A global assessment of the oligochaetous clitellate diversity in freshwater

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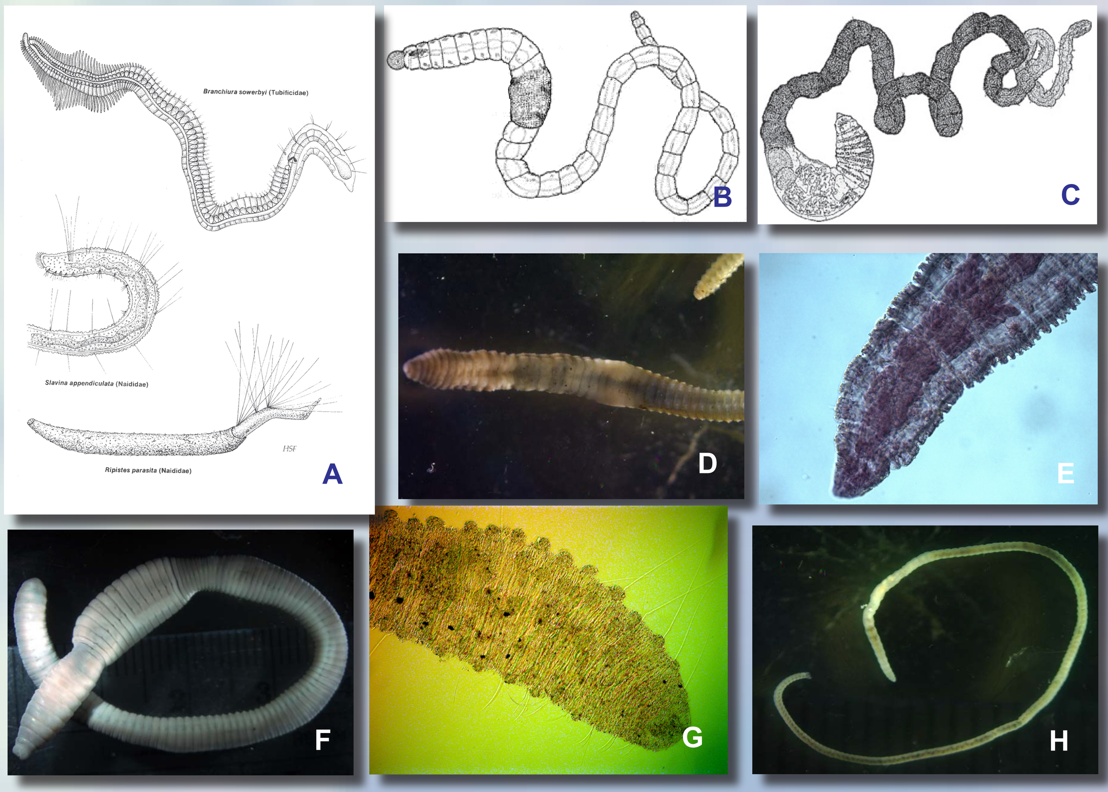

Fig. 1: *Some aquatic oligochaetes. A. Tubificinae and Naidinae (microdriles); B. Generalized oligochaete; C. Tubificoides vestibulatus (Tubificidae, microdrile); D. Eiseniella tetraedra (Lumbricidae; megadrile); E. Spiridion phreaticola (Phallodrilinae; microdrile); F. Glossoscolecidae (megadrile); G. Baikalodrilus dividus (Tubificidae, microdrile); H. Tubificidae (microdrile). Freshwater oligochaetes are found in all kind of inland waters with the exception of temporary waters.*

Family	Subfamily	
Alluroididae	Alluroidinae	6
	Syngenodrilinae	1
	Total Alluroididae	**7**
Almidae	Almidae subfam.	1
	Alminae	17
	Total Almidae	**18**
Biwadrilidae		**1**
Capilloventridae		**3**
Dorydrilidae		**3**
Enchytraeidae		**125**
Haplotaxidae		**18**
Lumbricidae		**19**
Lumbriculidae		**202**
Megascolecidae	Megascolecinae	**2**
Narapidae		**1**
Ocnerodrilidae		**2**
Opistocystidae		**8**
Parvidrilidae		**2**
Phreodrilidae	Phreodrilinae	15
	Phreodriloidinae	23
	Total Phreodrilidae	**38**
Propappidae		**3**
Sparganophilidae		**3**
Tiguassidae		**1**
Tubificidae	Naidinae	225
	Phallodrilinae	18
	Rhyacodrilinae	118
	Telmatodrilinae	3
	Tubificidae subfam.	1
	Tubificinae	207
	Total Tubificidae	**572**
Total		**1028**

