

The parasito Fauna of *Scomber japonicus* Houttuyn, 1782 (Pisces: Scombridae) in two zones of the Argentine Sea ¹

Florencia Cremonte ^{a,*}, Norma Haydee Sardella ^b

^a CIC, Centro de Estudios Parasitológicos y de Vectores (CEPAVE), 2 No. 584, (1900) La Plata, Argentina

^b Laboratorio de Parasitología, Departamento de Biología, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Funes 3350, (7600) Mar del Plata, Argentina

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Abstract

Between September 1993 and August 1995, parasitological examinations of 173 specimens of *Scomber japonicus* were made from two areas of the Argentine Sea: Mar del Plata, 37–38°S ($N = 90$) and El Rincón, 39–41°S ($N = 83$).

94.75% of the mackerel harboured 6081 parasites belonging to the following taxa: *Kuhnia scombri* (Kuhnia, 1829) Sproston, 1945 (Monogenea); *Opechona* spp.; *Nematobothrium* spp. (Digenea); *Hysterothylacium* spp., *Anisakis* spp., *Contracaecum* spp. and *Pseudoterranova* spp. (Nematoda); *Scolex pleuronectis* Müller, 1788 (Cestoda); *Corynosoma australe* Johnston, 1937 (Acanthocephala).

With the exception of *K. scombri*, all the parasites are reported for the first time in mackerel from the area under study. *C. australe* is the first record for this host.

Prevalence and abundance of infestation were calculated for each parasite species and for each area. The importance of host sex, body size, diet and fishing area, as related to the level of infestation of each parasite, is also examined.

On the basis on a multivariate analysis, detrended correspondence analysis (DECORANA), the quantitative variations in some parasites show the possibility of their use as tags of different ecological conditions of the two geographic areas. © 1997 Published by Elsevier Science B.V.

Keywords: Parasites; *Scomber japonicus*; South-west Atlantic; Biological tags

1. Introduction

In the South-west Atlantic Ocean, the mackerel *Scomber japonicus* Houttuyn, 1782 is found between 23°S and 44°45' W (Angelescu, 1980; Perrotta, 1992).

Its commercial importance is as a basic species in the canning industry of Mar del Plata (38°S).

Previous biological studies on mackerel in Argentina concerned the following topics: feeding habits (Angelescu, 1979, 1980; Pájaro, 1993), age and growth (Gagliardi and Cousseau, 1970; Forciniti and Perrotta, 1988; Perrotta, 1992), comparative geographic studies of morphometric and meristic characters (Perrotta et al., 1989; Perrotta and Aubone, 1991), fishing strength and catching capability at Mar del Plata harbour (Perrotta, 1988, 1993) and its

* Corresponding author. Tel.: +54 21 233471; fax: +54 21 232327; e-mail: Postmaster@cepave.edu.ar

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fishing in relation to schooling behaviour (Perrotta and Christiansen, 1992).

The parasitic fauna of *S. japonicus* that inhabits other regions is rich in species (Love and Moser, 1983; Arandas-Rego and Santos, 1983; Solonchenko, 1968; Dailey, 1969; Khadzhiiski, 1981; Pozdnyakov and Vasilenko, 1994).

For some years past numerous parasites have been used as biological indicators (Williams et al., 1992; MacKenzie et al., 1995). Different stocks of *S. scombrus* have been differentiated using *Grillotia smaragdina* (Cestoda: Trypanorhyncha) as a biological tag (MacKenzie, 1990). Rohde (1987) distinguished populations of *S. australasicus* using monogenean sclerites. Gibson et al. (1981) suggested a didymozoid digenean as a possible biological tag.

Previous records of parasites of *S. japonicus* living in the Argentine Sea are *Pseudolepidapedon* sp. (Digenea: Alloeoadidae) (Angelescu, 1980) and *Kuhnia scombri* (Kuhn, 1829) Sproston, 1945 (Monogenea: Polyopisthocotylea) (Rohde, 1985), both in samples from the Mar del Plata area.

The aim of this paper is to examine the parasitism of *S. japonicus* captured in two zones of the Argentine Sea: Mar del Plata and El Rincón, in order to relate parasitic infrapopulations with host size, sex and feeding habits and to compare the parasite component communities of both groups of mackerel with a view to their possible use as biological tags.

2. Materials and methods

A total of 173 adult specimens of *S. japonicus* were collected between September 1993 and August 1995 from two areas of the Argentine Sea: Mar del Plata (37–38°S/56–57°W) ($N = 90$) and El Rincón (39–41°S/60–61°W) ($N = 83$) (Fig. 1). The samples were collected from commercial catches and during research cruises of R.V. Cap. Oca Balda and Dr. E. Holmberg (INIDEP).

