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Species composition and diversity of free-living Plathelminthes (Turbellaria) from sandy beaches at the Belgian coast

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Abstract

Ten sandy beaches at the Belgian coast were sampled monthly on a qualitative basis. Six of them were also sampled quantitatively every two months. In total, 130 species were encountered, 38 % of them occur only in 1 or 2 localities, 32 % have a more general distribution (in 3 to 7 localities) and 30 % are found in at least 8 localities. Schizorhynchia generally form the dominant taxon in number of species, followed by the Proseriata. In Knokke and Het Zwin, equal numbers of species were found for both taxa.

Mariakerke, Bredene, Knokke and Het Zwin have the most diverse turbellarian fauna's, with the lowest dominance ratio's. In the semi-exposed beach of Oostende the fauna is slightly less diverse, dominated by a few species, while the sheltered beach in Heist clearly has the least diverse fauna, strongly dominated by one species, *Archilopsis arenaria*.

Keywords: free-living Plathelminthes, Belgian coast, species richness, diversity.

Samenvatting

Tien zandstranden aan de Belgische kust werden maandelijks bemonsterd op kwalitatieve basis. Zes ervan werden ook tweemaandelijks kwantitatief bemonsterd. In totaal werden 130 soorten aangetroffen, waarvan 38 % maar in 1 of 2 localiteiten voorkomen, 32 % een meer algemene verspreiding hebben (in 3 tot 7 stranden) en 30 % in minstens 8 localiteiten aangetroffen worden. Schizorhynchia vormen doorgaans het grootste taxon in aantal soorten, gevolgd door de Proseriata. In Knokke en Het Zwin worden gelijkaardige aantallen soorten van beide taxa gevonden.

Mariakerke, Bredene, Knokke en Het Zwin hebben de meest diverse turbellariënfauna's, met de laagste dominantie verhoudingen. Het semi-geëxposeerde strand van Oostende heeft een iets minder diverse fauna, die gedomineerd wordt door enkele soorten. Het beschutte strand van Heist heeft duidelijk de minst diverse fauna, die sterk gedomineerd wordt door één soort, *Archilopsis arenaria*.

Trefwoorden: vrijlevende Plathelminthes, Belgische kust, soortenrijkdom, diversiteit.

Introduction

Free-living Plathelminthes and other soft-bodied meiofaunal taxa are often disregarded in biodiversity studies or numbers are highly underestimated when they have been considered. In most biodiversity surveys, fixed samples are used, while the soft-bodied fauna should be studied alive to allow proper identification (after which they can be recognised in fixed samples). Data on species diversity of Plathelminthes are very rare: H' values of 1.20-3.35 were recorded in beaches of the German Island of Sylt (REISE 1983a, b, 1984; WEHRENBERG 1988) and of 2.55 maximum in mangrove sandflats of northern Queensland, Australia (DITTMANN 1991). MARTENS *et al.* (1985) and MARTENS & SCHOCKAERT (1986) stated that turbellarian diversity can be of the same magnitude as that of nematodes or harpacticoids, and that turbellarians may represent up to more than 25 % of the meiofaunal density. The data presented here are in the same order of magnitude.
A general species list of the Belgian coast and adjacent areas, listing about 250 species, is given by SCHOCKAERT *et al.* (1990). In this contribution, detailed species lists are given for ten sandy beaches at the Belgian coast. Species composition, efficiency of specific extraction methods for soft-bodied meiofauna and diversity of the turbellarian populations are discussed.

Material and methods

In ten localities along the 64 km long Belgian coast, live samples from the sandy beaches have been investigated monthly from April 1985 till June 1986 (see table 2). In six of these localities, every two months, 2 cores of 10 cm^2 (40 cm deep) were taken and fixed for quantitative analysis, and one for sediment analysis. Samples were taken in the medio-litoral zone, where high numbers of individuals and of species are to be found (JOUK *et al.* 1988). Living Turbellaria are extracted from the sand by the $MgCl_2$-decantation method (HULINGS & GRAY 1971, MARTENS 1984, see SCHOCKAERT 1996), identified under the compound microscope and mounted in lactophenol for later comparison. Fixed samples are extracted with the Barnett-method (BARNETT 1968, MARTENS 1984), all flatworms mounted in lactophenol and identified.

