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Infestation of Atlantic chaetognaths with helminths and ciliates

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ABSTRACT: The parasite fauna of chaetognaths was investigated at 3 locations: (i) Patagonian Shelf, (ii) 'Great Meteor Bank', (iii) upwelling region off north-west Africa. On the Patagonian Shelf, 4 out of 3,000 chaetognaths (0.16%) were infested by *Contracaecum*-type larvae, 1 chaetognath harboured an *Ectenurus* sp. metacercaria. On the 'Great Meteor Bank', 18 out of 8,600 chaetognaths (0.21%) were infested by *Cercaria owreae, Ectenurus lepidus,* hemiuroid metacercariae or ciliates in April, whereas only 1 *E. lepidus* metacercaria was found in 4,400 chaetognaths (0.02%) in July. In the north-west African upwelling-region, 640 out of 20,000 chaetognaths (3.2%) were infested mainly by metacercariae of *E. lepidus* and by hemiuroid metacercariae, larval cestodes or ciliates. The distribution of *E. lepidus* in this area is outlined. The lengths of *E. lepidus* metacercariae from north-west African waters increase significantly with distance from the coast. *E. lepidus* metacercariae were found predominantly in the tail coelom of the chaetognaths.

INTRODUCTION

Parasitism – a special form of coexistence of different species of organisms, in which one species lives at the expense and to the disadvantage of the other – is primarily considered as a problem of ecology, but also entails other aspects: physiological, ontogenetical, taxonomic, population dynamic and zoogeographical. The study of the life cycles of marine parasites – especially of those which require several intermediate hosts for their development – as well as of their significance for the marine ecosystem is encumbered by the fact that the various hosts may be members of different ecosystems and phyla. In general, marine organisms are studied – usually without taking into consideration the problem of parasitic infestation – by various scientists with quite different approaches and scopes of research. The present knowledge of parasitism regarding the various groups of organisms and the various oceanographic regions is very unbalanced. The knowledge concerning one specific region cannot be applied to other regions, nor that concerning one species to another one, in spite of the existence of general functional principles.

Even in poorly investigated regions it might be possible to trace the life cycles of marine parasites, if only the infestation of hosts were studied rigorously and quantitatively, and a series of complementary work were comprehended, instead of recording parasites in terms of chance observations.

While plankton parasites are mentioned in many papers, most of these were observed by chance. For chaetognaths such studies have been summarized by Dollfus (1960) and Alvariño (1965). As many plankton organisms are more or less transparent, quantitative data on their infestation are rather easy to gather. We have worked on the chaetognath material collected by 3 expeditions and found different parasite faunas for different marine regions; judging from their geographical position, these were not measurably affected by pollution.

MATERIAL AND METHODS

Sampling data. (1) Patagonian Shelf. FRV 'Walther Herwig'-cruise 36, 2–26 Feb 1971 from 38° S to 55° S, including Burdwood Bank. Vertical hauls from 50 to 0 m with Helgoland Larvae Net, diameter 1.1 m, mesh size 0.3 mm.

(2) 'Great Meteor Bank'. 24 hauls (900 to 0 m) of 6 samples each, taken at 3 h intervals with a Helgoland

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Larvae Net, equipped with a changing bucket device. RV 'Meteor'-cruise 9a, 23–24 Apr 1967, long-term station at 30° 18' N, 29° 20' W, water depth 4,300 m. RV 'Meteor'-cruise 9c, 20–21 July 1967, long-term station at 30° 10' N, 28° 55' W, water depth 3,000 m.

(3) Upwelling region off north-west Africa. RV 'Meteor'-cruise 36, oblique hauls with a modified Bongo Net (diameter 0.6 m, mesh size 0.3 mm) from 200 to 0 m (except at stations of water depth less than 200 m). Transect C: 28–30 Jan 1975, from 21° 31.3' N, 18° 43.2' W to 21° 16.2' N, 17° 04.5' W. Transect B: 2–3 Feb 1975, from 23° 04.8' N, 18° 16.8' W to 22° 47.7' N, 16° 32.2' W.

