

Patterns of Occurrence of the Platyhelminth Parasites of the Wild Bullseye Puffer (*Sphoeroides annulatus*) Off Sinaloa, Mexico

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ABSTRACT: This study provides basic information on the occurrence of platyhelminths in the wild bullseye puffer (*Sphoeroides annulatus*) from Sinaloa, Mexico. Specimens of pufferfish were collected from 2 localities: Teacapan (n = 161) and Mazatlan (n = 66). Six species of platyhelminths were recorded: 2 monogeneans (Diclidophoridae: *Heterobothrium ecuadori* and Capsalidae: *Neobenedenia melleni*) and 4 digeneans (Apocreadiidae: *Homalometron longisinosum*, Lepocreadiidae: *Bianium plicatum*, Gorgoridae: *Phyllodistomum mirandai*, and Fellodistomidae: *Lintonium vibex*). This is the first record of the platyhelminth *L. vibex* in *S. annulatus* in the Mexican Pacific. *Bianium plicatum* was the most abundant species, and *H. ecuadori* was the most prevalent species. The fish from Teacapan had the higher prevalence of platyhelminths. Teacapan had higher specific richness index, whereas Mazatlan had a higher dominance, 3.098 (Teacapan = 2.38). A relative risk analysis showed that *B. plicatum* was more likely to be present on fish in water within the temperature range of 21–25 C and from Teacapan compared with fish from the warmer water (26–30 C) or from Mazatlan. *Heterobothrium ecuadori* was more likely to be present at water temperatures of 23–24.5 C on fish from Teacapan and when other ectoparasites were present. *Neobenedenia melleni* also was more likely to be present when other parasites were present.

The bullseye pufferfish (*Sphoeroides annulatus*) is found along the Pacific coast from San Diego, California, to Peru, including the Galapagos Islands (Thomson et al., 2000). Along the northwest coast of Mexico, this is an economically important species for artisanal fishery, and it is believed to have good potential for aquaculture. The biotechnologies required to culture this species at experimental and pilot scales have been developed (Duncan et al., 2002). However, adult fish have protozoan (see Dykova et al., 2002) and helminth (see Fajer-Ávila et al., 2003) parasites in wild populations. There is little information available on basic ecological features of the helminths that infect bullseye puffers in the wild. A thorough review of the literature showed that the only taxonomic information available on the parasites of this species are from Mexico and Panama (Lamothe-Argumedo et al., 1996; Ho et al., 2001; Moravec and Fajer-Ávila, 2001).

Several studies of fish have shown an increase in parasite abundance with host size or host age. Comparative analyses have also shown positive relationships between fish size and parasite species richness (Lo et al., 1998). The number of studies on parasitic fauna of marine fish has increased in recent years; however, there remains a large number of fish species of economic importance for which little parasite information is available (González and Acuña, 1998).

The objective of this study was to provide basic information on some patterns of occurrence of platyhelminth parasites in wild bullseye puffers (*S. annulatus*) in Sinaloa, Mexico, for future comparisons with parasitism in cultured fish.

During 3 spawning seasons (February to May) in 1999, 2000, and 2001, specimens of wild bullseye puffer (*S. annulatus*) were collected from 2 different localities in the state of Sinaloa, Mexico (Teacapan: 22°32'N, 105°44'W and Mazatlan: 23°11'N, 106°25'W). These localities were selected because of their importance for this fishery. In Teacapan, during the bullseye spawning season, this is the only species being caught because of its value in the market (Duncan and Roque, pers. obs.).

Fish were captured with hook and line and transported alive to the facilities in 500-L transport tanks with oxygenated, ambient seawater. Temperature and salinity of the seawater from which the fish were collected were recorded using a mercury thermometer and a handheld re-

fractometer. Analyses were restricted to mature adult fish (they could not be aged more precisely) to minimize the effects of host age.