Table 1 — Sediment characteristics and exposition per locality.

	De Panne	**St.-Idesbald**	**Mariakerke**	**Oostende**	**Bredene**
* Sand:					
– mean median particle size (mm)	0.200	0.211	0.215	0.208	0.234
– classification	fine	fine	fine	fine	fine
– sorting	very well	very well to less well	very well	very well	very well to well
* mean silt %	0.04	0.04	0.01	0.03	0.01
* mean sand %	09 8	96.54	96.51	91.56	09 9
* mean gravel %	2.45	3.42	3.48	8.39	1.19
	Blankenberge	**Zeebrugge**	**Heist**	**Knokke**	**Zwin**
* Sand:					
– mean median particle size (mm)	0.243	0.226	0.197	0.332	0.316
– classification	fine	fine	fine	medium	medium
– sorting	very well to well	very well to well	very well to well	less well	less well
* mean silt %	0	0.02	0.16	0.02	0.02
* mean sand %	09 9	09 9	99.01	97.35	88.57
* mean gravel %	0.75	0.77	0.84	2.36	11.41

Results

The localities and the sediment

The sand become coarser from west to east (see table 1). Roughly spoken, there is a gradient in the sediment from west to east, with the coarse and less well sorted sand in the eastern localities. The most sheltered locality Heist however has the finest sand and the highest silt content of the ten localities. The relatively sheltered beach of Oostende (''Klein Strand'') has finer sand than the neighbouring localities. Except for the two most western (very wide) beaches and the most eastern locality, jetties and/or piers have been built on the beaches. If sediment characteristics reflect the degree of exposure, it can be said that Het Zwin and Knokke are the most exposed beaches, which can indeed be confirmed by (subjective) observation of the sites.

Species composition

In total, about 130 species of free-living Plathelminthes were encountered (table 2). Within the Acoela, only *Paratomella rubra* was identified to species level. At least 15 other species were present, but not identified (sectioned material necessary for species identification). For the same reason, the three Catenulida-species were only identified to family level.

Based on the live samples, 108 species (Acoela and Catenulida not included) were found throughout the survey. Generally, 50 to 60 species were recorded per locality. In Heist, only 20 species were found. After study of the fixed material, only 3 additional species were added to the overall list. However, there is a significant increase from 10 to 50 % of the number of species per locality (table 3): 10-14 % for Mariakerke, Oostende and Bredene, 19 and 29 % resp. for Knokke and Het Zwin and

Table 2 — Species list per locality. X: present in live samples (10 localities); O: present in fixed samples (6 localities).

