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ORIGINAL ARTICLE

# Parasite structure of the Ocean Whitefish *Caulolatilus princeps* from Baja California, México (East Pacific)

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**Abstract** The metazoan parasite fauna of *Caulolatilus princeps* from northern Baja California, Mexico is quantitatively described for the first time. Further, the ecological aspects of prevalence, abundance, and intensity of infection are examined through an annual cycle. Six parasite species were recorded; 2 ectoparasites (1 monogenean and 1 copepod) and 4 endoparasites (2 digeneans and 2 nematodes). The digeneans *Choanodera caulolatili* and *Bianium plicitum*, the nematodes *Anisakis* sp. and *Hysterothylacium* sp., and the copepod *Hatschekia* sp. set new geographical and host records. The highest values of prevalence and abundance were in *Anisakis* sp. (prevalence = 93.3%, abundance = 12.4 ± 4.7 ind/host) and in *Hysterothylacium* sp. (prevalence = 86.6%, abundance = 16.5 ± 3.4 ind/host). The mean intensity of infection showed maximum values in summer (August = 14.2) and minimums in winter (February = 4.2). The mean intensity was higher in *Hatschekia* sp. (20.3 ± 7.8) followed by *Hysterothylacium* sp. (18.6 ± 1.4) and *Anisakis* sp. (12.9 ± 2.2). Larval stages of *Anisakis* and *Hysterothylacium* were particularly important due to their high abundance and prevalence, because they represent a human health risk (anisakiasis). In addition, the relationships between the metazoan parasites of *C. princeps* and host size and weight, fish condition and water temperature (bottom) are discussed.

**Keywords** Parasites · *Caulolatilus princeps* · Prevalence · Abundance · Intensity of infection · Mexico

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## Introduction

Knowledge about the parasite fauna of marine fishes from the Mexican Pacific coasts is still scarce (Pérez-Ponce de León et al. 1999; Sánchez-Ramírez and Vidal-Martínez 2002). The ocean whitefish, *Caulolatilus princeps* (Malacanthidae), ranges from Vancouver Island in British Columbia (Canada) to Peru, including the Galapagos Islands (Dooley 1978), and inhabits rocky reefs from 10 to 150 m depth (Hammann and Rosales-Casián 1990).

In the northwestern coasts of Mexico (both coasts of Baja California peninsula), this fish species is caught all year by coastal commercial and recreational fishing (Elorduy-Garay and Ruiz-Córdova 1998; Rosales-Casian and Gonzáles-Camacho 2003; Siri-Chiesa and Moctezuma-Hernández 1989); the *C. princeps* catch during 2000 from Baja California Sur constituted 1,073 tons, 93% of the total catch for this species in Mexico (SAGARPA 2002). However, studies have focused on growth (Elorduy-Garay and Ramírez-Luna 1994), reproduction (Elorduy-Garay and Peláez-Mendoza 1996), and feeding (Elorduy-Garay et al. 2005), whereas the parasite community is poorly studied.

Therefore, the goals of the present study are (1) to identify the parasite fauna on *C. princeps* from the northwestern coasts of Baja California (México), (2) to determine the parasite community structure by their prevalence, abundance, intensity of infection and its variability through an annual cycle, and (3) to determine the relationships between parasite abundance and host size and weight, condition factor and water temperature.

## Materials and methods

Ocean whitefish specimens were captured in the coast of San Quintín, Baja California, México by sport-fishing boats during 2005. The fishing area is in the Pacific Ocean outside of Bahía de San Quintín (30º33′37″ N; 115º56′33″ W), located 310 km south from the California border (USA) and 6 km from El Molino Viejo harbor (Old Mill). Fishing harvests pelagic and bottom fish species (Rosales-Casian and Gonzáles-Camacho 2003; Rodríguez-Santiago and Rosales-Casián 2008) from surface to 150 m depth and as far as 50 km from rocky point Punta Entrada, outside of the bay. The whitefish individuals were captured from different rocky reefs in the area with random sampling which was dependent upon the boat catches.

Surface water temperatures (ºC) during 2005 were obtained from boat captain reports. Temperatures at 50–140 m depth were obtained from station 107.32 of the IMECOCAL cruises (Lat. 30°27.288′ N, Long. 116°9.696′ W), located close to Isla San Martin (García-Córdova et al. 2005).

