Verhandlungen der Gesellschaft für Ichthyologie, Band 5, 165-191

Parasites of commercially important fish species from the southern Java coast, Indonesia, including the distribution pattern of trypanorhynch cestodes

Parasiten kommerziell bedeutender Fischarten von der Südküste Javas, Indonesien, einschließlich des Verbreitungsmusters von trypanorhynchen Cestoden

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Summary: A total of 118 commercially important fish species from the southern Java coast, Indonesia, were studied for the parasite fauna. The fish belonged to the oceanic families Gempylidae (*Gempylus serpens*, *Thyrsitoides marleyi*), Trichiuridae (*Trichiurus lepturus*) and Bramidae (*Brama dussumieri*). In addition, a single specimen of the deep-sea fish species *Alepisaurus ferox* and the pelagic *Tylosurus crocodilus crocodilus* were studied for comparison. A total of 38 parasite species was found, and 23 new host records could be established. The most diverse component community was found in *T. lepturus* and *G. serpens* with 17 and 16 species/taxa, respectively. The infracommunity was highest in *G. serpens* and *T. marleyi* with a mean of 9.1 and 6.5 species. The cestode order Trypanorhyncha recorded as extraintestinal larval stages was the most diverse taxon with 13 different species, followed by the Crustacea (8), Nematoda (5), Digenea (5) and Acanthocephala (3). The trypanorhynch *Mixonybelinia lepturi* was the parasite with the highest intensity of infestation, and was recorded from *G. serpens*, *T. marleyi*, *T. lepturus*, *B. dussumieri* and *A. ferox* at a prevalence of 10-100% and an intensity of 1-243. The host specificity of the tentaculariid trypanorhynchs was low, with 4 species infesting 2 up to 5 of the studied host fish species. The overlapping infestation pattern in fish from entirely different families underlines the low specificity of trypanorhynchs in their second intermediate hosts, and their ability to infest various fishes without respect to their host phylogeny. The helminths *Nybelinia africana*, *Mixonybelinia lepturi*, *Tentacularia coryphaenae*, *Scolex pleuronectis*, *Anisakis* sp. and *Gorgorhynchus* cf. *robertdollfusi* are characteristic for the studied fish species within the oceanic, into the deep-sea reaching environment along the tropical outer continental shelf region off the Java coast. A high prevalence of infestation of 97-100% with the zoonotic *Anisakis* sp. demonstrates a high risk of predatory fish to get infested. *T. lepturus* as an economically important fish species within the region as well as other oceanic and pelagic fish from the southern Java coast should be cooked well before consumption or deep frozen before further processing to prevent any risk of the *Anisakis*-infection in humans, locally as well as on the international market.

Keywords: fish parasites, Indonesia, deep-sea fish, zoonotic parasites, *Anisakis* spp., anisakiasis, Trypanorhyncha, biodiversity, vertical distribution, zoogeography

Zusammenfassung: Insgesamt wurden 118 Exemplare von kommerziell bedeutenden Fischarten an der Südküste Javas, Indonesien, auf ihre Parasitenfauna hin untersucht. Die Fische stammten aus den pelagisch lebenden Familien Gempylidae (*Gempylus serpens* und *Thyrsitoides marleyi*), Trichiuridae (*Trichiurus lepturus*) und Bramidae (*Brama dussumieri*). Zum Vergleich wurde zusätzlich ein Exemplar der Tiefseefischart *Alepisaurus ferox* und der pelagisch lebende *Tylosurus crocodilus crocodilus* untersucht. 38 Parasitenarten wurden nachgewiesen und 23 neue Wirtsnachweise erbracht. Die Komponentengemeinschaften von *T. lepturus* mit 17 Arten/Gattungen und *G. serpens* mit 16 Arten/Gattungen erwiesen sich als sehr divers. The Infragemeinschaft war mit 9,1 and 6,5 Arten am höchsten bei *G. serpens* and *T. marleyi*. Die Trypanorhyncha aus der Gruppe der Cestoda waren mit 13 Arten die dominierende Ordnung, gefolgt von den Crustacea mit acht, den Nematoda und Digenea mit jeweils fünf und den Acanthocephala mit drei nachgewiesen Arten. Die Art *Mixonybelinia lepturi* zeigte die höchsten Befallsintensitäten und wurde aus *G. serpens*, *T. marleyi*, *T. lepturus*, *B. dussumieri* und *A. ferox* mit Prävalenzen von 10-100% und Intensitäten von 1-243 isoliert. Die Wirtsspezifität der tentaculariiden Trypanorhyncha war sehr gering. Vier Arten befielen gleichzeitig zwischen zwei bis fünf Arten der untersuchten Fische. Die sich überlappenden Befallsmuster in Fischen aus unterschiedlichen Fischfamilien zeugen von einer geringen Spezifität in den zweiten Zwischenwirten und weisen darauf hin, dass die Wirtsökologie und nicht die Phylogenie der Fische für den Befall entscheidend ist. Die Helmithen *Nybelinia africana*, *Mixonybelinia lepturi*, *Tentacularia coryphaenae*, *Scolex pleuronectis*, *Anisakis* sp. und *Gorgorhynchus* cf. *robertdollfusi* sind charakteristisch für die untersuchten Fischarten in einem ozeanischen, bis in die Tiefsee reichenden Lebensraum, entlang der tropischen Kontinentalabhangregion vor der Küste Südjavas. Die hohe Prävalenz des Befalls mit den zoonotischen Larven von *Anisakis* sp. zwischen 97-100% deutet auf ein hohes Risiko von räuberischen Fischen hin, sich mit diesen zoonotischen Parasiten zu infestieren. *T. lepturus* als eine ökonomisch wichtige Fischart sollte, ebenso wie andere ozeanisch-pelagische Fischarten, vor dem Verzehr ausreichend gekocht oder tief gefroren werden, um jegliches Risiko einer Anisakiasis-Erkrankung für den Konsumenten zu verhindern.

Schlüsselwörter: Fischparasiten, Indonesien, Tiefseefische, Zoonotische Parasiten, *Anisakis* spp., Anisakiasis, Trypanorhyncha, Biodiversität, vertikales Verbreitungsmuster, Zoogeographie

1. Introduction

Fish parasitology is an important field in aquatic sciences. Fish parasites play a major role in marine biodiversity, and estimates suggest up to 100000 species of fish parasites. The biodiversity of fish parasites has been studied by several authors and published in parasite-host and host-parasite checklists. These checklists cover different geographical regions, such as Canada (Margolis and Arthur 1979, McDonald and Margolis 1995), USA (Love and Moser 1983), Bangladesh (Arthur and Ahmed 2002), the Philippines (Arthur and Lumanlan-Mayo 1997), Indonesia (unpublished) and Australia (Beumer et al. 1983). A checklist of the metazoan parasite fauna from deep-sea fish species was published by Klimpel et al. (2001). To date, only a fraction of the possible total number of 30,000 to 35,000 existing fish species (Froese and Pauly 2000) has ever been studied for its parasite fauna, though fish parasites clearly constitute a major part of the living animal species within the world's oceans (Palm 2004).

Parasites are of interest for ecological studies because they can indicate environmental conditions such as eutrophication (Palm and Dobberstein 1999) and the ecology of the host. For example, fish parasites can be used as biological indicators for fish stock separation (MacKenzie 1983) as well as for the fish feeding ecology (Campbell et al. 1980, Williams et al. 1992, Palm 1999). Of special interest for the fish consumer are zoonotic parasites, which can cause diseases and devaluate the fish. Parasite data can be an economically important indicator for seafood dealers or brokers as well as fishery managers (Palm and Overstreet 2000) to get a better understanding of the occurrence of potential harmful parasites and the natural infestation patterns

in order to estimate the real threat to human consumers as well as to the fish handling industry. Due to overexploitation and overfishing of the natural resources, modern aqua- and mariculture tries to fulfil the raising demand for fish and fisheries products. Again, diseases and parasites with direct life cycles can spread rapidly in aquaculture facilities and can cause severe financial and economical losses due to high fish mortality rates.
The maritime Nation of Indonesia consists of 17,508 Islands and similar to other Asian countries, fisheries and marine food products are a main food resource and play an important economical role. So far over 400 marine fish parasites have been recorded from Indonesian waters. However, considering Indonesia as the country with the highest marine biodiversity (approximately 3,000 marine fish species) and a large number of expected fish parasites living in that region, the knowledge on the marine fish parasite fauna is still scarce. Following the statement that a fish is infested by an average of more than three metazoan parasite species (Palm et al. 1999, Klimpel et al. 2001), less than 4 % of the expected Indonesian fish parasite diversity is known to science. First large-scale studies were carried out between 1952 and 1954 when Yamaguti described the fish parasite fauna from Indonesian coastal waters, especially from Sulawesi and adjacent waters. The author focused on metazoan parasites, trematodes (Yamaguti 1952, 1953a), monogeneans (Yamaguti 1953b), nematodes (Yamaguti 1954a), acanthocephalans (Yamaguti 1954b), crustaceans (Yamaguti 1954c) and cestodes (Yamaguti 1954d). In 1978, several fish species from the Java Sea were examined for the presence of zoonotic anisakid nematodes (Hadidjaja et al. 1978, Ilahude et al. 1978), which are known to cause the anisakiasis, a painful inflammation of the human gastrointestinal tract (Petersen et al. 1993). Most recently, Palm (2000, 2004) studied the Indonesian trypanorhynch cestodes, a worldwide distributed taxon of shark parasites that infest marine teleosts as intermediate hosts. One of the results was besides over 200 new host records and the description of several new species that the Indonesian archipelago is at the centre of trypanorhynch distribution.
Due to overfishing of many natural fish stocks, the artisanal fisheries along the southern Java coast of Indonesia is focusing more and more also on oceanic and deep water species, such as the cutlessfish and snake mackerels. Though some of these fish species also become exported to other Asian nations and also to Europe, fish parasitological examinations are still missing. So far, no examinations of the commercially important pelagic and mesopelagic deep water fish species from the Indian Ocean along the southern coast of Java do exist. The present study was carried out in order to examine the metazoan parasite fauna of the pelagic, deep water fish species *Gempylus serpens* (Cuvier, 1829), *Thyrsitoides marleyi* (Fowler, 1929), *Trichiurus lepturus* (Linnaeus, 1758), and *Brama dussumieri* (Cuvier, 1831) from the southern Java coast. In addition, the pelagic fish species *Tylosurus crocodilus crocodilus* (Péron and Lesueur, 1821) and the trypanorhynch fauna of the deep-sea fish *Alepisaurus ferox* (Lowe, 1833), both from the same locality, were studied for comparison. Special emphasis was given to the distribution of the, especially in tropical waters species rich order Trypanorhyncha, giving first evidence for a vertical distribution pattern of these fish parasites along the southern Java coast. The knowledge on the depth range of these worldwide distributed parasites is important for our general understanding on how the invasion of fish parasites into the deep-sea might have taken place, and how the obvious worldwide distribution pattern of many marine fish helminths has evolved.