Tab. 1: *Number of oligochaete species per family and subfamily when relevant*

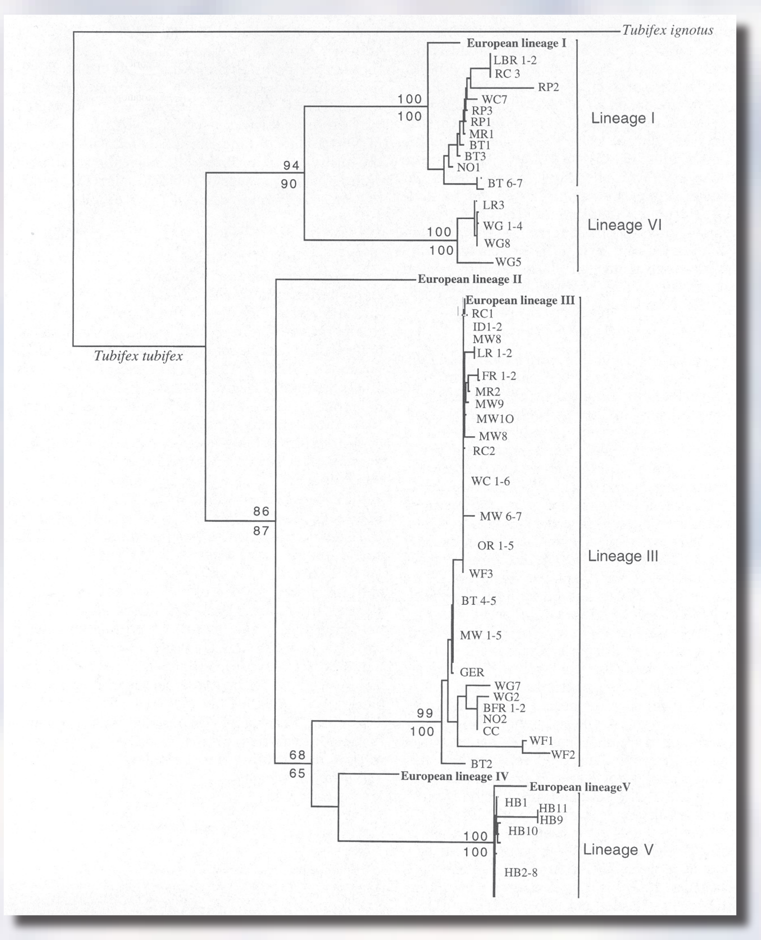

Fig. 6: *The cosmopolitan Tubifex tubifex is one of the most commonly studied freshwater oligochaete as a health indicator of aquatic environment and as a host of several myxozoan parasites of fish. Unfortunately, recent molecular studies indicated that there may be several cryptic species of Tubifex co-occurring in North America and Europe, which exhibit unique physiological and toxicological responses to environment.*

The Oligochaeta constitutes, together with leeches and leech-like worms, the group Clitellata within Annelida (segmented worms). They are marine, freshwater and terrestrial (Fig. 1, 2). About two-thirds of the almost 5000 described oligochaete species are terrestrial (earthworms or "megadriles"). They vary in length between 2 cm and 4 m. Four of the 14 described megadriles families have an aquatic or semi-aquatic mode of life. Aquatic oligochaetes ("sludge worms") are about 1 mm to a few cm long. They are loosely termed "microdriles" and group together a set of 13 families. Most of them are fully aquatic with the exception of the Enchytraeidae which are primarily terrestrial.

Species diversity

About 1500 valid species of aquatic oligochaetes are known to date, of which more than 350 are marine, 1028 are freshwater, and about a hundred is exclusively found in ground water (Table 1). Recent years have seen a continuous increase in the number of described species so that any prospective is an extremely risky business (Fig. 3).

