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New species and records of microturbellarians from coastal rock pools of Jamaica, West Indies

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With 3 figures and 3 tables in the text

Abstract: A system of small erosional pools formed on the coastal rocks of the Jamaican north shore is home to many invertebrate species. The fauna of the pools comprises a rarely reported mixture of species from both marine and freshwater habitats. Turbellarians identified include six species of which two, belonging to the genus ***Gieysztoria,*** are new. One species, ***Gyratrix hermaphroditus,*** is a habitat generalist and occurs in a number of pools with markedly different physical and morphological characteristics. The other five species have a more restricted distribution and appear to be habitat specialists within the rock pool system, Both temperature and salinity strongly affect the local distribution of microturbellarians. The total number of brackish and freshwater species of microturbellarians reported from the Caribbean islands thus increases to nine, a very low number by comparison to any other geographical area, even a single lake.

Introduction

Turbellarians, with the exception of the Tricladida, have been studied predominantly in Europe and North America. There are very few ecological, taxonomic, or biogeographic studies conducted in other regions of the world. Intensive but highly localized studies have been limited to West Africa, Brazil, Australia, and Papua New Guinea (e.g. **YOUNG 1976, MARCUS 1946, KOLASA 1987).** While many new species were found in each region, numerous species were shared among regions **(KOLASA 1991).** That all these locations are geologically old regions leads to questions of biogeographic patterns regarding smaller and younger regions. While polyclads and triclads in the region have been studied by several taxonomists, microturbellarians – those in the size range 300 µm to **1,200** µm – have not been extensively documented in the New World. Only three species of microturbellarians have been recorded previously

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from small pools in the Caribbean islands and these belong to the genera *Mesostoma* (SMITH 1998) and *Bothromesostoma* (MARCUS 1960). Notably, the *Mesostoma* species in Puerto Rico both live in a habitat similar to that found on the north coast of Jamaica – small erosional pools formed in the limestone bedrock. Excluding purely marine habitats, the only other reported cases of microturbellarians from the Caribbean islands include the genera *Microstomum* and *Stenostomum*, each reported from marshes on the island of St. Vincent (HARRISON & RANKIN 1976). Here we report new records of known species and provide descriptions of two new species of the genus *Gieysztoria* (Turbellaria, Dalyellidae) from a unique habitat of miniature rock pools in Jamaica.

Material and methods

Habitat

The specimens were collected in several rock pools in the proximity of the Discovery Bay Marine Laboratory, Jamaica (Fig. 1). Forty-nine rock pools (labelled 1–18, 20–50) were sampled in December 1989, January 1990, January 1991, January 1992, January 1993, January 1997, and June 1997. These rock pools are situated no further than five meters from the ocean and span elevations from 0–3 m above sea level. Although some of the pools can be characterized as tidal, most cannot as the tide generally does not exceed 30 cm. The pools range from 0.5 to 150 L in volume and from 300 to 46,000 cm^2 in area. Salinity varies from 0 to 80 ‰ and is influenced by such factors as elevation, exposure to the sun, and surface-to-volume ratio. Dissolved oxygen concentrations, pH, conductivity, temperature, and productivity vary among pools. Some pools are highly variable with respect to these factors while others are fairly stable, both at small time scales (hours) and long time scales (months or years). SCHUH & DIESEL (1995) and KOLASA et al. (1996) give intermediate time scale (weeks) data on physical conditions in several selected pools. Morphometric measures of selected pool parameters are given in Table 1 for pools that contained microturbellarians. Water-chemistry data collected at the time of sampling are given for each pool and each species, with the exception of *Gyrutrix hermuphroditus* which was found in 20 pools over the 7 sampling dates (sometimes repeatedly) and for which we provide summary information only (Table 2).

