Metazoan Parasite Fauna of the Bigeye Flounder, *Hippoglossina macrops,* from Northern Chile. Influence of Host Age and Sex

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The metazoan parasite fauna of Hippoglossina macrops *(n = 123) from northern Chile (30°S) is quantitatively described for the first time, and the role of host age and sex was evaluated. Twelve parasite species were recovered, including 5 ectoparasites (2 Monogenea, 2 Copepoda and 1 Piscicolidae) and 7 endoparasites (1 Digenea, 3 Cestoda, 2 Acanthocephala, and 1 Nematoda). The copepod* Holobomolochus chilensis*, the monogenean* Neoheterobothrium *sp., the adult acanthocephalan* Floridosentis *sp. and the hirudinean,* Gliptonobdella *sp. are new geographical and host records. The most prevalent ectoparasitic species were the monogenean,* Neoheterobothrium *sp. and the copepod,* H. chilensis. *Among endoparasites, the acanthocephalans* Floridosentis *sp. and* Corynosoma australe *were most prevalent and abundant. Prevalence and mean intensity of infection for most parasitic species were not affected by host sex, however the prevalence of* Floridosentis *sp. was significantly greater in males. Intensity of infection was positively correlated with host age for* Neoheterobothrium *sp., and negatively correlated for* Floridosentis *sp. and* H. chilensis. *The helminth species richness of the host* H. macrops *was lower compared to related flatfishes from the Northern Hemisphere. The relationship of the helminth fauna of* H. macrops, *its feeding habits and ecological habitats are discussed.*

Key words: parasites - *Hippoglossina macrops* - flatfish - ecology - Chile

Knowledge about the parasite fauna of marine fishes from the Chilean coast is still scarce, specially for deep water fishes. There are only two quantitative parasitological studies on flatfishes from Chilean coast. Riffo (1991) analyzed the metazoan parasites of *Hippoglossina macrops* (Steindachner, 1876) off central Chile (36°S), and Oliva et al. (1996) studied the parasite fauna of *Paralichthys adspersus* (Steindachner, 1867) from northern Chile (23°S).

H. macrops is a flounder with a geographical distribution from Mazatlán (Mexico) to Puerto Montt (Chile) (Fischer et al. 1995), occurring from shallow waters to 600 m depth (Yáñez & Barbieri 1974). This fish is an economic resource for local fishermen and it is also a common component of the discard of three important crustacean fisheries, the deep-sea shrimp *Heterocarpus reedi* Bahamonde 1955, the yellow squat lobster *Cervimunida johni* Porter, 1903 and the red squat lobster *Pleuroncodes monodon* (Milne Edwards 1837). Because of the importance of *H. macrops*, previous studies have been carried out on several aspects of its biology, such as growth (Miranda 1959), reproduction (Voigth & Balbontín 1981) and feeding (Arancibia & Meléndez 1987, Villarroel & Acuña 1999).There are no studies of the parasite fauna of this fish species from northern Chile.

The purpose of this paper is to report for the first time the metazoan parasite fauna of the bigeye flounder, *H. macrops* from the ocean off northern Chile (30°S), to describe parasitism of the host both qualitatively and quantitatively, and to evaluate parasitism with respect to host age and sex.

MATERIALS AND METHODS

A total of 123 specimens of *H. macrops* were caught in April 1997 and from March to June 1998. All fishes were obtained from by-catches in the shrimp and squat lobster fisheries. Trawls were done in front of Coquimbo area, between 29°18’S, 71°37’W and 30°50’S, 71°45’W, at depths from 160 to 342 m. Fishes were collected onboard, frozen (-18°C) and transported to the laboratory. After defrosting, fishes were measured (total length, near-

This work was developed during the Research Program “Monitoring of the Crustacean Fishery from Northern Chile”.

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Received 14 November 2000
Accepted 6 June 2001

est mm), dissected, sexed, and examined for ectoparasites and endoparasites. The parasites obtained were separated and transferred to 10% formalin and sorted and counted by species. Parasite location in the host was recorded.

Because the taxonomy of Anisakids is confused, (*A. simplex* seems to be a species complex, Mattiucci et al. 1997) these were identified to the generic level.

Fish age was assigned using the parameters of the Von Bertalanffy growth function. We took into account that growth parameters are different for male and female (males $L_\infty = 37.29$, $t_o = -0.373$, $k = 0.325$: females $L_\infty = 41.57$, $t_o = -0.4157$, $k = 0.281$) (Andrade 1999).