Chaetognaths. Plankton samples were fixed in 4% formalin-seawater. Subsamples were drawn from large samples; small samples were examined as a whole. Chaetognaths were sorted out quantitatively and identified under a microscope (magnification 50 to 250×). Infested specimens were picked out quantitatively. The work on chaetognaths was carried out by H. Kapp.

Parasites. Helminths were dissected from their hosts under a stereomicroscope, transferred to 70 % ethanol, stained in hydrochloric acid-carmine, differentiated in 1 % hydrochloric acid-ethanol (Vogel 1969), dehydrated in an alcoholic series, cleared in creosote and mounted in Canada balsam (Gibson 1979). The work on helminths was carried out by C. Jarling.

RESULTS AND DISCUSSION

Patagonian Shelf

Chaetognaths with parasites were very rare on the Patagonian Shelf including Falkland Current and Burdwood Bank. Only 1 out of 47 chaetognath samples contained 5 infested specimens (i.e. 0.16 % of 3,000 chaetognaths examined). This nearshore sample from the north of the Gulf of St. George (45° 05' S, 65° 00' W) consisted exclusively of *Sagitta friderici* Ritter-Záhony, 1911, the predominant neritic chaetognath species of this area (Kapp 1980). Four of these parasites were larval nematodes of the *Contracaecum* type in their third larval stage. As identification at the species level is based on the reproductive structures of the adult stage, they could not be identified with certainty, but they probably belong to the species *Hysterothylacium* (syn. *Thynnascaris*) *aduncum* (Rudolphi 1802), for which a number of fish species of this area are known as final hosts (Szidat 1961). The fifth parasite was a metacercaria of the genus *Ectenurus*, probably belonging to *E. virgula* Linton, 1910, which Szidat (1961) frequently found in fish (*Urophycis brasiliensis* Kaup 1858) from Argentinian coastal waters. However, as the differences between *E. virgula* and *E. lepidus* Looss 1907 are small, and the variation of specific characters is relatively large (Szidat 1961), positive identification of a single specimen is not completely certain.

'Great Meteor Bank'

The incidence of infestation at 'Great Meteor Bank' was also very low. From Cruise 9a (Apr) 18 out of 8,600 chaetognaths (0.2 %) were infested – 16 of them harboured cercariae and metacercariae of trematodes, and 2 were parasitized by *Metaphyra sagittae* Ikeda 1917 (Ciliata). From Cruise 9c (Jul) only 1 out of 4,400 chaetognaths (0.02 %) was infested by a metacercaria of *Ectenurus lepidus.* One of the metacercariae from Cruise 9a was also identified as *E. lepidus,* and 9 were other hemiuroid metacercariae, which could not be identified any further, due to bad preservation. They probably belonged to at least 3 different species. The 6 cercariae found are *Cercaria owreae* (Hutton, 1954), which has been reported from the Caribbean Sea (Hutton 1954, Caabro 1955, Dawes 1958, 1959), from the western coast of Africa (Furnestin & Rebecq 1966, Reimer 1975) and from the Indian Ocean off Madagascar (Furnestin & Rebecq 1966). The adult stage of this species is still unknown.

Cercaria owreae does not shed its 2 tail appendages upon entering the second intermediate host, the chaetognath, because the intestinal caeca extend into them. Instead, the tails are resorbed relatively slowly so that these cercariae can be found with tails of variable length. We have, for the first time, found a specimen with completely reduced tails, which, therefore, is definitely a metacercaria (Fig. 1). Samples from 'Great Meteor Bank' were taken from 900 m to 0 m

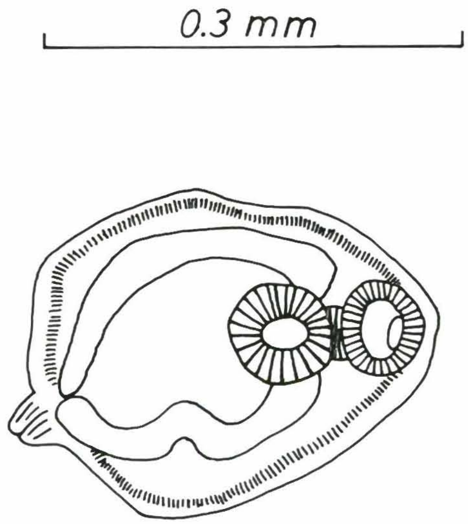

Fig. 1. Metacercaria of *Cercaria owreae* from *Sagitta hexaptera*, RV 'Meteor' cruise 9a, 'Great Meteor Bank'

water depth, but infested chaetognaths were only observed in the upper 100 m water layer.