Phylogeny and historical processes

The Oligochaeta have long been suspected to be a paraphyletic group. Molecular studies corroborate that all leech-like taxa (Hirudinea, Acanthobdellida and Branchiobdellida) constitute a clade derived within "Oligochaeta", closely related to the family Lumbriculidae. They also confirm that an aquatic (freshwater?) origin of the clitellates is the most likely (Fig. 4). Aquatic megadriles do not constitute a basal clade of the megadriles, which implies that their adaptation to fresh water is secondary.

Present distribution and main areas of endemicity

The Palaearctic region holds the most abundant and diverse freshwater oligochaete fauna (Fig. 5; Table 2). Some families have a cosmopolitan distribution (Tubificidae, Enchytraeidae), others are limited in the Holarctic region (Lumbriculidae), the southern hemisphere (Phreodrilidae) or the Palaearctic region (Dorydrilidae, Parvidrilidae). 63 % of the Palaearctic fauna is endemic to the region. Taking into account the number of species still to be described, the Australian region harbours 94 % of endemic species. Ancient lakes are important centres of endemicity. Unfortunately, they have been poorly studied except for Lake Baikal. Ground waters are an important centre of endemicity and relictuality.

		Family	Subfamily	Palaearctic	Palaearctic (Baikal excl.)	Neoarctic	Oriental	Ethiopian	Neotropical	Australian	Oceanic islands	Groundwater
megadrile	aqua-	Almidae		1	1	0	0	18	0	0	0	0
megadrile	aqua-	Biwadrilidae		0	0	0	1	0	0	0	0	0
megadrile	aqua-	Sparganophilidae		2	2	0	0	0	2	0	0	0
megadrile	terri-	Lumbricidae		16	16	0	1	3	0	0	0	1
megadrile	terri-	Megascolecidae		2	2	0	0	0	0	0	0	0
megadrile	terri-	Ocnerodrilidae		1	1	0	0	2	0	0	0	0
microdrile		Alluroididae		0	0	0	0	5	3	0	0	0
microdrile		Capilloventridae		0	0	0	0	0	0	3	0	1
microdrile		Dorydrilidae		3	3	0	0	0	0	0	0	3
microdrile		Enchytraeidae		60	58	22	9	0	19	2	1	70
microdrile		Haplotaxidae		10	10	1	3	0	2	4	0	10
microdrile		Lumbriculidae		137	93	56	14	1	1	2	0	51
microdrile		Narapidae		0	0	0	0	0	1	0	0	0
microdrile		Opistocystidae		0	0	3	0	1	5	0	0	0
microdrile		Parvidrilidae		1	1	1	0	0	0	0	0	3
microdrile		Phreodrilidae		0	0	0	3	5	5	38	6	9
microdrile		Propappidae		3	3	0	2	0	0	0	0	1
microdrile		Tiguassidae		0	0	0	0	0	1	0	0	0
microdrile		Tubificidae	Naidinae	106	79	67	88	55	96	47	2	62
microdrile		Tubificidae	Phallodrilinae	11	11	2	0	1	0	4	0	0
microdrile		Tubificidae	Rhyacodrilinae	59	40	9	12	10	15	21	1	0
microdrile		Tubificidae	Telmatodrilinae	1	1	2	0	0	0	0	0	0
microdrile		Tubificidae	Tubificinae	153	105	49	25	12	21	16	0	93
		Total		**566**	**426**	**212**	**158**	**113**	**171**	**137**	**10**	**304**

Tab. 2: *Species diversity of freshwater oligochaetes at the level of the main zoogeographical regions.*

Human related issues

Aquatic oligochaetes have potentially a great utility in human related issues because of: their importance in the aquatic food chain; many species are widely distributed and well studied; representatives include fresh, estuarine and marine species; as a group, they range from sensitive to insensitive over a wide range of environmental insults; they have a long history of use in pollution monitoring and assessment; and, relevant toxicity and bioaccumulation tests exist (Fig. 6).