Total length (TL, from mouth to end of caudal fin) of each fish was determined with a conventional ichthyometer (precision 0.1 cm). Each fish was weighed (wet weight) using a digital balance (LS 5000, precision 0.1 g; Ohaus, Florham, New Jersey). The gills and fins of each fish were examined for platyhelminth ectoparasites. In addition, scrapings were taken from the body surfaces and each of the following organs: liver, spleen, kidneys, swim bladder, digestive tract, and urinary bladder. All collections were made between the first and fifth day after capture. All platyhelminths recovered were counted.

Some platyhelminths were flattened between a coverslip and a glass slide, and others were fixed alive in hot water, preserved with 70% ethanol, stained with Semichon's acetocarmine, and mounted in Canada balsam. Some specimens were deposited in Centro de Investigación en Alimentación y Desarrollo, A. C., Unidad Mazatlán, Sinaloa, México, and in Instituto de Biología, Universidad Nacional Autónoma de México, México City, México.

Prevalence, mean abundance, mean intensity, total number of parasites, and range, as defined by Bush et al. (1997), were calculated for each species of platyhelminth. Values and standard deviation are given subsequently. Frequencies of fish infected with 1, 2, 3, and 4 species, and those of fish not infected, were calculated for the total number of fish sampled and for each locality separately. A quantitative relative risk analysis was made to identify associations between the presence of parasites and some of the variables monitored using the software Epiinfo 2000 (Dean et al., 1995). Using the available data, factors such as water temperature at time of collection, collection site, and presence of other parasite species on the same organ or tissue were analyzed. The strength of association or relative risk analysis between a factor and an infection is calculated as the ratio between the extent of infection (fish with a certain species of platyhelminth) in the exposed group (i.e., to Teacapan water) and extent of infection in the unexposed group. If the relative risk is greater than 1, the factor may be viewed as a risk factor (Wayne et al., 1987). The value of the relative risk gives how great the risk is for an exposed fish to have the parasite. A relative risk of 2 for fish from Teacapan to have *Heterobothrium ecuadori* means that fish coming from Teacapan are twice as likely to be infected with *H. ecuadori* than are fish from Mazatlan. For this analysis, temperature at time of collection was classified in temperature ranges of 1.5 C. The analysis was made for each species of platyhelminth against each temperature class. Other characteristics assessed were specific richness, defined as the total number of species found at each locality, and relative abundance, defined as the number of individuals of 1 species divided by the total number of parasites (Salgado-Maldonado and Kennedy, 1997). Relative abundance was used to calculate the dominance index ($H = 1/\sum [\text{relative abundance}]^2$). All indices were calculated separately for both localities (Begon et al., 1996).

A total of 66 fish were collected from Mazatlan (February to May), and 161 fishes were collected from Teacapan (March to May). The average TL of the Mazatlan fish was 28.2 ± 3.3 cm, with a mean weight of 517.9 ± 222.6 g. The average TL of the Teacapan fish was 29.7 ± 3.7 cm, with a mean weight of 654.8 ± 238.2 g. Six species of platyhelminths parasitizing bullseye puffers were found. They included 2 monogeneans, Diclidophoridae: *H. ecuadori* (Meserve, 1938) Sproston, 1946 and Capsalidae: *Neobenedenia melleni* (MacCallum, 1927), and 4 adult digeneans, Apocreadiidae: *Homalometron longisinosum* Cribb and Bray, 1999; Lepocreadiidae: *Bianium plicatum* (Linton, 1928) Stunkard, 1930; Gorgoridae: *Phyllodistomum mirandai* Lamothe, 1969; and Fellodistomidae: *Lintonium vibex* (Linton, 1900) Stunkard and Nigrelli,

TABLE I. Platyhelminth species found in bullseye puffer. Prevalence (P), mean abundance (A ± SD of the mean), mean intensity (I ± SD), total number of parasites per species, and range during this study.