Methods

All turbellarians were collected by mixing a pool and filtering 0.5 L of water through a 60 µm mesh net with an attached plastic collecting container. Sediments and invertebrates were immediately flooded with 50 % ethanol and preserved for further sorting and examination. At the lab, all animals were extracted from samples following an established protocol that involved visual examination of the sediment under a dissecting microscope. Turbellarians were mounted in CMC mounting medium for further examination. None of the specimens were examined alive and all the measurements of soft

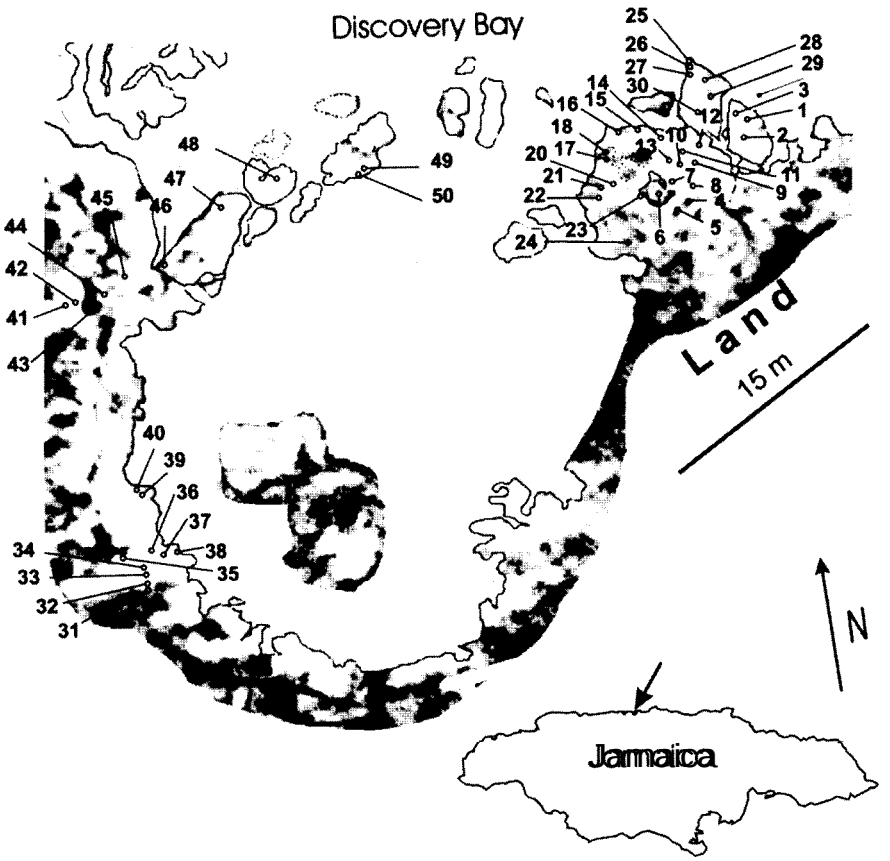

Fig. 1. Map of the rock pools in the proximity of the Discovery Bay Marine Lab, Jamaica. All sampled pools are shown and include pools with and without microturbellarians (note there is no pool 19). The numbers on the map correspond to the numbers in Table 1.

body parts must be treated with caution as different degrees of shrinking may have affected their relative dimensions. Ethanol was used in the field as a general preservative for a variety of organisms and, as such, represented a compromise method of preserving fauna. All turbellarians retained their general appearance and were easy to distinguish and identify to the genus level in the sorting dishes.

Species recorded in Jamaican rock pools

Macrostomum balticum LUTHER 1947

The similarity of the sclerotized stylet of the copulatory apparatus between the specimens from Jamaica and those from the Baltic Sea is striking and leaves

Table 1. Morphometric measures of pools in which various species of Turbellaria were found.

