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Marine gastrotrichs from the sand beaches of the northern Gulf of Mexico: species list and distribution

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Abstract

In this meio-faunistic survey along the northern coast of the Gulf of Mexico, gastrotrichs were found in sand collected mostly from beaches on barrier islands. Sediment from Florida and Alabama contained the largest species number. South Texas collecting sites also hosted a very diverse gastrotrich fauna. Paucitubulate Chaetonotida, previously unreported from the area, accounted for about one half of the 45 species encountered. After comparing local specimens also with high resolution videosequences of individuals collected from distant geographic regions, the amphi-Atlantic and/or cosmopolitan distribution of 27 of these species, is confirmed.

Introduction

Gastrotricha are aquatic micrometazoans, commonly considered a separate phylum or among the aschelminthes, as being closely related to the nematode round worms. In interstitial marine sediment, gastrotrichs typically rank third in abundance among the meiofaunal taxa behind the Nematoda and the harpacticoid Copepoda, although in a South Carolina location they were found to be the second most abundant taxon over an 11 year period (Coull, 1985). Gastrotricha live between the grains of sand of beaches and feed on microalgae, bacteria and occasionally on protozoans such as flagellates or foraminiferans. They have no larval stage and spend their entire existence within the sediments. Despite this life history, many species are not restricted to confined areas, but instead seem to have a widespread geographic distribution with some amphi-Atlantic or broader cosmopolitanism having been reported (Saito, 1937; Wieser, 1957; Ruppert, 1977).

Currently, gastrotrich taxonomy is based solely on morphometric data. Museum specimens are rare and often of poor comparison quality and species identifications typically rely on comparisons of the specimens of interest with published descriptions and ichnographic material when this is available. A conspicuous number of misidentifications may have derived from such an approach, which in turn may have lead to overestimation of the number of truly cosmopolitan species (Sterrer, 1972). Recently Evans & Hummon (1991), Hummon *et al.* (1992), Evans (1992), and Hummon *et al.* (1993), have utilized a novel technique that should reduce such problems. Beside the classic approach of describing and figuring, specimens are also recorded on high-resolution, image-enhanced videotapes. The resulting video database is used to morphologically compare individuals that are found in distant geographic areas. Indeed, videomicroscopy using differential interference contrast optics, as well as scanning electron microscopy, makes gastrotrich taxonomy and hence the zoogeography of this group far more reliable.

These advances have coincided with a new interest in the biogeography of gastrotrichs (Hummon *et al.*, 1991; Todaro *et al.*, 1991; Balsamo *et al.*, 1992; Clausen, 1992; Evans & Hummon, 1992; Evans, 1992, 94; Hummon, 1992; Hummon *et al.*, 1992; Todaro, 1992; Todaro *et al.*, 1992; Hummon *et al.*, 1993). As yet, none of those papers deals with the gastrotrichs of the Gulf of Mexico, and no satisfactory taxonomic survey has ever been carried out in this region. To date only 6 genera of gastrotrichs (*Acanthodasys*, *Dolichodasys*, *Macrodasys*, *Neodasys*, *Tetranchyroderma* and *Turbanella*) and three species (*Dolichodasys carolinensis*, *D. elongatus* and *Turbanella ocellata*) have been reported (Friauf, 1968; Ruppert & Shaw, 1977; Fox & Powell, 1986; Meyers *et al.*, 1987; Meyers *et al.*, 1988). It is a common belief that the finer sediment (mean grain size of 200 μm or less), which characterizes most of the northern Gulf shore, is an unsuitable environment for psammic organisms, particularly gastrotrichs (Wieser, 1959; Giere, 1993). However reports in the region of some of the most speciose macrodasyid genera (i.e. *Macrodasys*, *Tetranchyroderma*), and the absence of paucitubulate chaetonotids records both suggest that a more diverse gastrotrich fauna may in fact populate the area.

The purpose of this research is to assess gastrotrich species diversity and distribution along the U.S. coasts of the Gulf of Mexico. In a larger framework, added information regarding this poorly understood segment of the northern Gulf of Mexico gastrotrich fauna should contribute to future debates of global gastrotrich biogeography.

Environmental context

The area investigated extends for some 1200 miles and comprises the coasts of Texas, Louisiana, Mississippi, Alabama and northwestern Florida. Most of these coastlines are characterized by bays and estuaries that are separated from the continental shelf by barrier islands. The tidal regime is diurnal with amplitude rarely exceeding 0.5 m. High freshwater inflow is characteristic of the eastern coast of Texas, and of Louisiana and Mississippi; consequently salinity is low and turbidity is high. The reduced fresh-water inflow in the regions of south Texas and western Florida results in higher salinity and lower suspended matter in the water column (Britton & Morton, 1989).