2. Material and Methods

From June-July 2004 a total of 118 pelagic fish species belonging to *Gempylus serpens* (35), *Thyrsitoides marleyi* (4), *Trichiururs lepturus* (55), *Brama dussumieri* (19) and *Tylosurus crocodilus* (5) were examined macro- and microscopically for the presence of metazoan parasites (table 1). The fish was obtained from artisanal fishermen on the fish market of the fishing village Pelabuhan Ratu, southern coast of West Java, Indonesia (6°59' S and 106°33' O).
The examination of the fish followed the standard protocol after Palm et al. (1998). After examination of the skin, fins, nasal capsules and buccal and branchial cavity by naked eye, the gills were studied separate in Petri dishes filled with saline under a stereomicroscope. To study the internal organs the fish was dissected by opening the body cavity from anterior to posterior. The body cavity and mesentery were studied by naked eye for free moving, encysted or encapsulated parasites. All internal organs, separated in Petri dishes filled with saline, were studied under a stereo-microscope. The heart, liver, pyloric caeca and spleen were studied by pressing the tissue between the lid and the base of a Petri dish under the stereomicroscope or by using a candling table. Additionally, one drop of undiluted pyloric and intestine contents was examined under a light microscope under 10 time magnification. The stomach and intestinal contents were mixed with saline and examined under the stereomicroscope. The stomach and intestinal wall, belly flaps and musculature were also studied for encapsulated parasites by using the candling table. All isolated parasites were then placed in clean dishes of saline until further fixation. Additionally, the total length of each fish specimen was measured and the sex determined.
The isolated parasites were fixed in 4% formol or in 70% ethanol. The Acanthocephala were transferred to aqua dest. until the proboscis everted prior to fixation. For identification purposes, Digenea, Nematoda and Acanthocephala were transferred into 100% glycerine (Riemann 1988). The Cestoda were stained in Acetic carmine, dehydrated in a gradated ethanol series, cleared with methyl-salicylate and mounted in Canada balsam.
To study the tentacular armature and surface ultrastructure of the trypanorhynch cestodes and the proboscis and body hooks of the Acanthocephala, some specimens were dehydrated in a gradated acetone series, critical point dried with CO_2 and mounted with double adhesive tape onto SEM stubs. These stubs were sputtered with gold in an argon atmosphere and examined under a LEITZ-AMR 1000 scanning electron microscope at 30 kV.
Parasite identification literature included original descriptions, as well as Gibson et al. (2002) for Digenea, Palm (2004) for Trypanorhyncha, Gibson (1973), Moravec (1994, 1998) and Moravec et al. (1998) for Nematoda, Golvan (1969) for Acanthocephala and Boxshall and Halsey (2004), Jones (1985), Kabata (1979) and Yamaguti (1963) for Copepoda. The ecological

Tab. 1: Number (n), total length and sex of the examined fish species.
Tab. 1: Anzahl (n), Gesamtlänge und Geschlecht der untersuchten Fische.

Family	Fish species	Number (n)	Total length (cm)	Sex (♀/♂)
Gempylidae	*Gempylus serpens*	35	64-120	16/19
Gempylidae	*Thyrsitoides marleyi*	4	79-140	4/0
Trichiuridae	*Trichiurus lepturus*	55	<70-114	31/24
Bramidae	*Brama dussumieri*	19	24-38	14/5
Belonidae	*Tylosurus crocodilus*	5	71-124	5/0
Alepisauridae	*Alepisaurus ferox*	1	120	1/0

Tab. 2: Recorded fish parasites and prevalence of infestation (%) in six fish species from the southern Java coast, Indonesia. New host records are marked in light grey.
Tab. 2: Nachgewiesene Fischparasiten und Befallsprävalenz (%) in sechs Fischarten von der Südküste Javas, Indonesian. Neue Wirtsnachweise sind hellgrau eingefärbt.

Fish species / **Parasites species**		Gempylidae *Gempylus serpens*	Gempylidae *Thyrsitoides marleyi*	Trichiuridae *Trichiurus lepturus*	Bramidae *Brama dussumieri*	Belonidae *Tylosurus crocodilus*	Alepisauridae *Alepisaurus ferox*
Lecithochirium cf. *trichiuri*	**Digenea**		-	22.9	-	-	/
Lecithocladium sp.	"	8.6	-		-	-	/
Prosorhynchoides sp.	"	-	100	-	-	-	/
Hemiuridae indet.	"	-	-	-	5.3	-	/
Digenea indet.	"	-	-	-	5.3	-	/
Tentacularia coryphaenae	**Cestoda**	88.6	50	2.9	10.5	-	100
Nybelinia africana	"	100	-	94.3	42.1	-	100
Nybelinia indica	"	25.7	-	-	-	-	-
Heteronybelinia yamagutii	"	88.6	25	-	-	-	-
Heteronybelinia estigmena	"	-	-	-	5.3	-	-
Mixonybelinia lepturi	"	100	25	100	10.5	-	100
Hepatoxylon trichiuri	"	2.9	-	-	-	-	-
Sphyriocephalus dollfusi	"	-	-	-	-	-	100
Sphyriocephalus tergestinus	"	-	-	-	10.5	-	-
Pseudogrillotia multimina-cantha	"	-	-	5.7	-	-	-
Callitetrarhynchus gracilis	"	-	-	2.9	-	-	-
Floriceps saccatus	"	5.7	-	-	-	-	-
Otobothrium penetrans	"	-	-	-	-	40	-
Tentaculariidae indet.	"	100	-	91.4	-	-	100
Tetraphyllidea indet. (*Scolex pleuronectis)*	"	100	100	100	89.5	40	-
Cestoda indet.	"	-	-	34.3	15.7	-	-
Anisakis sp.	**Nematoda**	97.1	100	97.1	10.5	-	/
Pseudanisakis sp. (L2)	"	82.8	-	-	-	-	/
Pseudanisakis sp. (L3)	"	25.7	-	-	47.3	-	/
Raphidascaris sp. (L2)	"	-	-	-	84.2	-	/
Raphidascaris sp. (L3)	"	-	25	22.8	-	-	/
Philometra sp.	"	-	-	-	-	20	/
Rhabdochonidae indet.	"	97.1	-	-	-	-	/
Nematoda indet.	"	25.7	25	14.3	-	-	/
Gorgorhynchus cf. *robertdoll-fusi*	**Acanthoc.**	51.4	100	51.4	47.4	-	/
Gorgorhynchus sp.	"	-	-	25.7	-	-	/
Radinorhynchus sp.	"	-	-	-	5.3	-	/
Caligodes laciniatus	**Cestoda**	-	-	-	-	20	/
Caligus elongatus	"	-	-	-	10.5	-	/
Metacaligus uruguayensis	"	-	-	34	-	-	/
Lernanthropinus sp.	"	-	-	5.7	-	-	/
Lernanthropus tylosuri	"	-	-	-	-	100	/
Hatschekia conifera	"	-		-	26.3	-	/
Hatschekia sp.	"	-	100	-		-	/
Nothobomolochus sp.	"	-	-	2.9	-	-	/

terms (e.g. prevalence as percentage of infested fish per sample, mean intensity as the mean number of parasites in each infested fish specimen, intensity and mean density as the mean number of parasites in 1 cm^2 of a fish organ in each infested fish specimen) follow Bush et al. (1997) and Margolis et al. (1982).

3. Results

A total of 38 parasite species were found, and 23 new host records were established. The predominant parasite was *Scolex pleuronectis* (unidentified tetraphyllidean larvae) at a prevalence of 40% to 100%, *Anisakis* sp. from 10% to 100% and *Mixonybelinia lepturi* from 10% to 100%. The cestode order Trypanorhyncha was the most diverse taxon during the present study with 13 different species. No myxozoans, monogeneans and hirudineans could be detected. The prevalence of infestation for each parasite species is given in table 2.

The most diverse parasite fauna (component community) was found in *Trichiurus lepturus* and *Gempylus serpens* with 17 and 16 species/taxa, respectively. *Brama dussumieri* also harboured 16 parasites species/taxa, followed by *Thyrsitoides marleyi* with 10 and *Tylosurus crocodilus crocodilus* with 5. The single *Alepisaurus ferox* was infested with 4 different trypanorhynch species. The infracommunity ranged from 9.1 (6-12) in *G. serpens*, 5.9 (3-9) and 6.5 (5-8) in *T. lepturus* and *T. marleyi*, followed by 4.3 (2-8) and 2 (0-4) in *B. dussumieri* and *T. crocodilus* respectively. Between 30.8 and 50% of these species consisted of larval trypanorhynchs, having a species richness of 4.2 (2-6) in *G. serpens*, 2 (0-3) in *T. lepturus* and *T. marleyi*, and 1.4 (0-3) in *B. dussumieri* and 1 in *T. crocodilus*. Details on individual parasite species with comments on the main species diagnostic characters are given below.

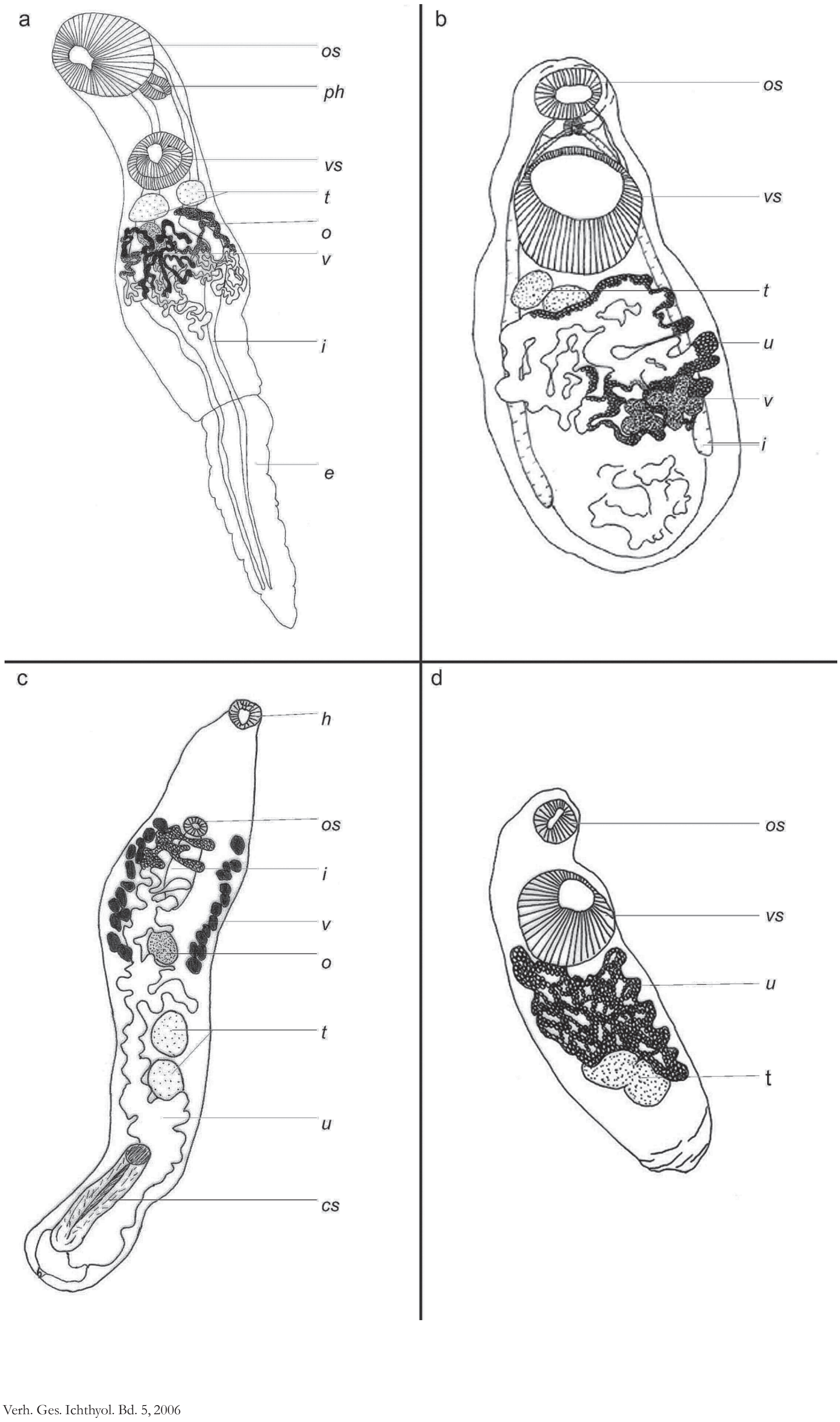
3.1. Digenea

Five different Digenea were isolated out of two families. *Prosorhynchoides* sp. (Bucephalidae Poche, 1907) from the stomach and pyloric caeca of *Thyrsitoides marleyi* was the most predominant species at a prevalence of 100% and an intensity of 5-123. The main characteristic of this species was the elongated body shape with a simple sucker (haptor) located apically, a simple and saclike intestinal caecum, the follicular vitellarium and the conspicuous posterior located cirrus-sac (fig. 1c).

