia is 8 µm**,** The body is brownish pigmented and the vacuolated cytoplasm contains diversely distributed granules: the anterior end is not as much granulated as specimens described by Dragesco (1960) and is therefore lighter up to the end of the «neck» as the rest of the cell. The nuclear apparatus, in the center of the cell, consists of 2 macronuclei (MaN) with an intercalary micronucleus (MiN). Algues were taken up as food.

Mesopsammal distribution:

Kiel Bay (Bock, 1952 a; Kahl, 1933), Norwegian Coast (Fjeld, 1955), boreal coasts of the U.S.S.R. (Burkovsky, 1970, a, b, c; Kovaleva, 1967; Raikov, 1960, 1962), French Atlantic Coast (Dragesco, 1960), Black Sea (Kovaleva, 1966; Petran, 1968 a, 1971), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), North Sea Island Sylt (Hartwig, 1963 a, b).

Geleia orbis Fauré-Fremiet, 1950 (Fig. 2 B)

Locality:

Tuckers Town Beach (sandbar).

Body length: 1360 µm. Very slender, cylindrical and flexible body shape with a long extended, hook-like tail. The animals were

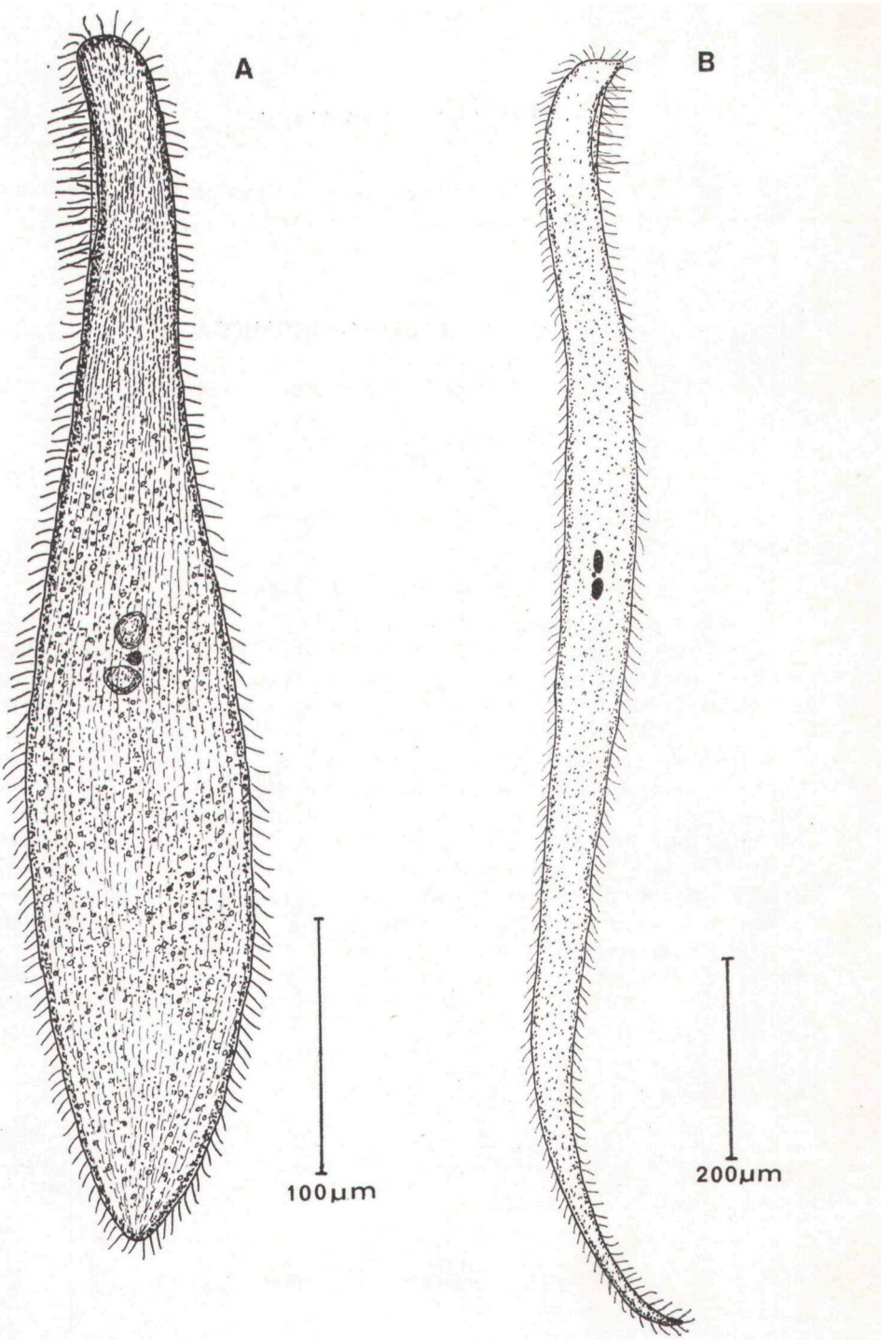

FIG. 2

A: *Geleia nigriceps* (general aspect); B: *Geleia orbis* (schematic).

of brown colour, the shade of which became lighter towards the anterior end. Nearly 40 ciliary rows at each body side. The anterior end is above the clearly visible peristome extended to **a** «beak». The nuclear apparatus consists of 2 MaN, which are forming a single group (MiN were not visible).

Mesopsammal distribution:

