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Tapeworms (Cestoda: Proteocephalidea) of teleost fishes from the Amazon River in Peru: additional records as an evidence of unexplored species diversity

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Abstract: This paper represents an update of the previous list of adult proteocephalidean tapeworms (Cestoda) parasitizing freshwater teleosts from the Peruvian Amazon, which was presented by de Chambrier *et al.* (2006a). Four new samplings made it possible to almost double the number of species found, all of them representing new geographical records from Peru. With 34 newly added species, a total of 63 proteocephalidean cestodes (46 named species of 27 genera) are now reported from Amazonia in Peru (compared to 54 named species of 28 genera from its Brazilian part). The genera previously unreported by de Chambrier *et al.* (2006a) are *Ageneiella*, *Brayela*, *Endorchis*, *Ephedrocephalus*, *Gibsoniella*, *Harriscolex*, *Jauella*, *Lenhataenia*, *Manaosia*, and *Megathylacus*. Four species, namely *Jauella glandicephalus*, *Monticellia belavistensis*, *M. santafesina*, and *Proteocephalus hobergi*, are reported from the Amazon River basin for the first time. *Harriscolex piramutab* (Woodland, 1934) n. comb. is proposed for specimens previously identified as *Proteocephalus piramutab* Woodland, 1934 from *Brachyplatystoma vaillantii*. The highest number of proteocephalidean cestodes is reported from *Pseudoplatystoma fasciatum* (a total of 10 cestode species), *Zungaro zungaro* (previously named *Paulicea luetkeni*; 9 species) and *Phractocephalus hemioliopus* (6 species). A high number of unnamed species found in Peru (17), which most probably represent taxa new to science including at least two new genera, demonstrates that the species richness of proteocephalidean cestodes in Amazonia is still poorly known.

Keywords: Catfish - freshwater fish - Siluriformes - Peru - Pimelodidae - Amazonia - species diversity - faunal survey.

INTRODUCTION

The Amazon River basin is by far the largest river basin in the world and drains roughly 40 percent of the South American continent. This river basin hosts the most diverse fish fauna in planet, with about 2,500 species described and another 1,000 species estimated to be described (Junk *et al.*, 2007). However, recent large-scale environmental degradation due to anthropogenic pressure such as deforestation, water pollution, overfishing and intensive farming has had negative effect on water ecosystems, including considerable decrease of population density of big pimelodid catfishes (Siluriformes) in the Brazilian part of Amazonia (Angelini *et al.*, 2006; Pelicice & Agostinho, 2008; Boni *et al.*, 2011; Reis, 2013).

These fishes serve as definitive hosts of a unique rich fauna of proteocephalidean tapeworms (Cestoda) that probably underwent explosive radiation and represent an interesting model for co-evolutionary studies because of strict host specificity of most taxa (de Chambrier & Vaucher, 1997, 1999; Zehnder & Mariaux, 1999; de

Chambrier *et al.*, 2004a; Hypša *et al.*, 2005). Unlike most parts of the Brazilian Amazonia, in which population density of big catfish has declined (Angelini *et al.*, 2006; Pelicice & Agostinho, 2008), numerous stocks of these fishes including pimelodids still inhabit the Peruvian part of the Amazon River basins.

Parasitological examination of 276 fishes of 73 species from the Amazon River and its tributaries around Iquitos, Loreto Region in Peru, carried out by the present authors and their co-workers in 2004 and 2005, revealed an extraordinary richness of proteocephalidean tapeworms, which were all reported from Peru for the first time (de Chambrier & Scholz, 2005; de Chambrier *et al.*, 2006a). De Chambrier *et al.* (2006a) listed as many as 29 species of 17 genera found in 10 species of siluriform fishes and cichlids. New sampling in this region in 2006, 2008, 2009 and 2011 made it possible to obtain additional material that includes many cestodes not having been previously reported from Peru or from the Amazon River basin; some may even be new to science. To provide a robust baseline for forthcoming analyses of zoogeographical patterns

and phylogenetic relationships of proteocephalideans in the Neotropical Region, updated information is presented on the species composition, host-parasite associations and geographical distribution of these cestodes, which represent an important component of the parasite fauna of Neotropical fishes (Thatcher, 2006).

MATERIAL AND METHODS

A total of 611 fish from the Amazon River and its tributaries around Iquitos (72°50'–73°40'W; 3°34'–4°53'S), Loreto Region, Peru, were examined for parasites in September 2006 and 2008, and in October 2009 and 2011. Intestines of freshly captured hosts as well as those sold on the market of Belén in Iquitos were transported in coolers to the provisional laboratory (courtesy of Acuário Río Momón in Iquitos), where they were immediately examined. For morphological evaluation, only specimens in good condition were used, but quantitative parameters such as intensity or abundance could not be reliably assessed.

Cestodes were gently washed in saline, fixed with hot (almost boiling) 4% formaldehyde solution and then processed using standard procedure used for fish tapeworms as described by de Chambrier *et al.* (2014). Fragments of strobila were also fixed with 96% molecular-grade ethanol for molecular analyses (DNA sequencing), which forms part of a large-scale study on the phylogenetic relationships of cestodes supported by the National Science Foundation project (programme Planetary Biodiversity Inventory; see www.tapeworm.uconn.edu). In the present paper, scanning electron micrographs (SEM) of the scoleces of five species are provided (Figs 1–5); these species were not studied using SEM or their SEM pictures were based on contracted or deformed specimens.

Most specimens found are deposited in the Natural History Museum, Geneva, Switzerland (MHNG-PLAT), which hosts one of the most comprehensive collections of proteocephalidean cestodes (http://www.ville-ge.ch/mhng/dpt_inve_coll_e.php#platyhelminthes). See Table 1 for more details. Classification of cestodes, including original descriptions of taxa, follows the Global Cestode Database (Caira *et al.*, 2012). However, the recently erected order Onchoproteocephalidea, which groups the proteocephalideans and some 'hooked' tetraphyllidean cestodes (see Caira *et al.*, 2014), is not considered herein for the reasons presented by Arredondo *et al.* (2014), especially because no morphological synapomorphies of the new order were provided by Caira *et al.* (2014). Field numbers correspond to the numbers of fish examined in field protocols (PI = Peru, Iquitos, Loreto Region, Peru; letters after host number distinguish different worm samples). Since 2008, every fish dissected was

photographed together with its field number (PI); in 2009 and 2011, tissue samples, usually a small piece of musculature, of every infected fish were taken and fixed with 96% molecular-grade ethanol for future DNA sequencing to confirm host identification. Photographs of fishes and their tissue samples are available upon request from the authors.

Names of teleosts follow those in FishBase (Froese & Pauly, 2014) and PlanetCatfish (<http://www.planetcatfish.com>) except for *Brachyplatystoma rousseauxii* (Castelnau), which was erroneously reported as *B. flavicans* (Castelnau) by de Chambrier *et al.* (2006a) following Fishbase (see Lundberg and Akama, 2005; <http://www.planetcatfish.com/>). In addition, *Zungaro zungaro* (Humboldt) was wrongly reported as *Paulicea luetkeni* (Steindachner) (for current nomenclature, see Froese & Pauly, 2014; John Lundberg, pers. comm.).

RESULTS

Survey of species found

Species not reported by de Chambrier *et al.* (2006a) are marked by an asterisk (*); species reported by de Chambrier *et al.* (2006a), but not found in 2006–2011, are also listed herein to provide a complete list of cestodes found. Collection numbers refer to the Natural History Museum, Geneva, Switzerland – MHNG-PLAT, unless otherwise stated. Cestode taxa are listed alphabetically.

