

Parasites of the Flatfish *Paralichthys adspersus* (Steindachner, 1867) (Pleuronectiformes) from Northern Chile

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Three species of protistan and 22 species of metazoan parasites were obtained from a sample of 179 flatfish, (Paralichthys adspersus) taken-off Antofagasta, northern Chile. Prevalence of infection of seven parasites (Protista: 1, Copepoda: 2, Digenea: 1, Acantocephala: 1, Nematoda: 2) was significantly and positively correlated with host size. Host's sex do not seem to affect prevalence of infection, except for Nybelinia surmenicola, Capillaria sp. and Anisakis sp. (prevalence of infection significantly greater in males than females) and Philometra sp. (prevalence higher in females). Mean abundance is correlated with size in nine species (Protista: 1, Copepoda: 2, Digenea: 3, Acantocephala: 1, Nematoda: 2). Host's sex do not affect mean abundance, except for Cainocreadium sp. and Philometra sp. (mean abundance higher in females) and Nybelinia surmenicola, Capillaria sp. and Anisakis sp. (mean abundance higher in males).

Key word: parasites - marine fishes - ecology - northern Chile

Paralichthys adspersus is a flatfish inhabiting the Pacific coast of South America, from Paita (northern Perú) to Lota (central Chile) (Chirichigno 1974). Parasite fauna of *P. adspersus*, like other flatfishes from Chile is poorly known. Currently, the copepods *Lepeophtheirus edwardsii* Castro & Baeza, 1980 and *Neobrachiella paralichthyos* Castro & Baeza 1986 are the only known parasites of this fish in Chilean waters. The objective of this study is to examine the impact of host's sex and size on some demographic characteristics of the infection, such as prevalence and abundance.

MATERIALS AND METHODS

A total of 179 flatfish were collected between April 1993 and June 1994 from sandy beaches near Antofagasta (23° 24' S 70° 36' W) with gill nets, beach seine, or hand line. Fishes were carried to laboratory, dissected, and examined for ecto and endoparasites. Each fish was measured (total length to nearest mm) and the sex was determined. A record of parasites (species, number and location in host) for each fish was made. Quantification of protistan was made according to an empirical scale obtained from the average of counts of spores in at

least five fields of a microscope at 400 magnifications: 1 (less 5 spores), 2 (6 to 10 spores) and 3 (more than 11 spores). An ANOVA was performed to test if mean size of male and female flatfishes were significantly different. The Mann-Whitney "U" test and the log-likelihood "G" test were performed to evaluate if abundance and prevalence of infection were affected by host's sex, respectively. Finally, the Spearman correlation coefficient was calculated to evaluate if mean abundance and prevalence are affected by host's sex. Significance was considered at $\alpha = 0.05$. Statistical analysis follows Wilkinson (1990). Ecological terminology follows Margolis et al. (1982)

RESULTS

One hundred and seventy six flatfish were analyzed. The size of three fishes could not be accurately determined because injuries in the tail, thus those fishes were eliminated from quantitative but not qualitative analysis. Females were significantly greater than males (females 34.2 cm, males 31.2 cm $F = 12.79$, $GL = 1, 174$, $P < 0.001$). Twenty five parasitic species were obtained (Protista: 3, Metazoan: 22). Parasite species, developmental stages, location in host body, prevalence and mean abundance are presented in Table I. Statistical analysis were performed only for those parasites considered common (prevalence of infection $\geq 5\%$). Values of Spearman correlation coefficients for the relation size-abundance (Table II) show positive

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TABLE I
Parasites, developmental stage, location in the host, prevalence and mean abundance