Fish were measured for total length and sexed. The buccal cavity, together with the branchial cavities and external body surface of each mackerel were examined. As each fish was dissected, examinations were made of heart, liver, spleen, stomach, pyloric caeca, intestine, gall bladder, swim bladder and gonads. The inner surface of each operculum was

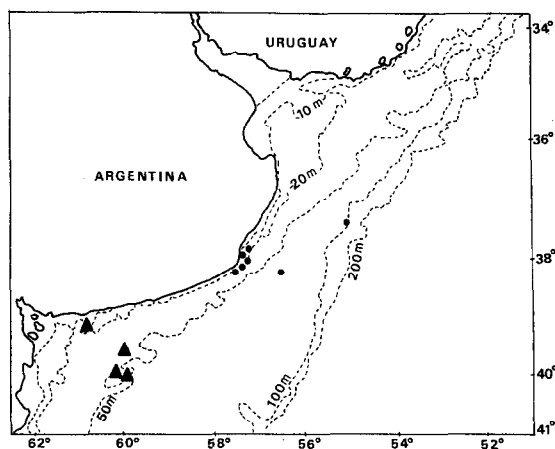


Fig. 1. • Mar del Plata, ▲ El Rincón. Geographic location of the sampling area.

examined in 94 specimens. Parasites were collected, fixed in AFA and stored in ethanol (70%) (Pritchard and Kruse, 1982).

Taxonomic identifications of parasites were carried out using: Hartwich (1974) and Yorke et al. (1969) for Nematoda, Schell (1970) for Trematoda, Skrjabin (1964) and Yamaguti (1971) for Digenea, Yamaguti (1963) for Acanthocephala and Avdeeva and Avdeev (1989) for Cestoda.

The qualitative composition of the diet was examined.

Prevalence and abundance of infestation (Margois et al., 1982) were calculated for each parasite species in relation to the body size and sex of the host. Spearman rank correlations between fish length and both prevalence and abundance were calculated for each geographic zone. The significance of sex differences and zones on prevalence were assessed by the X^2 test (Siegel, 1990).

Multivariate analysis was performed on the component community and univariate analyses were applied on the results. Detrended correspondence analysis (DCA), using DECORANA, was used in order to arrange and to represent simultaneously the parasitic taxa in a reduced space to one or two dimensions (Hill, 1979; Gauch, 1982; George-Nascimento and Arancibia, 1992, 1994; Rizzo and George-Nascimento, 1992; Rodriguez and George-Nascimento, 1996). Spearman correlation was used to explore if the composition of the infracommuni-

ties varied with total length and geographical origin of the host.

3. Results

Lengths of the hosts examined from the Mar del Plata area ranged from 309 to 534 mm (mean = 389, 69 mm), 56 of them were males (62%) and 34 of them were females (38%). The hosts from El Rincón ranged from 297 to 440 mm (mean = 380, 33 mm), 41 of them were males (45%) and 42 of them were females (55%).

A total of 9 parasite taxa were found in *S. japonicus* from the samples examined: each parasitized mackerel harboured at least one of the parasites listed in Table 1.

Encapsulated Nematoda were found in the visceral cavity and mesenteries in both sampling areas. These capsules were melanized and the worms inside the capsules had degenerated. Some of them were identified as *Hysterothylacium* spp.; the rest were not identified.

The values of prevalence, number of parasites and abundance for Mar del Plata and El Rincón samples for each taxon are given in Table 2.

Nematobothrium spp. was not considered in the

Table 2

Parasites of *Scomber japonicus* for Mar del Plata and El Rincón zones

Parasites	Mar del Plata			El Rincón		
	P ^a	NP ^b	A ^c	P	NP	A
Monogenea						
<i>Kuhnia scombri</i>	1.10	1	0.01	1.10	1	0.01
Digenea						
<i>Opechona</i> spp.	77.77	3658	40.64	20.48	90	1.10
<i>Nematobothrium</i> spp.	8.57	5	0.14	6.78	8	0.13
Nematoda						
<i>Hysterothylacium</i> spp.	50	172	1.91	77.11	296	3.61
<i>Anisakis</i> spp.	36.67	67	0.74	87.35	66	0.80
<i>Contracaecum</i> spp.	26.67	51	0.57	18.07	20	0.24
<i>Pseudoterranova</i> spp.	6.67	8	0.09	8.43	37	0.45
Unidentified	13.33	28	0.31	20.48	38	0.46
Cestoda						
<i>Scolex pleuronectis</i>	5.56	63	0.70	1.21	2	0.02
<i>Acanthocephala</i>						
<i>Corynosoma australe</i>	64.44	956	10.62	49.40	518	6.32

^a P = prevalence.

^b NP = number of parasites.

^c A = abundance.

quantitative analysis because this parasite was not looked for in all the hosts examined.