Ageneiella sp.*

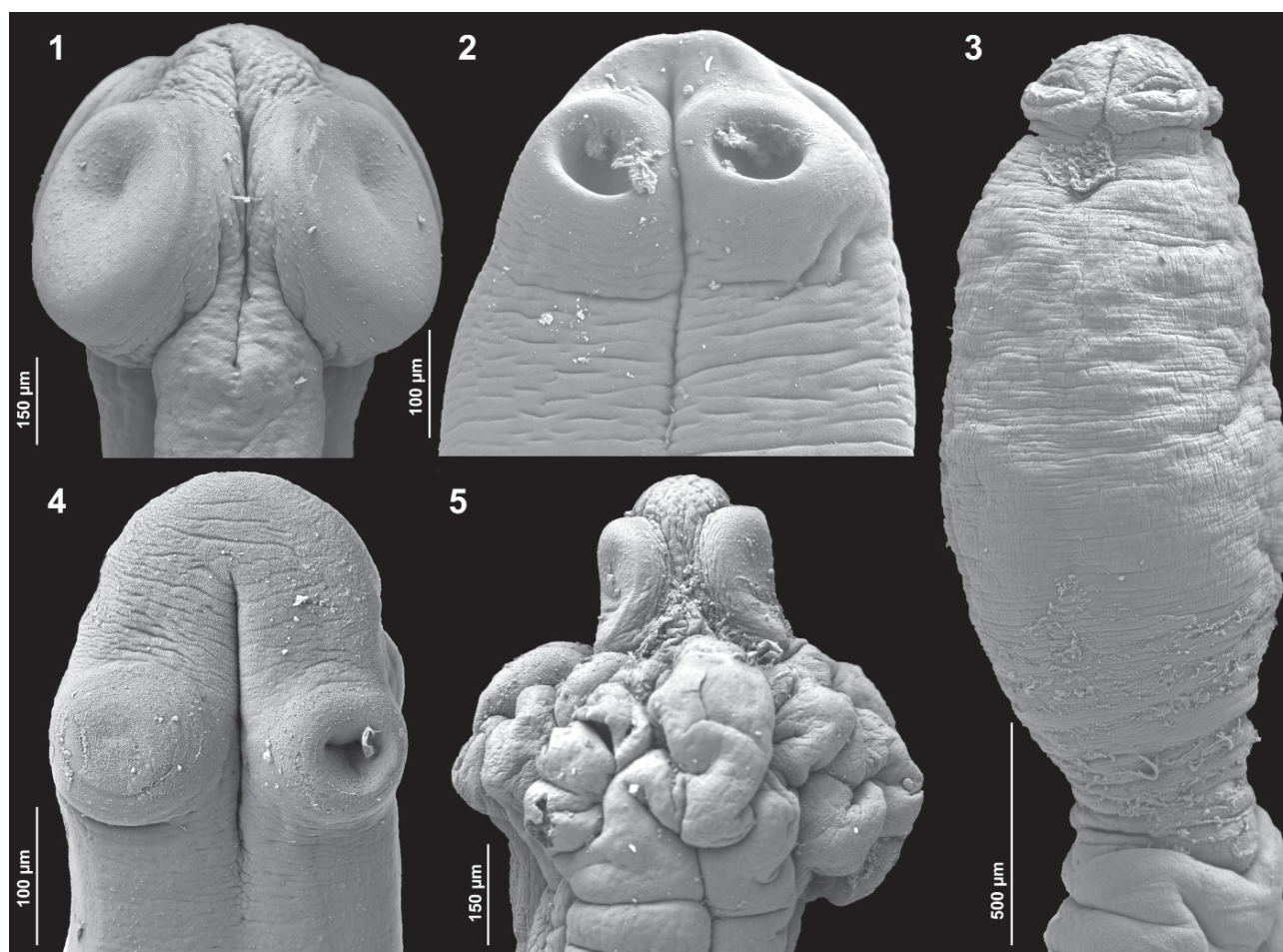
Host: *Ageneiosus inermis* (L.) (1 fish infected of 16 fish examined, i.e. prevalence of 6%).

Remarks: Specimens found in *A. inermis* are partly decomposed and contracted, which impedes their reliable identification to the species level. However, they apparently belong to an undescribed species of *Ageneiella* de Chambrier & Vaucher, 1999, a hitherto monotypic genus proposed to accommodate *A. brevifilis* de Chambrier & Vaucher, 1999 from *Ageneiosus brevifilis* (L.) (synonym of *A. inermis*) from Paraguay by de Chambrier & Vaucher (1999). They possess biloculate suckers with a sphincter and lateral lobes of the ovary penetrating into the cortex (see de Chambrier & Vaucher, 1999).

Immature cestodes were found in two additional *Ageneiosus* sp., but their identification is not possible.

Amphoteromorphus ovalis Carfora, de Chambrier & Vaucher, 2003*

Host: *Brachyplatystoma* cf. *filamentosum* (Lichtenstein); 1/3, 33%).



Figs 1-5. Scanning electron micrographs of representative scoleces of proteocephalidean cestodes found in the Peruvian Amazon. (1) *Nomimoscolex lopesi* from *Pseudoplatystoma fasciatum* (PI 708). (2) *Proteocephalus* sp. 2 from *Pterodoras granulosus* (PI 635). (3) *Jauella glandicephalus* from *Zungaro zungaro*. (4) *Proteocephalus kuyukuyu* from *Megalodoras uranoscopus* (PI 324). (5) *Spatulifer rugosa* from *P. fasciatum* (PI 708). 1, 3, 5 = lateral view; 2, 4 = dorsoventral view.

***Amphoteromorphus parkamoo* Woodland, 1935**

Host: *Zungaro zungaro* (3/30, 10%).

Remarks: Redescribed by Carfora *et al.* (2003), who confirmed the validity of the species.

Amphoteromorphus peniculus* Diesing, 1850

Host: *Brachyplatystoma rousseauxii* (1/3, 33%).

***Amphoteromorphus piriformis* Carfora,
de Chambrier & Vaucher, 2003**

Host: *Brachyplatystoma rousseauxii* (1/3, 33%).

Remarks: *A. piriformis* was described from *B. rousseauxii* collected in Itacoatiara, Brazil in September 1992 and October 1995 (Carfora *et al.*, 2003).

Brayela karuatayi* (Woodland, 1934)

Host: *Platynematachthys notatus* (Jardine) (5/13, 38%).

Remarks: This species, which had never been found since its original description by Woodland (1934a), has recently been redescribed by de Chambrier *et al.* (2014) on the basis of new material collected in Peru. The authors also described correctly its scolex morphology and provided the evidence that the actual fish host of this cestode is *P. notatus*, not '*Glanidium* sp.' as reported in the original description (see de Chambrier *et al.*, 2014).

***Chambriella agostinhoi* (Pavanelli & Machado dos
Santos, 1992)**

Host: *Zungaro zungaro* (11/30, i.e. 37%).

***Chambriella paranaensis* (Pavanelli & Rego, 1989)**

Host: *Hemisorubim platyrhynchos* (1/12, 8%).

Remarks: de Chambrier *et al.* (2006a) designated this species erroneously as the type species of *Chambriella* Rego, Chubb & Pavanelli, 1999. Rego *et al.* (1999) actually did not explicitly mention the type species of the genus in its generic diagnosis on p. 314, but *C. agostinhoi* was mentioned as the type species of the genus in remarks to that species (Rego *et al.*, 1999: 317).

Chambriella* sp. 1

Host: *Brachyplatystoma vaillantii* (Valenciennes) (4/39, 10%).

Remarks: This cestode is a rare parasite of *B. vaillantii*.

***Chambriella* sp. 2 (= *Chambriella* sp. of de Chambrier *et al.*, 2006a)**

Host: *Phractocephalus hemioliopus* (Bloch & Schneider) (5/10, 50%).

Chambriella* sp. 3

Host: *Pseudoplatystoma fasciatum* (7/42, 17%).

Chambriella* sp. 4

Host: *Sorubimichthys planiceps* (Spix & Agassiz) (6/22, 27%).

Remarks: de Chambrier & Scholz (2008) reported but did not describe the morphology of this species, which may be new to science, similarly as the three species listed above (*Chambriella* spp. 1-3). Their taxonomic study is in preparation and will be presented in a separate account.

***Choanoscolex abscisus* (Riggenbach, 1896)**

Host: *Pseudoplatystoma fasciatum* (14/42, 33%).

Remarks: Compared to de Chambrier *et al.* (2006a), new collections enabled us to obtain sufficient material of this cestode, which has been found in a wide spectrum of unrelated fish hosts (Rego, 1987, 1990; Rego & Pavanelli 1990; Rego *et al.*, 1999).

In its strobilar morphology, the species closely resembles *Spatulifer surubim* Woodland, 1934 from the same fish host, differing only in a much less developed metascolex. However, some intermediate forms with a more developed metascolex were found, which indicates that differences between these taxa of two different genera should be critically assessed. Molecular data also

indicate close relatedness of *S. surubim* and *C. abscisus* from *P. fasciatum* (A. Waeschenbach, unpubl. data).

Choanoscolex* sp.

Host: *Sorubimichthys planiceps* (3/22, 14%).

Remarks: de Chambrier & Scholz (2008) reported cestodes of the genus *Choanoscolex* La Rue, 1911 that differ from those of *C. abscisus*, the only species of the genus (see above).

Endorchis piraieba* Woodland, 1934

Host: *Brachyplatystoma* cf. *filamentosum* (1/3, 33%).

Remarks: At present, the genus includes *E. piraieba* from *B. filamentosum* and *Endorchis auchenipteri* de Chambrier & Vaucher, 1999 from *Auchenipterus osteomystax* (Miranda Ribeiro) from the Paraná River in Paraguay (de Chambrier & Vaucher, 1999). In addition, de Chambrier & Vaucher (1999) reported unidentified cestodes of *Endorchis* from *Pimelodus* cf. *maculatus* Lacépède and *Trachelyopterus striatulus* (Steindachner) from Paraguay.

An immature specimen with a similar scolex was found in *Pseudoplatystoma fasciatum* (1/42, i.e. 2%).

Endorchis* sp.

Host: *Pimelodus altissimus* Eigenmann & Pearson (1/1).

Remarks: These specimens resemble those of *E. auchenipteri* but their large-sized Mehlis gland is unique among the Proteocephalidea.

***Euzetiella tetraphylliformis* de Chambrier, Rego & Vaucher, 1999**

Host: *Zungaro zungaro* (5/30, 17%).

Remarks: Worms collected in 2009 were immature, but are supposed to belong to the only known species of the genus, which was described from the same host in Itacoatiara, Brazil (de Chambrier *et al.*, 1999). One immature specimen was also found in *Pseudoplatystoma fasciatum*.

Gibsoniella mandube* (Woodland, 1935)

Host: *Ageneiosus inermis* (2/16, 13%), *Ageneiosus* sp. (3/10, 30%).

Remarks: The species was described as *Anthobothrium mandube* Woodland, 1935, (Phyllobothriidae) and transferred to *Gibsoniella* Rego, 1984 by Rego (1984). From the same host (*A. inermis*) and same locality

(Amazon River in Brazil), Woodland (1935a) described *Endorchis mandube*, but Rego (1984) suggested that both species may be synonymous and de Chambrier (1990) confirmed this synonymy.