	De Panne	S-Idesbald	Mariakerke	Oostende	Bredene	Blankenb.	Zeebrugge	Heist	Knokke	Zwin
Acoela										
Acoela spp. (15 sp.)	X	X	XO	XO	XO	X	X	XO	XO	XO
Paratomella rubra Rieger & Ott, 1971	X	X	X	X	X	X	X		X	
Catenulida										
– Retronectidae										
Retronectidae spp. (3 sp.)	X	X	XO	XO	XO	X	X	X	O	XO
Macrostomida										
– Macrostomidae										
Bradynectes sterreri Rieger, 1971	X	X		XO		X	X			O
Macrostomum pusillum Ax, 1951							X	XO		
Myozona stylifera Ax, 1956	X	X	XO		XO	X	X	O	XO	XO
– Dolichomacrostomidae										
Paromalostomum dubium (De Beachamp, 1927)	X	X	XO	XO	XO	X	X		X	X
Paromalostomum fusculum Ax, 1952	X	X	XO	XO	XO	X	X	O	XO	XO
Prolecithophora										
– Pseudostomidae										
Pseudostomum gracilis Westblad, 1954	X	X	XO	X	XO	X	X		X	
Proseriata										
– Coelogynoporidae										
Carenscoilia bidentata Sopott, 1972	X	X	XO	X	XO	X	X		XO	X
Carenscoilia biforamen Sopott, 1972	X	X	XO	XO	XO	X	X		XO	
Cirrifera aculeata (Ax, 1951)	X	X	XO	X	XO	X			X	X
Cirrifera sp,	X	X	X	X		X	X	XO		
Cirrifera sopottehlersae Noldt & Jouk, 1988	X									
Coelogynopora axi Sopott, 1972									O	XO
Coelogynopora forcipes Sopott, 1976			O		X	X	X		XO	XO
Coelogynopora gynocotyla Steinbck, 1924				XO					XO	XO
Coelogynopora solifer Sopott, 1972									O	
Coelogynoporidarum sp,	X	X		O						
– Nematoplanidae										
Nematoplana coelogynoporoides Meixner, 1938		X	X		O	X	X		XO	XO
– Monocelididae										
Archilopsis arenaria Martens, Curini-Galletti & Puccinelli, 1988	X	X	XO				X	XO	X	XO
Monocelopsis otoplanoides Ax, 1951	X	X	XO	XO	XO	X	X	XO	XO	XO
Promonotus marci Ax, 1954	X	X	XO		X	X			X	X
– Archimonocelididae										
Archimonocelis oostendensis Martens & Schockaert, 1981	X	X	XO	XO	XO	X	X	O	XO	
– Otoplanidae										
Kataplana germanica (Meixner in Ax, 1951)		X		X	XO	X			XO	XO
Otoplanella baltica (Meixner, 1938)	X	X	XO	XO	XO	X	X		XO	XO
Otoplanella schulzi (Ax, 1951)									X	X
Otoplanidia endocystis Meixner, 1938									XO	XO
Paratoplana capitata Meixner, 1938										XO
Paratoplana papii Ax, 1956		X	O		XO		X		XO	XO
Praebursoplana reisingeri Ax, 1956		X								XO
Pseudosyrtis subterranea (Ax, 1951)			X							X
Otoplanidarum sp, 1									X	X
Otoplanidarum sp. 2									XO	
Rhabdocoela										
***Typhloplanoida**										
– Ciliopharyngiellidae										
Ciliopharyngiella constricta Martens & Schockaert, 1981						X	X	XO		XO
– Solenopharyngidae										
Aulopharynx aestuarius Ehlers, 1972			XO							
Doliopharynx geminocirro Ehlers, 1972			X				X	XO		
Proceropharynx litoralis Ehlers, 1972									XO	XO
– Trigonostomidae										
Lonchoplanella axi Ehlers, 1974	X	X		XO	X		X	O	XO	
Petaliella spiracauda Ehlers, 1974		X	XO	XO	XO	X			XO	XO
Proxenetes fasciger Ehlers, 1974	X	X	XO	XO	XO	X	X	XO	XO	O
Proxenetes tenuispinosus Ehlers, 1974								XO		O
– Promesostomidae										
Adenorhynchus balticus Meixner, 1938									XO	XO
Litucivis serpens Ax & Heller, 1970							X			XO
Listea simplex Ax & Heller, 1970										XO
Promesostoma serpentistylum Ax, 1952				X					XO	X
Subulagera rubra Martens & Schockaert, 1981		X	XO	XO	XO	X	X	O	XO	XO
Promesostomidarum sp. 1									XO	X
Promesostomidarum sp. 2	X	X	XO		O	X		XO	XO	O
Promesostomidarum sp. 3	X	X	XO	XO	XO			X	XO	O
Promesostomidarum sp. 4									O	O
– Typhloplanidae										
Haloplanella longituba Ax & Heller, 1970									X	O