The site was sampled bimonthly, and parasite information was grouped by seasons: spring (April and June), summer (August), autumn (October), and winter (December and February). Ocean whitefish was identified using Miller and Lea (1972). All specimens were measured using total length (mm, LT) and weighed (g) with a digital balance Accu-Lab (6 kg); whitefish individuals ranged 370–510 mm LT, those lengths represented a range of 13–21 years old (Elorduy-Garay et al. 2005; Manríquez-Ledezma 2009). The Fulton's Condition Factor (Ricker 1975) was calculated for each specimen of *C. princeps* as: $K = [W/TL^3]$ 100,000 where: $W$ = weight (g) and TL = total length (mm).

Specimens were dissected, and organs stored in plastic bags on ice. In the laboratory, internal organs (gills, liver, spleen, intestine, pyloric cecum, heart, gonads, and digestive tract) and external structures (skin and fins) were examined under a stereoscopic microscope, and all parasites were removed. Monogeneans and digeneans were fixed in AFA (acetic acid-formaldehyde-alcohol) solution for 2–24 h, then preserved in ethylic alcohol (70%), and stained with Gomori's trichromic stain (Vidal-Martínez et al. 2002). Nematodes were fixed in Berland's liquid, preserved in ethylic alcohol (70%), cleared with a solution of phenol-ethanol (Lent's solution), and mounted on slides covered with glycerin-gelatin (Moravec et al. 1992). Copepods were first fixed in ethylic alcohol (70%), then cleared using a solution of glycerin-alcohol, and mounted on slides covered with glycerin-gelatin.

Identification of parasites was made using keys proposed by Yamaguti (1961, 1963, 1971), Vidal-Martínez et al. (2002), Bravo-Hollis (1967, 1982a, b) and Anderson et al. (1974–1983). To determine genera, Cressey and Boyle (1980, 1985), Kabata (1979, 1992a, b), and Boxshall (2004) were used. The parasitological material was deposited in the Laboratorio de Ecología Pesquera of the Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE), México.

Prevalence (%), abundance (number of parasites per host), and intensity (number of parasites/infected hosts) of parasites were determined according to Margolis et al. (1982). To assess significant variations in the mean abundance of parasites over seasons, a non-parametric analysis of variance of Kruskall-Wallis (KW) was performed (Steel and Torrie 1986). Spearman rank correlations were used to assess relationships between the abundance of parasites and host size and weight, fish condition and water temperature (bottom).

## Results

Surface water temperature (ºC) in the area showed a mean (±SE) of 16.0 ± 0.3°C. The highest temperature mean was in August (18.2 ± 0.5°C), and lowest in February (14.9 ± 0.3°C). At fishing depth (50-140 m), annual temperature mean was 10.9 ± 0.09°C with highest in October (11.5 ± 0.20°C) and lowest in June (10.2 ± 0.08°C).

### Species composition and organ specificity on *C. princeps*

A total of 91 specimens of *C. princeps* were examined (spring = 15 individuals; summer = 16; autumn = 38; and winter = 22). A total number of 3,820 parasites, belonging to 6 parasite species were identified (Table 1). They were 1 monogenean (*Choricotyle caulolatili*), 2 digeneans (*Choanodera caulolatili* and *Bianium plicitum*), 2 larval stages of nematodes (*Anisakis* sp. and *Hysterothylacium* sp.), and 1 copepod (*Hatschekia* sp.). The scientific names of *Choanodera caulolatili* and *Choricotyle caulolatili* are stated in full to avoid confusion.

The digestive tract was the most infested organ with 4 species. *Choanodera caulolatili* and *B. plicitum* were found in intestine and stomach. *Choricotyle caulolatili* and *Hatschekia* sp. were found on gills. *Anisakis* sp. was found in mesentery. Larvae of *Hysterothylacium* sp. were found in mesentery, stomach, intestine, and cecum (Table 1).