Parasites	Location in body	Site	P (%)	A	I	Total no.	Range
<i>Heterobothrium ecuadori</i>	Gills	Mazatlan	18	1 ± 5	6 ± 11	67	0–41
		Teacapan	52	3 ± 6	6 ± 7	478	0–37
		Total	42	2 ± 6	6 ± 7	545	0–41
<i>Neobenedenia melleni</i>	Skin	Mazatlan	22	0.3 ± 0.7	1 ± 1	20	0–5
		Teacapan	23	0.6 ± 2	3 ± 4	96	0–28
		Total	23	0.5 ± 2	2 ± 4	116	0–28
<i>Homalometron longisinosum</i>	Intestine	Mazatlan	0	0	0	0	0
		Teacapan	5	0.1 ± 0.6	3 ± 2	20	0–6
		Total	4	0.1 ± 0.5	3 ± 2	20	0–6
<i>Bianium plicatum</i>	Intestine	Mazatlan	6	0.3 ± 1	5 ± 4	19	0–10
		Teacapan	42	6 ± 15	15 ± 20	1,011	0–132
		Total	32	5 ± 13	14 ± 20	1,030	0–132
<i>Lintonium vibex</i>	Air sacs	Mazatlan	8	0.5 ± 3	6 ± 8	31	0–21
		Teacapan	7	0.7 ± 4	10 ± 13	115	0–49
		Total	7	0.6 ± 4	9 ± 12	146	0–49
<i>Phyllodistomum mirandai</i>	Urinary bladder	Mazatlan	2	0.02 ± 0.1	1 ± 0.1	1	0–1
		Teacapan	8	0.1 ± 0.6	1 ± 2	19	0–7
		Total	6	0.1 ± 0.5	1 ± 2	20	0–7

1930. Other parasites found in the same organs or tissues included a ciliate protozoan, *Trichodina* spp., and the copepod, *Lepeophtheirus simplex* Ho, Gómez and Fajer-Ávila, 2001, both in skin, and 3 other copepods found in the gills and branchial cavity, belonging to the families Lernaeopodidae, Bomolochidae, and Chondracanthidae.

The location of the platyhelminth parasites in the body of the host, prevalence, mean abundance, mean intensity, total number of parasites per specimen, and range are summarized in Table I. The most abundant platyhelminth species that had the highest mean intensity was the digenean *B. plicatum*, followed by the monogenean *H. ecuadori*, whereas the most prevalent species was *H. ecuadori*, followed by *B. plicatum* (Table I). Forty-two percentage of the sampled pufferfish were parasitized by *H. ecuadori*, 32% by *B. plicatum*, and 23% by *N. melleni*.

The pufferfish from Teacapan had a greater prevalence of platyhelminths than fish from Mazatlan, with the exception of the parasite *L. vibex*, which had a slightly higher prevalence in Mazatlan (Table I). The estimated frequencies showed that 37 of the fish from Mazatlan had no platyhelminths, 24 were parasitized by 1 species of platyhelminths, and the other 5 fish were parasitized by either 2 or 3 species of platyhelminths. For fish from Teacapan, 33 fish had no platyhelminths, 71 fish

were parasitized with 1 species of platyhelminths, 26 fish with 2 species, 26 fish with 3 species, and 5 fish with 4 species.

The relative risk analysis showed that there was no relation between the frequency of any of the platyhelminths studied and size of the fish or time elapsed between collection and analysis. *Bianium plicatum* was 1.5 times more likely to be present in the temperature range of 21–25 C than in the 26–30 C range (relative risk [RR] = 1.467, 1.34–1.605, $F = 0.050$). This parasite also was more likely to be present in fish collected from Teacapan than those from Mazatlan (RR = 1.85, 1.376–1.826, $F = 0.000$). A higher prevalence in Teacapan also was found for *H. ecuadori* (RR = 1.72, 1.40–2.11, $F = 0.010$). For *H. ecuadori* the relative risk analysis also showed that bullseye puffers parasitized with chondracanthids (Copepoda: Chondracanthidae) were 1.34 times more likely also to be parasitized by *H. ecuadori* (RR = 1.34, 1.055–1.708, $F = 0.010$). Temperatures of 23–24.5 C seemed to favor the presence of *H. ecuadori*, which had a prevalence of 52% and a mean abundance of 3 parasites per fish under these conditions (RR = 1.60, 1.28–2.00, $F = 0.000$). The analysis of *N. melleni* showed this parasite to be more likely to be present when other parasites, such as *L. simplex*, also were present on the tissue (RR = 1.306, 1.151–1.481, $F = 0.000$), trichodines (RR = 1.466, 1.190–1.783, $F = 0.000$).