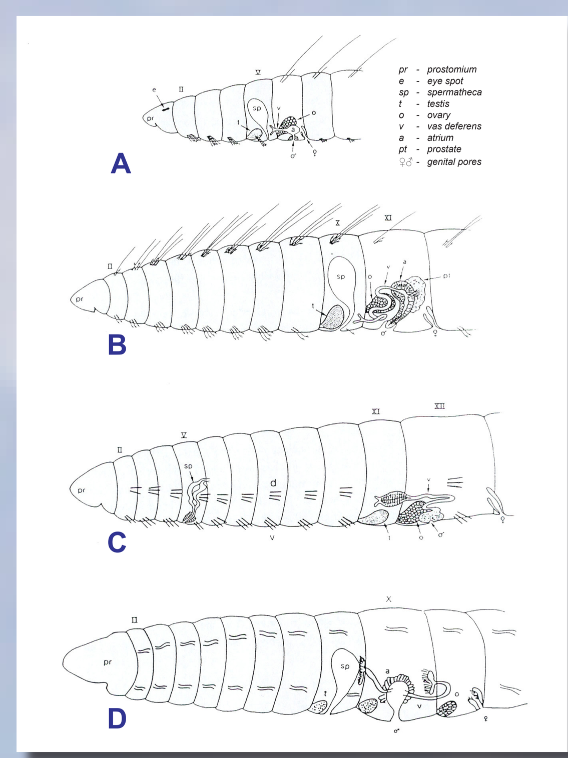

Fig. 2: *Generalized anatomy for four oligochaete families (from Brinkhurst and Kathman, 1998). A. Naidinae; B. Tubificinae; C. Enchytraeidae; D. Lumbriculidae.*

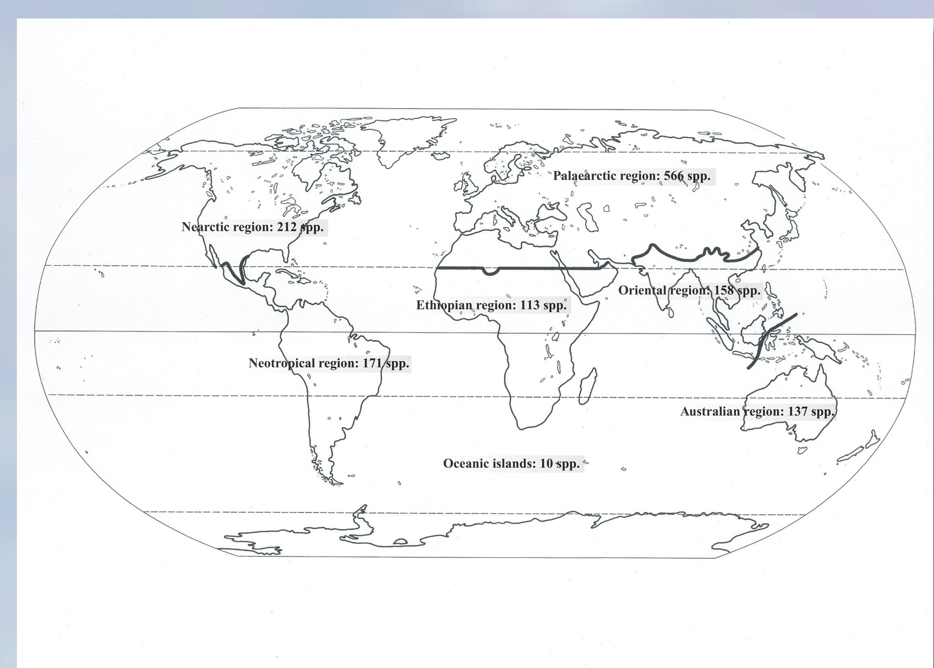

Fig. 5: *Species diversity of the Oligochaeta at the level of the main zoogeographical areas.*