Materials and methods

Most of our samples were taken at locations along barrier islands facing the ocean. Collections of sandy sediment (along with measurements of temperature and salinity) from the littoral and/or sublittoral sites, were made at 25 locations for a total of 34 sites over a two year period, 1991–93 (Fig. 1; Table 1). Littoral samples were taken at the Mid-Water-Mark either by digging 30 cm deep holes in the beach and removing sediment from the wall and bottom of the hole using a spoon or by inserting into the sediment a hand-held piston core, 2.5 cm inner diameter. Bulk sublittoral samples were taken at 1.5–2.0 meter depth using a 1.5 l plastic scoop. In all cases, sediment from each site was placed in three 200 ml plastic bags, and brought to the laboratory within 48 h. In the laboratory the sediment was kept in a cold-room at 14 °C and processed within one week. This time period is well within a gastrotrich life expectancy under those conditions. Specimens were extracted daily by the narcotization-decantation technique (Pfannkuche & Thiel, 1988) using a 7% magnesium chloride solution. Living, relaxed individuals were observed and identified using differential interference contrast optics with a Microphot-FXA Nikon microscope. At that time gastrotrichs were photographed and/or recorded on S-VHS video tape. Measurements of specimens were obtained from photographs or from video images. Some specimens were also examined with a Cambridge videoscan microscope. For S.E.M., animals were prepared according to Todaro, (1992).

Granulometric analysis of the substrata was carried out according to Giere *et al.*, (1988). Mean grain size, sorting coefficient, kurtosis, and skewnes were calculated by a computerized program based on the equations of Seward-Thompson & Hail (1973). Suspended matter was calculated by filtering 250 ml of water (previously treated with 10 formalin and filtered through a 500 μm sieve) through a pre-weighed 0.45 μm filter. Filters were then dried overnight at 60 °C, and desiccated for at least two hours at room temperature. Dry weights were obtained to the nearest 1 mg.

A species was defined as common when found in 30–60% of a sample series; rare when it constituted less than 1% of gastrotrichs found in a sample; numerous when it constitutes 10–20% of gastrotrichs of a sample (often a sub-dominant); prevalent when it constitutes more than 30% of a sample (usually a co-dominant or dominant), (as in Hummon *et al.*, 1993).

Cluster analysis, was performed with the Statistical Analysis System (SAS, 1990) software using the Bray-Curtis presence-absence similarity value and a flexible sorting strategy (β = 0.025) to examine relationship among sampling locations.

Table 1. Locations, physical characteristics and date of collections. T = water temperature (C); S = water salinity (ppt); SM = suspended matter in the water column (mg/L).

Location		Coordinates	T	S	SM	Date
	Florida					
1,	FSU Marine Laboratory	29°50′N; 84°34′ W	NA	NA	NA	07/93
2,	Old Beach	29°48′N; 84°40′W	NA	NA	NA	07/93
3,	East St. George Island	29°41′N; 84°44′W	26.0	34	110	07/93
4,	West St. George Island	29°37′N; 84°52′W	26.0	35	70	07/93
5,	Cape San Blas	29°40′N; 85°23′W	28.0	35	NA	07/93
6,	Mexico Beach	29°55′N; 85°25′W	28.0	33	NA	07/93
7,	Panama City Beach	30°06′N; 85°46′W	28.0	31	NA	07/93
8,	Navarre Beach	30°16′N; 86°55′W	25.0	34	NA	07/93
9,	Pensacola Beach	30°17′N; 87°08′W	25.0	34	39	06/92
	Alabama					
10,	Gulf State Park Public Beach	30°13′N; 87°40′W	18.0	32	49	04/92
11,	Gulf State Lagoon	30°13′N; 87°43′W	18.0	28	55	04/92
12,	Pine Beach	30°14′N; 87°44′W	18.0	32	52	04/92
	Mississippi					
13,	Dauphin Island	30°14′N; 88°09′W	18.0	32	185	04/92
14,	Gulf Estate Beach	30°31′N; 88°50′W	NA	29	190	04/92
15,	Biloxi East	30°32′N; 88°55′W	NA	22	195	11/91
16,	Biloxi West	30°32′N; 88°56′W	20.0	25	150	11/91
	Louisiana					
17,	Grand Isle	29°14′N; 89°56′W	NA	NA	NA	10/92
18,	Port Fourchon	29°09′N; 90°10′W	23.0	30	140	10/92
	Texas					
19,	Sea Rim State Park	29°40′N; 93°54′W	NA	30	120	05/92
20,	Galveston Island	29°11′N; 94°57′W	NA	31	NA	10/93
21,	Port Aransas	27°50′N; 97°03′W	20.0	30	115	03/93
22,	Central Mustang Island	27°43′N; 97°09′W	20.5	30	85	03/93
23,	North Padre Island	27°28′N; 97°16′W	20.5	32	90	03/03
24,	Central Padre Island	27°05′N; 97°23′W	20.5	30	85	03/93
25,	South Padre Island	26°06′N; 97°09′W	21.5	32	65	03/93