The X^2 test showed significant differences in prevalence between the two zones: higher for *Opechona* spp. ($X^2 = 56.93$, $p < 0.05$) and *C. australe*

Table 1

Parasites of *Scomber japonicus* with indication of stage and location in the host

Parasites	Stage	Location in host
Monogenea		
<i>Kuhnia scombri</i> Sproston, 1945	Adult	Gills
Digenea		
<i>Opechona</i> spp.	Adult	Pyloric caeca
<i>Nematobothrium</i> spp.	Adult	Cysts in operculum
Nematoda		
<i>Hysterothylacium</i> spp.	Adult	Stomach
	Larvae III	Mesenteries
	Larvae IV	Mesenteries
<i>Anisakis</i> spp.	Larvae III	Mesenteries
<i>Contracaecum</i> spp.	Larvae III	Mesenteries
<i>Pseudoterranova</i> spp.	Larvae III	Mesenteries
Cestoda		
<i>Scolex pleuronectis</i> Müller, 1788	Plerocerci	Stomach
<i>Acanthocephala</i>		
<i>Corynosoma australe</i> Johnston, 1937	Juvenile	Mesenteries

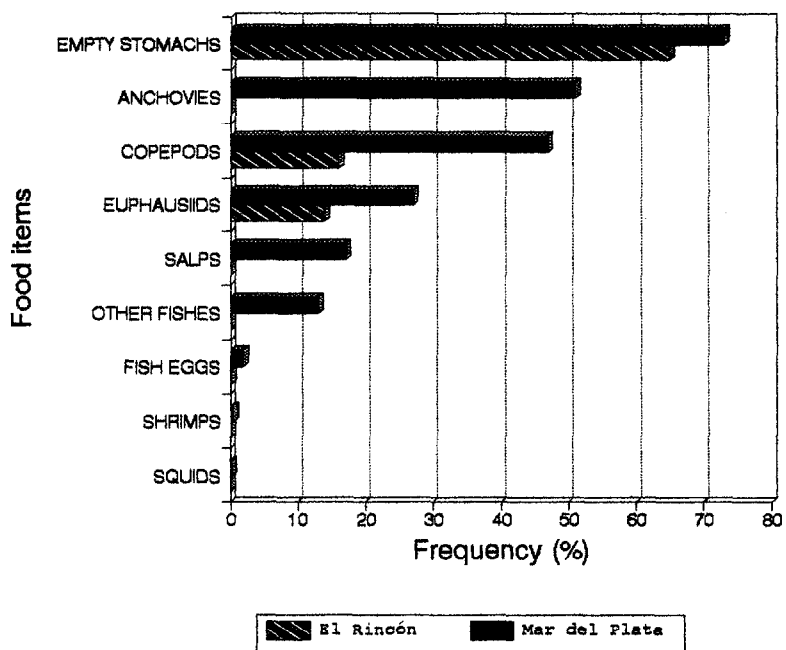


Fig. 2. Occurrence of different prey items in the stomach of *Scomber japonicus*.

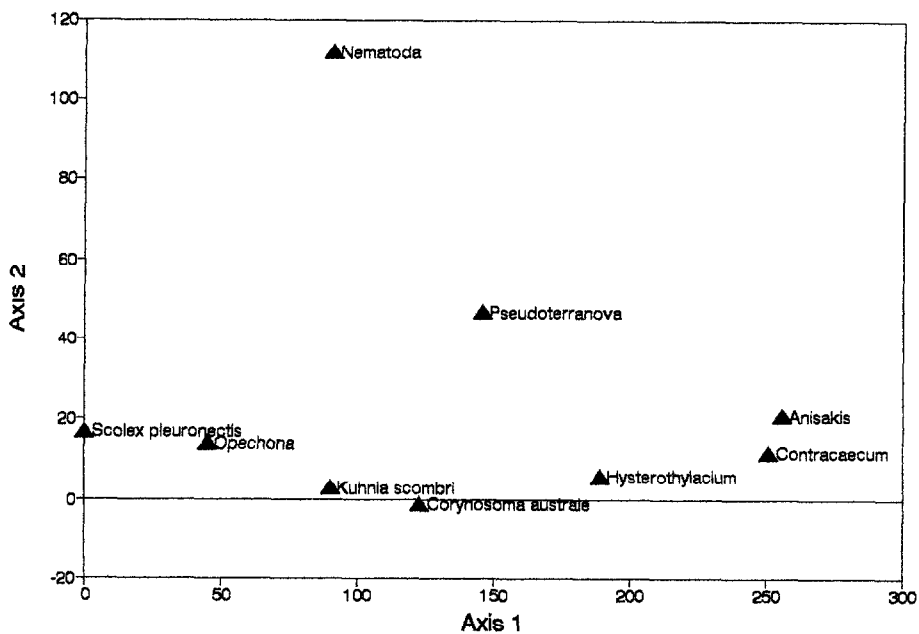


Fig. 3. Position of the parasitic taxa of *Scomber japonicus* in the two first axis of DECORANA.