Pool ID	Elevation (cm)	Length (cm)	Width (cm)	Depth from Lip (cm)	Surface Area (cm^2)	Volume (mL)
4	33	81	48	18	4412	26472
5	12	53	34	31	1976	13830
6	33	188	248	32	46624	372992
7	45	48	25	37	746	11184
8	51	38	16	19	912	9124
9	45	75	56	31	1133	27183
10	29	64	29	19	22170	22170
11	28	90	33	31	1829	12801
13	29	55	32	27	2334	7300
14	42	100	36	25	2113	21133
16	29	53	53	36	1046	7844
17	19	31	21	21	2082	40938
18	18	58	18	28	353	7755
20	30	100	420	21	2753	37172
21	20	106	406	34	5836	70037
22	5	62	61	32	4730	28381
23	5	67	41	19	2747	6868
25	27	14	12	16	168	336
39	30	35	18	22	913.13	9131
44	150	54	45	44	3554.59	35546
47	80	62	15	33.5	1366.8	21868
49	10	39	27	18	946.37	13249
50	3	48	37	43	2697.86	16187

little doubt as to the identity of this species (Fig. *2* a). Eleven individuals were found in Pool *25*. *M. balticum* has been known to occur in Europe, both in the Mediterranean Sea (LUTHER 1960) and as far north as the Faroe Islands **(Ax** 1995). On each occasion, it has been found in brackish coastal habitats. The Jamaican records extend this species distribution to the New World.

Macrostomum sp. cf. *ruebushi* var *kepneri* FERGUSON and JONES 1940

Only three specimens were found, all in Pool *5*, on two sampling occasions (January 1990 and January 1992). These specimens are small – their length after fixation was approximately 620–650 μm. The copulatory stylet, *22* μm in length between the extreme points, remains insufficiently discernible on the mounted specimen to photograph. Thus we report the hand drawing only (Fig. *2* b). This species is similar to *M. ruebushi* complex FERGUSON, especially ***M. ruebushi*** var ***kepneri*** (FERGUSON & JONES 1940), which also occurred in brackish water. Given the small sample size, fairly sketchy figures of *M.* ***rue-***

Table 2. Physiochemical conditions measured at the time of collection for various turbellarian species for each pool. Due to the abundance of *Gyratrix hemzaphroditus* we report combined pool conditions.

Species	Pool ID	Date of collection	Temp. (°C)	Salinity (‰)	Oxygen (mg L^{-1})	pH
Gieysztoria	39	Jun97	28.4	7	5.5	8.33
reggae	44	Jun97	29.4	4	2.8	7.71
	47	Jun97	28.4	2	6.9	8.4
G. rastafariae	4	Jun97	27	17	n/a	8.14
	20	Jun97	27.6	17	6.2	8.76
Macrostomum sp.	5	Jan90	26	15.25	n/a	n/a
	5	Jan92	26	25	11.3	n/a
M. balticum	25	Jan97	25.4	**0**	11.2	9.55
Polycystisfelis	21	Jan97	25.97	12	11.53	9.49
*Gyratrix hermaphroditus**	Mean	all dates	26.43	15.2	7.8	8.62
	Min		23.75	1	1.1	7.39
	Max		29.58	39	15.2	10.06
	N		48	48	36	30
	Std.Dev.		1.389	10.06	3.43	0.619

* This species was found in Pools 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 20, 21, 22, 23, 39, 49, **and** 50.

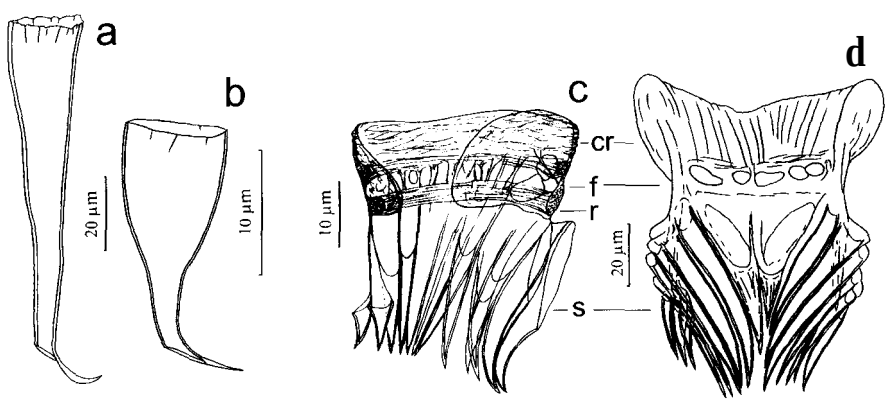

Fig. 2. Sclerotized parts of the copulatory organs: **a** – *Macrostomum balticum,* **b** – *Macrostomum* sp., **c** – *Gieysztoria reggae,* **d** – *Gieysztoria rastafariae.* The collar region (cr), the fenestrae region **(f)** including the reinforced ring **(r),** and the spine region(s) are indicated.