NA = data not available

Results and discussion

Abiotic factors: granulometric analysis of the sediments, revealed that Florida, Alabama and Mississippi collecting sites substrata were made of medium-fine sand while Louisiana and Texas sites have a fine to very fine sand. At a given location, sediment from the littoral site was coarser than the subtidal site (Table 2). Generally particles were silicious and moderately well sorted.

Salinity with few exceptions was over 30 ppt (Table 1). The amount of suspended matter in the water column ranged from less than 50 mg l^{-1} to about 200 mg l^{-1} generally being higher in Mississippi, Louisiana, and Texas locations (Table 1; Fig. 2). Water temperature 18–28 °C varied according to the time of the year and latitude (Table 1). Faunistic: collection from 25 locations (34 sites) along the north and northwest coast of the Gulf of Mexico (9 FL, 4 AL, 3 MS, 2 LA and 7 TX) yielded 45 species for a total of 152 records (species × site) (Tables 3, 4). These species belonged to 18 genera in seven families in the orders Macrodasyida (4 families) and Chaetonotida (3 families). Pine Beach, Alabama, West St. George Island and Cape San Blas, Florida, and South Padre Island, Texas, displayed the highest species richness with 23, 15, 14, and 10 species respectively. A cluster analysis (Flexible-Beta method) by locations performed on a species by location matrix reveled three main clusters (Fig. 3). Cluster A groups together locations from dif-

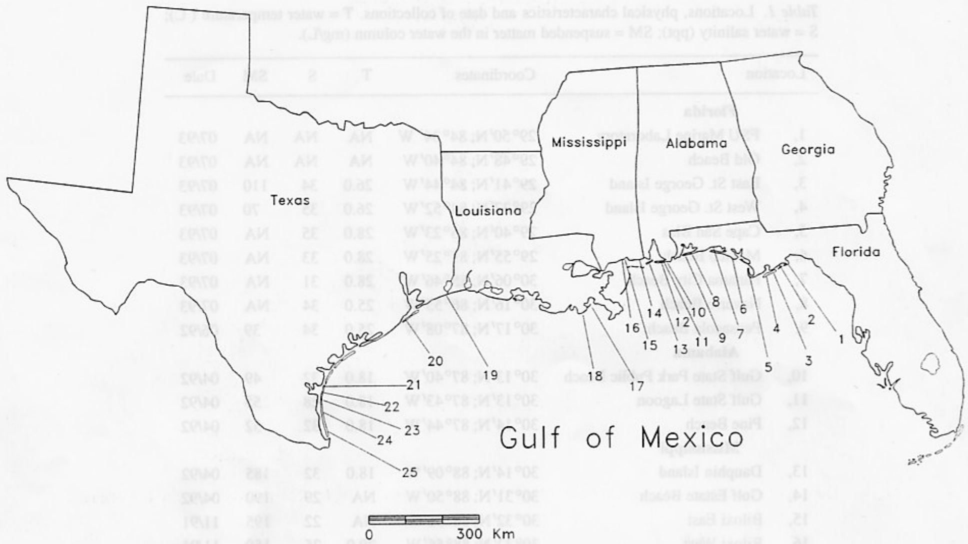

Fig. 1. Location of study sites in northern Gulf of Mexico. 1, Florida State University Marine Laboratory; 2, Old Beach; 3, East St. George Island; 4, West St. George Island; 5, Cape San Blas; 6, Mexico Beach; 7, Panama City Beach; 8, Navarre Beach; 9, Pensacola Beach; 10, Gulf State Park Public Beach; 11, Gulf State Lagoon; 12, Pine Beach; 13, Dauphin Island; 14, Gulf Estate Beach; 15, Biloxi East; 16, Biloxi West; 17, Grand Isle; 18, Port Fourchon; 19, Sea Rim State Park; 20, Galveston Island; 21, Port Aransas; 22, Central Mustang Island; 23, North Padre Island; 24, Central Padre Island; 25, South Padre Island.