Only 5 out of the 15 chaetognath species found at 'Great Meteor Bank' (Bückmann & Kapp 1973) were infested with parasites: *Pterosagitta draco* (Krohn, 1853), *Sagitta serratodentata* Krohn 1853, *S. bipunctata* Quoy & Gaimard 1827, *S. hexaptera* d'Orbigny 1834, and *S. decipiens* Fowler 1905. The fact that no parasites were found in 3 abundant surface species – *S. lyra* Krohn 1853, *S. enflata* Grassi 1881, and *Krohnitta pacifica* (Aida, 1897) – is probably due to the spot-check-like nature of the chaetognath material and the scarcity of the parasites.

Upwelling region off north-west Africa

The incidence of infestation in this region was an order of magnitude greater than that in the other 2 areas. From 312 parasitized chaetognaths found in subsamples it was calculated that 638 out of 20,000 chaetognaths sampled (3.2 %) were infested; 97 % of the chaetognaths found to be parasitized harboured metacercariae of *Ectenurus lepidus*. This trematode was calculated to be present in 421 out of 10,700 chaetognaths from Transect C (3.9 %) and in 187 out of 9,100 from Transect B (2.1 %). The distribution of *E. lepidus* is given in Tables 1 and 2, the positions of stations in Fig. 2. Most of the chaetognaths harboured only 1 metacercaria, but about 10 % were found with 2, and 2 specimens with even 3 *E. lepidus*. Six hemiuroid metacercariae could not be identified to species. They probably belong to more than 3 different species and were found in *Sagitta tasmanica* and *S. friderici*. One specimen in *S. tasmanica* might have been *Opechona* (syn. *Pharyngora*) *bacillaris* (Molin, 1885).

One individual of *Sagitta tasmanica* harboured a larval cestode, and another one harboured numerous ciliates, *Metaphryra sagittae*, in its trunk as well as in the tail coelom; they entirely agree with the photographs of *Metaphrya* of Nagasawa & Marumo (1979).

The metacercaria of *Ectenurus lepidus* – like other members of the Hemiuridae – is not very host specific. Nevertheless, differences existed in the frequency of infestation for the different chaetognath species:

	Transect C	Transect B	Average
Sagitta friderici Dominant in nearshore area	7.1 – 9.1 %	0 – 8.8 %	5.8 %
S. tasmanica Dominant in neritic area with more than 100 m water depth	0 – 3.4 %	1.7 – 5.0 %	2.5 %
S. minima Abundant in the whole area	0 – 11.9 %	0 – 7.7 %	3.8 %