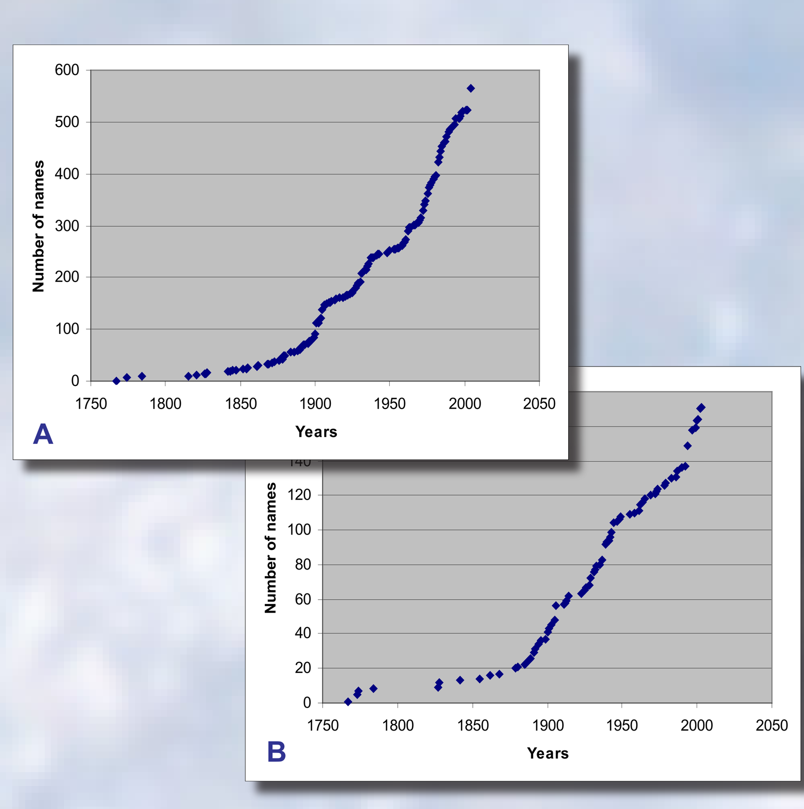

Fig. 3: *The evolution of numbers of names over time shows no trend towards stabilization, even in well-studied regions (A. Palaearctic region; B. Neotropical region).*

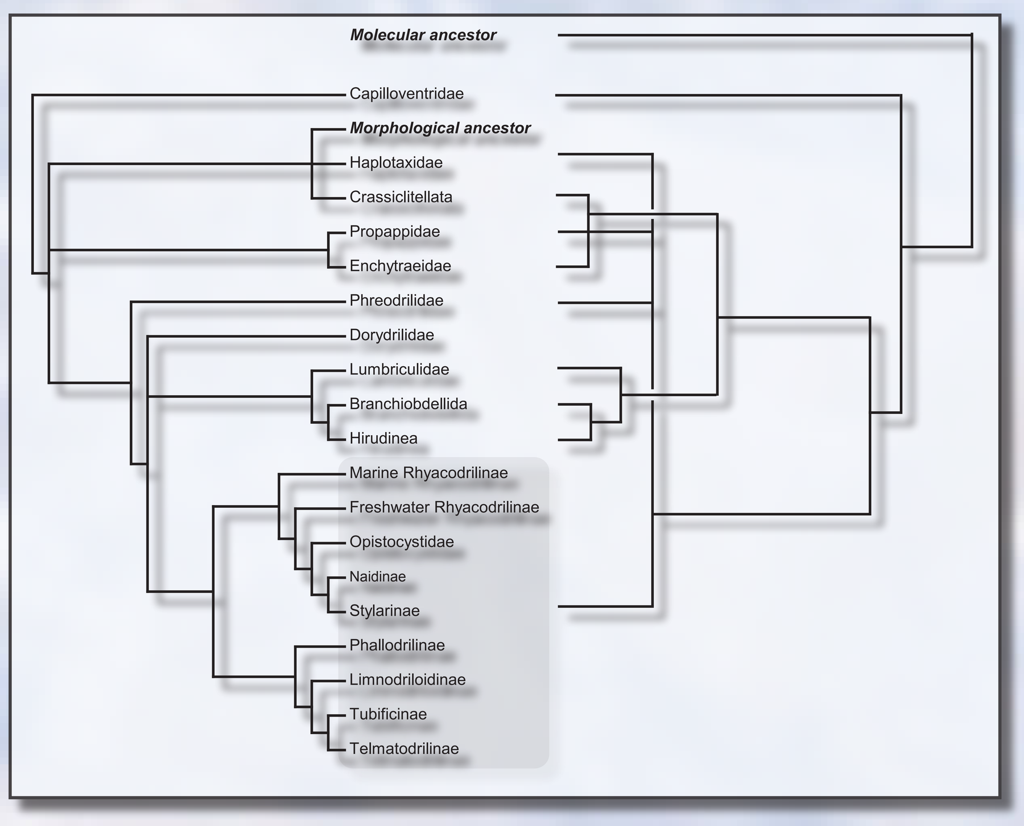

Fig. 4: *Based on the definition of a hypothetical ancestor, all oligochaetes derived from a worm close to extant haplotaxids which implies that the split between aquatic and terrestrial oligochaetes occur very soon during the evolution of the clitellates. Molecular analyses refute the proposal that the ancestor to Clitellata was adapted to terrestrial life and instead support the view that the first clitellates were aquatic.*