**Table 1** Characterization of parasitic infections of *Caulolatilus princeps* from the coasts of San Quintin, Baja California, Mexico

| Parasites | NF | PF | TNP | P | MA | MI | L |
|---|---|---|---|---|---|---|---|
| Monogenea | | | | | | | |
| *Choricotyle caulolatili* | 91 | 12 | 17 | 13.2 | 0.2 ± 0.1 | 2.6 ± 1.3 | G |
| Digenea | | | | | | | |
| *Bianium plicitum* | 91 | 57 | 247 | 62.6 | 2.7 ± 0.1 | 4.9 ± 1.1 | I |
| *Choanodera caulolatili* | 91 | 34 | 108 | 37.3 | 1.3 ± 0.1 | 3.5 ± 0.9 | I, S |
| Nematoda | | | | | | | |
| *Anisakis* sp. | 91 | 84 | 1,113 | 92.3 | 12.4 ± 4.7 | 12.9 ± 2.2 | M |
| *Hysterothylacium* sp. | 91 | 78 | 1,462 | 85.7 | 16.5 ± 3.5 | 18.6 ± 1.4 | M, S, I, IC |
| Copepoda | | | | | | | |
| *Hatschekia* sp. | 91 | 52 | 873 | 57.1 | 10.1 ± 1.9 | 20.3 ± 7.8 | G |

Total number of fishes examined (*NF*), number of fishes parasitized (*PF*), total number of parasites per taxa (*TNP*), percentage of prevalence (*P*). Mean abundance (*MA*) and mean intensity (*MI*) of parasites (±SE) were calculated from mean values of seasons. Localization (*L*) in the host body; *G* Gills; *IC* Intestinal cecum; *S* Stomach; *I* Intestine; *M* Mesentery

### Prevalence

The nematodes *Anisakis* sp. and *Hysterothylacium* sp. showed the highest prevalences (93.3 and 86.6%, respectively), and the monogenean *Choricotyle caulolatili* the lowest (13.3%); the species *B. plicitum*, *Anisakis* sp., and *Hysterothylacium* sp. had prevalences higher than 60% and were considered as principal species; *Hatschekia* sp. and *Choanodera caulolatili* were secondary species (58 and 38%, respectively), and *Choricotyle caulolatili* with a prevalence of 13.3% was considered a satellite species (Table 1).

From late winter to autumn (February-October), *Anisakis* sp. showed a prevalence of 100% and a decrease (72%) in early winter (December) (Fig. 1a). Similarly, *Hysterothylacium* sp. exhibited prevalences of 100% from late winter to summer (from February to August), a slight decrease in autumn (95%, October), and an abrupt diminution in December (50%). The other species such as *Hatschekia* sp., *B. plicitum*, *Choanodera caulolatili,* and *Choricotyle caulolatili* showed an abrupt decrease in prevalence from spring to summer (Fig. 1a).

### Abundance and intensity of parasites

The most abundant parasite species was *Hysterothylacium* sp. with a total of 1,462 individuals, and the lowest number was *Choricotyle caulolatili* with 17 individuals (Table 1). The overall mean abundance (±SE) of parasites on *C. princeps* was 7.2 ± 0.7 ind/host, and seasonal mean abundances showed significant changes over time (Kruskall-Wallis, $H = 22.20$, $P = 0.0001$). *Hysterothylacium* sp. showed the highest overall mean abundance (calculated from average values of seasons) (16.5 ± 3.5 ind/host), followed by *Anisakis* sp. (12.4 ± 4.7 ind/host), *Hatschekia* sp. (10.1 ± 1.9 ind/host), *B. plicitum* (2.7 ± 0.1 ind/host), *Choanodera caulolatili* (1.3 ± 0.1 ind/host), and *Choricotyle caulolatili* (0.2 ± 0.1 ind/host) (Fig. 1b).

The abundance of *Hysterothylacium* sp. was higher in late spring (21.6 ind/host) and lower in winter (7.8 ind/host), while *Anisakis* sp. showed the highest abundance in spring (16.4 ind/host) and lowest in winter (5.5 ind/host) (Fig. 1b). With respect to species, only the mean abundances of *Anisakis* sp. showed significant changes (Kruskall-Wallis, $H = 11.05$, $P = 0.011$) with the seasons.