To analyze if mean age and mean size of male and female fish differed significantly a test-*t* was used. The influence of sex on prevalence was tested with the "G" likelihood test and the possible effect of sex on mean intensity of infection (previous log n+1, transformation of intensity), was evaluated with an ANOVA and later a HSD Tukey when the ANOVA indicated significant difference. Pearson correlation coefficient (*r*) was calculated to evaluate the strength of the relationship between host age and intensity of infection. Changes in prevalence of infection with age were tested with the "G" likelihood test. Relationships between mean host size and prevalence were explored with the Spearman's correlation coefficient (r_s). Ecological descriptors follow Bush et al. (1997) and the statistical analyses were done according to Zar (1996).

Only sexually determined fishes were included in the quantitative analyses, of those 34 were male and 72 were female. Fish ranged from 1.6 to 5.4 years old ($x = 2.9$ year, SD = 0.83) and between 18 and 33.6 cm ($x = 24.5$ cm, SD = 3.6). No significant difference between the age of males and females was determined ($t = 1.101$, df = 102, P = 0.273), but mean size between sexes differed significantly ($t = 2.137$, df = 102, P = 0.035), the females (25 cm) were larger than males (23.2 cm)

RESULTS

Twelve parasite species were found in the host *H. macrops*, including five ectoparasites: *Neoheterobothrium* sp. Price, 1943, *Entobdella hippoglossi* (Müller, 1776) *Protochondria longicauda* Ho, 1970, *Holobomolochus chilensis* Cressey & Cressey, 1985 and *Gliptonobdella* sp. (Sawyer & White, 1969); and 7 endoparasites: *Floridosentis* sp. Ward, 1953, *Corynosoma australe* Johnston, 1937, *Neobothriocephalus adspinosus* Mateo & Bullock, 1966, *Nybelinia surmenicola* (Okada, 1929), *Scolex pleuronectis* Müller, 1788, *Anisakis* sp. Dujardin, 1845 and an unidentified Hemiuridae (Digenea). Site of infection in the host, developmental stage, mean intensity and prevalence are summarized in Table I.

The copepod *H. chilensis*, the monogenean *Neoheterobothrium* sp., the adult acanthocephalan *Floridosentis* sp. and Piscicolidae *Gliptonobdella* sp. are new geographical and host records. The most prevalent and abundant ectoparasite species were the monogenean *Neoheterobothrium* sp. and the copepod *H. chilensis*. Among endoparasites, the most prevalent and abundant species were the acanthocephalans, *Floridosentis* sp. and *C. australe* (Table I).

Ninety three percent of the fish were parasitized with a range of one to 266 individuals, and the species range was one to 6. Eighty-two percent of the infracommunities of *H. macrops* harbored between two and four parasite species ($x = 2.6$, SD = 1.1).

TABLE I

Parasites recovered from specimens of *Hippoglossina macrops*, site of infection, mean intensity (M.I.), prevalence (P %) and range of infection

Parasites	Site of infection	M. I.	P (%)	Range
Hemiuridae (D)	Intestine	1.0	1.9	1
Neoheterobothrium sp. (M)	Gill filaments	4.7	70.7	1-34
Entobdella hippoglossi (M)	Skin	1.0	4.9	1
Neobothriocephalus adspinosus (Ce)	Intestine	5.1	5.7	1-28
Scolex pleuronectis [a] (Ce)	Intestine	1.0	0.8	1
Nybelinia surmenicola [a] (Ce)	Intestine	1.0	0.8	1
Anisakis sp.[a] (N)	Coelomic cavity	1.2	7.3	1-2
Floridosentis sp. (A)	Intestine	4.8	52	1-24
Corynosoma australe [a] (A)	Coelomic cavity	11.3	54.5	1-257
Gliptonobdella sp. (H)	Skin	1.2	4.9	1-2
Protochondria longicauda (Co)	Gill filaments	0.9	20.3	1-4
Holobomolochus chilensis (Co)	Skin	3.4	35.8	1-12

a: larval stage; D: Digenea; M: Monogenea; Ce: Cestoda; N: Nematoda; A: Acanthocephala; H: Hirudinea; Co: Copepoda

There was no significant difference in mean intensity and prevalence of parasite species between male and female fish, except for *Floridosentis* sp., which was significantly greater in males ($G = 7.0$, $P = 0.01$).