French Coast (Dragesco, 1953, 1960; Fauré-Fremiet, 1950), Norwegian Coast (Fjeld, 1955), Black Sea (Kovaleva, 1966; Petran, 1967, 1968, a, 1971), White Sea (Burkovsky, 1970 a, c; Raikov, 1962), Barents Sea (Kovaleva, 1967; Raikov, 1960), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), Cap Cod (East Coast of the U.S.; Fauré-Fremiet, 1951), Brazilian Coast (Kattar, 1970), Gulf of Naples (Nobili, 1957).

Family Trachelocercidae

Tracheloraphis incaudatus (Kahl, **1933)**

Locality:

North Reef (3-4 m depth).

Body length 900 *µm.* Body form slender with «burled» body sides visible by contraction (Dragesco, 1960**).** Broadly rounded posteriorly. Mouth terminal, funnel-shaped, without a longitudinal slit at its dorsal edge. Wide glabrous stripe. The nuclear apparatus consists of *6* MaN forming a single group.

Tracheloraphis incaudatus is placed together with other species of this genus in an «*incaudatus*»—complex (Borror, 1973). The morphological features of these «*incaudatus*»—species are listed up by Hartwig and Parker (1976).

Mesopsammal distribution:

Baltic Sea (Bock, 1952 a, 1960; Kahl, 1930-35), Coast of North Yorkshire (England; Hartwig and Parker, 1976), French Atlantic Coast (Dragesco, 1960), Gulf of Naples (Nobili, 1957), Bay of Bengal (Rao and Ganapati, 1968), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), Caspian Sea (Agamaliev, 1967 a, b, 1970), Russian and Rumanian Coast of the Black Sea (Kovaleva, 1966; Petran, 1967, 1968 a, 1971), White Sea (Burkovsky, 1969, 1970 a, b, c, 1971; Raikov, 1962), Norwegian Coast (Fjeld, 1955) and the Northern Adriatic Sea (Kiesselbach, 1936).

Order Prostomatida

Family **Colepidae**

Coleps tesselatus Kahl, 1930 (?)

Locality:

Tuckers Town Beach (flat).