With respect to the intensity of parasite infection, the highest mean value was exhibited by *Hatschekia* sp. (20.3 ± 7.8), followed by *Hysterothylacium* sp. (18.6 ± 1.4), and *Anisakis* sp. (12.9 ± 2.2); the rest of species had intensity values lower than 10 (Table 1). In the case of *Hatschekia* sp., the intensity increased from spring (14.6) to summer (40.2), which then decreased in winter (10.5). *Hysterothylacium* sp. showed the highest intensity in spring (21.6), followed by a decrease to the lowest (15.6) in winter (Fig. 1c). The rest of parasite species did not show important variations over time (Fig. 1c).

The Spearman rank correlations showed a significant positive correlation between prevalence and parasite abundance ($r = 0.943$, $P < 0.05$). Also, a significant correlation between the abundance of the nematode *Hysterothylacium* sp. and the surface water temperature ($r = 0.880$, $P < 0.05$) was detected. In addition, a significant negative correlation was found between the overall parasite abundance and the 50–140 m depth temperature ($r = -0.829$, $P < 0.05$). No correlations were found between the abundance of parasites with the host size and weight, and with fish condition.

## Discussion

Four parasite species had been reported for ocean whitefish: 2 monogeneans: *Choricotyle caulolatili* (as *Diclidophora*

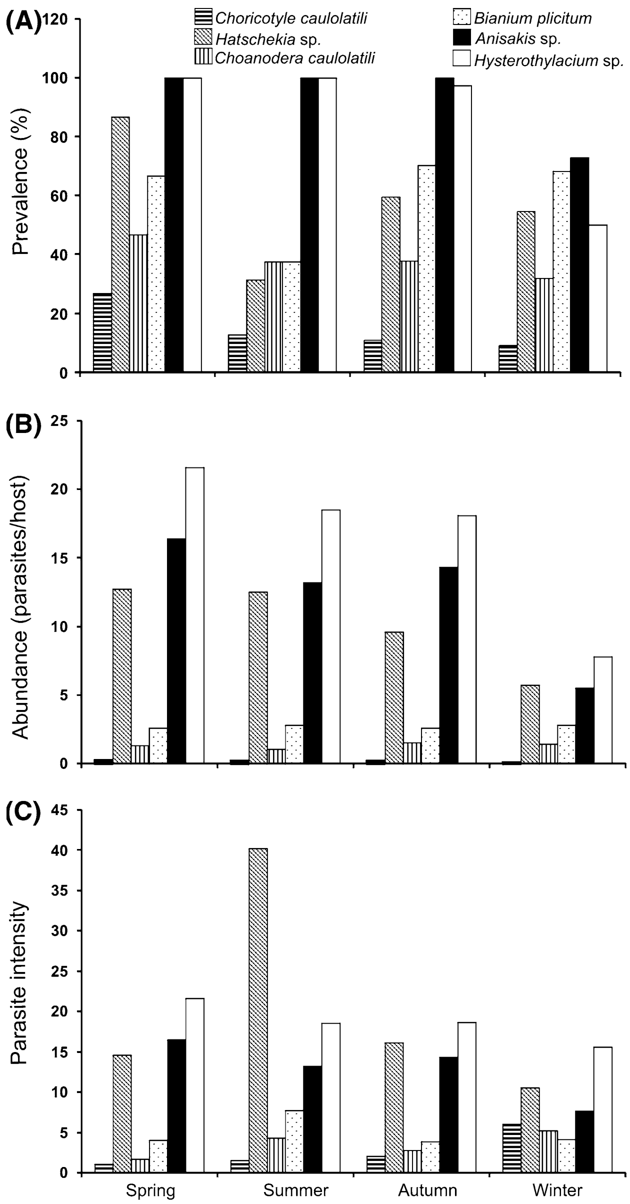


**Fig. 1** **a** Prevalence (%), **b** abundance (parasites/host) and **c** intensity of parasites on specimens of *Caulolatilus princeps* collected at San Quintín, Baja California, during an annual cycle, 2005

*caulolatili*, Meserve 1938) in Galapagos Islands (Merseve 1938) and *Jaliscia caballeroi* in Sonora Mexico (Bravo-Hollis 1982c), 1 digenean: *Proctoeces magnorus* in Isla Cedros Baja California, Mexico (Winter-Howard 1959), and 1 parasitic copepod: *Brachiella gracilis* in Ensenada, Baja California, México (Causey 1960). In our study, *Choanodera caulolatili*, *B. plicitum*, *Hysterothylacium* sp., *Choricotyle caulolatili,* and *Hatschekia* sp. constitute new geographical records and *Anisakis* sp., *B. plicitum*, *Hysterothylacium* sp., and *Hatschekia* sp. were new host records.