However, de Chambrier & Vaucher (1999) studied the type material and newly collected specimens of both taxa from the Amazon River and concluded that they represent two distinct species of the same genus. To avoid their homonymy, they proposed *Gibsoniela meursaulti* de Chambrier & Vaucher, 1999 to accommodate *Endorchis mandube*; tapeworms redescribed by Rego (1992) as *G. mandube* actually belonged to *G. meursaulti* (de Chambrier & Vaucher, 1999).

Harriscolex kaparari* (Woodland, 1935)

Host: *Pseudoplatystoma fasciatum* (3/42, 7%).

Remarks: Described as *Nomimoscolex kaparari* Woodland, 1935 by Woodland (1935a) from *Pseudoplatystoma tigrinum* (Valenciennes) in Brazil.

***Harriscolex piramutab* (Woodland, 1934) n. comb.**

Host: *Brachyplatystoma vaillantii* (8/39, 20%).

Remarks: de Chambrier *et al.* (2006a) reported *Proteocephalus piramutab* Woodland, 1934 from *Brachyplatystoma vaillantii*. A detailed morphological study of newly collected specimens and material of *Proteocephalus piramutab* from museum collections, and their comparison with those of *H. kaparari*, revealed that the former species should be transferred to *Harriscolex* Rego, 1987, because it possesses a scolex with a dome-shaped anterior end and suckers with two triangular projections (see Rego, 1994). Therefore, a new combination, *Harriscolex piramutab*, is proposed for specimens previously identified as *P. piramutab*, including those reported from Peru by de Chambrier *et al.* (2006a).

***Houssayela sudobim* (Woodland, 1935)**

Host: *Pseudoplatystoma fasciatum* (3/42, 7%).

Remarks: Described as *Myzophorus sudobim* Woodland, 1935 from *P. fasciatum* from the Amazon River in Brazil by Woodland (1935b) and found and redescribed by de Chambrier & Scholz (2005) for the first time since original description on the basis of a single specimen from *P. fasciatum* in Iquitos (PI 76a – 22. 4. 2004).

Jauella glandicephalus* Rego & Pavanelli, 1985

Fig. 3

Host: *Zungaro zungaro* (9/30, 30%).

Remarks: Described from *Zungaro jahu* (Ihering) (as *Paulicea luetkeni*) from the Paraná River in Brazil by Rego & Pavanelli (1985). This is the first record of the parasite in the Amazon River basin.

Lenhataenia megacephala* (Woodland, 1934)

Host: *Sorubimichthys planiceps* (11/22, 50%).

Remarks: The genus was erected by de Chambrier & Scholz (2008) to accommodate *Monticellia megacephala* Woodland, 1934, which is a common, host-specific parasite of *S. planiceps*.

Manaosia bracodemoca* Woodland, 1935

Host: *Sorubim lima* (Bloch & Schneider) (3/29, 10%).

Remarks: The species was described by Woodland (1935a) from '*Platysoma* sp.' (vernacular name 'braço de moça') in the Amazon River in Brazil. De Chambrier (2003) clarified the systematic position of this species, which is a rare parasite of *S. lima*. He considered *Paramonticellia* Pavanelli & Rego, 1991 to be a junior synonym of *Manaosia* Woodland, 1935.

***Mariauxiella piscatorum* de Chambrier & Vaucher, 1999**

Host: *Hemisorubim platyrhynchos* (2/12, i.e. 17%).

Remarks: This species was found only in 2004 (de Chambrier *et al.*, 2006a).

Megathylacus jandia* Woodland, 1934

Host: *Zungaro zungaro* (2/30, 7%).

Remarks: This species was originally identified as *Megathylacus brooksi* Rego & Pavanelli, 1985, but a detailed study of type and new material of *Megathylacus* cestodes from the Amazon and Paraná River basins (de Chambrier *et al.*, 2014) has demonstrated conspecificity of this species with *M. jandia*, which was described by Woodland (1934a) from the Amazon River in Brazil.

Megathylacus* sp.

Host: *Pseudoplatystoma fasciatum* (4/42, 10%).

Remarks: These cestodes from *P. fasciatum* differ from *Megathylacus travassosi* by a few morphological characters and potentially belong to a new species. This species was collected also in 2004, but not reported by de Chambrier *et al.* (2006a).

***Monticellia amazonica* de Chambrier & Vaucher,
1997**

Host: *Calophysus macropterus* (Lichtenstein) (5/33, 15%).

Remarks: Scholz *et al.* (2008) redescribed the species on the basis of specimens found in Iquitos, Peru in 2005.

***Monticellia belavistensis* Pavanelli, Machado dos
Santos, Takemoto & dos Santos, 1994***

Host: *Pterodoras granulosus* (Valenciennes) (1/24, 4%).

Remarks: This cestode, which was described by Pavanelli *et al.* (1994) from *P. granulosus* from the Paraná River basin in Brazil and then reported by de Chambrier & Vaucher (1999) from the Paraguay River in Paraguay, was found in Peru only once. It is the first record of this species from the Amazon River basin.

Monticellia lenha* Woodland, 1933

Host: *Sorubimichthys planiceps* (13/22, 59%).

Remarks: Originally described by Woodland (1933) from specimens found in *S. planiceps*, and redescribed by de Chambrier & Scholz (2008), who studied type specimens and new material from Iquitos collected in 2006 (see Table 2). It is a specific and the most frequent parasite of *S. planiceps*.

***Monticellia santafesina* Arredondo &
Gil de Pertierra, 2010***

Host: *Megalonema platycephalum* Eigenmann (1/1).

Remarks: Described from *Megalonema platanum* (Günther) from the Paraná River basin in Argentina (Arredondo & Gil de Pertierra, 2010). This is the first geographical record of this cestode from the Amazon River basin. *M. platycephalum* represents a new definitive host of the parasite.

Monticellia ventrei* de Chambrier & Vaucher, 1999

Host: *Pinirampus pirinampu* (Spix & Agassiz) (4/30, 13%).

Remarks: *Monticellia ventrei* was described by de Chambrier & Vaucher (1999) from specimens found in *P. pirinampu* from the Paraguay River in Paraguay. Specimens found in Peru represent a new geographical record and expand the distribution area of the species to include the Amazon River basin.

Nomimoscolex admonticellia* (Woodland, 1934)

Host: *Pinirampus pirinampu* (11/30, 37%).

Remarks: This is a relatively common parasite specific of *P. pirinampu*, which was originally described by Woodland (1934b) from *Pinirampus* sp. from the Amazon River near Itacoatiara, Brazil.

Nomimoscolex lenha* (Woodland, 1933)

Host: *Sorubimichthys planiceps* (5/22, 23%).

Remarks: de Chambrier & Scholz (2008) redescribed the species based on 2 specimens they collected in Itacoatiara, Brazil in 1995 and 1 specimen from Iquitos, Peru in 2006. Interestingly, the prevalence of *N. lenha* in Brazil (22%, n = 9; see de Chambrier & Scholz, 2008) was almost identical to that in the same host from Peru.

***Nomimoscolex lopesi* Rego, 1989**

Fig. 1

Host: *Pseudoplatystoma fasciatum* (11/42, 26%).

Remarks: This species was studied using scanning electron microscopy for the first time (Fig. 1).

***Nomimoscolex sudobim* Woodland, 1935**

Host: *Pseudoplatystoma fasciatum* (10/42, 24%).

Remarks: Also found in *P. tigrinum* from Peru by de Chambrier *et al.* (2006a). The species was redescribed by de Chambrier *et al.* (2006b).

***Nomimoscolex suspectus* Zehnder, de Chambrier,
Vaucher & Mariaux, 2000***

Host: *Brachyplatystoma* cf. *filamentosum* (1/3, 33%).

Remarks: Described from tapeworms found in *Brachyplatystoma filamentosum* (type host), *B. flavicans* (now *B. rousseauxii*) and *B. vaillantii* from the Amazon River in Brazil (Zehnder *et al.*, 2000); it was found in Peru only once.

Nomimoscolex* sp.

Host: *Pimelodus ornatus* Kner (2/13, 15%).

Remarks: These cestodes differ from *N. microacetabula* Gil de Pertierra, 1995 by a few morphological characters and potentially belong to a new species.

Nupelia sp.

Host: *Goeldiella eques* (Müller & Troschel) (3/28, 11%).

Remarks: Despite great efforts to collect more material allowing for its description, only one additional specimen from this species was found since 2005 (see de Chambrier *et al.*, 2006a). These tapeworms are mainly characterized by extraordinarily wide ventral osmoregulatory canals.

Peltidocotyle lenha (Woodland, 1933)

Hosts: *Sorubimichthys planiceps* (13/22, 59%); *Zungaro zungaro* (13/30, 43%).

Remarks: de Chambrier & Scholz (2008) reported the species from the type host, *S. planiceps*. *Zungaro zungaro* is another host of the tapeworm (Zehnder & de Chambrier, 2000).

Peltidocotyle rugosa Diesing, 1850*

Host: *Pseudoplatystoma fasciatum* (10/42, 24%).

Remarks: de Chambrier *et al.* (2006a) did not report this frequent parasite of *P. fasciatum*.

Proteocephalus gibsoni Rego & Pavanelli, 1991

Host: *Astronotus ocellatus* (1/4, 25%).

Proteocephalus hemioliopteri de Chambrier & Vaucher, 1997*

Host: *Phractocephalus hemioliopterus* (1/10, 10%).