Very large specimens **(**128 µm). The body is laced at equator. The specimen was determined as *Coleps tesselatus* according to the

type of pellicular plates as described by Kahl (1930; p. 133, fig. 19.17). The plates are of the following shape: no arrangement of a frame or «windows» (as at *Coleps hirtus, C. nolandi* and others), the main ridge is developed in the middle of the plate, the wave-like main ridge is caused by arched stiffening of the bottom side of plates (therefore clearly to separate from *Coleps pulcher).* 3 lateral anterior spines at each body side. A difference to the descriptions of *Coleps tesselatus* by Kahl (1930) consists in the number of caudal spines: altogether 7 spines are partitioned into three groups; a terminal group of 2 spines, one latero-terminal group of 2 and one latero-terminal group of 3 spines (Kahl, 1930: 3-5; Hartwig, 1973 a: 3-4 spines). A number of papers correspond in the opinion that the number of caudal spines is not the important species-specific feature, but that the type of the ectoplasmatic plates is more important and such a species-specific feature. So this specimen is determined as *Coleps tesselatus.*

Mesopsammal distribution:

Cape Cod (American East Coast; Fauré-Fremiet, 1951), Island of Sylt (Hartwig, 1973 a; Kahl, 1930), Kiel Bav and Western Baltic Sea (Bock, 1952 a, 1960; Fenchel and Jansson, 1966), Hiddensee Island (Baltic Sea; Petzold, 1955), Atlantic Coast of France (Roscoff, Dragesco, 1960; Concarneau, Fauré-Fremiet, 1950), Mediterranean Sea (Marseilles, Vacelet, 1961 a, b; Naples, Nobili, 1957), boreal coasts of the U.S.R.R. (Burkovsky, 1969, 1970 b, c; Kovaleva, 1967; Raikov, 1960), Caspian Sea (Agamaliev, 1967 a, 1974 b), Japan Sea (Raikov, 1963), Bay of Bengal (Rao and Ganapati, 1968), Black Sea (Petran, 1971).

Family Enchelyidae

Helicoprorodon multinucleatum Dragesco, 1960 (Fig. 3)

Locality:

Tuckers Town Beach (flat).

Large, worm-shaped species with body length of 1000 µm (one specimen only 400 µm). The anterior end, filled with granules and darker than the rest of the cell, has no «horns» like the more or less pronounced in *Helicoprorodon barbatus, H. maximus* and *H. minutus* (see Dragesco, 1960). The contractile vacuole is posterior. The cytoplasm contains trichites irregularly distributed and bundled. The nuclear apparatus consists of a large number of small, spherical MaN (a clear separation from *H. gigas).* A difference to *H. maximus* with a similar nuclear apparatus is existing in the arrangement of ciliary rows at the mouth region: the anterior ciliature of *H. maximus* curves in two horizontal rings (see Dragesco, 1960; p. 90, fig. 28): in *H. multinucleatum,* the rings are more inclined. Dragesco stated in *H. maximus* a more plicated ectoplasm similar to that of the Trachelocercidae. This was not found in *H. multinucleatum* from Bermuda.

Mesopsammal distribution:

White Sea (Raikov, 1962), French Atlantic Coast (Dragesco, 1960), Brazilian Coast (Kattar, 1970).