ferent areas which host few or no gastrotrich species. Cluster B groups together Louisiana and Texas locations while cluster C groups Alabama and Florida locations. The chaetonotid *Xenotrichula intermedia* was the most common species, found in 13 locations, but not as yet in Louisiana. The macrodasyid *Turbanella ocellata* was very common and was often the prevalent species in the Louisiana and Texas sites, while *Tetranchyroderma bunti* and *T. swedmarki* were common and numerous species along the coasts of Florida, Alabama and Mississippi. *Acanthodasys* species seemed to be restricted to the two eastern-most states. The geographic range of *Chaetonotus triacanthus* is thus far limited to the Texas (numerous at Galveston Island) and Louisiana sites.

The present investigation doubled the number of gastrotrich genera known from the northern Gulf of Mexico while increasing by 10 fold the number of known species. *Chaetonotus triacanthus* and *Heteroxenotrichula texana* have been described as new species in a recent paper (Todaro, 1994). Likewise, the ten unnamed species reported in Tables 3 and 4 appear to be undescribed taxa. Their definitive affiliation however will be made at the end of the ongoing taxonomical survey and published in a forthcoming paper along with a description of the most common species. Increases in species numbers are due mostly to the fact that, for the first time, paucitubulate chaetonotids are reported from the area.

The suborder Paucitubulatina, which comprises half of all marine gastrotrich species, is cosmopolitan. Thus to find representatives in the Gulf of Mexico should not come as a surprise. In our samples paucitubulate chaetonotids account for some 47% of the total species (Table 1). By comparison, in the central Mediterranean Sea Hummon *et al.*, (1990) report 150 gastrotrich species evenly divided between macrodasyids and paucitubulate chaetonotids in Italy, and 63 species with chaetonotids outnumbering macrodasyids by almost more than 2:1 in Greece (Hummon & Hummon, 1993). In the U.S., along the east coast of Florida, paucitubulate chaetonotids make up about 37% of all gastrotrich species (Todaro *et al.*, 1991). Other extensive investigations also report the

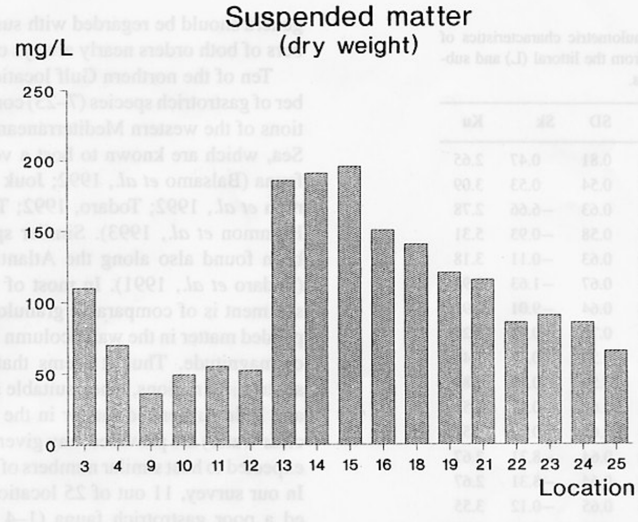

Fig. 2. Amount of suspended matter in the water column in 17 out of 25 locations; for 8 locations data are not available.

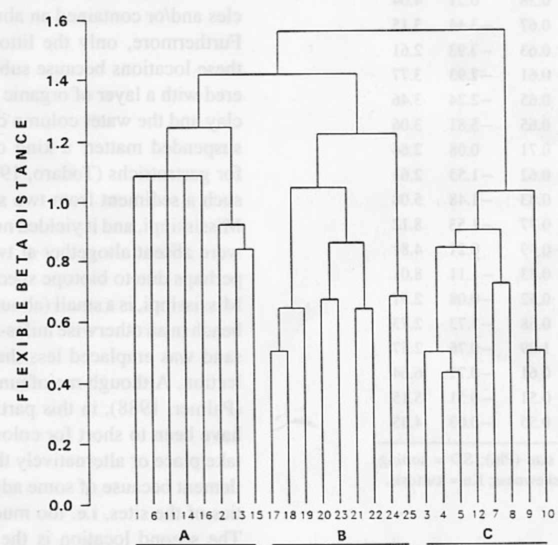

Fig. 3. Dendrogram showing locations (1–25) grouped in three main clusters as a result of a flexible beta method cluster analysis performed on a species by location matrix.

co-occurrence of macrodasyids and chaetonotids, i.e. Scotland (Hummon, 1976), Somalia (Valbonesi & Luporini, 1984, 87), English channel (Kisielewski, 1987, 88), Isles of Scilly, U.K. (Hummon & Warwick, 1990) Belgian coast (Jouk *et al.*, 1992), Red Sea and Mediterranean coasts of Israel (Hummon & Hummon, 1992).