bushi in FERGUSON'S monograph (FERGUSON **1939-1940),** and a certain degree of morphological differences, we treat this species as unidentified. This species appears to be more salt tolerant than *M. balticum* as it was found in a pool with relatively high salinity (Table 2).

Gieysztoria reggae sp. nov.

The description is based on specimens lulled and preserved in 40-50 % ethanol. Body length ranged from 240 to 370 µm. The pharynx is relatively large and ranges from 120 to 150 µm, with a mean pharynx-to-total body length ratio of 0.43 (four specimens).

Eyes are cup shaped and range from 10 to 17.5µm in diameter. General body features such as the extent of intestine, shape of yolk glands, basic arrangement of the reproductive organs are either typical of the genus or difficult to assess from the preserved specimens. The primary diagnostic features in the genus *Gieysztoria* involve the copulatory organ structure and these were well preserved and accessible to detailed examination (Figs. 2 c, 3 a). The total length of sclerotized parts is 33 to 39 µm with an average of 35.5 µm (five specimens). The sclerotized apparatus forms an incompletely closed basket with two different sections: the spines and the girdle. There are eight to twelve spines of different lengths. Notably, the terminal spines are much shorter but appear to have longer proximal openings. The average length of the spine region is 23.5µm (four specimens). The girdle region is separated from the spine region by a distinct ring-like reinforcement. This sclerotic ring is proximally followed by the fenestrae section of approximately 6µm in height and a thin collar section. The collar section is also separated by a ring-like reinforcement from the fenestrae region but this reinforcement is not as strong and prominent as the one separating the spines. The number of fenestrae roughly corresponds

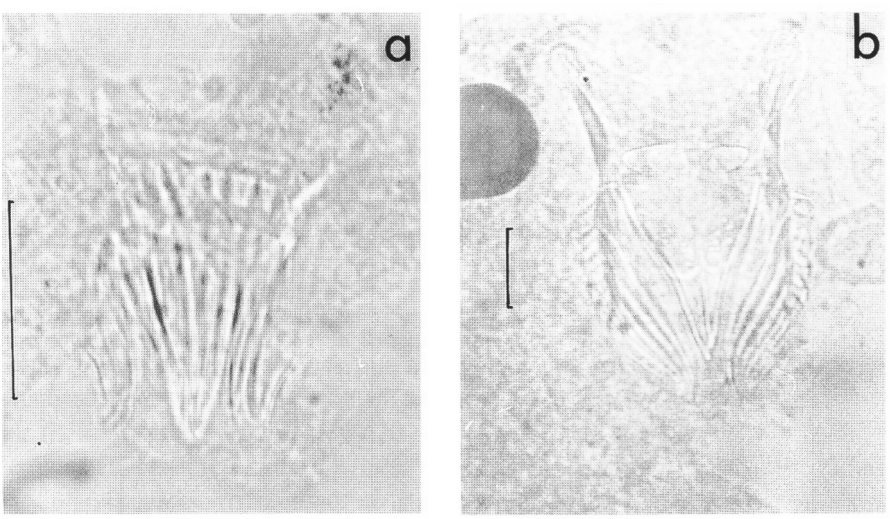

Fig. 3. Photographs of sclerotized parts of the copulatory organs (specimens different from those drawn in Fig. 2; the black vertical bars are 10 µm long): **a** – *Gieysztoria reggae*, **b** – *Gieysztoria rastafariae.*

to the number of spines directly attached to the girdle. While the fenestrae struts appear to be direct extensions of the spines, there are occasional diagonal filaments. Such filaments were also depicted by Papi (Fig. 35N in LUTHER 1955). The collar section varies in its development from specimen to specimen and may appear absent in some individuals, possibly due to age differences. In most specimens it appears to be formed of short fibers woven in parallel to the sclerotized rings. Its average height is approximately the same as that of the fenestrae section although the ratio is not necessarily 1 : 1 in any single individual.