Parasite	Stage	Location	Prevalence	Mean abundance
PROTISTA				
<i>Ceratomyxa</i> sp.	T P S	Gb	67.9	0.79
<i>Sinuolinea</i> sp.	T P S	Ub	48.2	0.58
<i>Chloromyxum</i> sp.	T P S	Ub	11.3	0.13
Monogenea				
<i>Entobdella hippoglossi</i>	A	Bs	3.4	0.06
Copepoda				
<i>Lepeophtheirus edwardsii</i>	A C	Bs G	18.8	0.43
<i>Neobrachiella paralichyos</i>	A	G Mo	8.0	0.17
<i>Bomolochus</i> sp.	A	Mo G O	2.1	0.05
<i>Chondracanthus psetti</i>	A	Mo G	12.5	0.18
Isopoda				
Aeglidae gen. sp.	A	Mo	2.3	0.02
Annelida				
Hirudinea gen sp.	A	Bs	2.1	0.01
Digenea				
<i>Cainocreadium</i> sp.	A	In Pc	54.5	3.96
<i>Proisorhynchus</i> sp.	A	In Pc	18.2	3.12
Opecoelidae	M	G Cc S	21.6	1.7
Eucestoda				
Pseudophyllidea gen. sp.	A	In	4.5	0.07
<i>Nybelinia surmenicola</i>	L	Cc Mu G	9.1	0.12
<i>Scolex pleuronectis</i>	L	In	5.7	0.29
<i>Lacistorhynchus dollfussi</i>	L	Mu G Cc	8.0	1.58
Acantocephala				
<i>Corynosoma australis</i>	L	In S Cc	56.3	11.37
Unidentified Acantocephala	A	In	0.56	0.006
Nematoda				
<i>Anisakis physeteris</i>	L	Mu Cc	2.1	0.01
<i>Capillaria</i> sp.	A	S	18.8	2.37
<i>Philometra</i> sp.	A	Go	17.6	0.57
<i>Pseudoterranova decipiens</i>	L	Mu Cc	9.1	0.26
<i>Hysterothylacium</i> sp.	L	S	1.7	0.05
<i>Anisakis</i> sp.	L	In S	16.5	0.33

T: trophozoite, P: plasmodia, S: spore, A: adult, L: larvae, C: chalimus, M: metacercariae, Gb: gall-bladder, Ub: urinary bladder, Bs: body surface, G: gills, Mo: mouth, Go: gonads, O: operculum, In: intestine, Pc: piloric caeca, Cc: coelomic cavity, S: stomach, Mu: muscle

and significant correlation only for the protista *Ceratomyxa* sp., the copepods, *L. edwardsii* and *Ch. psetti*, the digeneans, *Cainocreadium* sp. and *Proisorhynchus* sp., the Acanthocephala, *C. australis* and the nematodes *P. decipiens* and *Anisakis* sp. Table II also shows values of the Spearman correlation coefficient for the relation between prevalence and mean host size. Prevalence is positively and significantly correlated with size only

for the following parasites: *Ceratomyxa* sp., *L. edwardsii*, *Ch. psetti*, *Cainocreadium* sp., Opecoelidae (Metacercariae), *C. australis*, *P. decipiens* and *Anisakis* sp.

Table III shows values of the χ^2 approximation to the Mann-Whitney "U" test. The hypothesis of effect of the sex on mean abundance was not rejected for the following five species: *Cainocreadium* sp., *Proisorhynchus* sp. and

TABLE II
Effect of host size on mean abundance and prevalence of infection

	Mean abundance ^a		Prevalence ^b	
	r	p	r	p
<i>Ceratomyxa</i> sp.	.32	P < 0.001	0.98	0.001 > P
<i>Sinuolinea</i> sp.	.09	P > 0.20	0.69	0.20 > P > 0.10
<i>Chloromyxum</i> sp.	-.097	P > 0.10	0.44	0.50 > P > 0.20
<i>L. edwardsii</i>	.28	P < 0.001	0.91	0.02 > P > 0.01
<i>N. paralychthyos</i>	.05	P > 0.50	0.55	0.50 > P > 0.20
<i>C. psetti</i>	.22	P < 0.005	0.94	0.01 > P > 0.005
<i>Cainocreadium</i> sp.	.28	P < 0.001	0.89	0.02 > P > 0.01
<i>Prosorhynchus</i> sp.	.25	P < 0.001	0.75	0.10 > P > 0.05
Opecoelidae	.12	P > 0.10	0.92	0.01 > P > 0.005
<i>N. surmenicola</i>	.07	P > 0.20	0.81	0.10 > P > 0.05
<i>S. pleuronectis</i>	-.082	P > 0.20	0.13	P > 0.5
<i>L. dollfusi</i>	-.028	P > 0.50	0.54	0.5 > P > 0.20
<i>C. australis</i>	.38	P < 0.001	0.88	0.05 > P > 0.02
<i>Capillaria</i> sp.	-.121	P > 0.10	0.7	0.20 > P > 0.10
<i>Philometra</i> sp.	.05	P > 0.5	0.23	P > 0.5
<i>P. decipiens</i>	.16	P < 0.05	0.83	0.05 > P > 0.02
<i>Anisakis</i> sp.	.17	P < 0.05	0.89	0.02 > P > 0.01

r: Spearman correlation coefficient, p: probability, a: degree of freedom = 166 for protistan and 174 for metazoan, b: degree of freedom = 4 for all parasites