The Hemiuridae (Looss, 1899) were the most abundant family. *Lecithochirium* cf. *trichiuri* (Gu and Shen, 1981) was isolated from the stomach of *Trichiurus lepturus* at a prevalence of 22.9% and an intensity of 1-12. The body shape of this species is fusiform when the ecsoma is retracted, the ventral sucker is larger than the oral sucker and the vitellarium has four short lobes (fig. 1b). The genus *Lecithocladium* (Lühe, 1901) from the stomach of *Gempylus serpens* at a prevalence of 8.6% and an intensity of 1-17 could not

Figs. 1a-d: a Habitus of *Lecithocladium* sp. from *Gempylus serpens*. Total length: 10 mm. **b** Habitus of *Lecithochirium* cf. *trichiuri* from *Trichiurus lepturus*. Total length: 2.1 mm. **c** Habitus of *Prosorhynchoides* sp. from *Thyrsitoides marleyi*. Total length: 5.3 mm. **d** Habitus of Hemiuridae indet. from *Brama dussumieri*. Total length: 0.95 mm. cs=cirrus sac, e=ecsoma, i=intestine, o=ovar, os=oral sucker, p=pharynx, t=testis, u=uterus, vs=ventral sucker.

Abb. 1a-d: a Habitus von *Lecithocladium* sp. aus *Gempylus serpens*. Gesamtlänge: 10 mm. **b** Habitus von *Lecithochirium* cf. *trichiuri* aus *Trichiurus lepturus*. Gesamtlänge: 2,1 mm. **c** Habitus von *Prosorhynchoides* sp. aus *Thyrsitoides marleyi*. Gesamtlänge: 5,3 mm. **d** Habitus von Hemiuridae indet. aus *Brama dussumieri*. Gesamtlänge: 0,95 mm. cs = Cirrus Sack, e = Ecsoma, i = Darm, o = Ovar, os = Mundsaugnapf, p = Pharynx, t = Hoden, u = Uterus, vs = Bauchsaugnapf.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be identified to the species level. This trematode has an elongated body with a long ecsoma, the oral sucker is funnel-shaped and much larger than the ventral sucker and the vitellarium has long, thread-like processes (fig. 1a). From the stomach of *Brama dussumieri* a single specimen of Hemiuridae indet. (fig. 1d) and one specimen of Digenea indet. could be isolated.

3.2. Cestoda

The most predominant parasite was *Scolex pleuronectis* Müller, 1788 (unidentified tetraphyllidean larvae). These parasites were present in all pyloric caeca and intestines of the examined fish. The larval stages are characterised by a scolex with four lateral and one terminal sucker, an unsegmented trunk and a body filled with calcareous corpuscles.

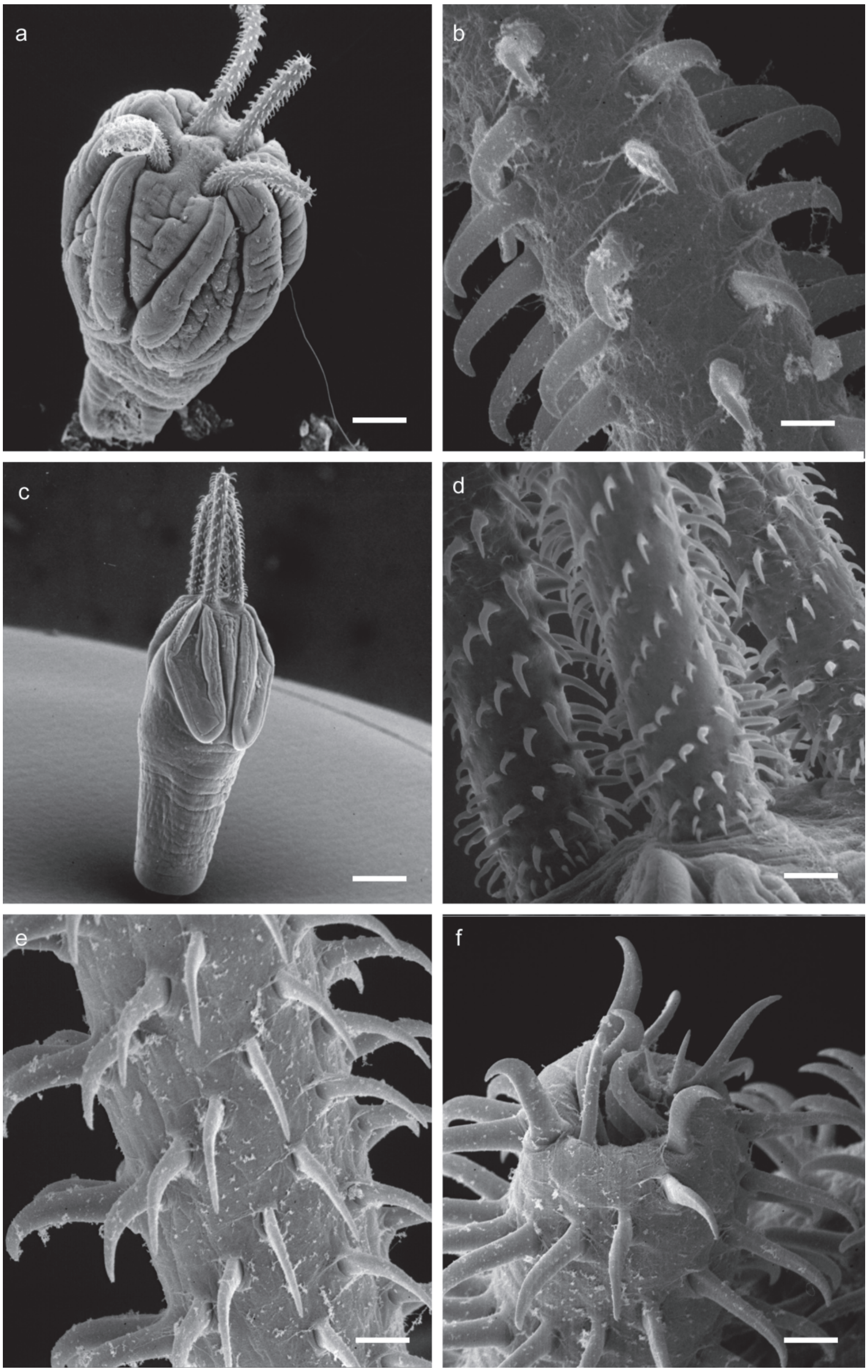
The Trypanorhyncha Diesing, 1863 was the predominant cestode order with 13 identified species out of four families. This group of parasites also represented a major part of the infracommunity (see above). These parasites use teleosts as second intermediate hosts and elasmobranchs as definitive hosts. All identified species follow the morphological characters as given in Palm (2004).

The Tentaculariidae Poche, 1926 was the most diverse family with six species. They were found in the stomach wall, the musculature, belly flaps and in the body cavity of the fish hosts. *Tentacularia coryphaenae* (Bosc, 1797) was isolated from the musculature, belly flaps and body cavity of *G. serpens* at a prevalence of 88.6% and an intensity of 1-12, and from the stomach wall of *T. marleyi* at a prevalence of 50% and an intensity of 1-2, from *T. lepturus* at a prevalence of 2.9 and an intensity of 1, from *B. dussumieri* at a prevalence of 10.5% and an intensity of 1 and from *A. ferox* at a prevalence of 100% and an intensity of 3, respectively.

Nybelina africana (Dollfus, 1960) (figs. 2 a-b) was isolated from the stomach wall and body cavity of *G. serpens* at a prevalence of 100% and an intensity of 4-86, from *T. lepturus* at a prevalence of 94.3% and an intensity of 1-31, from *B. dussumieri* at a prevalence of 42.1% and an intensity of 1-4 and from *A. ferox* in 24 specimens. *N. indica* (Chandra, 1986) could be isolated from the stomach wall of *G. serpens* at a prevalence of 25.7% and an intensity of 1-2. *Heteronybelina yamagutii* (Dollfus, 1960) (figs. 2 c-f) was found in the stomach wall, body cavity and belly flaps of *G. serpens* at a prevalence of 88.6% and an intensity of 1-20 and from the stomach wall of *T. marleyi* at a prevalence of 25% and an intensity of 2. *H. estigmena* (Dollfus, 1960) was only collected from the stomach wall of *B. dussumieri* at a prevalence of 5.3% and an intensity of 2. *M. lepturi* Palm, 2004 was the parasite species with the highest intensity and was isolated from *G. serpens* at a prevalence of 100% and an intensity of 20-243, from *T. marleyi* at a prevalence of 25% and an intensity of 1, from *T. lepturus* at a prevalence of 100% and an intensity of 2-67, from *B. dussumieri* at a prevalence of 10.5% and an intensity of 1-2 and from *A. ferox* in 20 specimens. Out of the family

Figs. 2a-f: *Nybelinia africana* from *Gempylus serpens*; **a** habitus, **b** metabasal armature of the tentacle (b). Scale bar: a= 112 μm, b= 8 μm. *Heteronybelinia yamagutii* from *Gempylus serpens*; **c** habitus, **d** basal part of the tentacles, **e** metabasal armature, **f** apical part of tentacle. Scale bar: c=320 μm, d=36 μm, e=16 μm, f=16 μm.

Abb. 2a-f: *Nybelinia africana* aus *Gempylus serpens*; **a** Habitus, **b** metabasaler Bereich des Tentakels. Scale bar: a = 112 μm, b = 8 μm. *Heteronybelinia yamagutii* aus *Gempylus serpens*; **c** Habitus, **d** basaler Bereich der Tentakel, **e** metabasaler Bereich des Tentakels, **f** apikaler Bereich des Tentakels. Maßstab: c = 320 μm, d = 36 μm, e = 16 μm, f = 16 μm.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Sphyriocephalidae Pinter, 1913, three species could be isolated. *Hepatoxylon trichiuri* (Holten, 1802) was found in the body cavity of *G. serpens* at a prevalence of 2.9% and an intensity of 1. One single specimen of *Sphyriocephalus dollfusi* (Bussieras and Aldrin, 1968) was isolated from the stomach wall *A. ferox* and two specimens of *Sphyriocephalus tergestinus* (Pinter, 1913) (figs. 3 a-b) were collected from the stomach wall of *B. dussumieri*.