Remarks: de Chambrier & Vaucher (1997) proposed a new name, *Proteocephalus hemioliopteri*, for *Myzophorus woodlandi* Rego, 1984 [syn. *Nomimoscolex woodlandi* (Rego, 1984) Rego & Pavanelli, 1992]; de Chambrier *et al.* (2005) redescribed this species, which was found only once in Peru.

Proteocephalus hobergi de Chambrier & Vaucher, 1999*

Host: *Oxydoras niger* (Valenciennes) (1/16, 6%).

Remarks: de Chambrier & Vaucher (1999) described the species from *Oxydoras kneri* Bleeker from the Paraná and Paraguay rivers in Paraguay. The specimens found in Peru represent new host and geographical records and the first report of the species from the Amazon River basin.

Proteocephalus kuyukuyu Woodland, 1935*

Fig. 4

Hosts: *Megalodoras uranoscopus* (Eigenmann & Eigenmann) (3/4, 75%); *Pterodoras granulosus* (2/24, 8%); *Pterodoras* sp. (1/1).

Remarks: This parasite of doradid catfishes was described by Woodland (1935c) from the kuyukuyu, vernacular name of *Oxydoras niger* (as *Pseudodoras niger*), from Codajaz, Brazil. Even though Woodland (1935c) found over 50 specimens, no one was mature. The same situation was observed in Peru and none of 347 cestodes found was fully mature. This may indicate hyperapolytic development, i.e. release of proglottids precociously before they contain any eggs, which then complete their development while free in the intestine of the host (see glossary in Khalil *et al.*, 1994), but no free proglottids were found in hosts infected with immature cestodes.

Proteocephalus macrophallus (Diesing, 1850)

Host: *Cichla monoculus* (2/15, 13%).

Proteocephalus microscopicus Woodland, 1935

Host: *Cichla monoculus* (6/15, 40%).

Remarks: Both species, similarly as *P. gibsoni* from another cichlid (see above), were not found since 2005 because no other hosts, *C. monoculus* and *A. ocellatus*, were examined.

Proteocephalus sophiae de Chambrier & Rego, 1994*

Host: *Zungaro zungaro* (6/30, 20%).

Remarks: This is a host-specific parasite of the *Z. zungaro*, described from the Amazon River in Brazil by de Chambrier & Rego (1994).

Proteocephalus sp. 1 of de Chambrier *et al.* (2006a)

Host: *Phractocephalus hemioliopterus* (2/10, 20%).

Remarks: Only immature specimens have been found.

Proteocephalus sp. 2 of de Chambrier *et al.*, (2006a)

Fig. 2

Host: *Pterodoras granulosus* (2/24, 8%).

Remarks: Additional immature specimens were found in 5 *P. granulosus* and possibly belong to the same taxon.

Proteocephalus* sp. 3

Host: *Pimelodus blochii* Valenciennes (2/8, 25%).

Remarks: All specimens are immature.

***Rudolphiella piracatinga* (Woodland, 1935)**

Host: *Calophysus macropterus* (10/33, 30%).

Rudolphiella* sp.

Host: *Pinirampus pirinampu* (5/30, 17%).

Remarks: These cestodes differ from both *R. myoides* Woodland, 1934 and *R. piranabu* Woodland, 1934 from the same host in Brazilian Amazon and potentially belong to a new species.

***Scholzia emarginata* (Diesing, 1850)**

Host: *Phractocephalus hemioliopterus* (10/10, 100%).

Remarks: This is the most frequent specific parasite of *P. hemioliopterus*.

***Sciadocephalus megalodiscus* Diesing, 1850**

Host: *Cichla monoculus* (1/15, 7%).

Remarks: Woodland (1933b) redescribed this taxa established by Diesing (1850), based on his material collected in the Amazon River in 1931. Rego *et al.* (1999) reported this species from the Paraná River basin and amended a generic diagnosis.

***Spasskyellina spinulifera* (Woodland, 1935)**

Hosts: *Pseudoplatystoma fasciatum* (12/42, 29%), *P. tigrinum* (Valenciennes) (2/13, 14%; no new material found since 2005).

Remarks: This species was originally described as *Monticellia spinulifera* by Woodland (1935b) from *P. fasciatum* from the Amazon River in Brazil. Freze (1965) proposed a new genus, *Spasskyellina*, to accommodate this species. De Chambrier & Vaucher (1999) synonymized the genus with *Monticellia*, but later de Chambrier *et al.* (2006a) listed *Spasskyellina* as a valid genus, ignoring the previous paper from 1999. Three species of *Pseudoplatystoma*, namely *P. corruscans*, *P. fasciatum* and *P. tigrinum*, from the Amazon and Paraná River basins in Peru, Brazil and Paraguay serve as definitive hosts of *S. spinulifera* (Woodland, 1935b; Rego, 1990; de Chambrier & Vaucher, 1999; de Chambrier *et al.*, 2006a; present study).

***Spatulifer maringaensis* Pavanelli & Rego, 1989**

Host: *Hemisorubim platyrhynchos* (Valenciennes) (2/12; 17%); *Sorubim lima* (3/29, 10%).

Remarks: Originally described from *H. platyrhynchos* and found by de Chambrier *et al.* (2006a) in the same host from Peru. Arredondo & Gil de Pertierra (2008) confirmed that tapeworms from this catfish and *S. lima* from the Paraná River basin are conspecific, which was supported by the present study.

***Spatulifer rugosa* (Woodland, 1935)**

Fig. 5

Host: *Pseudoplatystoma fasciatum* (14/42, 33%).

Remarks: Described as *Monticellia rugosa* from *P. fasciatum* from the Amazon River, Brazil by Woodland (1935a), who reported prevalence of 55%.

***Spatulifer* sp. (probably *S. surubim* Woodland, 1934)**

Host: *Pseudoplatystoma tigrinum* (1/13, 8%).

Remarks: Only immature specimens were found; see de Chambrier *et al.* (2006a).

***Travassielia jandia* (Woodland, 1934)**

Host: *Zungaro zungaro* (1/30, 3%).

Remarks: de Chambrier *et al.* (2014) synonymized *Travassielia avitellina* Rego & Pavanelli, 1987 described from *Zungaro zungaro* (in fact *Zungaro jahu*, see Lundberg & Littmann, 2003) with *Proteocephalus jandia* Woodland, 1934 described from *Z. zungaro* from the Amazon River in Brazil and proposed a new combination, *T. jandia* (Woodland, 1934). This is the rarest species found in *Z. zungaro* in Peru.

No new specimens were found since 2004 (see de Chambrier *et al.*, 2006a).

***Zygobothrium megacephalum* Diesing, 1850**

Host: *Phractocephalus hemioliopterus* (1/10, 10%).

Monticelliinae gen. sp.*

Host: *Phractocephalus hemioliopterus* (1/10, 10%).

Remarks: This material differs from all known species of the Monticelliinae and potentially belong to a new species and genus.

Proteocephalidea gen. sp.*

Host: *Cichlasoma amazonarum* Kullander (3/29, 10%).

Remarks: This material differs from all known species of the Proteocephalidae and potentially belong to a new species and genus.

DISCUSSION

Our four recent sampling trips in the Peruvian Amazon enable us to double the number of proteocephalidean cestodes reported in 25 species of fishes of the upper part of the Amazon River around Iquitos. Besides the 29 proteocephalidean species found in 8 species of pimelodid, 1 heptapterid and 1 doradid catfishes, and 2 species of cichlids, the present account adds another 34 species, thus providing evidence of the occurrence of as many as 63 species of these cestodes in Peru. Out of them, 46 species could be identified to the species level and represent already known taxa. This is only slightly less than the known fauna of the Brazilian part of Amazonia, from which 54 species have been reported (Table 1). However, more than a dozen species found only in Peru are probably new taxa awaiting formal description. In total, as many as 64 named species of proteocephalidean cestodes are now known from the Amazon River basin (Table 1).

Unlike Peru, with almost no history of studies on cestode parasites of freshwater teleosts, research on fish parasites in the Brazilian part of the Amazon River basin started as early as in the 19th century, when Diesing (1850) described several taxa based on material collected by an Austrian naturalist and explorer Johann Natterer, who spent 18 years in Brazil from 1817 to 1835. More systematic studies on proteocephalidean cestodes started in the early 1930's when W.N.F. Woodland published 9 papers with descriptions of 32 species and 8 genera of proteocephalidean cestodes from catfishes and other teleost fishes in the Amazon River in Brazil (de Chambrier *et al.*, 2014). After a couple of decades since Woodland's pioneer studies, Brazilian authors, especially A.A. Rego, studied the cestode fauna of fishes in Brazil (see Rego *et al.*, 1999 for references), even though many of the studies were carried out in the Paraná River basin (Rego & Pavanelli, 1992; Fig. 6). Since the mid 1990's, the senior author with co-authors have also contributed considerably, with a number of papers dealing with proteocephalideans from the Brazilian Amazon (see de Chambrier *et al.*, 2006a, 2014 and references therein). From the Amazon River basin in Peru, de Chambrier *et al.* (2006a) reported 5 species of proteocephalideans from *Pseudoplatystoma fasciatum* and *Paulicea luetkeni* (= *Zungaro zungaro*) each, and 4 species in *Phractocephalus hemioliopertus* and *Pseudoplatystoma tigrinum*. In the present study, much higher numbers of cestodes were found in these hosts: 10 (and juveniles of

2 other species) in *P. fasciatum* (plus one unidentified species; 7 of these species were also reported from Brazilian Amazonia), 9 in *Z. zungaro* (1 unidentified species) and 6 in *P. hemioliopertus* (1 unidentified species). As typical for proteocephalidean cestodes in the Neotropical Region (e.g., de Chambrier & Vaucher, 1999), most species are specific to a single fish host, more rarely to congeneric host species. In the present study, 9 species were found in more than one fish host and only 2 species, namely *Proteocephalus kuyukuyu* and *Spatulifer maringaensis*, occur in fish of more than one genus (Table 2). However, there could be a sampling bias, considering that the number of dissected hosts per species varied considerably, from 1 to 42 specimens (Table 2). *Pseudoplatystoma fasciatum* was the most frequently examined host and also harboured the highest number of species of proteocephalideans.