TABLE III
Effect of sex on abundance and prevalence of infection

	Abundance		Prevalence	
	χ^2	p	G	p
<i>Ceratomyxa</i> sp.	0.73	0.39	0.34	0.75 > P > 0.50
<i>Sinuolinea</i> sp.	1.1	0.3	2.33	0.25 > P > 0.10
<i>Chloromyxum</i> sp.	0.1	0.74	0.12	0.75 > P > 0.50
<i>L. edwardsii</i>	0.6	0.43	0.29	0.75 > P > 0.50
<i>N. paralychthyos</i>	0.1	0.76	0.04	0.90 > P > 0.75
<i>C. psetti</i>	0.2	0.63	0.21	0.75 > P > 0.50
<i>Cainocreadium</i> sp.	3.9	(*)	0.3	0.75 > P > 0.50
<i>Prosorhynchus</i> sp.	3.5	0.06	1.46	0.25 > P > 0.10
Opecoelidae (Metacercaria)	1.1	0.3	1.0	0.50 > P > 0.25
<i>Nybelinia</i> sp.	4.0	0.04	3.88	0.05 > P > 0.03
<i>S. pleuronectis</i>	0.9	0.33	0.9	0.50 > P > 0.25
<i>L. dollfusi</i>	0.66	0.42	0.59	0.50 > P > 0.25
<i>C. australis</i>	1.97	0.16	0.84	0.50 > P > 0.25
<i>Capillaria</i> sp.	5.65	0.02	5.42	0.025 > P > 0.01
<i>Philometra</i> sp.	13.18	(*)	14.3	0.001 > P
<i>P. decipiens</i>	0.89	0.34	0.82	0.50 > P > 0.25
<i>Anisakis</i> sp.	4.62	0.03	3.86	0.05 > P > 0.025

χ^2 : Chi-square approximation to Mann-Whitney "U" test, G: value of the Log-likelihood "G" test, p: probability (*) = < 0.001

Philometra sp. (with mean abundance greater in females than in males) and *N. surmenicola* and *Capillaria* (higher mean abundance in females). The same Table shows "G" values that demonstrates the evidence of effect of host's sex on

prevalence of infection for the following parasites: *N. surmenicola*, *Capillaria* sp. and *Anisakis* sp. with higher prevalence in males and *Philometra* sp. with prevalence in female greater than in males.

DISCUSSION

As a rule, in all host species that have been accurately studied for parasites, infection changes with age (Rohde 1984). This is true for both qualitative and quantitative changes in the parasite fauna. As have been pointed by Polyansky (1961), as a fish grows, the diet normally changes and consequently, the fauna of trophically transmitted parasites will be replaced by new species of parasites. Quantitative differences in parasite infection between sex can be expected and are explained as a consequence of different habitat occupied by males and females, differences in the diet and/or physiology (Kennedy 1975). Our results show absence of a common pattern of infection for all the parasitic species. Prevalence of infection was significantly and positively correlated with size for the monoxenics *Ceratomyxa* sp., *L. edwardsii*, *Ch. psetti*, and the heteroxenics *Cainocreadium* sp., *C. australis*, *P. decipiens*, *Anisakis* sp. and metacercariae of an unidentified opecoelid. Abundance also increases with size for the same parasites and *Proserhynchus* sp. but not for the opecoelid metacercaria. This means that, as fishes in the population grow, chances of infection increase for those parasites, due to a long period of exposition to free living infective stages of the monoxenic parasites and an increased use, as food, of the intermediate host of the heteroxenic parasites (Polyansky 1961, Rohde 1993). Sex affects mean abundance and prevalence only for six species, all of them are trophically transmitted parasites, this means that differences are due mainly to diet and or physiology, but no differences in habitat could be expected for male and female flatfishes, as suggested by the

absence of differences in monoxenic parasites. Moreover, Kong et al. (1995) were unable to found differences in diet of male and females *P. adspersus*. Thus, differences in some ecological parameters of the infectious process could be a consequence of differential physiology of male and females flatfishes.