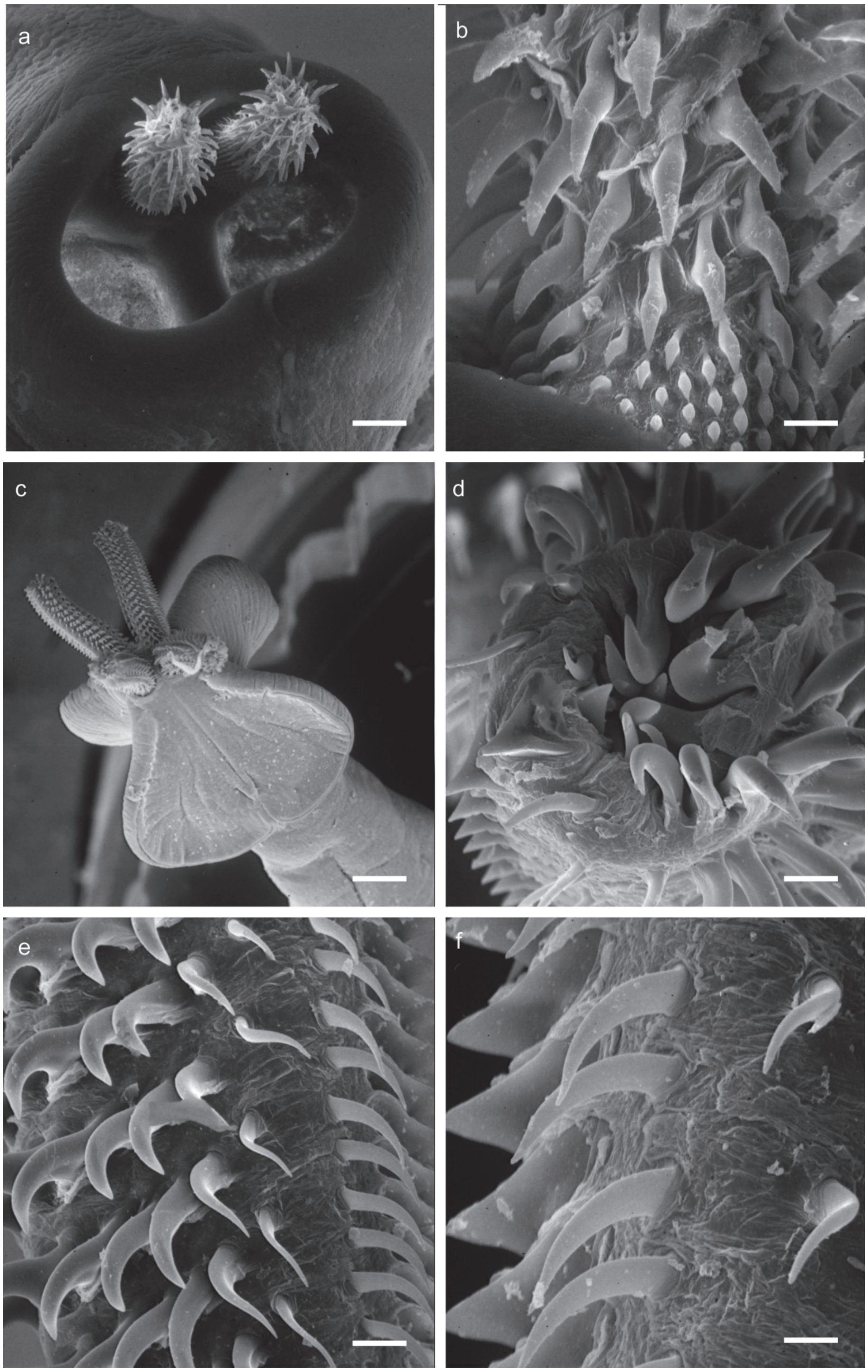
Three species of the family Lacistorhynchidae Guiart, 1927 were identified. One specimen of *Callitetrarhynchus gracilis* (Pintner, 1931) and *Pseudogrillotia multiminacantha* Palm, 2004 at a prevalence of 5.7% and an intensity of 3-4 were isolated from the body cavity of *T. lepturus*. *Floriceps saccatus* (Cuvier, 1817) (figs. 3c-f) was found in a blastocyst in the body cavity of *G. serpens* at a prevalence of 5.7 and an intensity of 1-2. Out of the family Otobothriidae Dollfus, 1942, only *Otobothrium penetrans* (Linton, 1907) could be isolated from the musculature of *T. crocodilus* at a prevalence of 40% and an intensity of 1-2. Some isolated trypanorhynchs from *Gempylus serpens*, *Trichiurus lepturus* and *Alepisaurus ferox* could not be identified to the species level because of inverted tentacles. Due to further morphological characters the identification to the family level was possible and they were treated as Tentaculariidae indet. In *Gempylus serpens*, *Trichiurus lepturus*, *Thyrsitoides marleyi* and *Brama dussumieri* further cestode larvae were found which could not be identified because of the developmental stage. These larvae were treated as Cestoda indet.

3.3. Nematoda

The predominant nematode family was the Anisakidae Railliet and Henry, 1912 and from this family, three genera were identified. The larval stages (L3) of *Anisakis* Dujardin, 1845 with the characteristic long ventriculus, the mucron at the posterior end and the three primordial lips with the boring tooth at the anterior end were isolated from the body cavity of *Brama dussumieri* at a prevalence of 10.5% and an intensity of 1-2, of *Gempylus serpens* at a prevalence of 97.1% and an intensity of 1-32, of *Thyrsitoides marleyi* at a prevalence of 100% and an intensity of 9-25 and of *Trichiurus lepturus* at a prevalence of 97.1% and an intensity of 1-70. The genus *Pseudanisakis* Layman and Borovka, 1929 was found as L2 and L3 stages in the body cavity, stomach wall and pyloric caeca. The L2 stages from *Gempylus serpens* were isolated at a prevalence of 82.8% and an intensity of 2-44 and the L3 stages at a prevalence of 25.7% and an intensity of 1-3. From *Brama dussumieri* the L3 stages was isolated at a prevalence of 47.3% and an intensity of 1-4. The morphological characteristics are the head with three lips but without boring tooth, the long ventriculus and the conical tail. The larval stages of the genus *Raphidascaris* Railliet and Henry, 1915 are characterised by a head with three lips and a boring tooth, an almost spherical ventriculus with a posterior directed ventricular appendix and a conical tail. The L2 stages were isolated from the stomach wall of *Brama dussumieri* at a prevalence of 84.2% and an intensity of 1-210.

Figs. 3a-f: *Sphyriocephalus tergestinus* from *Brama dussumieri*; **a** pars bothrialis with two tentacles, **b** basal part of tentacular armature. Scale bar: a=221 μm, b=15 μm. *Floriceps saccatus* from *Gempylus serpens*; **c** Scolex, **d** apical part of tentacle, **e** metabasal armature, **f** external hooks. Scale bar: c=16 μm, d=7 μm, e=94 μm, f=16 μm.

Abb. 3a-f: *Sphyriocephalus tergestinus* aus *Brama dussumieri*; **a** Bothridie mit zwei Tentakeln, **b** basaler Bereich des Tentakels. Maßstab: a = 221 μm, b = 15 μm. *Floriceps saccatus* aus *Gempylus serpens*; **c** Scolex, **d** apikaler Bereich des Tentakels, **e** metabasaler Bereich des Tentakels, **f** externe Haken. Maßstab: c = 16 μm, d = 7 μm, e = 94 μm, f = 16 μm.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The L3 stages were isolated from the body cavity of *Thyrsitoides marleyi* at a prevalence of 25% and an intensity of 2 and from *Trichiurus lepturus* at a prevalence of 22.8% and an intensity of 1-5. The genus *Philometra* (Philometridae Baylis and Daubney, 1926) was found in the musculature of *Tylosurus crocodilus crocodilus* at a prevalence of 20% and an intensity of 3. These adult nematodes with an average total length of 13,5 cm were dark red coloured and contained viable larvae. Nematodes of the family Rhabdochonidae Travassos, Artigas and Peieira, 1928 could not be identified to the species level. They were isolated as adults from the body cavity of *Gempylus serpens* at a prevalence of 97.1% and an intensity of 1-44. The morphological characters are the absence of pseudolabia, the spherical ventriculus and the conical tail with a cuticular spike on the tip. Some isolated nematodes from *Gempylus serpens*, *Thyrsitoides marleyi* and *Trichiurus lepturus* could not be identified and were termed Nematoda indet.

3.4. Acanthocephala

All collected Acanthocephala belonged to the family Rhadinorhynchidae Travassos, 1923. The cystacanth of *Gorgorhynchus* cf. *robertdollfusi* (Golvan, 1956) was isolated from the body cavity of *Brama dussumieri* at a prevalence of 47.4% and an intensity of 1-4, of *Gempylus serpens* at a prevalence of 51.4% and an intensity of 1-4, of *Thyrsitoides marleyi* at a prevalence 100% and an intensity of 5-14 and of *Trichiurus lepturus* at a prevalence of 51.4% and an intensity of 1-12. The elongated body of this Acanthocephala has an elliptic proboscis with 18 rows of eight hooks each, a long neck and a field with cuticular hooks (fig. 4a). From the pyloric caeca of *Trichiurus lepturus* a further species of the genus *Gorgorhynchus* Chadler, 1934 was found at a prevalence of 25.7% and an intensity of 1-2. The proboscis had 23 rows of eight to nine hooks each, a short neck and a field with cuticular hooks (figs. 4b-d). Two adult specimens of the genus *Rhadinorhynchus* Lühe, 1911 were isolated from the intestine of *Brama dussumieri* at a prevalence of 5.3% and an intensity of 2. The characters of this genus are the long proboscis with 17 rows of 43 hooks each, a slender neck and two fields with a few cuticular hooks (figs. 4e,f).