($X^2 = 4.01$, $p < 0.05$) in Mar del Plata area and higher for *Hysterothylacium* spp. ($X^2 = 13.67$, $p < 0.05$) in El Rincón area.

Comparisons of parasitism in relation to host sex showed no significant differences for either zone for any parasite taxon ($p > 0.05$).

Significant correlations between host length and prevalence were positive for *Hysterothylacium* spp. ($r_s = 0.94$, $p < 0.04$) and for *Anisakis* spp. ($r_s = 0.89$, $p < 0.05$) in Mar del Plata samples and positive for *Anisakis* spp. ($r_s = 0.94$, $p < 0.05$) but negative for *Opechona* spp. ($r_s = -0.89$, $p < 0.05$) in El Rincón samples.

Significant correlations between host length and abundance were positive for *Hysterothylacium* spp. ($r_s = 0.89$, $p < 0.05$) in Mar del Plata and positive

for *Anisakis* spp. ($r_s = 0.94$, $p < 0.04$) but negative for *Opechona* spp. ($r_s = -0.89$, $p < 0.05$) in El Rincón.

Fig. 2 shows the food items found in the stomachs of *S. japonicus* for both zones.

With respect to DECORANA results, the first axis of arrangement significantly explains the distribution of parasites and hosts. The values of the axis 1 and 2 for the arrangement of all the 9 parasite taxa (the unidentified encapsulated nematode was considered as a taxon) and 164 infracommunities were 0.62 and 0.53 respectively. Taxa located at the end of the first composition gradient were *Anisakis* spp. and *Contracaecum* spp. (Fig. 3).

The correlation between the first axis of the DCA and the total length of the host was significant