Similar species include *G. subsalsa* LUTHER 1955, *G. tridesma* MARCUS 1946, and *G. hymanae* MARCUS 1946. *Gieysztoria subsalsa* has been reported from a warm, brackish sea shore pool in Italy near San Rossore, Pisa. It differs from the new species by having more spines in the sclerotized copulatory organ, 23 compared to 8–12 in *G. reggae. Gieysztoria tridesma,* described from several sites in Brazil (MARCUS 1946), is similar in several respects. These include a small body size, general structure of the sclerotized part of the copulatory organ and, to some extent, the preferred habitat. The main differences among the new species and *G. tridesma* include a greater number of spines in the latter (15), and a larger sclerotized portion of the copulatory apparatus (55–60ym compared to less than 30–39 in *G. reggae). Gieysztoria hymanae* MARCUS 1946 also from Brazil, appears to be related as well. It differs from the new species by having a larger sclerotized apparatus (60 μm) and a strong differentiation of spines into four thick ones and four to six thin ones.

We collected 40 individuals from three different pools (39, 44 and 47 in June 1997). In addition, similar specimens were collected by one of the authors (J.K.) in Papua New Guinea (in a rain puddle at the University of Technology, Lae, Jan. 1982). Pool temperatures ranged from 28.4 to 29.4 "C and salinity was relatively low, ranging from 2 to 7‰ (Table2).

This species tended to occur in pools with ostracods and crustaceans and a mean species richness of almost 7 (Table 3). In one pool, Pool 39, *G. reggae* was found to coexist with the habitat generalist, *Gyratrix hermaphroditus.*

Gieysztoria rastafariae sp. nov.

The description is based on specimens lulled and preserved in 40–50 % ethanol. Body length ranged from 770 to 1,270 μm (four specimens). Despite the preservation in alcohol the posterior end retained several papillae. Eyes ranged from 20 to 30 μm in diameter. The pharynx is typical for the family. Its size ranged from 200 to 250 μm (three specimens). The intestine is relatively small and does not extend to the end of body. Several individuals had a large oval egg located at the end of the intestine. The eggs ranged from 155 to 185ym along the longer axis (three specimens).

Table 3. Invertebrate species composition for pools that contained various turbellarians, including the two new species of *Gieysztoria*. Due to the abundance of *Gyratrix hermaphroditus* we do not report pool communities for this species.

Species	Pool ID and date	Pool richness	Ostracods	Crustaceans	Insects	Other worms
G. reggae	39 Jun 97	7	1	3	0	2*
	44 Jun 97	6	2	0	3	0
	47 Jun 97	7	4	2	*0*	*0*
G. rastafariae	4 Jun 97	4	*0*	2	1	*0*
	20 Jun 97	6	0	3	*2*	0
Macrostomum sp.	5 Jan 90	11	1	4	1	4*
	5 Jan 92	10	3	4	0	2
M. balticum	25 Jan 97	4	0	1	1	1
Polycystisfelis	21 Jan 97	9	0	3	*2*	3"

* Note that *Gyratrix hermaphroditus* was also found in these pools. The only cases observed where several species of microturbellarians coexisted.