3.5. Crustacea

All isolated Crustacea belonged to the Copepoda. The predominant family was the Caligidae Burmeister, 1835 with three identified species. Some morphological characters of this family are the broad, dorsal-ventrally flattened carapace, the fusion of the first three thorax segments with the head, the enlarged genital segment and no sexual dimorphism. One female specimen of *Caligodes lacinatus* (Krøyer, 1863) was attached to the gills of *Tylosurus crocodilus crocodilus* at a prevalence of 20% and an intensity of 1. The most important character of this genus is the acron-shaped genital segment which is prolonged at its posterior corners. One female and one male specimen of *Caligus elongatus* (Nordmann, 1832) were isolated from the gills of *Brama dussumieri* at a prevalence of 10.5% and an in-

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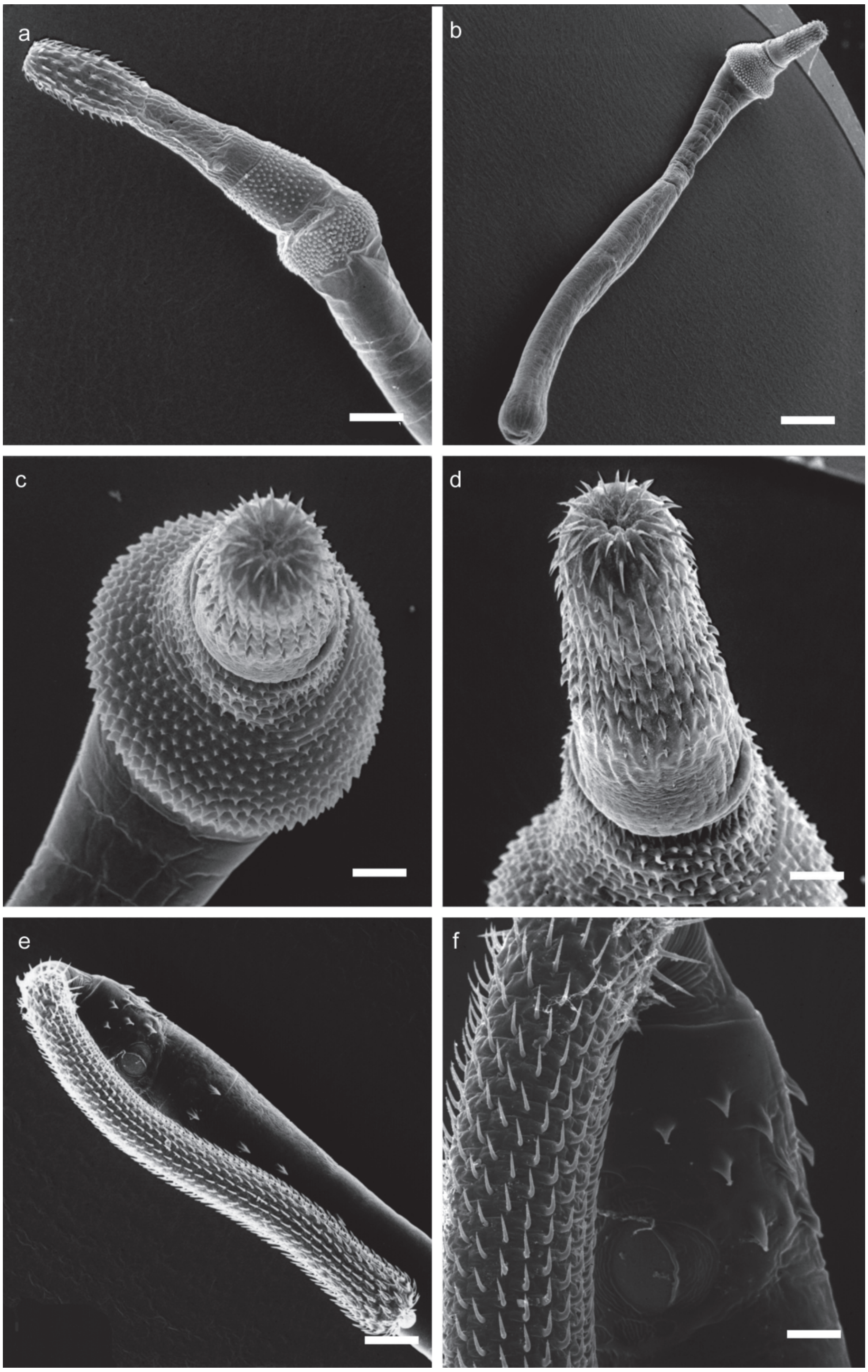
Figs. 4a-f: a *Gorgorhynchus* cf. *robertdollfusi* from *Gempylus serpens*. Scale bar: 193 µm. *Gorgorhynchus* sp. from *Trichiurus lepturus*; **b** habitus, **c, d** proboscis. Scale bar: b=526 µm, c=110 µm, d=80 µm. *Rhadinorhynchus* sp. from *Brama dussumieri*; **e** proboscis, **f** cuticular hooks. Scale bar: e=180 µm, f=50 µm.
Abb. 4a-f: a *Gorgorhynchus* cf. *robertdollfusi* aus *Gempylus serpens* (a). Maßstab: 193 µm. *Gorgorhynchus* sp. aus *Trichiurus lepturus*; **b** Habitus, **c, d** Proboscis. Maßstab: b = 526 µm, c = 110 µm, d = 80 µm. *Rhadinorhynchus* sp. aus *Brama dussumieri*; **e** Proboscis, f cuticulare Haken. Maßstab: e = 180 µm, f = 50 µm.



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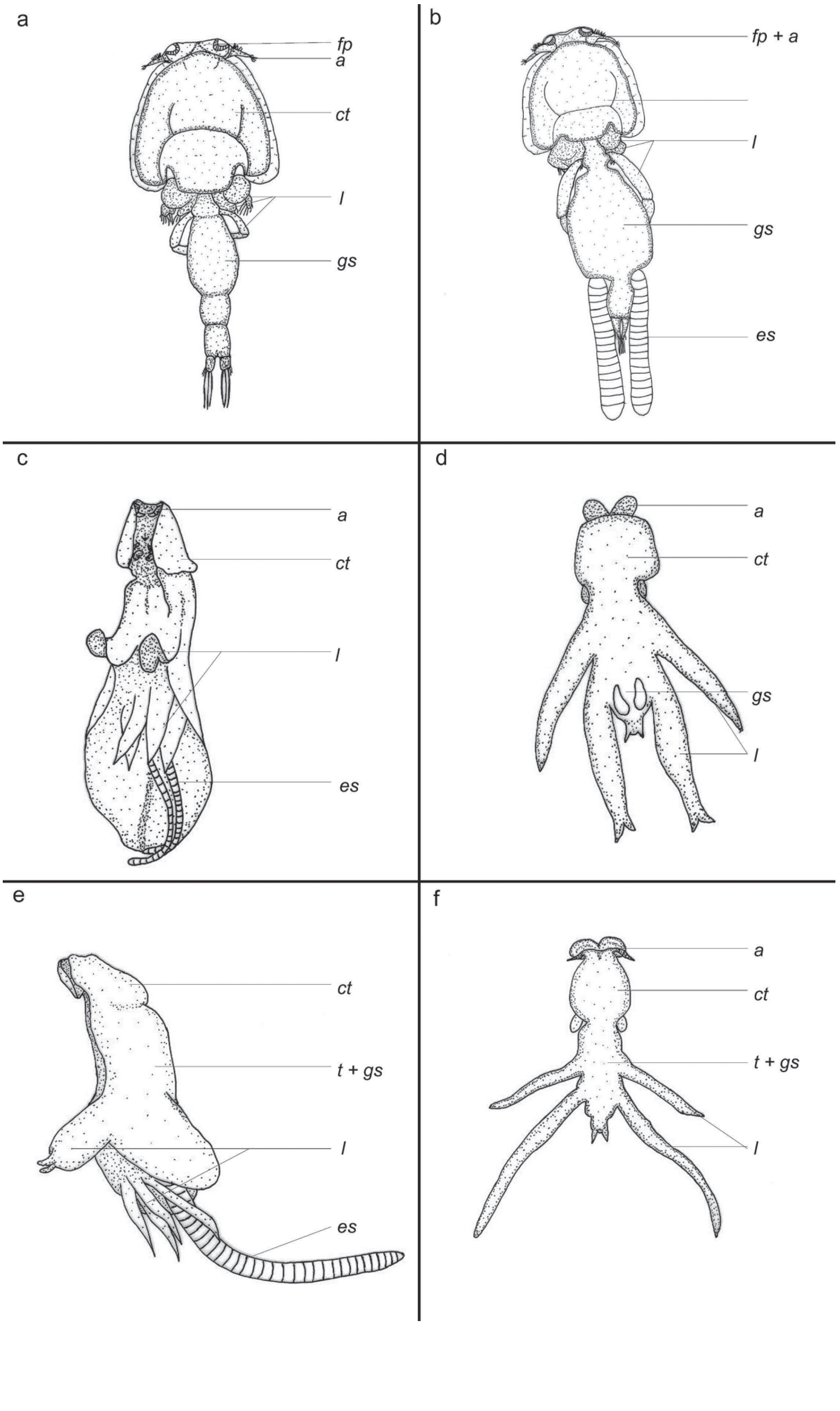

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tensity of 1 (fig. 5a). *Metacaligus uruguayensis* (Thomsen, 1949) was attached to the oral cavity of *Trichiurus lepturus*. The isolated male and female (fig. 5b) specimens had a prevalence of 34% and an intensity of 1-2. One important character of this genus is the absence of the sternal furca. Out of the family Lernanthropidae Kabata, 1979, one genus and one species were identified. This family has a distinct sexual dimorphism in body size and shape. The female's head is fused with the first thorax segment to a pyriform cephalothorax and a dorsal carapace with ventrally turned margins. The other segments are fused with the genital segment covered by a backwards prolonged dorsal plate (Yamaguti 1963). The cephalothorax of the males contains the first segment and all other thoracic and genital segments are fused into an elongate trunk (Yamaguti 1963).

Lernanthropinus Do in Ho and Do, 1985 from the gills of *Trichiurus lepturus* was found as male and female specimens at a prevalence of 5.7% and an intensity of 1-5 (figs. 5e,f). From the gills of *Tylosurus crocodilus crocodilus* the species *Lernanthropus tylosuri* (Richiardi, 1880) was isolated at a prevalence of 100% and an intensity of 4-23 (figs. 5c,d). One species and one genus of the family Hatschekiidae Kabata, 1979 were identified. One of the characters of this family is the reduction in both appendages and segmentation of the body and form of a cylindrical trunk. From the gills of *Brama dussumieri*, *Hatschekia conifera* (Yamaguti, 1939) was isolated at a prevalence of 26.3% and an intensity of 1-2. The genus *Hatschekia* Poche, 1902 was attached to the gills of *Thyrsitoides marleyi* at a prevalence of 100% and an intensity of 3-110. A single specimen of the genus *Nothobomolochus* Vervoort, 1962 (Bomolochidae Sumpf, 1871) was isolated from the gills of *Trichiurus lepturus*. The body shape is "cyclopodid", the head is fused with the first segment to a cephalothorax and the rest of the body tapered backwards. The genital segment is a fusion of seven thorax segments and the first abdominal segment and the first antenna shows a modification with three stable, cuticular outgrowths instead of the third, fourth and fifth seta.

4. Discussion

4.1. Parasite fauna of the examined fish species

4.1.1. *Trichiurus lepturus*

The most diverse parasite fauna (component community) was found in *Trichiurus lepturus* with 17 species/taxa belonging to

Figs. 5a-f: a Habitus of *Caligus elongatus* from *Brama dussumieri*, female. Total length: 4.8 mm. **b** Habitus of *Metacaligus uruguayensis* from *Trichiurus lepturus*, female. Total length: 7.0 mm. **c** Habitus of *Lernanthropus tylosuri* from *Tylosurus crocodilus*, female. Total length: 8.0 mm (without egg sacs). **d** Habitus of *Lernanthropus tylosuri* from *Tylosurus crocodilus*, male. Total length: 3.0 mm. **e** Habitus of *Lernanthropinus* sp. from *Trichiurus lepturus*, female. Total length: 3.2 mm (without egg sacs). **f** Habitus of *Lernanthropinus* sp. from *Trichiurus lepturus*, male. Total length: 3.0 mm. a=antenna, ct=cephalothorax, es=egg sac, fp=frontal plate, gs=genital segment, l=leg, t=thorax.