Extensive material of proteocephalidean cestodes was collected in a wide spectrum of teleosts during six visits by the present authors and their co-workers to the Peruvian Amazonia. This material will make it possible to compare the species composition of the cestode fauna and host-parasite associations in the Amazon River basin with those in the Paraná River basin (Fig. 6). Some proteocephalideans occur in closely related hosts from different river basins, such as *Proteocephalus macrophallus* and *P. microscopicus* in species of *Cichla* Bloch & Schneider, 1801, or in recently separated 'couples' of fish hosts that occur only in one of the two principal river basins in South America, i.e. Amazon and Paraná, such as *Zungaro zungaro* in the former river basin and *Z. jahu* in the latter one.



Fig. 6. Map of South America with two principal river basins, Amazon and Paraná Rivers.

Table 1. List of species of proteocephalidean cestodes found in fishes from the Amazon River basin.

Species	Brazil	Peru
<i>Amazotaenia yvetteae</i> de Chambrier, 2001	+	-
<i>Amphoteromorphus ninoi</i> Carfora, de Chambrier & Vaucher, 2003	+	-
<i>Amphoteromorphus ovalis</i> Carfora, de Chambrier & Vaucher, 2003	+	+
<i>Amphoteromorphus parkamoo</i> Woodland, 1935	+	+
<i>Amphoteromorphus peniculus</i> Diesing, 1850	+	+
<i>Amphoteromorphus piraeeba</i> Woodland, 1934	+	-
<i>Amphoteromorphus piriformis</i> Carfora, de Chambrier & Vaucher, 2003	+	+
<i>Brayela karuatayi</i> (Woodland, 1934)	+	+
<i>Brooksiella praeputialis</i> (Rego, dos Santos & Silva, 1974)	+	-
<i>Chambriella agostinhoi</i> (Pavanelli & Machado dos Santos, 1992)	-	+
<i>Chambriella paranaensis</i> (Pavanelli & Rego, 1989)	-	+
<i>Choanoscolex abscisus</i> (Riggenbach, 1896)	+	+
<i>Endorchis piraeeba</i> Woodland, 1934	+	+
<i>Ephedrocephalus microcephalus</i> Diesing, 1850	+	-
<i>Euzetiella tetraphylliformis</i> de Chambrier, Rego & Vaucher, 1999	+	+
<i>Gibsoniella mandube</i> (Woodland, 1935)	+	+
<i>Gibsoniella meursaulti</i> de Chambrier & Vaucher, 1999	+	-
<i>Goezeella siluri</i> Fuhrmann, 1915	+	-
<i>Harriscolex kaparari</i> (Woodland, 1935)	+	+
<i>Harriscolex piramutab</i> (Woodland, 1934) n. comb.	+	+
<i>Houssayella sudobim</i> (Woodland, 1935)	+	+
<i>Jauella glandicephalus</i> Rego & Pavanelli, 1985	-	+
<i>Lenhataenia megacephala</i> (Woodland, 1934)	+	+
<i>Mariauxiella piscatorum</i> de Chambrier & Vaucher, 1999	-	+
<i>Manaosia bracademoca</i> Woodland, 1935	+	+
<i>Megathylacus jandia</i> Woodland, 1934	+	+
<i>Monticellia amazonica</i> de Chambrier & Vaucher, 1997	+	+
<i>Monticellia belavistensis</i> Pavanelli <i>et al.</i> , 1994*	-	+
<i>Monticellia lenha</i> Woodland, 1933	+	+
<i>Monticellia magna</i> (Rego, Santos & Silva, 1974)	+	-
<i>Monticellia santafesina</i> Arredondo & Gil de Pertierra, 2010	-	+
<i>Monticellia ventrei</i> de Chambrier & Vaucher, 2009	-	+
<i>Nomimoscolex admonticellia</i> (Woodland, 1934)	+	+
<i>Nomimoscolex dorad</i> (Woodland, 1935)	+	-
<i>Nomimoscolex lenha</i> (Woodland, 1933)	+	+
<i>Nomimoscolex lopesi</i> Rego, 1989	-	+
<i>Nomimoscolex microacetabula</i> Gil de Pertierra, 1995	+	-
<i>Nomimoscolex piraeeba</i> Woodland, 1934	+	-
<i>Nomimoscolex sudobim</i> Woodland, 1935	+	+
<i>Nomimoscolex suspectus</i> Zehnder <i>et al.</i> , 2000**	+	+
<i>Nupelia portoricensis</i> Pavanelli & Rego, 1991	+	-
<i>Peltidocotyle lenha</i> (Woodland, 1933)	+	+
<i>Peltidocotyle rugosa</i> Diesing, 1850	+	+
<i>Proteocephalus gibsoni</i> Rego & Pavanelli, 1991	+	+
<i>Proteocephalus hemioliopteri</i> de Chambrier & Vaucher, 1997	+	+
<i>Proteocephalus hobergi</i> de Chambrier & Vaucher, 1999	-	+
<i>Proteocephalus kuyukuyu</i> Woodland, 1935	+	+
<i>Proteocephalus macrophallus</i> Diesing, 1850	+	+
<i>Proteocephalus microscopicus</i> Woodland, 1935	+	+
<i>Proteocephalus platystomi</i> Lynsdale, 1959	+	-
<i>Proteocephalus sophiae</i> de Chambrier & Rego, 1994	+	+
<i>Pseudocrepidobothrium eirasi</i> (Rego & de Chambrier, 1995)	+	-
<i>Pseudocrepidobothrium ludovici</i> Ruedi & de Chambrier, 2012	+	-
<i>Rudolphiella myoides</i> (Woodland, 1934)	+	-
<i>Rudolphiella piracatinga</i> (Woodland, 1935)	+	+
<i>Rudolphiella piranabu</i> (Woodland, 1934)	+	-
<i>Scholzia emarginata</i> (Diesing, 1850)	+	+
<i>Sciadocephalus megalodiscus</i> Diesing, 1850	+	+
<i>Spaskyellina spinulifera</i> (Woodland, 1935)	+	+
<i>Spatulifer maringaensis</i> Pavanelli & Rego, 1989	+	+
<i>Spatulifer rugosa</i> (Woodland, 1935)	+	+
<i>Spatulifer surubim</i> Woodland, 1934	+	-
<i>Travassiiella jandia</i> (Woodland, 1934)	+	+
<i>Zygobothrium megacephalum</i> Diesing, 1850	+	+
Total	64	46

* Pavanelli, Machado dos Santos, Takemoto & dos Santos, 1994

**Zehnder, de Chambrier, Vaucher & Mariaux, 2000

Table 2. List of fish hosts and their proteocephalidean cestodes found in the Peruvian Amazonia, with values of prevalence. Cestode species found in 2006–2011, but not reported by de Chambrier *et al.* (2006a), in bold.