The parasite composition of *C. princeps* was represented by 6 species, where digeneans contributed with 2 species and 40% of the total individuals, this group of parasites are frequent in marine fishes (Rhode 1982; Castillo-Sánchez et al. 1998; Sánchez-Ramírez and Vidal-Martínez 2002; Muñoz et al. 2006).

The trematode species are common in marine and estuarine fishes of California, Oregon, and Washington (Love and Moser 1983). In the estuarine fish *Mugil cephalus,* a trematode frequency of 50% was found, and similar values in fishes from families Sciaenidae (*Leiostomus xanthurus* and *Micropogonias undulatus*), Scombridae (*Euthynnus lineatus*), and Khyphosidae (*Khyphosus elegans*) (Thoney 1993; León-Regagnon et al. 1997; Juárez-Arroyo and Salgado-Maldonado 1989). Parasite community structure may be influenced by factors such as the host biology, benthic habitat and territorial behavior (González and Poulin 2005).

The nematodes are important in fish parasitic diseases and are frequently found in different organs or microhabitats (Love and Moser, 1983; Alvarado-Villamar and Ruiz-Campos 1992; Thoney 1993; Castillo-Sánchez et al. 1998; Aloo et al. 2004). In the present study, parasites with high specificity were the ectoparasites *Choricotyle caulolatili* and *Hatschekia* sp., which were found on gills only; Anisakis sp. and *B. plicitum* were found in the mesentery and intestines, respectively. This specificity could be due to the kind of nutrients that these organs offer.

Larvae of *Hysterothylacium* sp. and *Anisakis* sp. were the most abundant parasites in the ocean whitefish and accounted for 67.4% of total parasites. Most parasite groups, which infect marine fishes, are at adult stages, indicating that fishes are important as final hosts rather than as intermediate hosts (Juárez-Arroyo and Salgado-Maldonado 1989; Castillo-Sánchez et al. 1998; León-Regagnon et al. 1997). Previous studies have suggested that some parasites of *C. princeps* come from larvae hosted in intermediate hosts such (mollusk gasteropods, cephalopods, fishes), which harbor mainly digeneans whose abundance depends on diet (Elorduy-Garay et al. 2005). Furthermore, demersal fish studies indicated that many species are intermediate links in the marine food chain (Muñoz et al. 2006; Oliva and Luque 1998; Cordeiro and Luque 2004; Sánchez-Ramírez and Vidal-Martínez 2002).

In this study, larvae of *Hysterothylacium* sp. showed higher values of prevalence (87%) and parasite intensity (18.5 parasites/fish infected) than those reported for *Hysterothylacium aduncum* in Chilean salmon farms (prevalence = 79.1%; mean intensity = 4.9 parasites/fish infected) (González 1998). A common pattern in marine fish is that parasite intensity shows variability by species complexity with low prevalences and abundances (Valtonen et al. 2001; Tavares and Luque 2004).

Our study indicated that parasite abundance was not correlated with size of *C. princeps*; however, we did not analyze smaller sizes that are unavailable for sport-fishing.

Nevertheless, Poulin (2000) documented a significant correlation between fish length and intensity of infection for cestodes, larval digeneans, and gnathiid isopods. The condition of *C. princeps* was also independent of number of parasites hosted. This independence was similar to brown trout (*Salmo trutta*) from Fernworthy, Devon, United Kingdom (Kennedy and Lie 1976), where the parasites did not alter the condition.

Finally, larvae of *Hysterothylacium* sp. and *Anisakis* sp. were relatively abundant in the ocean whitefish and were important for the anthropocenoses that can develop. These parasite species can be infective to humans and cause Anisakiasis, and fish which have been infected with *Anisakis* spp. can produce an anaphylactic reaction in people who have become sensitized to immunoglobulin E (Domínguez-Ortega et al. 2001). Therefore, we recommend not eating raw or inadequately cooked fish. The present study is the first parasitological record for this fish species in the northwestern coasts of Baja California. Further, our results on the prevalence, abundance, and intensity of parasites over an annual cycle helped us to diagnose the health status of this important marine fish for the region.

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