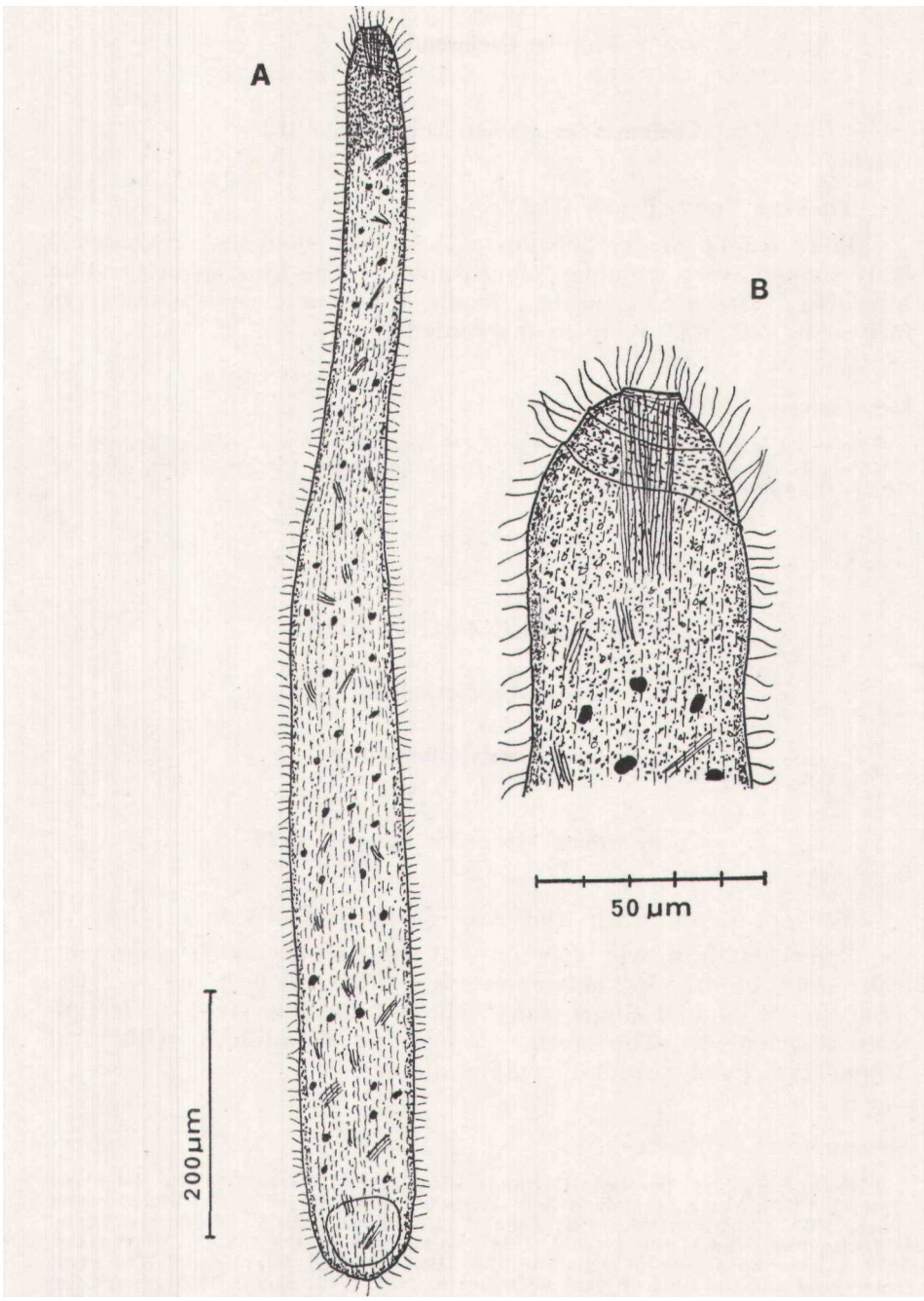

FIG. 3

Helicoprorodon multinucleatum.

A: general aspect; B: anterior part.

Order Trichostomatida

Family Coelosomididae

Coelosomides ***marina*** Anigstein, **1912**

Locality:

Tuckers Town Beach (flat).

Body length nearly **200** µm. The ovoid elongated, cylindrical body shape is very variable. Mouth apical. The kineties are ending bipolarly. The ectoplasm is reticular. The nuclear apparatus is formed by one **MaN** lying in the center.

Mesopsammal distribution:

French Coast (Dragesco, 1960; Fauré-Fremiet, 1950), Caspian Sea (Agamaliev, 1967 a, b), Black Sea (Petran, 1971), Brazilian Coast (Kattar, 1970), Bay of Bengal (Rao and Ganapati, 1968).

CLASS POLYHYMENOPHORA

Order Heterotrichida

Family **Condylostomatidae**

Condylostoma arenarium Spiegel, **1926**

Localities:

Tuckers Town Beach (flat) and North **Reef (3-4** m depth).

Body length nearly **600 µm.** Body circular in cross-section, contractile, bluntly flattened anteriorly, rounded posteriorly. Between the **28** parallel ciliary rows yellow protrichocysts were irregularly distributed. The nuclear apparatus moniliform with oval fragments. Food vacuoles contain diatoms.