Paucitubulate chaetonotids are minute, 80–300 μm in total body length, with a maximum body width rarely exceeding 50 μm, so that the use of sieves

Table 2. Granulometric characteristics of the sediment from the littoral (L) and sublittoral (S) sites.

Site	M	SD	Sk	Ku
1 L	1.21	0.81	0.47	2.65
2 L	1.72	0.54	0.53	3.09
3 L	1.81	0.63	−6.66	2.78
3 S	2.35	0.58	−0.93	5.31
4 L	1.39	0.63	−0.11	3.18
4 S	1.79	0.67	−1.63	2.98
5 L	1.76	0.64	−9.01	2.91
5 S	1.98	0.72	−0.71	3.26
6 L	1.66	0.52	0.43	3.45
7 L	1.71	0.59	0.12	2.89
7 S	1.89	0.62	−0.11	2.51
8 S	1.84	0.62	−0.02	2.57
9 L	1.82	0.64	−8.31	2.67
9 S	1.82	0.64	−8.31	2.67
10 L	1.46	0.65	−0.12	3.55
10 S	1.92	0.64	−0.13	2.58
11 L	1.62	0.58	0.21	4.04
12 L	1.26	0.67	−3.44	3.15
12 S	1.91	0.63	−7.93	2.61
13 L	1.51	0.61	−7.93	3.77
14 L	1.64	0.65	−2.24	3.46
15 L	1.67	0.65	−5.81	3.06
16 L	1.29	0.71	0.08	2.64
17 L	2.46	0.62	−1.53	2.61
18 L	2.25	0.83	−1.48	5.08
19 L	2.62	0.77	−1.53	8.12
20 L	2.58	0.49	0.21	4.81
21 L	2.55	0.83	−1.11	8.01
22 L	2.51	0.52	−0.08	2.57
23 L	2.51	0.68	−1.73	2.73
24 L	2.07	1.09	−0.76	2.57
24 S	2.64	0.61	−0.71	6.64
25 L	2.42	0.51	−0.51	5.15
25 S	2.53	0.55	−0.03	4.35

M = mean grain size (Phi); SD = sorting coefficient; Sk = skewness; Ku = kurtosis.

during the extraction process may contribute to their loss from samples. Thus, it is not by coincidence that the only chaetonotid gastrotrich previously reported from the Gulf of Mexico was *Neodasys* (Meyers *et al.*, 1987), since species of this genus are large, exceeding 300 μm in length. In our experience in the marine interstitial environment, macrodasyids and chaetonotids are always sympatric. Further, with few exceptions, reports finding species belonging only to macrodaysid genera should be regarded with suspicion since members of both orders nearly always co-occur.

Ten of the northern Gulf locations support a number of gastrotrich species (7–23) comparable with locations of the western Mediterranean Sea and the North Sea, which are known to host a very rich gastrotrich fauna (Balsamo *et al.*, 1992; Jouk *et al.*, 1992; Hummon *et al.*, 1992; Todaro, 1992; Todaro *et al.*, 1992; Hummon *et al.*, 1993). Similar species richness has been found also along the Atlantic coast of Florida (Todaro *et al.*, 1991). In most of these locations the sediment is of comparable granulometry and the suspended matter in the water column is of a similar order of magnitude. Thus it seems that in temperate and subtropical regions, when suitable sediment grain size and little suspended matter in the water column (i.e. clear water) are provided, any given location should be expected to host similar numbers of gastrotrich species. In our survey, 11 out of 25 locations clearly supported a poor gastrotrich fauna (1–4 species). At these sites the sediment was composed either of fine particles and/or contained an abundance of organic matter. Furthermore, only the littoral sites were sampled in these locations because sublittoral sediment was covered with a layer of organic matter mixed with silt and clay and the water column contained large amounts of suspended matter, a kind of environment unsuitable for gastrotrichs (Todaro, 1992). In fact we did collect such a sediment from two sites, east and west Biloxi, Mississippi, and it yielded no gastrotrichs. Gastrotrichs were absent altogether at two locations (Tables 3, 4), perhaps due to biotope specificity. Gulf Estate Beach, Mississippi, is a small (about 50 m long) anthropogenic beach in an otherwise miles-long muddy coastline. The sand was emplaced less than 3 years before our collection. Although meiofauna usually colonize rapidly (Palmer, 1988), in this particular case the time might have been to short for colonization by gastrotrichs to take place or alternatively they may have avoided settlement because of some adverse physical characteristics of the sites, i.e. too much organic matter (Fig. 2). The second location is the lagoon of the Sea Shore State Park, Alabama. The site of our collection was located at the head of the *ca* 100 meter-long channel that connects the lagoon to the Sea. We collected twice at the same site (the second collection was made on 07/5/1992), though in neither case were gastrotrichs found. Since we have collected only one site we cannot tell if the absence of gastrotrichs is site-specific or more general to the lagoon. We exclude that the relatively low salinity, 28 ppt plays a role in the gastrotrich absence from this site since many species have been reported to be euryhaline (i.e. Boaden, 1976; Hummon, 1972, 1975; Balsamo & Todaro, 1988), and we found gastrotrichs in Biloxi, Mississippi, where the salinity is even lower (Table 1).