The intensity of infection was positive and significantly correlated with host age for the ectoparasite *Neoheterobothrium* sp. ($r = 0.326$, $P = 0.005$, n = 71). The copepod *H. chilensis* ($r = -0.399$, $P = 0.017$, n = 35), and the adult acanthocephalan *Floridosentis* sp. ($r = -0.405$, $P << 0.001$, n = 52) were significantly but negatively correlated with host age. The intensities of infection for remainding species were not correlated with host age. Prevalence of infection increased with host age for *Neoheterobothrium* sp. ($r = 0.991$, $P = 0.009$, n = 4) and *H. chilensis* ($r = 0.983$, $P = 0.017$, n = 4) while it decreased for *Floridosentis* sp. ($r = - 0.979$, $P = 0.021$, n = 4). Species richness ($r = 0.159$, $P = 0.122$, n = 96), ectoparasites ($r = 0.205$, $P = 0.072$, n = 78) and endoparasites ($r = 0.061$; $P = 0.604$, n = 75) were not correlated with host age.

DISCUSSION

Rhode (1992, 1993) considered that there is an important effect of latitudinal gradient on metazoan species richness and prevalence of infection of each species, suggesting that it increase towards low latitudes close to the equator. On the other hand, Scott (1982) indicated that parasite species richness is higher in hosts with extensive latitudinal distributions. Riffo (1991) found 11 parasite species in *H. macrops* from the central-southern Chilean coast (36ºS), while in this study we found 12 parasite species, only 7 of them (58%) previously recorded by Riffo. Despite the wide geographical distribution of *H. macrops*, species richness in this host does not increased towards lower latitudes, as proposed by Rohde (1992, 1993) and Scott (1982). Replacement of species of parasites does occur and the structure of component communities differ markedly compared to those of Riffo (1991). In the central-southern area the infracommunities of *H. macrops* show predominance of ectoparasites. The most important species are the monogenean *Neoheterobothrium* sp. (erroneously identified as *Hargicotyle* sp., in Riffo 1991) with 96 % prevalence and the copepod, *L. edwardsii* with 68% prevalence. In our study, the predominant species were *Neoheterobothrium* sp. (71% prevalence) and the endoparasites, *Floridosentis* sp. and *C. australe* with prevalences of 52% and 55% respectively.

The parasite fauna of the flatfish *Paralichthys adspersus* from northern Chile (23ºS) shows higher species richness, 22 parasite species (Oliva et al. 1996). Six of these are shared with *H. macrops* (*E. hippoglossi, N. surmenicola, S. pleuronectis, C. australe,* and *Anisakis* sp.). Even though *P. adspersus* has a greater species richness only two species, the digenean *Cainocreadium* sp. and the larval acanthocephalan, *C. australe* with prevalences of 54% and 56% respectively predominate (Oliva et al. 1996).

The generic composition of the parasite fauna of *H. macrops* is similar to species of hosts (Pleuronectiformes) from other geographical localities sharing the genera *Entobdella, Neoheterobothrium, Corynosoma,* and the complex eucestode *S. pleuronectis*. The species richness in *H. macrops* is lower when compared with other species of flatfish from the Northern Hemisphere (Table II), mainly due to the almost complete absence of digeneans and the scarcity of cestode and nematode species in *H. macrops*. The lower species richness in *H. macrops* has also been observed in other species of fish from the northern Chilean coast (Oliva et al. 1996, González & Acuña 1998, Oliva 1999).

Sixty percent of the parasite fauna of *H. macrops* is composed of parasites with a low specificity (*H. chilensis, Gliptonobdella* sp., *C. australe, S. pleuronectis, N. surmenicola,* Anisakidae). Only the monogenean genera *Neoheterobothrium* and *Entobdella* are specific for flatfishes.

The increase in intensity of *Neoheterobothrium* sp. with host age could be a consequence of a long exposure time to the infective stage of this monogenean and probably also to a larger gill surface in older, larger fishes. Likewise, the increase in prevalence of *Neoheterobothrium* sp. and *H. chilensis* with host age could be explained by the habit of this host. The occurrence of older demersal fish species inhabiting deeper waters than their younger conspecifics has been repeatedly observed in the marine and freshwater environments (Macpherson & Duarte 1991). *H. macrops*, like other flatfishes lives close associated with the bottom, the sedentary habit and relative high population density of mature specimens at deeper waters (Villarroel et al. 2000), can be synergistic forces that increase the infection, at least for those species with a direct life cycle. Host population density and schooling behavior are important factors in providing the opportunity for larval monogenean (oncomiracidia) to have access to new hosts (Campbell 1983). *H. macrops* shows a higher population density from 150 to 350 m depth (Acuña et al. 1999) where the specimens used in this study were obtained. Moreover, the changes in the ectoparasite fauna with host age suggest that this flatfish lives in different habitat depths during its lifetime, thus being subject to different parasite infections and rates.