Fish family	Fish host	No. Cestode species	Preval. PI No.*	Coll. No.**
Auchenipteridae	<i>Ageniostus inermis</i>	16	6% 827a,b	G 85110, 85111
	<i>Gibsoniella mandube</i>		13% 876a,b, 891a	G 85156, 85158, 85164
	<i>Gibsoniella mandube</i>	10	30% 484, 504a,b, 561	G 63059, 63119, 63203, 63209–63211, 63229 ¹
Cichlidae	<i>Ageniostus</i> sp.	4	25% 125	C 407; M 2222
	<i>Astronotus ocellatus</i>	15	7% 116a, 130a	C 247; G 36523; M 2219; U 97156
	<i>Cichla monoculus</i>		21% 116b, 117a, 120a, 123a, 185b, 248a	C 247; G 36524, 36525, 37330, 37331; M 2220; U 97155
			3% 185a	G 37332
			10% 470, 474d, 477a	G 63132, 63202, 63208
Doradidae	<i>Cichlasoma amazonarum</i>	29	6% 774a	G 85006
	<i>Oxydoras niger</i>	4	75% 324a, 444a, 581a	G 60019, 60107, 60103, 66750, 69708
	<i>Megalodoras uranoscopus</i>	24	4% 350b,c	G 60066, 60095
	<i>Pterodoras granulosus</i>		8% 636, 637	G 72081, 72971
			8% 350b,c, 634, 634b, 635a,b,x, 636, 638	G 60066, 60095, 69597, 69593, 69594, 69596 ²
	<i>Pterodoras</i> sp.	1	(100%) 588a	G 66572, 69709
	<i>Goeldiella eques</i>	28	11% 438	G 63185
	<i>Brachyplatystoma cf. filamentosum</i>	3	33% 516a	G 63125
	<i>Amphoteromorphus ovalis</i>		33% 516	G 63126, 63206
	<i>Endorchis piraeiba</i>		33% 516a–c	G 63060, 63205, 63207
<i>Brachyplatystoma rousseauxii</i>		3	33% 367a	G 60052, 63179
			33% 61d	G 36519
		39	10% 396a, 398a, 399a, 838	G 60063, 60091, 63183, 85133
<i>Brachyplatystoma vaillantii</i>			20% 236e, 308a,b, 362a, 398a, 399a, 400a, 437a	G 63216, 63152, 60024, 60054, 86402, 60053, 60058, 60088
		33	15% 573, 778a,b	G 79194, 85010, 85013
<i>Calophysus macropterus</i>			30% 408a, 409b, 755a, 778ad	G 60056, 60060, 85001, 85011, 85012, 85014 ³
		12	8% 95d	G 36430, 36431
<i>Hemisorubim platyrhynchos</i>			17% 83b, 95a	C 404; G 36510, 36518
			17% 76a, 83b, 95d	C 410; G 36511; M 2224
<i>Megalonema platycephalum</i>		1	(100%) 550a,b	G 69452, 69608
		10	50% 597, 613a,b, 727, 772	G 69618, 67060, 67065, 79199, 67054, 84851
<i>Phractocephalus hemiiopterus</i>			10% 613	G 79200
			20% 270b, 273a	C 416; G 37335
			100% 355a, 465a, 597, 613, 707, 727, 772y, 823	G 63177, 60131, 69617, 69676, 69677, 69678, 84850, 85107
<i>Pimelodus blochii</i>			10% 270c	C 401; M 2227
		8	10% 772a	G 84860
			25% 658, 661b	G 69605, 69606, 79202, 79203
<i>Pimelodus latissimus</i>		1	(100%) 571a,b	G 69536, 69537
		13	15% 517a, 519a	G 63127, 63212
<i>Pimelodus ornatus</i>			13% 776a–c, 809a,c,g, 835a,f, 880	G 85007–85009, 85020–85022, 79598, 85124, 85125, 79599
		30	37% 439, 672a, 674, 809b,d, 815b, 819b ⁴	G 60087, 78984, 79173, 85023, 85026, 79596 ⁵
<i>Pitirampus pirinampu</i>			17% 379a, 809e, 819a, 824, 850a	G 60070, 85025, 85161, 85108, 85152
<i>Nomimoscolex admonticellia</i>				
<i>Rudolphiella</i> sp.				

Fish family	Fish host	No. Cestode species	Preval. PI No.*	Coll. No.**
Platyemacanthichthys	<i>notatus</i>	13	38% 532a, 533a,b, 798a, 802	G 62587, 63128, 63213, 79595, 85018
	<i>Pseudoplatystoma fasciatum</i>	42	17% 318a, 319a, 359b, 361d, 457a, 708, 730	G 54741, 63149, 60090, 63172, 60025, 66566, 69695
Chocanosclex	<i>abscisus</i>		33% 319a, 320a, 347a,b, 359b, 361b,c ⁶	G 60074, 63153, 60042, 63165, 63173, 63174 ⁷
	<i>Endorchis cf. piraebea</i> (juv.)		2% 318a	G 63150
Euzetiella	sp. (juv.)		2% 618	-
	<i>kaparari</i>		7% 705, 706, 708	G 66561, 69701, 69702
Houssayella	<i>sudobim</i>		7% 509b, 708a	G 62586, 66553, 66554
	<i>Megathylacus</i> sp.		10% 78a, 629a, 708f, 730	G 22321, 36517, 74089, 74090, 66559, 69616
Nomimoscolex	<i>lopesi</i>		26% 322a, 332a, 347a,b, 359a, 361c, 456b ⁸	G 60100, 63155, 60050, 63176, 79176, 60064 ⁹
	<i>sudobim</i>		24% 304c, 332a, 347a,b, 359c, 360b, 361c ¹⁰	G 60067, 63156, 60022, 60049, 60093, 60102 ¹¹
Peltidocoyle	<i>rugosa</i>		24% 76a, 304b,d, 358a, 361a, 451a, 457b ¹²	G 36515, 60092, 63144, 60089, 60105, 60023 ¹³
	<i>Spasskyellina spinulifera</i>		29% 304d, 305a, 306a, 343a, 347a,b ¹⁴	G 63143, 63146, 63147, 63162, 63166, 79193 ¹⁵
Spatulifer	<i>rugosa</i>		33% 303a, 318a, 320a, 332a, 347a,b, 360a ¹⁶	G 60082, 60051, 63151, 63154, 60061, 60068 ¹⁷
	<i>Choanosclex abscisus</i>		8% 225a	G 37317
Nomimoscolex	<i>sudobim</i>		15% 225a, 226a	G 37322, 37323
	<i>Spasskyellina spinulifera</i>		14% 225a, 226a	G 37339, 37340
Spatulifer	sp.***		8% 226a	G 37324; M 2225
	<i>Manaostia bracedemoca</i>		10% 490a, 586, 670	G 63123, 66570, 79210
Spatulifer	<i>maringaensis</i>		10% 586b,c, 662, 670a	G 66569, 66571, 69599, 69607, 79209
	<i>Chambriella</i> sp. 4		27% 440c, 485a, 585, 592, 594, 595	C 478; G 60048, 63120, 70835, 79198, 69592, 69697
Choanosclex	sp.		14% 356, 440c, 593	C 479; G 4610, 69564
	<i>Lenhataenia megacephala</i>		50% 356a, 370c, 412b, 485a, 582a,b, 585 ¹⁸	G 86458, 54608, 60036, 63121, 66549, 68969 ¹⁹
Monticellia	<i>lenha</i>		59% 356a,d, 370b, 440a, 449a, 450b ²⁰	G 54628, 54740, 60038, 63220, 54606, 60045 ²¹
	<i>Nomimoscolex lenha</i>		33% 356a, 585, 592, 616, 728	G 54629, 63218, 63219, 79196, 69583, 69685, 67055, 69686
Peltidocoyle	<i>lenha</i>		59% 356a,b, 370a, 412a, 450a, 582, 585 ²²	G 60039, 63167, 54605, 60037, 60035, 69539 ²³
	<i>Amphoteromorphus par-kamoo</i>		10% 231b, 358a,b, 364a	G 37309, 60069, 60071
Chambriella	<i>agostinhoi</i>		37% 302b, 357a, 363a, 364b, 387b, 445a ²⁴	C 402; G 60065, 60084, 60099, 63169, 60021 ²⁵
	<i>Euzetiella tetraphylliformis</i>		17% 115, 583, 663, 664, 665	C 403; G 79195, 69610, 79207, 79208
Jauella	<i>glandicephalus</i>		30% 301a, 413b, 447a, 583, 663a,c, 664 ²⁶	G 60062, 60079, 60076, 69682, 66573, 66574 ²⁷
	<i>Megathylacus jandia</i>		7% 357a, 413a	G 63168, 60085
Peltidocoyle	<i>lenha</i>		43% 302a, 357a, 368a, 387a, 467a, 468a ²⁸	G 60027, 60020, 60072, 63180, 60101, 60134 ²⁹
	<i>Proteocephalus sophiae</i>		20% 583, 663, 664, 665b, 845b,c,e,f, 892b	G 68968, 67663, 69679, 69680, 79169, 79206 ³⁰
Travassostella	<i>jandia</i>		3% 115a	G 36520

Abbreviations: * Field number of the hosts, PI 1–136 April 2004, 137–276 April 2005, 300–469 September 2006, 470–545 October 2008, 546–752 October 2009, 753–910 October 2011; **G – Natural History Museum, Geneva, Switzerland (MHNG-PLAT); C – Institute of Parasitology, AS CR, České Budějovice, Czech Republic (IPCAS); M – Helminthological Collection of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru (MUSM); U – U.S. National Parasite Collection, Beltsville, Maryland, U.S.A. (USNPC). ***immature. Additional collection/host numbers: ¹G 63209–63211, 63229; ²G 69597, 69598, 69603, 69604, 72972, 79201; ³G 85015, 85137; ⁴PI 825a, 835g, 880, 887, 890b; ⁵G 79845, 85126, 79600, 79876, 85163; ⁶PI 466b, 562, 563, 708, 725, 729, 730, 777a; ⁷G 63201, 69462, 69704, 66567, 69690, 69693, 72970, 79174, 79175, 84853; ⁸G 466b, 708b,c,g, 730; ⁹G 63200, 66550, 66556, 66560, 66565, 69692; ¹⁰PI 535a, 618, 708e,h, 730; ¹¹G 63163, 63175, 63176, 63177, 69699, 66551, 66558, 66564, 69694; ¹²PI 466a, 563, 708h, 777a; ¹³G 60129, 60132, 69535, 66552, 84854; ¹⁴PI 536a,b, 708h, 730, 818a; ¹⁵G 66553, 66558, 69691, 85027; ¹⁶PI 378a, 466b, 509c, 534a, 536a,b, 708d, 726; ¹⁷G 60080, 60097, 63164, 60083, 63124, 63129, 63130, 63215, 66557, 66562, 69696; ¹⁸PI 592, 594, 595a,b, 611a,b, 728; ¹⁹G 69538, 69580, 72946, 72947, 79577, 69568, 69591, 72973, 72974, 69600, 69602, 79877; ²⁰PI 485b, 582, 585, 592, 594, 595, 616, 728; ²¹G 54607, 60043, 54742, 54743, 60044, 63122, 69581, 69703, 79197, 69567, 69700, 69683, 69684; ²²PI 592, 594, 595, 616, 665a, 666a, 728a; ²³G 69582, 69920, 69385, 69477, 69689, 69688, 69609, 69611, 69687; ²⁴PI 469a, 583; ²⁵G 60096, 60136, 69698; ²⁶PI 663a,c, 664, 665, 845a, 892a; ²⁷G 69681, 74081, 79204, 79205, 85139, 79808; ²⁸PI 663b, 664e, 845b,f; ²⁹G 60135, 79167, 79168, 85147, 85148; ³⁰G 85140, 85141, 85144, 85146, 79847.