Abb. 5 a-f: **a** Habitus von *Caligus elongatus* aus *Brama dussumieri*, Weibchen. Gesamtlänge: 4,8 mm. **b** Habitus von *Metacaligus uruguayensis* aus *Trichiurus lepturus*, Weibchen. Gesamtlänge: 7,0 mm. **c** Habitus von *Lernanthropus tylosuri* aus *Tylosurus crocodilus*, Weibchen. Gesamtlänge: 8,0 mm (ohne Eisäcke). **d** Habitus von *Lernanthropus tylosuri* aus *Tylosurus crocodilus*, Männchen. Gesamtlänge: 3,0 mm. **e** Habitus von *Lernanthropinus* sp. aus *Trichiurus lepturus*, Männchen. Gesamtlänge: 3.2 mm (ohne Eisäcke). **f** Habitus von *Lernanthropinus* sp. aus *Trichiurus lepturus*, Männchen. Gesamtlänge: 3,0 mm. a=Antenne, ct=Cephalothorax, es=Eischlauch, fp=Frontalplatte, gs=Genitalsegment, l=Bein, t=Thorax.

Tab. 3: Parasite fauna of *Trichiurus lepturus*, n=35 (a=adult, l=larva, bc=body cavity, g=gills, i= intestine, me=mesentery, oc=oral cavity, p= pyloric caeca, s=stomach, sw=stomach wall, *=mean density (density)/cm^2)
Tab. 3: Parasitenfauna von *Trichiurus lepturus*, n = 35 (a = adult, l = larval, bc = Leibeshöhle, g = Kiemen, i = Darm, me = Mesenterien, oc = Mundhöhle, p = Pylorische Darmanhänge, s = Magen, sw = Magenwand, * = Mittlere Dichte (Dichte)/cm^2)

Parasite species	a/l	Locality	Prevalence [%]	Mean intensity (intensity)
Digenea				
Lecithochirium cf. *trichiuri*	a	s	22.9	3.1 (1-12)
Cestoda				
Tentacularia coryphaenae	l	sw	2.9	1 (1)
Nybelinia africana	l	sw; bc	94.3	8.3 (1-31)
Mixonybelinia lepturi	l	sw; bc	100	19 (2-67)
Pseudogrillotia multiminacantha	l	bc	5.7	3.5 (3-4)
Callitetrarhynchus gracilis	l	bc	2.9	1 (1)
Tentaculariidae indet.	l	sw; bc	91.4	7.7 (1-39)
Tetraphyllidea indet. *(Scolex pleuronectis)*	l	i; p	100	615 (15-1269)*
Cestoda indet.	l	s; i; p; bc	34.3	2 (1-4)
Nematoda				
Anisakis sp.	l 3	bc; me	97.1	16.5 (1-70)
Raphidascaris sp.	l 3	me	23	2.1 (1-5)
Nematoda indet.	-	bc; me	14.3	2 (1-5)
Acanthocephala				
Gorgorhynchus cf. *robertdollfusi*	l	me	51.4	2 (1-12)
Gorgorhynchus sp.	l	p	25.7	1.2 (1-2)
Copepoda				
Lernanthropinus sp.	a	g	5.7	3 (1-5)
Metacaligus uruguayensis	a	oc	34	1.3 (1-2)
Nothobomolochus sp.	a	g	2.9	1 (1)

five orders as can be seen in table 3. The infracommunity was species rich, with a mean of 5.9 and up to 8 parasite species in each infested fish specimen. The distribution of the benthopelagic *T. lepturus* is throughout the tropical and temperate waters of the world, in a depth range between 0-385 m and occasionally in shallow waters and at the surface during the night. Adults mainly feed on fish such as anchovies, sardines, myctophids and occasionally on squids and crustaceans (Nakamura and Parin 1993). The typical standard length is between 50 and 100 cm.

In comparison to the other examined fish species within the present study, the parasite fauna of *T. lepturus* is well known due to a high commercial interest into the species. The digenean *Lecithichirium* cf. *trichiuri* was first described from Gu and Shen (1981) for *Trichiurus haumela*, and Shih (2004) and Shih et al. (2004) described *L. trichiuri* also for *T. lepturus* from Taiwanese waters. Also two other species of the genus *Lecithichirium* were earlier described from the cuttless fish *T. lepturus*, with *L. acutum* from the coast of Kuwait (Nahhas and Sey 2002) and *L. microstomum* from the coast of Rio de Janeiro (Da Silva et al. 2000). The cestode larvae of *Scolex pleuronectis* were isolated at a prevalence of 100% and a density up to 1269 per cm^2. Da Silva et al. (2000) detected a prevalence of 96.3% from the coast of Rio de Janeiro and Radhakrishnan et al. (1984) a prevalence of 75% from the south-western coast of India. The trypanorhynch cestode fauna of *T. lepturus* was well studied by Palm (2004), and the species *Tentacularia coryphaenae*, *Nybelinia africana*, *Mixonybelinia lepturi*, *Pseudogrillotia multiminanatha* and *Callitetrarhynchus gracilis* were collected within the present study. In contrast, Da Silva et al. (2000) recorded only *Callitetrarhynchus gracilis* from *Trichiurus lepturus* from the coast of Rio de Janeiro.

Two Nematoda genera were identified, *Anisakis* sp. and *Raphidascaris* sp. Both species are already known from *T. lepturus*, and also da Silva et al. (2000) recorded these nematodes from Brazil. The acanthocephalans *Gorgorhynchus* cf. *robertdollfusi* and *Gorgorhynchus* sp. as well as the copepod genera *Lernanthropinus* and *Nothobomolochus* represent new host records. The third copepode species, *Metacaligus uruguayensis*, which was located in the buccal cavity of its host, has been recorded for *T. lepturus* by Ho and Bashirullah (1977) and da Silva et al. (2000).

Summarizing the above, *T. lepturus* serves for the digeneans and the copepods as a final host and for the cestodes, nematodes and acanthocephalans as intermediate or paratenic host, where the larval stages accumulate until they reach their final host. *T. lepturus* represents an important parasite transmitter within the region, especially for the mammalian and elasmobranch final hosts.

4.1.2. *Gempylus serpens*

Gempylus serpens is a worldwide distributed, strictly oceanic fish species in the tropical und subtropical regions with a typical standard length of 60 cm and a maximum length of 100 cm (Nakamura and Parin 1993). It preys on fishes, squids and crustaceans and inhabits the epi- and mesopelagial, having a depth range from the surface down to 600 m due to extensive vertical migration (Froese and Pauly 2005).

Tab. 4: Parasite fauna of *Gempylus serpens*, n=35 (a=adult, l=larva, bc=body cavity, bf= belly flaps, i= intestine, me=mesentery, p= pyloric caeca, s=stomach, sw=stomach wall, * =mean density (density)/cm^2)

Tab. 4: Parasitenfauna von *Gempylus serpens*, n = 35 (a = adult, l = larval, bc = Leibeshöhle, bf = Bauchlappen, i = Darm, me = Mesenterien, p = Pylorische Darmanhänge, s = Magen, sw = Magenwand, * = mittlere Dichte (Dichte)/cm^2)

Parasite species	a/l	Locality	Prevalence[%]	Mean intensity (intensity)
Digenea				
Lecithocladium sp.	a	s	8.6	6.3 (1-17)
Cestoda				
Tentacularia coryphaenae	l	bc; bf; m; sw	88.6	3.2 (1-12)
Nybelinia africana	l	sw; bc	100	32 (4-86)
Nybelinia indica	l	sw; bc	25.7	1(1-2)
Heteronybelinia yamagutii	l	sw; bc; bf	88.6	5.5 (1-20)
Mixonybelinia lepturi	l	sw; bc	100	100.8 (20-243)
Hepatoxylon trichiuri	l	bc	2.9	1(1)
Floriceps saccatus	l	bc	5.7	1.5 (1-2)
Tentaculariidae indet.	l	sw; bc	100	52.5 (4-543)
Tetraphyllidea indet. (*Scolex pleuronectis*)	l	i; p	100	131 (1-623)*
Cestoda indet.	l	i	2.9	1(1)
Nematoda				
Anisakis sp.	l3	me	97.1	9.7 (1-32)
Pseudanisakis sp.	l2	bc; me; sw; p	82.8	17.4 (2-44)
Pseudanisakis sp.	l3	bc; me; sw; p	25.7	1.3 (1-3)
Rhabdochonidae indet.	a	s	97.1	12.3 (1-44)
Nematoda indet.	-	bc; me	25.7	1.7(1-6)
Acanthocephala				
Gorgorhynchus cf. *robertdollfusi*	l	me	51.4	1.7 (1-4)

The parasite fauna of *G. serpens* with 16 species/taxa (component community) was similar diverse than the parasite fauna of *Trichiurus lepturus*, however, the intensities were the highest (see table 4). The infracommunity was also the species richest, with a mean of 9.1 and up to 12 parasite species in each infested fish specimen. 45.9% of these belonged to the trypanorhynch cestodes. Parasitological surveys of *G. serpens* are scarce. Blend et al. (1999) studied this fish species for its metazoan parasite fauna in the Golf of Mexico. The authors detected the cestode *Scolex polymorphus*, the digeneans *Minlicaecum*, *Torticaecum* and *Gonocerca phycidis* as metacercaria and *Dinurus barbatus* as adults. Further parasites were the nematode genus *Anisakis*, the acanthocephalan *Gorgorhynchus robertdollfusi* and the copepods *Bomolochus* sp. and *Sarcotretes gempyli*. Within the present study, *Scolex pleuronectis* (= *Scolex plymorphus*), *Anisakis* sp. and *Gorgorhynchus* cf. *robertdollfusi* were also collected, while the adult digenean of the genus *Lecithocladium* was recorded for the first time for this host. The nematode genera *Pseudanisakis* and the family Rhabdochonidae represent new host records. The trypanorhych cestode fauna was also highly diverse, consisting of seven different species: *Tentacularia coryphaenae*, *Nybelinia africana*, *N. indica*, *Heteronybelinia yamagutii*, *Mixonybelinia lepturi*, *Hepatoxylon trichiuri*, *Floriceps saccatus* (see Palm 2004). The high prevalence of infestation, with nine species reaching over 50% and high intensities, identifies *G. serpens* as an imporatant paratenic host for larval metazoan helminths. Especially for the predominant trypanorhynch cestodes and the nematode genus *Pseudanisakis*, *G. serpens* serves as an important parasite transmitter into the elasmobranch final hosts. Interestingly, mainly oceanic trypanorhynchs belonging to the Tentacularioidea and the

Tab. 5: Parasite fauna of *Brama dussumieri*, n=19 (a=adult, l=larva, bc=body cavity, g=gills, i= intestine, me=mesentery, s=stomach, sw=stomach wall, * =mean density (density)/cm^2).
Tab. 5: Parasitenfauna von *Brama dussumieri*, n = 19 (a = adult, l = larval, bc = Leibeshöhle, g = Kiemen, i = Darm, me = Mesenterien, s = Magen, sw = Magenwand, * = mittlere Dichte (Dichte)/cm^2).