The reproductive system could not be examined in its entirety but a number of diagnostic features were sufficiently well preserved. Yolk glands appear to be of the branching type. The copulatory apparatus is typical of the genus and consists of a seminal vesicle *(vesicula seminalis)*, granular secretions *(vesicula grunulorum)*, and a sclerotized portion. **As** in G. *reggae* sp. nov., the sclerotized portion of the copulatory organ is the most distinguishing and diagnostic feature of this new species (Figs. 2 d, **3** b). It consists of three main regions, the girdle, the fenestrae, and the spine region. The spines are mounted on two lateral branches, not unlike those in the genus *Microdulyellia.* The number of spines is variable and, most likely, depends on the age of the specimens. Some smaller individuals had only 5 spines per branch while others had as many as 11. The spines become shorter and more slender towards the distal end of the branch. The two branches extend proximally into the girdle region. There are usually two to four large openings (fenestrae) in the fenestrae region of the stylet. This region is clearly separated from the girdle region by a horizontal bar of thicker sclerotic tissue that spans the two lateral branches. The delineation of the fenestrae region is less obvious on the distal side. The respective dimensions of the three regions are 22–25 μm, 10–12.5 μm, and 57.5–62.5 pm. Thus, the sclerotized stylet is approximately 100μm in length. In addition to the rows of spines associated with the two lateral branches, there are two large and flat spines attached directly to the lower portion of the fenestrae region.

We collected 15 individuals of this species from two different pools **(4** and 20 in June 1997). This species appears to prefer a slightly cooler habitat with

higher levels of salinity than G. *reggae*. Average pool temperature was 27.3°C and average salinity was 17‰ (Table 2). We found from one to four rotifers in the intestine of some individuals indicating that rotifers are the main food resource in the studied habitat.

There are only two other *Gieysztoria* species that carry spines on two lateral branches, *G. beltrani* GIEYSZTOR 1931 and G. *therapaina* MARCUS 1946. The new species differs from the former by having two large central spines as opposed to a single central projection carrying many small spines. *Gieysztoria therapaina* differs from G. *rastafariae* by having a distinctly asymmetrical arrangement of spines and by the presence of numerous centrally located spines in addition to those attached to the lateral branches.

Gieysztoria rastafariae, unlike *G. reggae,* was found in pools that did not contain any ostracods or other worm species but did contain other crustaceans (including two copepod species) and insect larvae (Table 3). Also the total pool richness was lower for G. *rastafariae* than G. *reggae (5* versus 7).

Polycystis felis MARCUS 1948

Thus far we have identified only a single individual which was found in Pool 21. This is a well oxygenated pool with a moderate level of salinity (Table 2). *Polycystis felis* has a broad worldwide and eurytopic brackish water distribution and appears to be eurytopic within brackish water habitats (SCHOCKAERT 1982).

Gyrafrix hermaphroditus EHRENBERG 1831

While *Gyratrix hermaphroditus* specimens do not differ morphologically from those found in other parts of the world, from Europe to Papua New Guinea, the species is known to be strongly variable at the chromosomal level (CURINI-GALLETTI & PUCINELLI 1994, HEITKAMP 1978). This differentiation may eventually lead to a revision of biogeographical records. On the other hand, several ecologically broad turbellarian species show intraspecific genetic and biological differences. In this case, *G. hermaphroditus* occurs in the greatest variety of habitats within a very small spatial region (less than 80m across) (Fig. 1,Table 1). This suggests that we are dealing with an extremely adaptable single species rather than a collection of sibling species as may be the case with *Mesostoma lingua* (cf. HEITKAMP & SCHRADE-MOCK 1977).

Discussion

This paper adds to the observation that many microturbellarian species are distributed broadly around the globe. There are numerous species known from re-

stricted locations, but this does not necessarily mean restricted distribution. Ax (1995) interprets the broad distribution of brackish water species as an indication of their ancient origin and good dispersal abilities. Our research is in agreement with his suggestions. The spottiness of the records may be indicative of limited data rather than biogeographic patterns.

It is possible that the microturbellarian fauna of the rock pools on the north coast of Jamaica represent endemic evolution of this taxonomic group. The most closely related species in the genus *Gieysztoria* were from South American locations, predominantly Brazil. Similarly, HARRISON & RANKIN (1976) indicated that the aquatic fauna of St. Vincent showed distinct relationships to the faunas of Central and South America. They also proposed a hierarchical structure of isolation and evolution that may be tied to the geo-tectonic background of the Caribbean. However, individual islands have quite different histories and continuing investigations of the faunae on different Caribbean islands may provide answers to the global biogeographical distribution of both the genus *Gieysztoria* and turbellarians in general.

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