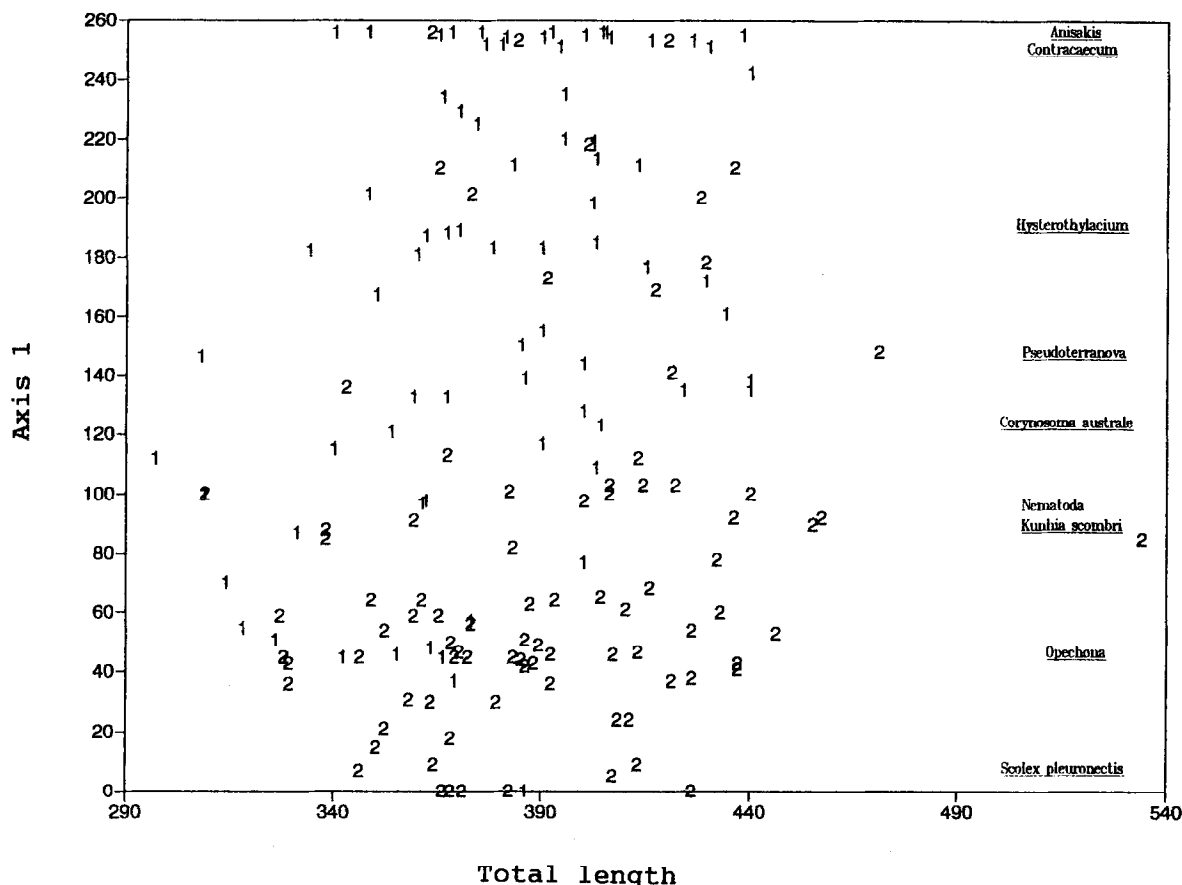


Fig. 4. Position of the individuals of *Scomber japonicus* in the first axis of DECORANA in relation to total length from both areas (1, El Rincón; 2, Mar del Plata).

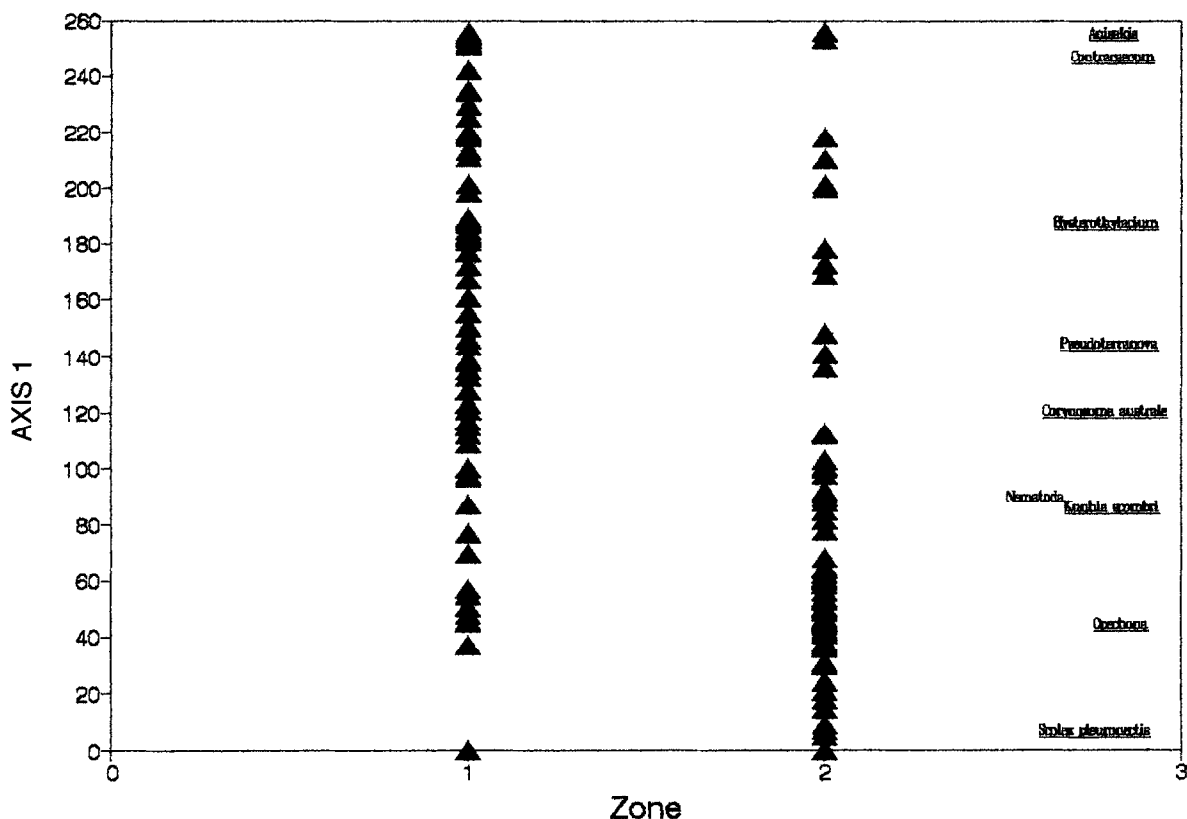


Fig. 5. Position of the individuals of *Scomber japonicus* in the first axis of DECORANA in relation to geographic zones (1, El Rincón; 2, Mar del Plata).

($p < 0.05$) (Fig. 4). The correlation between the first axis and each area of study was $r_s = 0.58$ ($p < 0.01$) (Fig. 5).

4. Discussion

All the parasites, with the exception of *Kuhnia scombri* are reported for the first time in these waters for *S. japonicus*. The acanthocephalan *Corynosoma australe* Johnston, 1937 is the first record for this host.