In locations where collections of both littoral and sublittoral sites were made, the abundance of species seems to reflect the situation found in other nearly atidal regions. Like the Mediterranean Sea, the shallow subtidal sediment in this region hosts a higher number of gastrotrich species (Hummon *et al.*, 1990) compared with the littoral one. Possibly the situation is similar in regions characterized by high tide amplitude, but unfortunately there is little information available.

As far as the tidal distribution of taxa is concerned, although at higher taxonomic ranks there seems not to be a substantial difference between the littoral and sublittoral sites, several species however show a clear preference for one or the other areas. For instance among the taxa encountered in three or more locations, and for which data are available for both littoral and sublittoral sites, *Acanthodasys aculeatus, A.* sp. 3, *Cephalodasys turbanelloides*, *Lepidodasys* sp. 1, *Mesodasys* sp. 1, *Tetranchyroderma swedmarki* and *T.* sp. 2 in the order Macrodasyida and *Aspidiophorus mediterraneus*, *A. paramediterraneus*, *Chaetonotus atrox*, *C. dispar*, *Halichaetonotus aculifer* and *Heterolepidoderma loricatum* in the order Chaetonotida, were found almost exclusively in the subtidal samples. On the other hand *Tetranchyroderma bunti* and *Xenotrichula intermedia* can be considered characteristic of the littoral area (since their abundance is by far greater in these sites; rare *vs.* numerous). For most of these species an analogous vertical preference has been reported in the Tuscan Archipelago, Italy, and other geographic areas (cfr. Balsamo *et al.*, 1992; Todaro *et al.*, 1992). By contrast, *Tetranchyroderma swedmarki* was originally described from an intertidal site of the Indian coast (Rao & Ganapati, 1968) and *Cephalodasys turbanelloides* has previously been reported abundant in four eulittoral sites along the Belgian coast while absent in three samples taken at 30 m depth (Jouk, *et al.*, 1992). It should be pointed out however that the latter species was originally discovered in sediment from a subtidal site, 22 meters depth, along the west coast of Sweden (Boaden, 1960).

The tidal distribution of *Turbanella ocellata* changes with location. Along the Florida and Alabama coast this species was found exclusively in sublittoral sediment, while in Louisiana and Texas it was found littorally (Table 3). We suspect its distribution is related to sediment characteristics. *Turbanella ocellata* is known to occur in hypoxic environments, and has been considered to be part of the thiobios (Fox & Powell, 1986; Meyers *et al.*, 1987; Meyers *et al.*, 1988). We believe that, given the choice, this species prefers an environment with low oxygen tension, and the subtidal sediment from Florida and Alabama and littoral one from Louisiana and Texas may provide such an environment. Due to our sampling technique, we do not know the vertical distribution of this species within the sediment at the sublittoral sites. Assuming that the bulk of the specimens do not inhabit the upper layer, which likely is fully oxygenated, then as far as oxygen is concerned these relatively coarser (M = 1.72–1.98 phi, Table 2) subtidal sediments may be considered similar to the finer (M = 2.07-2.62 phi, Table 2) littoral ones from Louisiana and Texas and thus may explain the observed species distribution.