Parasite species	a/l	Locality	Prevalence [%]	Mean intensity (intensity)
Digenea				
Hemiuridae indet.	a	s	5.3	1 (1)
Digenea indet.	a	s	5.3	1 (1)
Cestoda				
Tentacularia coryphaenae	l	sw	10.5	1 (1)
Nybelinia africana	l	sw; bc	42.1	2.25 (1-4)
Heteronybelinia estigmena	l	sw	5.3	2 (2)
Mixonybelinia lepturi	l	sw; bc	10.5	1.5 (1-2)
Sphyriocephalus tergestinus	l	sw	10.5	2 (2)
Tetraphyllidae indet. *(Scolex pleuronectis)*	l	i	89.5	57 (5-218)*
Cestoda indet.	l	bc; i; s	15.7	1.3 (1-2)
Nematoda				
Anisakis sp.	l3	bc; me	10.5	1.5 (1-2)
Pseudanisakis sp.	l 3	bc; me	47.3	2.2 (1-4)
Raphidascaris sp.	l 2	sw	84.2	20.1 (1-210)
Acanthocephala				
Gorgorhynchus cf. *robertdollfusi*	l	me	47.3	1.4 (1-4)
Rhadinorhynchus sp.	a	i	5.3	2 (2)
Copepoda				
Caligus elongatus	a	g	10.5	1 (1)
Hatschekia conifera	a	g	26.3	1.2 (1-2)

mammalian nematode *Anisakis* sp. at a prevalence of 97% were found. For this nematode, toothed whales serve as final host, indicating a very important role of *Gempylus serpens* within the oceanic and also deep-sea food web.

4.1.3. *Brama dussumieri*

Brama dussumieri is a circumtropical, pelagic and oceanodromous deep water fish species with a standard length of 19 cm (Froese and Pauly 2005). It typically occurs pelagic in deep waters, and its feeding ecology is not known. The parasitological survey of *Brama dussumieri* is limited to the order Trypanorhyncha from the southern coast of Java (Palm 2004). The present study illustrates for the first time the metazoan parasite fauna of this pelagic deep-sea fish, demonstrating a diverse component community of 16 species/taxa (see table 5). The infracommunity was less species rich than in the gempylids and trichiurid, with a mean of 4.3 and up to 8 parasite species in each infested fish specimen. *B. dussumieri* serves as final host for the digenean trematode family Hemiuridea, for the acanthocephalan *Radinorhynchus* sp. and for the copepods *Caligus elongatus* and *Hatschekia conifera*. *B. dussumieri* serves as intermediate host for the larval stages of the cestode *Scolex pleuronectis*, the nematodes *Raphidascaris* sp. and *Pseudanisakis* and for the acanthocephalan *Gorgorhynchus* cf. *robertdollfusi*. Beside the occurrence of the trypanorhynchs *Tentacularia coryphaenae*, *Nybelinia africana*, *Heteronybelinia estigmena* and *Spyriocephalus tergestinus* (see Palm 2004), *Mixonybelinia lepturi* represents a new host record. Due to the high diversity of trypanorhynchs, especially belonging to the Tentacularioidea with an oceanic and extended 4-host life cycle, and the infestation with *Pseudanisakis* sp., *Brama dussumieri* is an important transport host for these parasites into their final elasmobranch hosts. *B. dussumieri*, however, also might serve as an important prey of large predatory fishes within the region because of its small size. The infestation with larval *Gorgorhynchus* sp. and *Raphidascaris* sp., which use teleosts as final host, underlines this assumption.

Tab. 6: Parasite fauna of *Thyrsitoides marleyi,* n=4 (a=adult, l=larva, bc=body cavity, g=gills, i= intestine, me=mesentery, p= pyloric caeca, s=stomach, , sw=stomach wall, * =mean density (density)/cm^2)
Tab. 6: Parasitenfauna von *Thyrsitoides marleyi,* n = 4 (a = adult, l = larval, bc = Leibeshöhle, g = Kiemen, i = Darm, me = Mesenterien, p = Pylorische Darmanhänge, s = Magen, sw = Magenwand, * = mittlere Dichte (Dichte)/cm^2)

Parasite species	a/l	Locality	Prevalence [%]	Mean intensity (intensity)
Digenea				
Prosorhynchoides sp.	a	s; p	100	47.5 (5-123)
Cestoda				
Tentacularia coryphaenae	l	sw	50	1.5 (1-2)
Heteronybelinia yamagutii	l	sw	25	2 (2)
Mixonybelinia lepturi	l	sw	25	1(1)
Tetraphyllidea indet. *(Scolex pleuronectis)*	l	i	100	2 (1-3)*
Nematoda				
Anisakis sp.	l 3	bc; me	100	15.8 (9-25)
Raphidascaris sp.	l 3	me	25	2 (2)
Nematoda indet.	-	me	25	11 (11)
Acanthocephala				
Gorgorhynchus cf. *robertdollfusi*	l	me	100	10.3 (5-14)
Copepoda				
Hatschekia sp.	a	g	100	34.5 (3-110)

4.1.4. *Thyrsitoides marleyi*

Thyrsitoides marleyi is distributed in the Indo-West-Pacific and inhabits the bentho-meso-pelagial down to a depth of 400 m, and migrates to surface at night. The standard length is between 50-100 cm and the maximum length is 150 cm. It preys upon a composition of fish, squids and crustaceans (Nakamura and Parin 1993).

The metazoan parasite fauna of *Thyrsitoides marleyi* until now is insufficiently known. With the present study, 10 different parasite species could be identified (component community, see table 6). The infracommunity was also species rich, with a mean of 6.5 and up to 8 parasite species in each infested fish specimen. Again, with *Tentacularia coryphaenae*, *Heteronybelinia yamagutii* and *Mixonybelinia lepturi*, several trypanorhynch cestodes were collected (see also Palm 2004). The host-parasite list by Klimpel et al. (2001) summarized the parasite fauna of *T. marleyi* from the Moçambique coast (Indian Ocean). The monogeneans *Gempylitrema* sp. and *Winkenthugesia* sp., the cestodes *Nybelinia* sp. and *Scolex pleuronectis*, the nematode *Anisakis* sp., the acanthocephalan *Bolbosoma* sp. and the copepod *Lernanthropus lativentris* were detected. Only *Scolex pleuronectis* and *Anisakis* sp. also occurred in *T. marleyi* from the southern Java coast. In addition, the digenean genus *Prosorhynchoides*, the nematode genus *Raphidascaris*, the acanthocephalan *Gorgorhynchus* cf. *robertdollfusi* and the copedod genus *Hatschekia* were found. Ho and Lin (2003) collected the copepod *Caligus digitatus* from the deep-sea of the north eastern coast of Taiwan. *T. marleyi* serves for *Prosorhynchoides* sp. and *Hatschekia* sp. as final host and for the other isolated parasites as intermediate host. Again, the trypanorhynchs and the infestation with *Anisakis* sp indicate an important role as a parasite transmitter into the elasmobranch and marine mammal final hosts.

4.1.5. *Tylosurus crocodilus crocodilus*

Tylosurus crocodilus crocodilus is a tropical distributed pelagic fish species with a very low depth range between 0-13 m. The average standard length is 90 cm and the maximum total length is 150 cm. The species preys on fish (Froese and Pauly 2005). The parasite diversity of this fish species was low, with only five recorded species (component community, see table 7). The infracommunity consisted of a mean of 2 up to 4 parasite species in each infested fish specimen. For the nematode *Philometra* sp. and for the copepods *Lernanthropus tylosuri* and *Caligodes lacinatus, T. crocodilus crocodilus* is the final host. The cestodes *Scolex pleuronectis* and *Otobothrium penetrans* are typical elasmobranch parasites. Parasitological examina-

Tab. 7: Parasite fauna of *Tylosurus crocodilus*, n=5 (a=adult, l=larva, g=gills, i=intestine, m=musculature, *=mean density (density)/cm^2).

Tab. 7: Parasitenfauna von *Tylosurus crocodilus*, n = 5 (a = adult, l = larval, g = Kiemen, i = Darm, m = Musculatur, * = mittlere Dichte (Dichte)/cm^2).

Parasite species	a/l	Locality	Prevalence [%]	Mean intensity (intensity)
Cestoda				
Otobothrium penetrans	l	m	40	(1-2)
Tetraphyllidea indet. *(Scolex pleuronectis)*	l	i	40	8.5 (1-16)*
Nematoda				
Philometra sp.	a	m	20	3 (3)
Copepoda				
Caligodes laciniatus	a	g	20	1 (1)
Lernanthropus tylosuri	a	g	100	10 (4-23)

tions of this fish species are known from Philippine waters (Petersen et al. 1993). The authors also recorded *Philometra* sp. and *Otobothrium penetrans* from the musculature. The trypanorhynch *O. penetrans* only occurs in the flesh of belonids and hemirhamphids, which feed on a variety of organisms taken from the surface layer of the sea (Petersen et al. 1993). Carcharhinid and sphyrnid sharks serve as final hosts, infesting themselves by preying upon *T. crocodilus* in the surface waters. Consequently, *Otobothrium penetrans* can be considered having a life cycle in coastal surface waters, and does not infect the studied deep-sea fish. *T. crocodilus* was free of tentaculariid trypanorhynchs, and the parasite fauna had nothing in common with that of the other oceanic and deep-water species.

4.1.6. *Alepisaurus ferox*

Alepisaurus ferox is a worldwide distributed oceanic predator in the epi- and mesopelagic layers of the tropical and subtropical regions. The depth range of this vertical migrator is between 0 to 1830 m and the maximum total length is 215 cm. This fish preys upon a composition of fish, cephalopods, and tunicates (Froese and Pauly 2005). Also this oceanic fish harboured a highly diverse trypanorhynch cestode fauna, however, consisting only of the tentacularioids *Tentacularia coryphaenae*, *Nybelinia africana*, *Mixonybelinia lepturi*, *Sphyriocephalus dollfusi* and Tentaculariidae indet.

4.2. Characterisation of the oceanic and deep-sea parasite fauna

The parasite diversity of the four studied oceanic and deep-sea fishes from the southern Java coast, Indonesia, was high, with 17 species/genera isolated from *Trichiurus lepturus*, 16 species/genera from *Gempylus serpens*, 16 species/genera from *Brama dussumieri* and 10 species/genera from *Thyrsitoides marleyi*. According to the infracommunity, the mean species number was high, ranging from 4.3-9.1. Between 30.8 and 50% of the isolated species belonged to the cestode order Trypanorhyncha. All these fish can be characterized by a predatory, largely piscivorous feeding behaviour, and with the exception of *B. dussumieri* all are known for extensive daily vertical migrations. Consequently, all of them are able to prey upon a wide range of prey items, and can accumulate a wide range of different metazoan parasites, with most of them getting transmitted via the marine food web.