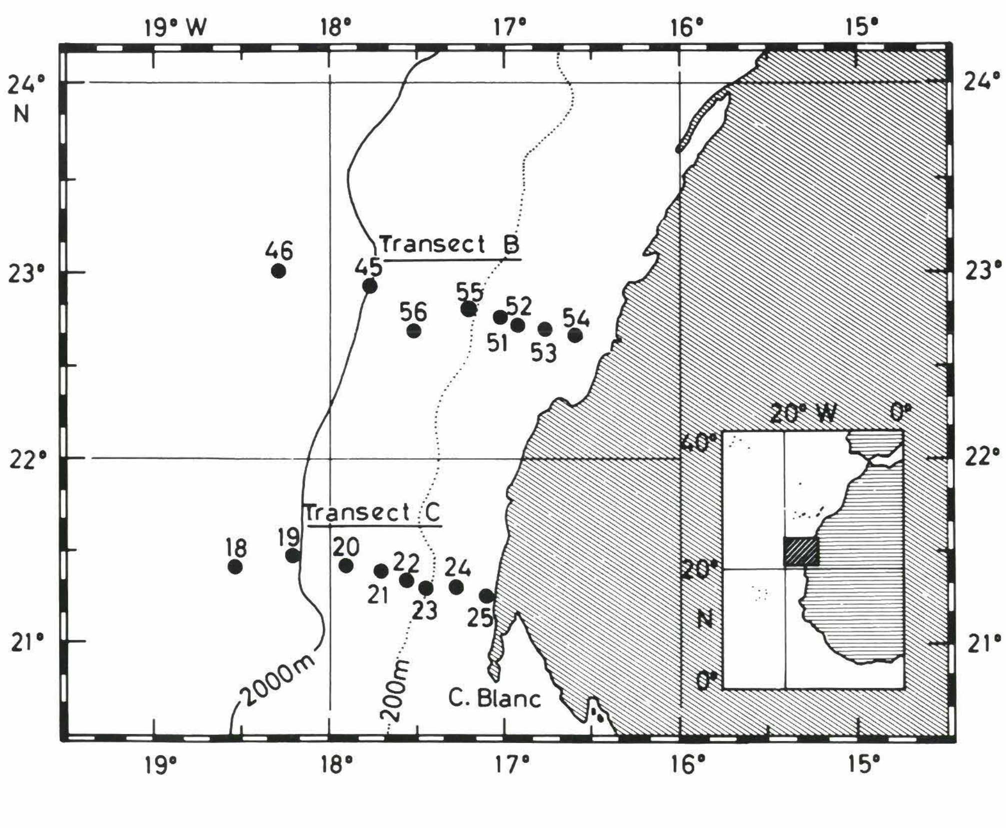

Fig. 2. Positions of sampling stations in the upwelling region off north-west Africa

These differences were probably caused by a combination of biological and hydrographical factors.

The distribution of *Ectenurus lepidus* is influenced by the distribution of the first and second intermediate as well as the final host. The first intermediate host is not known; probably it is a benthic mollusc. Also unknown is the manner in which *E. lepidus* infests its hosts. The cercariae may enter the chaetognaths directly or they may first infest copepods, which are then ingested by chaetognaths. The latter is reported from other marine regions for other hemiurid trematodes (Myers 1956, Weinstein 1974, Pearre 1976). The extent to which other plankton organisms, such as medusae (Reimer et al. 1975), may serve as intermediate or transport hosts for *E. lepidus* is virtually unknown. Final hosts for *E. lepidus* off north-west Africa are fishes, mainly of the family Carangidae (Fischthal 1972).

Differences in the hydrographic regime, which is characterized by a complex system of currents at different depths and by periods of upwelling of cold, nutrient-rich bottom water, may account for some of the variation in incidence within and between transects. Unfortunately, a correlation between incidence of infestation and hydrographic conditions could not be tested, because the data taken (for hydrographic data see Brockmann et al. 1977) were not sufficient for this purpose.

At Transect C (Table 2) in waters deeper than 100 m the infestation frequency of *Ectenurus lepidus* is distinctly lower (1.5 %) than in nearshore waters (6.6 %). This difference is highly significant ($P < 0.001$), as tested by Chi-square-goodness-of-fit. At Transect B (Table 1), infestation frequencies were 1.8 % and 2.1 % respectively, which are not significantly different ($0.25 < P < 0.5$).