Changes in the endohelminth fauna during host life history can be related to its feeding habits

TABLE II

Number of parasite species (by taxonomic groups) in some related flatfish (Pleuronectiformes)

Host	Location	Parasites							n	References
		H	M	C	D	Ce	N	A		
Hippoglossoides platessoides [a]					7	1	0	2	74	Arthur & Albert (1994)
Hippoglossus hippoglossus [a]	Northwestern Atlantic				16	2	2	2	272	Scott & Bray (1989)
Reinhardtius hippoglossoides [a]	Northwestern Atlantic				10	3	1	1	71	Scott & Bray (1989)
R. hippoglossoides	Northwestern Atlantic	1	1	2	18	6	7	5	350	Arthur & Albert (1994)
Parophrys vetulus	Northeastern Pacific	1	1	3	6	1	4	1	877	Olson (1978)
Liopsetta putnami	Great Bay Estuary, N. Hampshire	1	2	2	9	1	2	1	526	Burn (1980)
Paralichthys californicus	Northeastern Pacific	0	0	0	6	1	6	1	102	Castillo-Sánchez et al. (1998)
P. adspersus	Southeastern Pacific	1	1	4	3	4	6	2	179	Oliva et al. (1996)
Platichthys flesus	Northeastern Baltic Sea	1	0	2	5	3	11	5	200	Køie (1999)
Hippoglossus stenolepis	Northeastern Pacific	1	0	0	9	2	4	3	432	Blaylock et al. (1998)
H. macrops	Southeastern Pacific		1	3	1	3	2	1	60	Riffo (1991)
H. macrops	Southeastern Pacific	1	2	2	1	3	1	2	123	Present study

a: only endohelminths analized; H: Hirudinea; M: Monogenea; C: Crustacea; D: Digenea; Ce: Cestoda; N: Nematoda; A: Acanthocephala, n: size sample

(Campbell et al. 1980). The decrease of prevalence and intensity of *Floridosentis* sp. may be related to change in the diet of *H. macrops* (Villarroel & Acuña 1999). They reported that young fishes (< 3 years) fed mainly on juvenile squat lobsters (*Cervimunida johni* and *Pleuroncodes monodon*), while fishes > 3 years fed mainly on the deep sea shrimp (*Heterocarpus reedi*). It is also possible that the decrease in prevalence and intensity of endohelminth may be related to fish migration to deeper waters where the intermediate host can be absent.

Amphipods have been considered as intermediate hosts for acanthocephalans but have not been found as a dietary component of the bigeye flounder (Villarroel & Acuña 1999). However, crustaceans other than amphipods also harbor larval acanthocephalans (Oliva et al. 1992, Pulgar et al. 1995). The predominance of acanthocephalans in this fish can be suggested as a consequence of its food preference, basically crustaceans like juvenile squat lobsters and deep-sea shrimp. Since information about the life cycle of *Floridosentis* sp. is not available, we can only suggest as a hypothesis that the crustaceans are the intermediate hosts for acanthocephalans parasitizing *H. macrops.*

Acanthocephalans have been considered the most rarely found helminth parasites of fishes (Campbell 1983), but this does not apply to *H. macrops* or related flatfishes from other geographical areas, since all of them show the presence of adult acanthocephalans (mainly *Echinorhynchus gadi*) and species of the genus C*orynosoma*. In the bigeye flounder, as much as 65% of the abundance are larval and adult acanthocephalans.

Parasites may infect differently both sexes, because male and female fish often have different feeding habits (Rhode 1993). In our study, host sex did not have a significant influence on the parasite fauna of *H. macrops*, suggesting that habitat use and diet are similar for both sexes of this species. This agrees with the findings of Villarroel (pers. commun.), who did not detect spatial bathymetric segregation between males and females.

Noble (1973) and Campbell et al. (1980) have indicated that benthic fishes frequently harbor digeneans and nematodes, but this did not occur in the bigeye flounder. Only 1.6% and 7% of the fishes were parasitized with species representing those parasite groups, respectively. The scarcity of these parasites in the bigeye flounder could be explained by the smaller numbers of intermediate hosts such as benthic crustaceans and mollusks.

The parasite success in the deep sea is directly related to the abundance and diversity of hosts in the benthic community (Campbell et al. 1980, Oliva & Luque 1998), therefore, the parasite richness is correlated with the diversity of free-living fauna in a certain area (Poulin 1995). The narrowness of the continental shelf in this geographical area has also been considered as an important abiotic factor that explains this phenomenon (Oliva 1999). Thus, a combination of biotic and abiotic factors unique to the coast of Chile may explain the paucity fauna of trophically transmitted parasites, specifically digeneans, en *H. macrops*.

ACKNOWLEDGEMENTS

To research assistants who collected specimens onboard and to Lianella Díaz for collaboration in collecting parasites.

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