The distribution of species among genera in the northern Gulf of Mexico reflects certain known trends. Of all the species known world wide, the genera *Tetranchyroderma*, *Turbanella* and *Macrodasys* in the order Macrodasyida are the most species-rich accounting for some 30%. In our instance *Tetranchyroderma* and *Turbanella* make up 39% of the macrodasyid species (Table 3). The absence of *Macrodasys* from our samples is puzzling. In the U.S., species of this genus are frequent with large populations along the east coast of Florida (Evans, 1994; W. A. Evans, W. D. Hummon & M. A. Todaro, unpublished data) and their presence is known along the Atlantic coast of the Yucatan peninsula in Mexico (M. A. Todaro, unpublished data). The contrary exception is the genus *Acanthodasys*, which in the Gulf is represented by four species including the cosmopolitan *A. aculeatus*. No other investigated region in the world has such a variety of *Acanthodasys* species (but see Ruppert, 1978). It should be pointed out however that in the northern Gulf, the distribution of these species seems restricted mainly to the subtidal Florida sites from where *A. aculeatus*, *A.* sp. 2 and *A.* sp. 3, have been repeatedly reported. Pine Beach, Alabama however is the only location where all four species are sympatric (even though two species were found in the subtidal sample and two in the littoral one). Worldwide, the genera Chaetonotus and *Halichaetonotus* in the order Chaetonotida, comprise about sixty percent of all the species known. In our samples, species of these taxa, although the most abundant, make up only 50% of the total Chaetonotida (Table 4). The other genera are represented by a fair number of species.

Table 3. Macrodasyida: species list and distribution

Taxon	Location 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Family DACTYLOPODOLIDAE																									
Dactylopodola typhle	—	—	—	—	—	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—
Family LEPIDODASYIDAE																									
Cephalodasys turbanelloides	—	—	—	—	S	—	S	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	S	L;S
Dolichodasys elongatus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	L			
Lepidodasys sp.	—	—	—	S	S	—	S	S	-	—	—	L													
Mesodasys sp.	—	—	—	S	S	—	S	—	L	S	—	L;S	—	—	—	—	—	—	—	—	—	—	-	—	L;S
Family THAUMASTODERMATIDAE																									
Acanthodasys aculeatus	—	—	—	S	S	L	—	S	—	S	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Acanthodasys sp. 1	—	—	—	—	—	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	-	—	—
Acanthodasys sp. 2	—	—	—	—	S	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—
Acanthodasys sp. 3	—	—	S	S	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	-	—	—
Pseudostomella roscovita	—	—	—	—	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Pseudostomella plumosa	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetranchyroderma bunti	—	—	L	L;S	L;S	—	—	—	L	S	—	L	L	—	—	—	L	L	—	—	—	—	—	—	—
Tetranchyroderma cfr. sardum	—	—	—	—	—	—	—	—	S	L	—	L;S	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetranchyroderma swedmarki	—	—	S	S	S	—	S	S	S	L;S	—	L;S	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetranchyroderma sp. 1	—	—	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetranchyroderma sp. 2	—	—	S	S	S	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tetranchyroderma paradoxa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S	L
Family TURBANELLIDAE																									
Paraturbanella teissieri	—	—	—	—	—	—	-	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—
Paraturbanella aggregotubulata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—	—
Paraturbanella sp. 1	—	—	—	—	—	—	—	-	—	—	—	—	—	—	—	—	—	—	—	—	—	-	—	S	—
Turbanella ambronensis	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—
Turbanella ocellata	—	—	S	S	S	—	—	-	—	—	—	S	—	—	—	—	L	L	L	L	L	L	L		
Turbanella bocqueti	—	—	—	—	—	—	—	-	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—
# OF MACRODASYID SPECIES BY LOCATION	0	0	5	8	9	1	4	5	4	6	0	14	2	0	1	0	2	2	1	2	1	3	1	4	4

L = species present in the littoral samples; S = species present in the sublittoral samples; — = species not present.

A large fraction of the species found in the Gulf have an amphi-Atlantic or cosmopolitan distribution, including *Cephalodasys turbanelloides*, *Dactylopodola typhle*, *Tetranchyroderma sardum*, *Turbanella bocqueti*, *Chaetonotus apolemmus*, *Halichetonotus margaretae* and *Heterolepidoderma loricatum*, never before reported in print from the Americas. Some species have previously been found only along the east coast of the U.S., these include *Paraturbanella aggregotubulata*, *Pseudostomella plumosa*, *Tetranchyroderma bunti*, *T. paradoxa*, *Chaetonotus sagittarius*, and *Neodasys ciritus*. In addition, three or four of the as-yet-undescribed species have been found previously along the Atlantic coast of the U.S. (W. A. Evans, W. D. Hummon, M. A. Todaro, unpublished data). Some seven species have been found thus far only in this area and are therefore new to science, these include *Chaetonotus triacanthus*, *Heteroxenotrichula texana*, *Chaetonotus* sp.1, *Heterolepidoderma* sp.1, *Paraturbanella* sp.1 and *Acanthodasys* sp.1 and sp.2.