***Kalyptorhynchia**										
****Eukalyptorhynchia**										
– Gnathorhynchidae										
Carcharodognathus stilofer (Schilke, 1970)							X			
Gnathorhynchus conocaudatus Meixner, 1929	X	X	XO	X	X	X	X		XO	
Psittacorhynchus verweyi den Hartog, 1968								XO		
Uncinorhynchus flavidus Karling, 1947			O	XO						
– Cicerinidae										
Cicerina brevicirrus Meixner, 1928								X	XO	X
Cicerina remanei Meixner, 1928	X	X	XO	XO	XO	X	X	XO	XO	XO
Cicerina tetradactyla Giard, 1904	X					X	X	X	XO	XO
Paracicerina deltoides Martens & Schockaert, 1981	X	X	X	XO		X		XO		
Ptyalorhynchus caecus Meixner in Ax, 1951	X	X	O	XO	XO	X	X		XO	XO
– Polycystidae										
Neopolycystis tridentata Karling, 1955			X	X			X		X	
Polycystidarum sp.	X						X			
– Cystiplanidae										
Nigerrhynchus opisthoporus Schilke, 1970									XO	
– Psammorhynchidae										
Psammorhynchus tubulipenis Meixner, 1938	X	X		O	X	X	X	XO	XO	XO
– Species incertae cedis										
Elvertia krusei Noldt, 1989									X	
****Schizorhynchia**										
– Schizorhynchidae										
Amphirhynchus caudatus Schilke, 1970			O							
Carcharodorhynchus isolatus Schilke, 1970	X	X	XO	XO	XO	X			O	
Carcharodorhynchus listensis Schilke, 1970		X			O		X			
Limirhynchus danicus Schilke, 1970	X	X	XO	XO	XO	X	X		X	
Neoschizorhynchus brevipharynggus Schilke, 1970		X	XO	X	O	X			X	
Neoschizorhynchus longipharynggus Schilke, 1970	X	X	XO	XO	XO	X	X			X
Neoschizorhynchus parvorostro Ax & Heller, 1970	X	X	XO	XO	XO	X	X		XO	XO
Neoschizorhynchus sp.	X	X	XO	XO	XO	X	X		O	O
Paraschizorhynchoides glandulis Schilke, 1970		X								XO
Proschizorhynchus bivaginatus Schilke, 1970	X	X	XO		XO	X	X		O	O
Proschizorhynchus helgolandicus l'Hardy, 1965	X	X	XO	O	XO	X	X		O	
Proschizorhynchus gullmarensis Karling, 1950				XO						
Proschizorhynchus triductibus Schilke, 1970	X	X	XO	XO	XO	X			X	
Schizochilus choriurus Boaden, 1963	X	X	XO	XO	XO	X	X		XO	XO
Schizochilus marcusi Boaden, 1963	X	X	XO	XO	XO	X	X		XO	
Schizorhynchoides aculeatus l'Hardy, 1963							X			
Schizorhynchoides karlingi Martens & Schockaert, 1981		X			X		X			XO
Schizorhynchoides symmetricus Martens & Schockaert, 1981		X	XO	XO	XO	X			XO	
Thylacorhynchus ambronensis Schilke, 1970	X	X	XO	XO	XO	X	X		XO	XO
Thylacorhynchus caudatus Meixner, 1928		X								
Thylacorhynchus conglobatus Meixner, 1928	X	X	XO	XO	XO	X	X		O	O
Thylacorhynchus pyriferus Karling, 1950			XO							
Schizorhynchoidarum sp.									XO	
– Nematorhynchidae										
Nematorhynchus parvoacumine Schilke, 1969							X			
– Karkinorhynchidae										
Cheliplana boadeni Schilke, 1970	X	X			X	X	X		XO	XO
Cheliplana gemmifera Noldt, 1989		X	XO	X	XO	X				X
Cheliplana marcusi (Karling, 1956)		X	X		O		X	O		O
Cheliplana microcirrus Noldt, 1989			XO							
Cheliplana remanei (Meixner, 1928)	X	X	X		XO		X		X	X
Cheliplana stylifera Karling, 1949	X	X	XO	XO	XO	X	X	XO	XO	O
Cheliplanilla caudata Meixner, 1938	X	X	XO	XO	XO	X	X	O	XO	O
Karkinorhynchus bruneti Schilke, 1970	X	X	XO	XO	X	X	X		X	
Karkinorhynchides purpureus Schilke, 1970					XO		X		O	XO
– Diascorhynchidae										
Diascorhynchus rubrus Boaden, 1963	X	X	XO	XO	XO	X	X		XO	XO
***Dalyellioida**										
– Provorticidae										
Hangethellia calceifera Karling, 1940							X			
Pogaina kinnei Ax, 1970	X	X	XO	XO	XO	X	X	XO	XO	XO
Pogaina natans (Ax, 1951)	X	X		O	O			XO		X
Provortex tubiferus Luther, 1948								XO		
Provortex cf. psammophilus Meixner in Ax, 1951	X	X	X	O	XO	X	X	X	XO	XO
– Graffillidae										
Bresslauilla relicta Reisinger, 1929		X						X		
Dalyellioida sp. 1	X	X	XO	O	XO	X		O	XO	O
Dalyellioida sp. 2						X				
Dalyellioida sp. 3							X			
Dalyellioida sp. 4	X	X	XO	XO	XO	X		O		
Dalyellioida sp. 5				XO				O		
Dalyellioida sp. 6	X			O					O	
Dalyellioida sp. 7		X	O	XO	O				O	