The length of *Ectenurus lepidus* metacercariae found in chaetognaths increased with the distance of the sampling location from the coast. This was quite obvious at Transect C (from 352 to 775 µm up to 517 to

Table 1. Incidence of *Ectenurus lepidus* along Transect B (NW Africa) in different chaetognath species

Species	Station								Spec. total
	46*	45*	56*	55*	51	52	53	54	
S. tasmanica	1241	724	1188	604	138	2	–	–	3899
infested	*29 = 2.3%*	*36 = 5.0%*	*24 = 2.0%*	*10 = 1.7%*	*5 = 3.6%*	*1 = 50%*			*105 = 2.7%*
S. friderici	14	176	100	12	34	852	79	889	2156
infested		*8 = 4.5%*			*3 = 8.8%*	*36 = 4.2%*	*1 = 1.3%*	*13 = 2.9%*	*63 = 2.9%*
S. hexaptera	19	12	32	4	2	–	–	–	69
infested	*2 = 10.5%*								*2 = 2.9%*
S. minima	74	20	312	26	31	86	5	–	554
infested				*2 = 7.7%*		*1 = 1.2%*			*3 = 0.5%*
S. enflata	20	28	28	18	17	2	–	–	113
infested				*2 = 11.1%*					*2 = 1.8%*
S. decipiens	32	28	44	16	1	–	2	–	123
infested			*4 = 9.1%*						*4 = 3.3%*
Undeterm.	160	600	680	150	45	36	12	39	1722
infested			*8 = 1.2%*						*8 = 0.5%*
Stat. total**	1482	1732	2620	1000	276	985	98	930	9123
infested	*31 = 2.1%*	*44 = 2.5%*	*36 = 1.4%*	*14 = 1.4%*	*8 = 2.9%*	*38 = 3.9%*	*1 = 1.0%*	*1 = 0.1%*	*184 = 2.0%*
Subtotal (46–55; 51–54)		6834				2289			
infested		*125 = 1.8%*				*48 = 2.1%*			
Water depth (m)	2800	1500	1245	700	72	58	45	40	
Sampling depth (m)	200	200	200	200	70	50	32	32	
Distance from coast (km)	205	145	125	85	75	55	40	25	
Date	2 Feb 75	1 Feb 75	4 Feb 75	4 Feb 75	3 Feb 75	3 Feb 75	3 Feb 75	3 Feb 75	

* Extrapolated from subsamples

** Including the not infested species *Sagitta serratodentata*, *S. planctonis*, *Pterosagitta draco*, *Eukrohnia hamata*, *Krohnitta* sp. and *S. lyra*

Table 2. Incidence of *Ectenurus lepidus* along Transect C (NW Africa) in different chaetognath species

Species	Station 18	19	20•	21•	22	23•	24	25	Spec. total
S. tasmanica	152	570	2360	1180	128	450	160	2	4920
infested		*13 = 2.3%*	*48 = 2.0%*	*40 = 3.4%*		*12 = 2.7%*	*5 = 3.1%*		*118 = 2.4%*
S. friderici	17	–	60	80	27	1800	790	138	2912
infested						*164 = 9.1%*	*56 = 7.1%*	*11 = 8.0%*	*231 = 7.9%*
S. hexaptera	74	47	–	2	1	–	2	–	126
infested		*4 = 8.5%*							*4 = 3.2%*
S. minima	132	30	30	50	59	270	301	32	904
infested				*4 = 8.0%*		*32 = 11.9%*	*17 = 5.6%*		*53 = 5.9%*
S. enflata	70	29	10	40	27	30	9	25	240
infested						*4 = 13.3%*	*1 = 11.1%*		*5 = 2.1%*
Undeterm.	55	74	420	170	180	220	138	84	1341
infested			*4 = 1.0%*				*6 = 4.3%*		*10 = 0.7%*
Stat. total••	576	1053	3330	1771	615	2855	1459	385	10700
infested		*17 = 1.6%*	*52 = 1.6%*	*44 = 2.5%*		*212 = 7.4%*	*85 = 5.8%*	*11 = 2.9%*	*421 = 3.9%*
Subtotal			7345				4699		
infested			*113 = 1.5%*				*308 = 6.6%*		
Water depth (m)	2800	2400	1050	503	345	100	60	30	
Sampling depth (m)	200	200	210	200	200	90	50	24	
Distance from coast (km)	180	120	95	65	50	40	24	5	
Date	28 Jan 75	28 Jan 75	29 Jan 75	29 Jan 75	29 Jan 75	29 Jan 75	30 Jan 75	30 Jan 75	