The percentage proportion, of amphi-Atlantic/cosmopolitan, regional and endemic species, found by us in the Gulf are 60, 22 and 18% respectively. This confirms the phenomenon of broad geographic distribution that characterize most species of this phylum.

Table 4. Chaetonotida: species list and distribution.

Taxon	Location 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Suborder MULTITUBULATINA																									
Family NEODASIDAE																									
Neodasys ciritus	—	—	—	—	—	—	—	S	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L;S
Suborder PAUCITUBUATINA																									
Family CHAETONOTIDAE																									
As pidiophorus mediterraneus	—	—	—	S	—	-	S	—	—	—	—	S	—	—	—	—	—	—	—	L	—	—	—	—	—
As pidiophorus paramediterraneus	—	—	S	S	-	—	—	—	S	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetonotus apolemmus	—	—	—	S	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetonotus atrox	L	—	S	S	S	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetonotus dispar	—	—	—	—	—	—	S	S	S	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetonotus triacanthus	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—	L	L	—	L	—	—
Chaetonotus sagittarius	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chaetonotus sp. 1	—	L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Halichaetonotus aculifer	—	—	S	S	S	L	S	S	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—
Halichaetonotus decipiens	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L;S
Halichaetonotus margaretae	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Halichaetonotus paradoxus	—	—	—	—	—	—	—	—	—	—	—	S	—	—	—	L	—	—	—	—	—	—	—	—	—
Halichaetonotus spinosus	—	L	—	—	—	—	-	—	—	—	—	L	—	—	—	—	L	—	L	—	—	—	—	—	—
Heterolepidoderma loricatum	—	—	—	S	S	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	L;S
Heterolepidoderma sp. 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—	—	—	—
Family XENOTRICHULIDAE																									
Draculiciteria tesselata	—	—	—	—	—	—	-	—	—	—	—	S	—	—	—	—	—	—	—	—	L	L	—	L	L;S
Heteroxenotrichula pygmaea	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—
Heteroxenotrichula squamosa	—	—	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	—	—	—	—	L	—	S	—
Heteroxenotrichula texana	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L	—	—	L	—	—
Xenotrichula intermedia	—	L	L	S	L;S	—	L;S	—	S	L	—	—	L	—	L	—	—	—	—	L	L	L	—	—	L;S
Xenotrichula lineata	—	—	—	—	—	—	—	-	—	—	—	—	—	—	—	L	—	—	—	—	—	—	—	—	L;S
# OF CHAETONNOTID SPECIES																									
BY LOCATION	7	4	4	7	5	1	5	3	4	1	0	9	1	0	1	2	2	0	1	5	3	2	3	2	6
TOTAL SPECIES (M+C)																									
BY LOCATION	1	4	9	15	14	2	9	8	8	7	0	23	3	0	2	2	4	2	2	7	4	6	4	6	10

L = species present in the littoral samples; S = species present in the sublittoral samples; — = species not present.

Conclusions

The results of this survey indicate that the northern Gulf of Mexico supports a high number of gastrotrich species of both Macrodasyida and Chaetonotida orders. The overall high diversity contrasts with the generally low number of species from single sites. Likely species richness in this case is affected to a great extent by abiotic environmental factors such as organic content and small particles in both the water column and sediment: generally the higher their amount, the lower the number of species. This is consistent with the higher diversity found in most of the Florida locations and Pine Beach in Alabama. It is also consistent with the finding of ten species in South Padre Island, Texas, where 93% of the sediment particles are less than 200 μm, with little detritus, and the surrounding water is quite clear. Additionally, sites where the mean grain size is above 200 μm but the sediment is rich in detritus and the surrounding water is brownish support a lower number of gastrotrich species.

The affiliation of species to those individuals found in distant geographic areas based also upon the morphometric comparison of specimens with high definition video sequences confirms the overall high proportion of cosmopolitanism representative of this phylum:

sixty percent of the species found may be considered at least regional cosmopolitans. Another twenty-two percent have a wide bi-regional distribution, having been previously found along the east coast of the U.S. Only eighteen percent of the total species appear to be endemic. Eventually a survey along the south shore of the Gulf will allow us to see if the distribution of these species is restricted only to the presently investigated area or if it is broader. Further investigations along the Gulf coast will also shed light on the populations of *Macrodasys*, which has been considered ubiquitous elsewhere, but for which the present survey has shown no data.

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