Table 3 — Number of species per locality and taxon (X: present, not identified to species level).

	De Panne	Sint-Idesbald	Mariakerke		Oostende		Bredene		Blanken-berge	Zee-brugge	Heist		Knokke		Het Zwin	
	Live	Live	Live	Fixed	Live	Fixed	Live	Fixed	Live	Live	Live	Fixed	Live	Fixed	Live	Fixed
Acoela	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Catenulida	X	X	X	X	X	X	X	X	X	X	X	X	0	0	X	X
Macrostomida	4	4	3	3	3	3	3	3	4	5	1	3	3	3	3	4
Prolecithophora	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0
Proseriata	11	14	11	13	9	10	10	11	11	10	3	4	17	19	18	18
Rhabdocoela																
*Typhloplanoida	4	6	7	7	5	5	6	7	6	6	4	6	12	13	9	15
*Kalyptorhynchia																
**Eukalyptorhynchia	7	5	4	6	6	7	4	4	6	9	6	6	8	8	5	5
**Schizorhynchia	18	26	24	24	18	19	22	25	20	22	1	3	15	21	11	17
*Dalyellioida	6	7	4	5	4	8	4	6	5	4	5	8	3	5	3	4
Total	51	63	54	59	46	53	50	57	53	57	20	30	59	70	49	63

50 % for Heist. These results show that the $MgCl_2$-decantation method is clearly less efficient than the Barnett method, and that it has a better efficiency in fine, clean, (very) well sorted sand than in medium, less well sorted sand and/or silty, fine sand.

Thirty percent of the species were found in 8 to 10 localities, with only 8 species found in all 10 beaches. 32 % have a rather general distribution, and are encountered in 3 to 7 beaches. About 38 % of the species occur only in 1 or 2 localities: 16 species were only found in Knokke and/or Het Zwin, of which 5 were unique for Knokke and 2 unique for Het Zwin.

Schizorhynchia generally are the dominant taxon in number of species. In Heist however, only a few individuals of 3 species are present. The second species richest taxon is Proseriata. In Knokke and Het Zwin, the Proseriata are represented by the same number of species as the Schizorhynchia. These localities contain the most Otoplanidae-species (well known for their preference for dynamic habitats) and the most Typhloplanoida-species. Strikingly, 9 species with a wide distribution at the Belgian coast (found in minimum 8 localities) do not occur in Het Zwin.

Diversity

The diversity indices H', SI, N_0, N_1, N_2 and $N_{inf.}$ (HILL 1973, SOETAERT & HEIP 1990 and references therein) all show a significant correlation (Spearman-rank correlation test, $p<0.05$) with the median grain size and the silt content, indicating that beaches with clean, fine to medium sands have a more diverse turbellarian fauna than those with fine, silt-richer sediments. Mariakerke, Bredene, Knokke and Het Zwin have the most diverse turbellarian fauna's with the lowest dominance ratio's (table 4). The turbellarian diversity is slightly lower in the semi-sheltered beach of Oostende, with a dominance mainly by *Monocelopsis otoplanoides* and to a lesser extent also by *Neoschizorhynchus parvorostro* and *Diascorhynchus rubrus*. Heist significantly has the least diverse fauna, strongly dominated by *Archilopsis arenaria* (Kruskall-Wallis test, $p=0.002$-0.010 for H', SI, N_0, N_1, N_2 and $N_{inf.}$).