In the present study, we focused on adult cestodes and thus only very few proteocephalidean larvae (merocercoids, see Chervy, 2002) were found. The identification of the latter based on morphological characteristics is impossible, but their molecular analysis will enable us to match their DNA sequences with those of adults, which were obtained in the framework of a NSF-PBI project “A Survey of the Tapeworms (Cestoda: Platyhelminthes) from the Vertebrate Bowels of the Earth” (www.tapeworms.uconn.edu). This approach (see also Jensen & Bullard, 2010) is the most feasible way to elucidate life cycles of Neotropical proteocephalideans, which are almost completely unknown. Based on the fact that large catfishes are predatory (piscivorous) and do not consume plankton, it is reasonable to assume that life cycles of many, if not most, proteocephalidean cestodes that mature in large catfishes in South America include two intermediate (or one intermediate and one paratenic) hosts, the second host being small planktonophagous fish similarly to the developmental cycles of *Proteocephalus ambloplitis* in North America (Hunter, 1928; Freze, 1965; Scholz, 1999; Scholz & de Chambrier, 2003).

To summarize, the present study enriched considerably the current knowledge of the species composition and distribution areas of members of one of the dominant groups of metazoan parasites of freshwater teleosts in the Neotropical Region. However, there are still many fish hosts that have never been examined for parasites and thus a number of new taxa probably remain to be discovered. This will depend on sampling effort and time dedicated to future collecting trips and taxonomic evaluation of newly collected cestodes, using combined morphological and molecular approaches. A recent discovery of a new genus from the little known achenopterid catfish *Tocantinsia piresi* from the Xingú River in Brazil (Alves *et al.*, 2015) as well as the number of unidentified species found in Peru, which may represent new species, supports the argument that we are just at the very beginning of a long path towards representative mapping the species diversity, host-parasite relationships and zoogeography of the parasites of teleost fishes in one of the hottest spots of fish parasite diversity on the Earth. Since the existence of cryptic species among proteocephalidean cestodes cannot be excluded, it is impossible to provide a reliable estimate of the species richness of these parasites. However, it is reasonable to assume that the actual number of extant species would be at least twice as high as the number of the species currently considered to be valid.

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REFERENCES

- Alves P.V., de Chambrier A., Scholz T., Luque J.L. 2015. A new genus and species of proteocephalidean tapeworm (Cestoda), first cestode found in the driftwood catfish *Tocantinsia piresi* (Siluriformes: Auchenipteridae) in South America. *Folia Parasitologica* 62 (in press).
- Angelini R., Fabre N.N., da Silva U.L. Jr. 2006. Trophic analysis and fishing simulation of the biggest Amazonian catfish. *African Journal of Agricultural Research* 1: 151-158.
- Arredondo N.J., Gil de Pertierra A.A. 2008. The taxonomic status of *Spatulifer* cf. *maringaensis* Pavanelli & Rego, 1989 (Eucestoda: Proteocephalidea) from *Sorubim lima* (Bloch & Schneider) (Pisces: Siluriformes), and the use of the microthrix pattern in the discrimination of *Spatulifer* spp. *Systematic Parasitology* 70: 223-236.
- Arredondo N.J., Gil de Pertierra A.A. 2010. *Monticellia santafesina* n. sp. (Cestoda: Proteocephalidea), a parasite of *Megalonema platanum* (Günther) (Siluriformes: Pimelodidae) in the Paraná River basin, Argentina. *Systematic Parasitology* 76: 103-110.
- Arredondo N.J., Gil de Pertierra A.A., de Chambrier A. 2015. A new species of *Pseudocrepidobothrium* (Cestoda: Proteocephalidea) from *Pseudoplatystoma reticulatum* (Pisces: Siluriformes) in the Paraná River basin (Argentina). *Folia Parasitologica* 61: 462-472.
- Boni T.A., Padial A.A., Prioli S.M.A.P., Lucio L.C., Maniglia T.C., Bignotto T.S., Panarari-Antunes R.S., Prioli R.A., Prioli A.J. 2011. Molecular differentiation of species of the genus *Zungaro* (Siluriformes, Pimelodidae) from the Amazon and Parana-Paraguay River basins in Brazil. *Genetics and Molecular Research* 10: 2795-2805.
- Buitrago-Suárez U.A., Burr B.M. 2007. Taxonomy of the catfish genus *Pseudoplatystoma* Bleeker (Siluriformes: Pimelodidae) with recognition of eight species. *Zootaxa* 1512: 1-38.
- Caira J.N., Jensen K., Barbeau E. (Eds) 2012. Global Cestode Database. World Wide Web electronic publication. www.tapewormdb.uconn.edu. Accessed Month 07, 2014.

- Caira J.N., Jensen K., Waeschenbach A., Olson P.D., Littlewood D.T.J. 2014. Orders out of chaos – molecular phylogenetic reveals the complexity of sharks and stingrays tapeworm relationships. *International Journal for Parasitology* 44: 55-73.
- Carfora M., de Chambrier A., Vaucher C. 2003. Le genre *Amphoteromorphus* (Cestoda: Proteocephalidea), parasite de poissons-chats d'Amérique tropicale: Etude morphologique et approche biosystématique par électrophorèse des protéines. *Revue suisse de Zoologie* 110: 381-409.
- Chervy L. 2002. The terminology of larval cestodes or metacestodes. *Systematic Parasitology* 52: 1-33.
- de Chambrier A. 1990. Redescription de *Proteocephalus paraguayensis* (Rudin, 1917) (Cestoda: Proteocephalidae) parasite de *Hydrodynastes gigas* (Dum., Bibr. & Dum., 1854) du Paraguay. *Systematic Parasitology* 16: 85-97.
- de Chambrier A. 2003. Systematic status of *Manoosia bracedemoca* Woodland, 1935 and *Paramonticellia itaipuensis* Pavanelli et Rego, 1991 (Eucestoda: Proteocephalidea), parasites of *Sorubim lima* (Siluriformes: Pimelodidae) from South America. *Folia Parasitologica* 50: 121-127.
- de Chambrier A., Rego A.A. 1994. *Proteocephalus sophiae* n. sp. (Cestoda: Proteocephalidae), a parasite of the siluroid fish *Paulicea luetkeni* (Pisces: Pimelodidae) from the Brazilian Amazon. *Revue suisse de Zoologie* 101: 361-368.
- de Chambrier A., Rego A.A., Gil de Pertierra A.A. 2005. Redescription of two cestodes (Eucestoda: Proteocephalidea), parasites of *Phractocephalus hemiliopterus* (Siluriformes) from the Amazon and proposition of *Scholzia* gen. n. *Revue suisse de Zoologie* 112: 735-752.
- de Chambrier A., Rego A.A., Vaucher C. 1999. *Euzetiella tetraphylliformis* n. gen., n. sp. (Eucestoda: Proteocephalidae), parasite du poisson d'eau douce néotropical *Paulicea luetkeni* (Siluriformes, Pimelodidae). *Parasite* 6: 43-47.
- de Chambrier A., Scholz T. 2005. Redescription of *Houssayella sudobim* (Woodland, 1935) (Cestoda: Proteocephalidea), a parasite of *Pseudoplatystoma fasciatum* (Pisces: Siluriformes) from the River Amazon. *Systematic Parasitology* 62: 161-169.
- de Chambrier A., Scholz T. 2008. Tapeworms (Cestoda: Proteocephalidea) of firewood catfish *Sorubimichthys planiceps* (Siluriformes: Pimelodidae) from the Amazon River. *Folia Parasitologica* 55: 17-28.
- de Chambrier A., Scholz T., Kuchta R. 2014. Taxonomic status of Woodland's enigmatic tapeworms (Cestoda: Proteocephalidea) from Amazonian catfishes: back to museum collections. *Systematic Parasitology* 87: 1-19.
- de Chambrier A., Scholz T., Kuchta R., Posel P., Mortenthaler M., Chuquipiondo-Guardia C. 2006a. Tapeworms (Cestoda: Proteocephalidea) of fishes from the Amazon River in Peru. *Comparative Parasitology* 73: 111-120.
- de Chambrier A., Takemoto R.M., Pavanelli G.C. 2006b. *Nomimoscolex pertierra* n. sp. (Eucestoda: Proteocephalidea), a parasite of *Pseudoplatystoma corruscans* (Siluriformes: Pimelodidae) in Brazil and redescription of *Nomimoscolex sudobim* Woodland, 1935, a parasite of *Pseudoplatystoma fasciatum*. *Systematic Parasitology* 64: 191-202.
- de Chambrier A., Vaucher C. 1994. Etude morpho-anatomique et génétique de deux nouveaux *Proteocephalus* Weinland, 1858 (Cestoda: Proteocephalidae) parasites de *Platydoras costatus* (L.), poisson siluriforme du Paraguay. *Systematic Parasitology* 27: 173-184.
- de Chambrier A., Vaucher C. 1997. Révision des cestodes (Monticelliidae) décrits par Woodland (1934) chez *Brachyplatystoma filamentosum* avec redéfinition des genres *Endorchis* Woodland, 1934 et *Nomimoscolex* Woodland, 1934. *Systematic Parasitology* 37: 219-233.
- de Chambrier A., Vaucher C. 1999. Proteocephalidae et Monticelliidae (Eucestoda: Proteocephalidea) parasites de poissons d'eau douce du Paraguay avec descriptions d'un genre nouveau et de dix espèces nouvelles. *Revue suisse de Zoologie* 106: 165-240.
- de Chambrier A., Zehnder M.P., Vaucher C., Mariaux J. 2004. The evolution of the Proteocephalidea (Platyhelminthes, Eucestoda) based on an enlarged molecular phylogeny, with comments on their uterine development. *Systematic Parasitology* 57: 159-171.
- Diesing C.M. 1850. Systema helminthum. Vol. I. *Sumptibus Academiae Caesareae scientiarum, Vindobonae*, 680 pp.
- Freze V.I. 1965. Essentials of Cestodology. Vol. V. Proteocephalata in Fish, Amphibians and Reptiles. *Izdatel'stvo "Nauka", Moskva*, 538 pp. (In Russian: English translation, Israel Program of Scientific Translation, 1969, Cat. No. 1853. v + 597 pp.).
- Froese R., Pauly D. (Eds). 2014. FishBase. World Wide Web electronic publication. www.fishbase.org, version (07/2014).
- Gil de Pertierra A.A., de Chambrier A. 2013. *Harriscolex nathaliae* n. sp. (Cestoda: Proteocephalidea) from *Pseudoplatystoma corruscans* (Siluriformes: Pimelodidae) in the Parana River basin, Argentina. *Journal of Parasitology* 90: 480-486.
- Hunter G.W. 1928. Contributions to the life history of *Proteocephalus ambloplitis* (Leidy). *Journal of Parasitology* 14: 229-242.
- Hypša V., Škeříková A., Scholz T. 2005. Multigene analysis and secondary structure characters in a reconstruction of phylogeny, evolution and host-parasite relationship of the order Proteocephalidea (Eucestoda). *Parasitology* 130: 359-371.
- Jensen K., Bullard A.S. 2010. Characterization of a diversity of tetraphyllidean and rhinebothriidean cestode larval types, with comments on host associations and life-cycles. *International Journal for Parasitology* 40: 889-910.
- Junk W.J., Soares M.G.M., Bayley P.B. 2007. Freshwater fishes of the Amazon River basin: their biodiversity, fisheries, and habitats. *Aquatic Ecosystems and Health Management* 10: 153-173.
- Khalil L.F., Jones A., Bray R.A. (Eds). 1994. Keys to the Cestode Parasites of Vertebrates. *CAB International, Wallingford*, 751 pp.
- Lundberg J.G., Littmann M.W. 2003. Pimelodidae (long-whiskered catfishes) (pp. 432-446). In: Reis R.E., Kullander S.O., Ferraris C.J., Jr. (Eds), Checklist of the Freshwater Fishes of South and Central America. *EDIPUCRS, Porto Alegre, Brasil*.
- Pavanelli G.C., Machado M.H., Takemoto R.M., dos Santos L.C. 1994. Uma nova espécie de cestóide proteocefalídeo, *Monticellia belavistensis*, sp. n., parasita de *Pterodoras granulosus* (Valenciennes) (Pisces, Doradidae), do reservatório de Itaipu e Rio Paraná, Paraná, Brasil. *Revista Brasileira de Zoologia* 11: 587-595.
- Pavanelli G.C., Rego A.A. 1992. *Megathylacus travassosi* sp. n. and *Nomimoscolex sudobim* Woodland, 1935 (Cestoda: Proteocephalidea) parasites of *Pseudoplatystoma corruscans* (Agassiz, 1829) (Siluriformes, Pimelodidae) from the Itaipu Reservoir and Parana River, Paraná State, Brazil.