The characteristic of *P. adspersus*, when compared with other flatfishes, is the sparse of the parasite fauna. Table IV shows composition of the parasite fauna of some related fish, including complete and partial (only gastrointestinal parasites) parasitological analysis. Our data shows a poor digenea fauna, that is evident for the other chilean flatfish whose parasites are known. It has been demonstrated that digenea are good indicators of the diet of the host (Gaevskaya & Kovaleva 1982) and acquisition of the parasite by a definitive host is a consequence of the ingestion of the intermediate host (mainly invertebrates) but a postcyclic parasitism (transference from fish to fish via predation) can also occur (Arthur & Albert 1994). The bulk of the diet of *P. adspersus* in northern Chile are the anchovy *Engraulis ringens*, the silver side *Austromenidia laticlavia* and the sand crab *Emerita analoga*, that explain the 95% of the IRR (index of relative importance) (Kong et al. 1995). Parasites of *E. ringens* from Chile were studied by Riffo (1990) who was unable to found digenea (both larval or adult), there are not studies of parasites of *A. laticlavia* and parasites of the sand crab do not includes larval or adult digenea (Oliva et al. 1992). Thus the poor digenea fauna of *P. adspersus* can be a consequence of the monotonous diet (number of digenea species in flatfishes is not affected

TABLE IV
Number of parasites (by major taxonomic groups) in some related flatfish (Pleuronectiformes)

	PV	HM ^a	LP	HP ^b	HH ^b	RH1 ^b	RH2	RH3	PA
Protista	1	0	7	0	0	0	4	10	3
Monogenea	0	1	2	0	0	0	1	3	1
Digenea	10	1	9	7	16	11	18	28	3
Cestoda	1	3	1	1	3	3	6	9	4
Acantocephala	1	1	1	2	2	1	5	8	2
Nematoda	5	2	2	0	2	1	8	8	6
Crustacea	3	3	2	0	0	0	2	8	4
Hirudinea	1	0	1	0	0	0	1	2	1
Sample size	628	60	526	74	272	71	350	(*)	179

PV: *Parophrys vetulus*, HM: *Hippoglossina macrops*, LP: *Liopsetta putnami*, HP: *Hippoglossoides platessoides*, HH: *Hippoglossus hippoglossus*, RH: *Reinhardius hippoglossoides*, PA: *Paralichthys adspersus*. a: only metazoan studied, b: only gastrointestinal studied. RH1: according to Scott & Bray (1989), RH2: according to Arthur & Albert (1994), RH3 (*): a checklist from Arthur & Albert (1994) includes all the known parasites for *R. hippoglossoides*. References: Olson 1978, Burn 1980, Scott & Bray 1989, Riffo 1991, Arthur & Albert 1994, Siddall et al. 1994

TABLE V

Number of digenean parasitic in marine fishes from the Peruvian faunistic province (only data on quantitative surveys are considered)

Host species	ND	SS	GL	Author
<i>H. macrops</i>	1	60	CC	Riffo 1991
<i>E. ringens</i>	0	70	CC	Riffo 1990
<i>S. benticki</i>	0	50	CC	Riffo 1990
<i>M. cephalus</i>	7	107	CC	Fernandez 1987
<i>H. lengerichi</i>	4	30	CC	George-Nascimento & Iriarte 1989
<i>C. callorhynchus</i>	0	55	CC	Fernandez et al. 1986
<i>M. gayi</i>	3	140	CP	Duran & Oliva 1980
<i>M. australis</i>	2	100	SC	Fernandez 1985
<i>G. chilensis</i>	1	80	CC	Vergara & George-Nascimento 1982
<i>T. murphy</i>	1	78	NC	Oliva 1994
<i>P. peruanus</i>	1	124	CP	Luque & Oliva 1993
<i>S. minor</i>	1	311	CP	Oliva et al. 1990
<i>M. ophicephalus</i>	1	237	CP	Luque 1994

ND: number of digenean species per host species, SS: sample size. GL: geographic locality (CP: central Perú, NC: northern Chile, CC: central Chile, SC: southern Chile)

by host sample size, $r: 0.313, 0.5 > P > 0.20, df=6$). The poor digenean fauna of fishes from the South Pacific coast of America (central and northern Chile and southern and central Perú) mainly influenced by the Peruvian cool current, is a characteristic of all the host-parasite system quantitatively studied to date (Table V). Unfortunately, no accurately studies at community levels of pelagic and benthonic communities are available from this area. Studies at community levels from this particular area must be done in order to evaluate the role of highly productive but unstable system such as the "upwelling eco-system" on the parasite fauna of fishes.

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