• Extrapolated from subsamples

•• Including the not infested species *Sagitta serratodentata, S. decipiens, S. planctonis, S. lyra, Krohnitta* sp., *Eukrohnia hamata* and *Pterosagitta draco*

1208 µm; Fig. 3), and less pronounced but still significant at Transect B (from 446 to 893 µm up to 376 to 1081 µm; Fig. 4). Infestation is most likely to occur in shallow water, as indicated by the higher incidence of *E. lepidus* in the nearshore species *Sagitta friderici*. Obviously, the metacercariae grow while their hosts drift seaward. Different length distributions then reflect different current situations prior to sampling (Fig. 3 & 4).

The metacercariae were not only larger but also more mature farther offshore. Beyond 120 km from the coast at Transect C and 205 km at Transect B, progenetic metacercariae with small numbers of eggs were found. The presence of progenetic metacercariae in chaetognaths might be an indication that they are true intermediate hosts, not mere transport hosts, for *Ectenurus lepidus* in the same way as *Sagitta elegans* for *Derogenes varicus* in the north-west Atlantic (Weinstein 1974).

The metacercariae of *Ectenurus lepidus* live in the fluid-filled coelomic cavity of the chaetognaths, which is divided by a septum into a trunk coelom and a tail coelom. In 80 % of all infested chaetognaths, except *Sagitta minima, E. lepidus* was found predominantly in the tail coelom. The tail coelom of *S. minima* is prob-

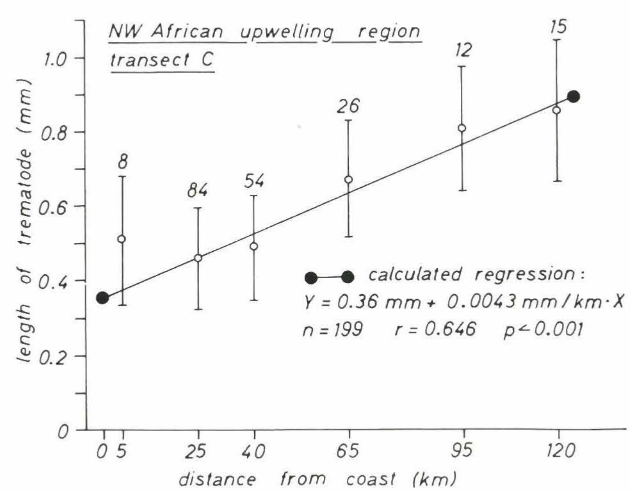

Fig. 3. Length of *Ectenurus lepidus* metacercariae (mean ± 1 SD) in relation to distance from the coast at Transect C; number of measurements indicated for each station

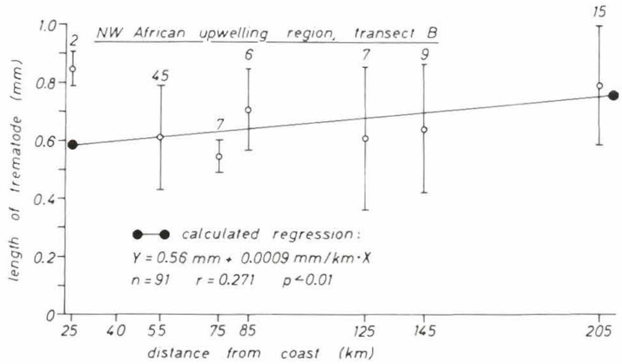

Fig. 4. Length of *Ectenurus lepidus* metacercariae (mean ± 1 SD) in relation to distance from the coast at Transect B; number of measurements indicated for each station

ably too small to accommodate a parasite of such size. The reason for the predominance of *E. lepidus* in the tail coelom of the other species is not known.

CONCLUSIONS

Our results document considerable variation in the species composition of parasite faunas and great differences regarding the frequency of infestation of chaetognaths in the different marine areas studied. As our studies comprise not more than a limited section of a highly complex system, many questions remain to be answered. Many more data are needed to evaluate the pattern of variation in time and space, and to discover the causative factors effective during the life cycles of marine parasites.

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