Mesopsammal distribution:

North Yorkshire Beaches (England; Hartwig and Parker, 1976), Helgoland (Spiegel, 1926), North Sea Island Sylt (Hartwig, 1973 a, b), Kiel Bay and Oresund (Bock, 1952 a, b; Fenchel, 1969; Fenchel and Jansson, 1966), Hiddensee Island (Munch, 1955; Munch und Petzold, 1958), boreal seas of the U.S.S.R. (Burkovsky, 1970 a, b, c; Kovaleva, 1967; Raikov, 1960, 1962), French Atlantic and Mediterranean Coast and the Gulf of Naples (Dragesco, 1953, 1960; Nobili, 1957), Black Sea (Czapik, 1952; Kovaleva, 1966; Petran, 1963, 1967, 1968 b, 1971), Caspian Sea (Agamaliev, 1967 a, 1970, 1972, 1973, 1974 a, b), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), American East Coast (Borror, 1963 b), Bay of Bengal (Rao and Ganapati, 1968), Coast of Mauretania (Dragesco, 1965), Brazilian Coast (Kattar, 1970).

Condylostoma remanei Spiegel 1928

Locality:

Tuckers Town Beach (flat).

Body length nearly 400 µm. Conforms with the descriptions by different authors in body shape (the cell body tapers towards the posterior end to a distinct, short tail), ciliary rows and nuclear apparatus (a chain of 15 MaN fragments; which serves as a clear separation from *Condylostoma fjeldi* Hartwig, 1973 a).

Mesopsammal distribution:

Beaches of North Yorkshire (England; Hartwig and Parker, 1976), Kiel Bay (Bock, 1952 a, 1960; Kahl, 1930-35; Spiegel, 1926), Island Sylt (Hartwig, 1973 a, b), Oresund (Denmark; Fenchel and Jansson, 1966), Norwegian Coast (Field, 1955), boreal seas of the U.S.S.R. (Burkovsky, 1970 a, b, c; Kovaleva, 1967, Raikov, 1960, 1962), French Atlantic and Mediterranean Coast (Dragesco, 1953, 1960, 1963; Fauré-Fremiet, 1950; Vacelet, 1961 a), Gulf of Naples (Nobili, 1957), Black Sea (Czapik, 1952; Kovaleva, 1966; Petran 1967, 1968 a, b, 1971), Caspian Sea (Agamaliev, 1967 a, b, 1970, 1974 b), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), American East Coast (Cape Cod; Fauré-Fremiet 1951), Brazilian Coast (Kattar, 1970).

Family **Peritromidae**

*Peritromus **taurei*** Kahl, 1932

Locality:

Tuckers Town Beach (sandbar).

Body length of the examined specimens 100 µm. Oval body shape. On the unciliated dorsal side, a dark granulated hump is visible; this hump corresponds to the «dorsal body» by Kahl (1932). Spines on this dorsal hump not clearly visible. The nuclear apparatus consists of 2 nearly opposite macronucleus fragments.

Mesopsammal distribution:

Kiel Bav (Bock, 1952 a, 1960), Island Sylt (Hartwig, 1973 a, b), Norwegian Coast (Fjeld, 1955), White Sea (Burkovsky, 1970 a, b, c; Raikov, 1962), French Atlantic and Mediterranean (England; Hartwig and Parker, 1976), Caspian Sea (Agamaliev, 1967 a, 1968, 1972, 1974 b), Japan Sea (Raikov, 1963; Raikov and Kovaleva, 1968), East Coast of the U.S. (Borror, 1963 b) and Black Sea (Czapik, 1952; Petran, 1971).

Order Hypotrichida

Family Spirofilidae

Urostrongylum caudatum Kahl, 1932

Locality:

Tuckers Town Beach (flat).