The same results are obtained by the k-dominance curves (SHAW *et al.* 1983, LAMBSHEAD *et al.* 1983). Figure 1 shows that Heist has the least diverse turbellarian fauna, followed by Oostende. Mariakerke, Bredene, Knokke and Het Zwin have the most diverse fauna's.

Table 4 — Diversity and evenness indices for Plathelminthes in six localities.

	Mariakerke	Oostende	Bredene	Heist	Knokke	Zwin
H'	2.66	2.34	2.52	1.81	2.64	2.51
SI	0.10	0.17	0.12	0.23	0.10	0.13
N_0	28	23	28	11	26	25
N_1	14.61	11.14	12.53	6.23	14.47	13.11
N_2	10.42	7.57	8.35	4.56	10.79	9.13
$N_{inf.}$	0.22	0.33	0.25	0.42	0.22	0.27
N_{10}	0.52	0.47	0.45	0.56	0.56	0.55
N'_{10}	0.51	0.45	0.43	0.51	0.54	0.53
N_{21}	0.71	0.66	0.66	0.73	0.73	0.70
N'_{21}	0.68	0.61	0.64	0.67	0.71	0.68

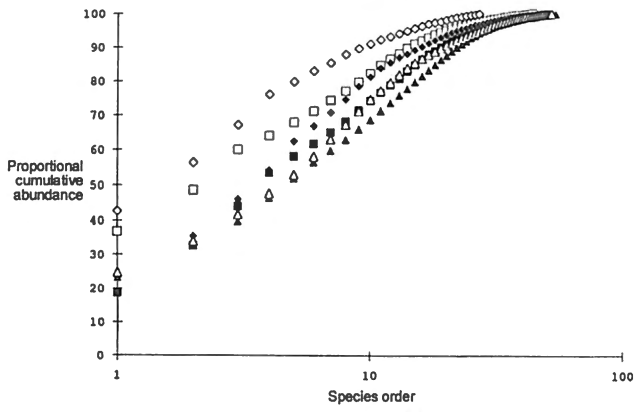

Fig. 1 — K-dominance curves (6 localities).

For the evenness-indices N_{10}, N'_{10}, N_{21}, N'_{21}, no significant differences were found between localities (Kruskall-Wallis test, $p>0.05$), nor was there a significant correlation with the sediment characteristics (Spearman-rank correlation test, $p>0.05$).

Discussion

With over 130 species in total and 50 to 60 species per locality, the Belgian beaches can be considered rich in turbellarian species, with a composition of the fauna very similar to that of similar beaches of the German Island Sylt, where studies on the Plathelminthes has been going on since the 50-ties (see REISE 1988 and references therein). As the studies in Sylt show, and as does this one on the Belgian coast, some species have a wide distribution, while others are restricted to limited habitats. As a general rule, it can be said that the more the habitats diverge, the smaller the similarities of the turbellarian fauna are. But considering that on the Belgian coast, 38 % of the species occur only in one or two beaches, it is clear that minor differences in the habitat (even those difficult to detect) may have an impact on the turbellarian fauna. This also explains why several previously unknown species can be found at our coast.

The diversity of the turbellarian fauna at the Belgian coast is also very similar to that noted for similar habitats on the German Island Sylt (ARMONIES & HELLWIG-ARMONIES 1987, REISE 1983 a, b, WEHRENBERG 1988, WELLNER & REISE 1989), with the H' ranging from 1.20 to 3.35, however with higher values for sheltered areas. DITTMANN (1998) found a H' value of 2.55 or less in sand flats adjacent to mangroves in northern Queensland, Australia, and own unpublished data on the diversity of turbellarians in Ecuadorian open beaches and mangrove sand flats of Zanzibar, Tanzania, again all result in H' values of 2.0 to 3.0.

The diversity of the free-living Plathelminthes is of the same magnitude as that of the nematodes and harpacticoid copepods, generally considered the two most dominant taxa in the meiofauna, in sandy habitats (BODIN 1988, HEIP *et al.* 1985, HICKS & COULL 1983, WARWICK & GEE 1984). It is clear that free-living Plathelminthes should be considered when assessing the biodiversity of any marine habitat.

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