Comparison of the parasite species from each examined fish species demonstrates that adult parasites seem to be very host specific. Especially the Copepoda are often highly adapted to a specific host and site, e.g. *Metacaligus uruguayensis* on *T. lepturus*. This contrasts a low level of host specificity in most larval stages. The cestodes *Scolex pleuronectis*, *Mixonybelina lepturi* and *Tentacularia coryphaenae* as well as the nematodes *Anisakis* sp. and the acanthocephalan *Gorgorhynchus* cf. *robertdollfusi* were detected in all four fish species. *Nybelina africana* was isolated from three and *Heteronybelinia yamagutii*, *Raphidascaris* sp. and *Pseudanisakis* sp. from two of the four fish species. In contrast, nine other parasite species in the larval stage appeared to be host specific, e.g. the three species of the trypanorhynch family Lacistorhynchidae occurred only within a single host species. However, Palm (2004) already demonstrated that also these parasites can infest a wide variety of different fish hosts, thus also having low host specificity. For example, *Nybelinia indica* was isolated only from *G. serpens* and appeared to be highly host specific. Palm (2004) recorded 28 intermediate hosts for this species. *Nybelinia indica* is worldwide distributed and occurs in several oceanic teleosts as intermediate and in widely distributed sharks as final hosts. Similarly, *Floriceps saccatus* was found to be host specific within the present study and Palm (2004) recorded 16 different fish intermediate hosts. Palm (2004) postulated that in both, intermediate and final hosts, the different trypanorhynchs are not random collections of locally available species but represent structured packets of parasites that travel together with other helminths along common and reliable transmission routes into the final host. Species such as the trypanorhynchs, many nematodes and also acanthocephalans indicate a specific ecology of the fish, living in a similar or the same habitat and following a similar feeding ecology. This is also true within the present study. Though *B. dussumieri*, *T. lepturus* as well as *G. serpens* and *T. marleyi* belong to three different fish families, the parasite fauna shows a somewhat overlapping pattern, with the fish ecology having more importance for the composition of the parasite fauna than the host phylogeny. Also *A. ferox*, belonging to another and typical deep-sea fish family, had trypanorhynchs that also occurred in one or more of the other studied fish species. It seems that *N. africana*, *M. lepturi*, *T. coryphaenae*, *S. pleuronectis*, *Anisakis* sp. and *G.* cf. *robertdollfusi* characterize a predatory fish species within the oceanic, into the deep-sea reaching environment along the tropical outer continental shelf region.

Each of the four oceanic and deep-sea fish species was infested with the third stage larva of *Ansiakis* sp., a species of economical importance. The infestation with this zoonotic anisakid reached a prevalence of 100% for *T. marleyi*, 97% for *G. serpens* and *T. lepturus*, and 10.5% for *B. dussumieri*. This prevalence is higher than the data obtained by Hadidjaja et al. (1978) from fish species from the Java Sea, being infested at a significant lower prevalence of 40%-50%. The Java Sea is a merely shallow environment in comparison to the situation found off Pelabuhan Ratu where the deep-sea begins already few miles off the coast. *Anisakis* spp. are known for a pelagic life cycle, where the second and third stage larvae develop within the egg and where the larvae hatch to freely float within the water column. Many different kind of pelagic crustaceans serve as first intermediate and euphausids or fish as second intermediate and paratenic hosts. Final hosts are whales, especially dolphins that are common in Javanese waters. The high prevalence of infestation along the southern Java coast demonstrates the open water, pelagic environment of the studied fish species, and the high risk or predatory fish to get infested. *T. lepturus* is a very important economic fish species and a main protein resource surrounding the Indian Ocean (Oryan et al. 1998). It is suggested that all oceanic and pelagic fish from the southern Java coast, including the studied fish species, must be well cooked before consumption or deep frozen before further processing to prevent any risk of the anisakiasis disease in fish consumers, either locally or on the international market.

4.3. Distribution pattern of trypanorhynch cestodes

With 13 different species, the Trypanorhyncha was the order with the highest diversity in the present study (see table 8). This is not astonishing because trypanorhynchs belong to the most abundant and diverse groups of parasitic helminths in tropical oceans. Members of the order are worldwide distributed, and many species have a wide range of distribution, or are cosmopolitan. Palm (2004) illustrated that the Indonesian archipelago is at the centre of the trypanorhynch distribution, with a total of 54 different trypanorhynchs out of 254 then known species recorded so far, mainly from the southern coast of Java since 2000. Consequently, trypanorhynchs significantly contributed to the infracommunity, ranging from a mean of 1-4.2 and up to six different species in a single fish (*Gempylus serpens*).

Tab. 8: Trypanorhynch cestodes from the southern Java coast, Indonesia, with the prevalence (%) and mean intensity (intensity) of infestation.
Tab. 8: Rüsselbandwürmer von der Südküste Javas, Indonesia, mit der Befallsprävalenz (%) und der mittleren Intensität (Intensität).

Fish species	**Alepisauridae *Alepisaurus ferox***	**Gempylidae *Gempylus serpens***	**Gempylidae *Thyrsitoides marleyi***	**Trichiuridae *Trichiurus lepturus***	**Bramidae *Brama dussumieri***	**Belonidae *Tylosurus crocodilus***
Number examined	**n=1**	**n=35**	**n=4**	**n=35**	**n=19**	**n=5**
Depth range (in m)	**0-1830**	**0-600**	**0-400**	**0-400**	**-**	**0-13**
Parasite species						
Tentaculariidae						
Tentacularia coryphaenae	100% 3 (3)	88.6% 3.2 (1-12)	50% 1.5 (1-2)	2.9% 1 (1)	10.5% 1 (1)	-
Nybelinia africana	100% 24 (24)	100% 32 (4-86)	-	94% 8.3 (1-31)	42.1% 2.3 (1-4)	-
Nybelinia indica	-	25.7% 1 (1-2)	-	-	-	-
Mixonybelinia lepturi	100% 20 (20)	100% 100.8 (20-243)	25% 1 (1)	100% 19 (2-67)	10.5% 1.5 (1-2)	-
Heteronybelinia yamagutii	-	88.6% 5.5 (1-20)	25% 2 (2)	-	-	-
Heteronybelinia estigmena	-	-	-	-	5.3% 2 (2)	-
Tentaculariidae indet.	100% 6 (6)	100% 52.5 (4-435)	-	91.4% 7.7 (1-39)	-	-
Sphyriocephalidae						
Hepatoxylon trichiuri	-	2.9% 1 (1)	-	-	-	-
Sphyriocephalus dollfusi	100% 1(1)	-	-	-	-	-
Sphyriocephalus tergestinus	-	-	-	-	10.5% 2 (2)	-
Lacistorhynchidae						
Pseudogrillotia multimina-cantha	-	-	-	5.7% 3.5 (3-4)	-	-
Callitetrarhynchus gracilis	-	-	-	2.9% 1 (1)	-	-
Floriceps saccatus	-	5.7% 1.5 (1-2)	-	-	-	-
Otobothriidae						
Otobothrium penetrans	-	-	-	-	-	40% 1.5 (1-2)

The host specificity of the observed species is low (see above). Especially the oceanic tentaculariids occurred in several hosts, with *Tentacularia coryphaenae* and *Mixonybelinia lepturi* infesting five, *Nybelinia africana* four, and *Heteronybelinia yamagutii* two different fish species. Species such *Callitetrarhynchus gracilis* from *Trichiurus lepturus* have been described from 142 intermediate hosts worldwide (Palm 2004), and *Hepatoxylon trichiuri* is known from 87 intermediate hosts throughout the tropical and boreal region. Trypanorhynch cestodes are also known to occur in the deep-sea below 200m water depth. Klimpel et al. (2001) recorded *Tentacularia coryphaenae*, *Nybelinia africana*, *Heter-*

onybelinia yamagutii, *Hepatoxylon trichiuri*, *Sphyriocephalus tergestinus* and *Callitetrarhynchus gracilis* from deep water fish species. Consequently, several deep-water trypanorhynchs were represented within the present study, in accordance to the extensive vertical migrations known from most of the studied fish species that reach several hundred meter water depth.

Though the infestation patterns among the fish species were similar, some differences could be observed in the prevalence and intensities of infestation. The overlapping infestation patterns of the same trypanorhynch species in fish from entirely different families indicates their low host specificity within the second intermediate or paratenic host and their ability to infest various fish without respect to their phylogeny (see above). Consequently, different infestation numbers are either due to a different depth range of the single trypanorhynch or depend on different fish ecology. The feeding ecology as well as depth range is somewhat similar in *Trichiurus lepturus*, *Gempylus serpens* and *Thyrsitoides marleyi*, as can be seen in similar diverse and overlapping parasites. However, there are typical shallow water species such as *Otobothrium penetrans* that only occur in shallow water fish species such as in *Tylosurus* spp. The congener *O. cysticum* has been identified as another shallow water species, being typical for estuarine conditions in tropical and subtropical waters (Palm and Overstreet 2000, Palm 2004). Other trypanorhynchs are typical deep-sea forms, such as *Microbothriorhynchus* spp. and *Grillotia borealis* (Palm 2002, Keeney and Campbell 2001). Within the present study, *Heteronybelinia yamaguti* only occurred in the gempylids that reach a water depth until 400-600 m. *H. yamagutii* has been earlier recorded from 21 different intermediate hosts from deep-waters below 200 m (Klimpel et al. 2001), and can be considered as a typical deep water form. The adult was recorded from *Carcharhinus signatus* (Poey, 1868) (Knoff et al. 2004), a benthopelagic shark with a depth range of 0-600 m. This oceanic shark might get infested during vertical migration into the deep-sea. Other trypanorhynch species seem to have a more extensive vertical distribution pattern, such as *Tentacularia coryphaenae*, *Mixonybelinia lepturi*, and *Nybelinia africana*. These species, typically occurring in carcharhinid, sphyrnid and lamnid sharks as final hosts (Palm 2004), were recorded from the deep-sea fish *Alepisaurus ferox*, the deep water pelagic species *Brama dussumieri* and the benthopelagic *Trichiurus lepturus* (0-400 m). However, *Gempylus serpens* with a depth range of 1-600 m had the highest prevalence and intensity of infestation. Though the exact depth range cannot be determined within the present study, these tentaculariids obviously are not restricted either to the surface or the deep-sea. Their non-specific four-host extended life cycle enables them to infest a wide range of fish intermediate hosts, including those migratory species that distribute them not only horizontally (intra- and inter-oceanic) but also vertically within many hundred meters of water column also into the deep-sea.

4.4. Conclusions

The present study demonstrates the high biodiversity of metazoan parasites in tropical oceanic fish species from Indonesia. The component community as well as the infracommunity was species rich. For the first time, commercially important fish from the southern Java coast around Pelabuhan Ratu were analysed and revealed parasitic digeneans, cestodes, nematodes, acanthocephalans and crustaceans. The zoonotic *Anisakis* sp. was present in all studied oceanic fish species, thus being of fish hygienic importance at the studied locality. The high prevalence and intensity of infestation with this nematode can be explained by the oceanic environment of the studied fish species combined with the presence of many marine mammals such as dolphins in the region, serving as final hosts. The elasmobranch parasitic cestode order Trypanorhyncha was the most species rich taxon, consisting of mainly low host specific species. They contributed significantly to the infracommunity of the oceanic fish species. The infestation pattern was overlapping among the studied fish species, demonstration the low host specificity especially of the tentaculariid trypanorhynchs. The infestation with the larval stages of these widely distributed fish parasites in tropical waters depends on the fish ecology and depth range and not on the host phylogeny. Being less host specific in the open water pelagic environment has the advantage that the transfer to the next fish host is more likely even under unfavourable conditions, such as under seasonal occurrence of the final hosts or less dense populations of the potential intermediate hosts. In addition, new exploration of other environments such as the deep-sea become more likely, explaining the occurrence of trypanorhynch cestodes also in the deep-sea fish. It can be stated that each examined fish species has a characteristic, often highly diverse parasite fauna according to the geographical region and coastal morphology combined with the distribution, host specificity and depth range of its potential parasites.

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