This widely distributed species goes conform with the descriptions of different authors (Dragesco, 1960; Kahl, 1930-35; a.o.). By

the intense granulation of the cytoplasm, the body is clearly distinguished from the light spine-like pointed tail.

Mesopsammal distribution:

North Sea Island Sylt (Hartwig, 1973 a), Western Part of the Baltic Sea (Bock, 1952 a; Fenchel, 1969), French Atlantic Coast (Roscoff; Dragesco, 1960), Gulf of Naples (Nobili, 1957), Caspian Sea (Agamaliev, 1967 a, 1972, 1974 b), White Sea (Burkovsky, 1970 a, b, c), East Coast of the U.S. (Fauré-Fremiet, 1951), Brazilian Coast (Kattar, 1970), Plymouth Area (England; Lackey and Lackey, 1963).

Family Urostylidae

Epidintes ambiguus (O.F. Millier, 1786)

Locality:

Tuckers Town Beach (sandbar).

Body length 200 µm. Body shape and ciliature correspond with descriptions of different authors. More than 30 macronuclei, oval.

Mesopsammal distribution:

Sylt (Hartwig, 1973 a), Baltic Sea (Bock, 1952 a, 1960; Kahl, 1930-35; Munch, 1955; Munch and Petzold, 1958), White Sea (Burkovsky, 1970 a, b, c; Raikov, 1962), Gulf of Naples (Nobili, 1957), French Atlantic and Mediterranean Coast (Dragesco, 1953, 1960; Fauré-Fremiet, 1950; Vacelet, 1961 a, b), Black Sea (Koyaleva, 1966; Petran, 1971), Caspian Sea (Agamaliev, 1971, 1974 b), Japan Sea (Raikov, 1963; Raikov and Kovalepa, 1968), Bay of Bengal (Rao and Ganapati, 1968; Rao 1969), American Atlantic Coast (Borror, 1963 b; Fauré-Fremiet, 1951), Coast of Mauretania (Dragesco, 1965), Brazilian Coast (Kattar, 1970), English Coast (Hartwig and Parker, 1976; Lackey and Lackey, 1963).

CONCLUSIONS

7 from the 11 species recorded so far from the sand lacunar system of Bermuda are already known from the East Coast of the U.S. (Borror, 1963 b; Fauré-Fremiet 1951): *Coleps tesselatus, Condylostoma arenarium, Condylostoma remanei, Epidintes ambiguus, Geleia orbis, Peritromus faurei* and *Urostrongylum caudatum.* An intense study of the ciliate fauna of the Bermuda would probably reveal a high conformity with the fauna of the Atlantic Coast of the United States. Sterrer (1973) determined for the gnathostomulids of Bermuda, that over 50 percent of the gnathostomulid species identified on these islands are known from the U.S. East Coast. Here now the question for the means of dispersal concerning the bridging of larger distances of open water for the interstitial sand fauna is generally of special interest (Gerlach, 1976). The reply to this question is interesting for two reasons and tough too: (1) for the meiofauna, a reduction of free-swimming larval stages is known

(Ax, 1966, 1969; Swedmark, 1964), (2) for the meio- and microfauna (to this I add the ciliates) a world-wide distribution is known in spite of their restriction to the lacunar system (Corliss and Hartwig 1976; Rao, 1974). For the possible colonization of the Bermuda, about one month's travel by Gulf Stream away from Florida, by the meiofauna from the U.S. East Coast, Sterrer (1973) gives an explanation, which also can be valid for the sand microfauna: «short-range transport by... rafting of small quantities of sand on floating objects, or transport of organisms on rafts that provide a quasi-interstitial biotope such as coconuts is a possibility». However a proof for this explanation must be still given.

Acknowledgements

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Summary

From two sampling stations on Bermuda (Tuckers Town Beach: eulittoral; North Reef: sublittoral) 11 interstitial ciliate species are recorded and their morphological features given; 7 species are known so far from the U.S. east coast. In this connexion, the means of dispersal e.g. for the colonization of island are discussed and the difficulties of verification of these means of dispersal are shown.

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