S. japonicus in the area under study acts as final host for *K. scombri*, *Opechona* spp., *Nematobothrium* spp. and *Hysterothylacium* spp. For the other ones, mackerel is an intermediate or paratenic host (*Hysterothylacium* spp. lives in the fish as larvae and as adult). *K. scombri* infest the host directly. The other parasites are acquired by feeding on zooplank-

ton and microneckton (Angelescu, 1979 and Pájaro, 1993), in which the larval stages develop and which form the base of the diet of the scombrids.

Parasitological records of *S. japonicus* from other localities include a wide spectrum of taxa. In mackerel collected in the Argentine Sea, Copepoda, adult acanthocephalans, Trypanorhyncha and different families of digeneans recorded by Love and Moser (1983) were absent.

Pseudolepidapedon spp. (Digenea) mentioned by Angelescu (1979) was not found in the present study. *Opechona* spp. (Digenea, Lepocreadiidae) was present in both zones of sampling with high prevalence and abundance. The paucity of taxa found in the Argentine mackerel can be explained by the fact that this area is at the southernmost limit of the distribution of *S. japonicus*.

Grubea cochlear Diesing, 1858 (Monogenea), *Lecithocladium harpodontis* Srivastava, 1937 (Di-

genea), plerocerci of Trypanorhyncha, *Rhinebothrium* spp. (Cestoda), *Bolbosoma* spp. and *Rhadinorhynchus pristis* (Rudolphi, 1802) (Acanthocephala) reported by Arandas-Rego and Santos (1983) in Brazilian samples were not found in Argentine mackerel. The prevalence of *K. scombr*i found by Arandas-Rego and Santos (1983) in Río de Janeiro (44%) was much higher than in Argentinian samples. This could be due to possible different biological stocks of host or to a difference in size composition of the Brazilian sample (lower than 200 mm).

All these differences can be explained either by the different trophic availability of prey items in the different areas or to different stock populations of host examined.

Hysterothylacium spp. was present in the mesenteries as larvae III and in the stomach as larvae IV and adult, indicating that *S. japonicus* acts as both intermediate and definitive host for this parasite. This situation is similar to the findings of Sardella and Timi (1996) for *Merluccius hubbsi*.

The higher prevalence found for *Opechona* spp. in Mar del Plata could be related to a greater ingestion of gelatinous zooplankton in this area. Arai (1988) stated that 36 fish species of 21 families include coelenterates in their diet. The principal vehicles of transmission of *O. bacillaris* (Molin, 1859) Loos, 1907 in *S. scombrus* are medusae, Ctenophora and Chaetognatha which harbour the metacercaria stage (Koie, 1975). *Trachurus lathami* (Carangidae), a pelagic fish that inhabits the area under study, is parasitized by adults of *Monascus filiformis* (Rudolphi, 1819) Loos, 1907 (Digenea); larval stages were found in hydromedusae (Girola et al., 1992).

The higher prevalence found for *C. australe* in Mar del Plata could be due to the mackerel these feeding more on crustaceans.

In El Rincón samples, the prevalence of *Hysterothylacium* spp. was significantly higher, but in Mar del Plata, higher number of the adult stage were found. This would be related to the consumption of *Engraulis anchoita* (Engraulidae) in the Mar del Plata area which harbour the infective stage (larvae III) (Timi, pers. com.). Therefore, *S. japonicus* would principally be a final host in Mar del Plata and an intermediate one in El Rincón.

The finding of an amount of melanized capsules

with dead Nematoda or their remains inside is coincident with the results of Ortucta and Sardella (unpublished data) for *Acanthistius brasiliensis* (Seranidae). This could be due to a process of parasite senescence and/or the result of defensive mechanism of the host. (Shields, 1987).

Positive correlations between prevalence and abundance and host length for *Hysterothylacium* spp. and *Anisakis* spp. in Mar del Plata and for *Anisakis* spp. in El Rincón samples show a cumulative effect as a result of continuous reinfestation by feeding. The opposite situation is evidenced for *Opechona* spp. in El Rincón samples.

The correspondence analysis allows us to infer that the geographic origin of mackerel would be the main factor responsible for the quantitative differences in the component community of *S. japonicus*. Those differences are mainly given by anisakids (*Anisakis* spp., *Contracaecum* spp. and *Hysterothylacium* spp.) for El Rincón and by *Opechona* spp., *S. pleuronectis* and *C. australe* for Mar del Plata.

These quantitative differences found in the parasitism of *S. japonicus* from two areas of the Argentine Sea suggest the possibility that the parasites could be used as biological tags.