- Memorias do Instituto Oswaldo Cruz* 87 (Suppl. 1): 191-195.
- Pelicice F.M., Agostinho A.A. 2008. Fish-passage facilities as ecological traps in large Neotropical rivers. *Conservation Biology* 22: 180-188.
- Rego A.A. 1984. Proteocephalidea from Amazonian freshwater fishes: new systematic arrangement for the species described by Woodland as *Anthobothrium* (Tetraphyllidea). *Acta Amazônica* 14: 86-94.
- Rego A.A. 1985. Proteocephalidea from Amazonian freshwater fishes: new systematic arrangement for the species described by Woodland as *Anthobothrium* (Tetraphyllidea). *Parasitologia al Día* 9: 4-9.
- Rego A.A. 1987. Cestóides proteocefalídeos do Brasil. Reorganização taxonômica. *Revista Brasileira de Biologia* 47: 203-212.
- Rego A.A. 1990. Cestóides proteocefalídeos parasites de pintado, *Pseudoplatystoma corruscans* (Agassiz) (Pisces, Pimelodidae). *Ciência e Cultura* 42: 997-1002.
- Rego A.A. 1992. Redescription of *Gibsoniella mandube* (Woodland, 1935) (Cestoda: Proteocephalidae), a parasite of *Aeneiosus brevifilis* (Pisces: Siluriformes) and reappraisal of the classification of the proteocephalideans. *Memorias do Instituto Oswaldo Cruz* 87: 417-422.
- Rego A.A. 1994. Order Proteocephalidea Mola, 1928. In: Khalil L.F., Jones A., Bray R.A. (eds), Keys to the Cestode Parasites of Vertebrates. *CAB International, Wallingford*, pp. 257-293.
- Rego A.A., Chubb J.C., Pavanelli G.C. 1999. Cestodes in South American freshwater teleost fishes: keys to genera and brief description of species. *Revista Brasileira de Zoologia* 16: 299-367.
- Rego A.A., Pavanelli G.C. 1985. *Jauella glandicephalus* gen. n. sp. n. e *Megathylacus brooksi* sp. n., cestóides proteocefalídeos patogênicos para o jaú, *Paulicea luetkeni*, peixe pimelodídeo. *Revista Brasileira de Biologia* 45: 643-652.
- Rego A.A., Pavanelli G.C. 1990. Novas especies de cestoides proteocefalídeos parasitas de peixes nao siluriformes. *Revista Brasileira de Biologia* 50: 91-101.
- Rego A.A., Pavanelli G.C. 1992. Checklist of the cestode order Proteocephalidea parasites from South America freshwater fishes. *Revista UNIMAR* 14 (Suppl.): 109-137.
- Reis R.E. 2013. Conserving the freshwater fishes of South America. *International Zoo Yearbook* 47: 65-70.
- Scholz T. 1999. Life cycles of species of *Proteocephalus* Weinland, 1858 (Cestoda: Proteocephalidae), parasites of freshwater fishes in the Palearctic region: a review. *Journal of Helminthology* 72: 1-19.
- Scholz T., de Chambrier A. 2003. Taxonomy and biology of proteocephalidean cestodes: current state and perspectives. *Helminthologia* 40: 65-77.
- Scholz T., de Chambrier A., Kuchta R. 2008. Redescription of the tapeworm *Monticellia amazonica* de Chambrier et Vaucher, 1997 (Cestoda: Proteocephalidea), a parasite of *Calophysus macropterus* (Siluriformes: Pimelodidae), from the Amazon River in Brazil and Peru. *Acta Parasitologica* 53: 30-35.
- Thatcher V.E. 2006. Amazon Fish Parasites. *Universidade Federal do Paraná, Curitiba, Paraná, Brazil*, 508 pp.
- Woodland W.N.F. 1933. On a new subfamily of proteocephalid cestodes – the Othinoscolecinae – from the Amazon siluroid fish *Platystomatichthys sturio* (Kner). *Parasitology* 25: 491-500.
- Woodland W.N.F. 1934a. On six new cestodes from Amazon fishes. *Proceedings of the Zoological Society, London* 1934: 33-46.
- Woodland W.N.F. 1934b. On the Amphilaphorchidinae, a new subfamily of proteocephalid cestodes, and *Myzophorus admonticellia*, gen. and sp. n., parasitic in *Pirinampus* spp. from the Amazon. *Parasitology* 26: 141-149.
- Woodland W.N.F. 1935a. Some more remarkable cestodes from Amazon siluroids fish. *Parasitology* 27: 207-225.
- Woodland W.N.F. 1935b. Additional cestodes from the Amazon siluroids pirarara, dorad, and sudobim. *Proceedings of the Zoological Society, London* 1934: 851-862.
- Woodland W.N.F. 1935c. Some new proteocephalids and a ptychobothriid (Cestoda) from the Amazon. *Proceedings of the Zoological Society*, 105: 619-623.
- Zehnder M.P., de Chambrier A. 2000. Morphological and molecular analyses of the genera *Peltidocotyle* Diesing, 1850 and *Othinoscolex* Woodland, 1933, and morphological study of *Woodlandiella* Freze, 1965 (Eucestoda, Proteocephalidea), parasites of South American siluriform fishes (Pimelodidae). *Systematic Parasitology* 46: 33-43.
- Zehnder M.P., de Chambrier A., Vaucher C., Mariaux J. 2000. *Nomimoscolex suspectus* n. sp. (Eucestoda: Proteocephalidea: Zygobothriinae) with morphological and molecular phylogenetic analyses of the genus. *Systematic Parasitology* 47: 157-172.
- Zehnder M.P., Mariaux J. 1999. Molecular systematic analysis of the order Proteocephalidea (Eucestoda) based on mitochondrial and nuclear rDNA sequences. *International Journal for Parasitology* 29: 1841-1852.