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References

- Angelescu, V., 1979. Ecología trófica de la caballa del Mar Argentino (Scombridae, *Scomber japonicus marplatensis*). Parte 1. Alimentación y crecimiento. Rev. Invest. Des. Pesq. 1, 5–44.
- Angelescu, V., 1980. Ecología trófica de la caballa del Atlántico sudoccidental (Scombridae, *Scomber japonicus marplatensis*). Bol. Inst. Ocenogr. 29, 41–47.
- Arai, M.N., 1988. Interactions of fish and pelagic coelenterates. Can. J. Zool. 66, 1913–1927.
- Arandas-Rego, A., Santos, C.P., 1983. Helminthofauna de cavalas, *Scomber japonicus* Houtt, do Río de Janeiro. Mem. Inst. Oswaldo Cruz 78, 443–448.
- Avdeeva, N.V., Avdeev, V.V., 1989. The plerocercoids of Cestodes of the Order Tetraphyllidae (problems in the identifica-

- tion). Biologi-Pochvenogo Institut DBO AN ASSR, Vladivostok, pp. 1–73 (In Russian).
- Dailey, M.D., 1969. A survey of helminth parasites in the squid, *Loligo opalescens*, smelt, *Osmerus mordax*, jack mackerel, *Trachurus symmetricus*, and Pacific mackerel, *Scomber japonicus*. Calif. Fish Game 55, 221–226.
- Forciniti, L., Perrotta, R.G., 1988. Sobre la edad y el crecimiento de la caballa (*Scomber japonicus*) marplatense. Rev. Invest. Des. Pesq. 8, 19–32.
- Gagliardi, R., Cousseau, M.B., 1970. Estudios biológico-pesqueros sobre la caballa (Scombridae, *Scomber japonicus marplatensis*). Proyecto Des. Pesq. Mar del Plata. Ser. Inf. Téc. Publ., 28: 36 pp.
- Gauch, H.G. Jr., 1982. Multivariate analysis in community ecology. Cambridge Univ. Press., Cambridge, 298 pp.
- George-Nascimento, M., Arancibia, H., 1992. Stocks ecológicos del jurel (*Trachurus symmetricus murphy* Nichols) en tres zonas de pesca frente a Chile, detectados mediante la comparación de su fauna parasitaria y morfometría. Rev. Chil. Hist. Nat. 65, 453–470.
- George-Nascimento, M., Arancibia, H., 1994. La fauna parasitaria y la morfometría de la merluza austral *Merluccius australis* (Hutton) como indicadores de unidades de stock. Biol. Pesq. 23, 31–47.
- Gibson, D.I., MacKenzie, K., Cottle, J., 1981. *Halvorsenius exilis* gen. et sp. nov., a new didymozoid trematode from the mackerel *Scomber scombrus*. J. Nat. Hist. 15, 917–929.
- Girola, C., Martorelli, S.R., Sardella, N.H., 1992. Presencia de metacercarias de *Monascus filiformis* (Digenea, Fellodistomidae) en hidromedusas del Océano Atlántico Sur. Rev. Chil. Hist. Nat. 65, 409–415.
- Hartwich, G., 1974. Keys to the Genera of Ascaridoidea. 2: 1–75. In: R.C. Anderson, A.G. Chabaud and S. Willnott (Eds.). CLH. Keys to the nematode parasites of vertebrates. Commonwealth Agricultural Bureau, Farnham Royal.
- Hill, M.O., 1979. DECORANA: a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Ecology and Systematics, Cornell University, Ithaca, NY, 30 pp.
- Khadzhiiski, Z., 1981. The parasite fauna of *Scomber colias* in the Black Sea. Izvestiya, Inst. Ribni Resursu, Varna, Bulgaria 18, 147–154.
- Koie, M., 1975. On the morphology and life history of *Opechona bacillaris* (Molin, 1859) Loos, 1907 (Trematoda Lepocreadiidae). Ophelia 13, 63–86.
- Love, M.S., Moser, M., 1983. A checklist of parasites of California, Oregon and Washington marine and estuarine fishes. NOAA Tech. Rep. NMFS SSRF-777, 576 pp.
- MacKenzie, K., 1990. Cestode parasites as biological tags for mackerel in the North-east Atlantic. J. Cons. int. Explor. Mer 46, 155–166.
- MacKenzie, K., Williams, H.H., Williams, B., McVicar, A.H., Siddall, R., 1995. Parasites as indicators of water quality and the potential use of helminth transmission in marine pollution studies. Adv. Parasitol. 35, 85–144.
- Margolis, L., Esch, G.W., Holmes, J.C., Kuris, A.M., Schad, G., 1982. The use of ecological terms in parasitology (Report of an ad hoc Committee of the American Society of Parasitologists). J. Parasit. 68, 131–133.
- Pájaro, M., 1993. Consideraciones sobre la alimentación de la caballa con especial énfasis en la depredación de huevos y larvas de peces. INIDEP. Doc. Cient. 2, 19–29.
- Perrotta, R.G., 1988. Acerca del poder de pesca y capturabilidad en la pesquería de caballa (*Scomber japonicus*) de Mar del Plata. Rev. Invest. Des. Pesq. 8, 33–49.
- Perrotta, R.G., 1993. Estudio biológico y pesquero de la caballa (*Scomber japonicus*). INIDEP Doc. Cient. 2, 7–17.
- Perrotta, R.G., 1992. Growth of Mackerel (*Scomber japonicus* Houttuyn, 1782) from the Buenos Aires–north Patagonian region (Argentina Sea). Sci. Mar. 56, 7–16.
- Perrotta, R.G., Aubone, A., Sanchez, F., 1989. Estudio comparado de los caracteres morfométricos y merísticos de la caballa (*Scomber japonicus* Houttuyn, 1782) (Teleostei: Scombridae) del sur de Brasil y del área marplatense (Mar Argentino). Sci. Mar. 54, 47–53.
- Perrotta, R.G., Aubone, A., 1991. De nuevo sobre la morfometría de la caballa (*Scomber japonicus*). Frente Marítimo, 8 (A): 37–41.
- Perrotta, R.G., Christiansen, H.E., 1992. Estimación de la frecuencia reproductiva y algunas consideraciones acerca pesca de la caballa (*Scomber japonicus*) en relación con el comportamiento de los cardúmenes. Physis, Sec. A 49, 1–14.
- Pozdnyakov, S.E., Vasilenko, A.V., 1994. Distribution, migration and the helminth fauna of the Japanese mackerel, *Scomber japonicus*, in the north-western Pacific Ocean. J. Ichthyol. 34, 74–91.
- Pritchard, M.H., Kruse, G.O.W., 1982. The collection and preservation of animal parasites. Univ. of Nebraska Press., 141 pp.
- Riffo, R.L., George-Nascimento, M., 1992. Variaciones de la abundancia de *Anisakis* sp. (Nematoda: Anisakidae) en la merluza de cola, *Macruronus magellanicus* Lonnberg, 1862: la importancia del sexo, tamaño corporal y dieta del hospedador. Estud. Oceanol. 11, 79–84.
- Rodriguez, L., George-Nascimento, M., 1996. La fauna de endoparásitos metazoos del bacalao de profundidad *Dissostichus eleginoides* Smitt, 1898 (Pisces: Nototheniidae) en Chile central: aspectos taxonómicos, ecológicos y zoogeográficos. Rev. Chil. Hist. Nat. 69, 21–33.
- Rohde, K., 1985. Morphology and geographical variation of *Pseudokuhnia minor* n.g., n. comb. (Monogenea: Polyopisthocotylea). I. J. Parasitol. 15, 557–567.
- Rohde, K., 1987. Different populations of *Scomber australasicus* in New Zealand and south-eastern Australia, demonstrated by a simple method using monogenean sclerites. J. Fish Biol. 30, 651–657.
- Sardella, N.H., Timi, J.T., 1996. Parasite communities of *Merluccius hubbsi* from the Argentinian–Uruguayan common fishing zone. Fish. Res. 27, 81–88.
- Schell, S., 1970. How to know the Trematodes. W.M.C. Brown Co. Publ., 355 pp.

- Shields, J.D., 1987. Pathology and mortality of the lung fluke *Haematoloechus longiplexus* (Trematoda) in *Rana catesbiana*. J. Parasit. 73, 1005–1013.
- Siegel, S., 1990. Estadística no paramétrica aplicada a las ciencias de la conducta. 3ª Edición. Ed. Trillas, España, 344 pp.
- Skrjabin, K.I., 1964. Keys to the trematodes of animals and man. University of Illinois Press, Urbana, 351 pp.
- Solonchenko, A.I., 1968. Parasitofauna of mackerel *Scomber colias* Gmelin inhabiting the Atlantic Ocean near the southwestern coast of Africa. Biology of the Sea. Parasites of Marine Animals. Akad. Nauk Ukr. SSR 14, 90–95.
- Williams, H.H., MacKenzie, K., MacCarty, A.M., 1992. Parasites as biological indicators of the population biology, migrations, diet, and phylogenities of fish. Rev. Fish Biol. Fish. 2, 144–176.
- Yamaguti, S., 1963. Systema Helminthum. Vol. 5, Acanthocephala. Interscience Publ., 423 pp.
- Yamaguti, S., 1971. Synopsis of digenetic trematodes of vertebrates. Vol. 1. Keigaku publishing. Co. Tokyo Japan, Vol. 1–2, 1074 pp.
- Yorke, W., Maplestone, P.A., Stiles, C.W., 1969. The nematode Parasites of Vertebrates. Hafner Publ. Co., New York and London, 356 pp.