The relative abundance estimated for each species is shown in Table II. *Bianium plicatum* was the most abundant species in Teacapan, and *H. ecuadori* was the most abundant species in Mazatlan. Teacapan had a higher specific richness index, 6 (Mazatlan = 5); Mazatlan had a higher dominance, 3.098 (Teacapan = 2.38).

Eight species of pufferfish belonging to the genus *Sphoeroides* inhabit the tropical eastern Pacific (Walker and Bussing, 1996) and, according to the few published studies (Caballero et al., 1953; Caballero and Brenes, 1958; Arai, 1962; Travassos et al., 1963; Lamothe-Argumedo, 1965; Correa, 1969), the greatest helminthic diversity occurs in *S. annulatus* (6 species recorded here) compared with *S. lobatus*, for which only *L. vibex* (Winter, 1958) has been recorded. The present study is the first record of *L. vibex* in *S. annulatus* in the Mexican Pacific.

The higher prevalence of *H. ecuadori* during the study compared with the other helminths analyzed may be explained because monogeneans have a direct life cycle. Specifically, the eggs of parasites from this genus have a large filament that curls itself to the host or is freed in the water to complete the cycle. The higher prevalence of *H. ecuadori* observed in the Teacapan area can be explained by the behavior of the bullseye puffer. This species congregates in large numbers in lagoons, such as Teacapan, to spawn, increasing the population density and therefore facilitating the transmission of parasites with direct life cycles

TABLE II. Relative abundance of platyhelminth species found in bullseye puffer at Mazatlan and Teacapan. Number of fish collected in Mazatlan = 66 and in Teacapan = 161.

Platyhelminth species	Locality	No. of parasites	Relative abundance
<i>Heterobothrium ecuadori</i>	Mazatlan	67	0.485
	Teacapan	478	0.275
<i>Neobenedenia melleni</i>	Mazatlan	20	0.145
	Teacapan	96	0.055
<i>Homalometron longisinosum</i>	Mazatlan	0	0
	Teacapan	20	0.011
<i>Bianium plicatum</i>	Mazatlan	19	0.138
	Teacapan	1,011	0.581
<i>Lintonium vibex</i>	Mazatlan	31	0.225
	Teacapan	115	0.066
<i>Phyllodistomum mirandai</i>	Mazatlan	1	0.007
	Teacapan	19	0.011

among individuals. Moreover, coastal lagoons have calm waters compared with the open sea (Mazatlan), allowing the parasites to encounter and stay on the fish more easily. In an evaluation of *S. testudineus* parasites, Boucher (1974) reported that the study population occurred at a high density, and most of the fish had ripe gonads and appeared ready to spawn. These fish also were heavily infected with *H. ecuadori*, and the author suggested the high population density was conducive to the spread of *H. ecuadori*, and that this could account for the higher prevalence and intensity of *H. ecuadori* in the spawning season.

Ectoparasites such as the copepods *L. simplex* and the monogenean *N. melleni* had a high prevalence on the skin of the bullseye puffer (22% of the fish collected from Mazatlan had *N. melleni*). Boucher (1974) reported the lack of parasitic copepods on *S. testudineus* on the Mexican Atlantic coast, in spite of their abundance on *Mugil cephalus* in Biscayne Bay, Florida (Skinner, 1974), and attributed it to the checkered puffer's tough toxic skin and protected branchial chamber. Studies on toxicity and distribution of the tetrodotoxin (TTX) in the tissues of bullseye puffers (*S. annulatus*) found along the coast of the Baja California Peninsula, Mexico, showed that *S. annulatus* does not contain TTX in the mucus of the skin and only 5 µg/g of epi TTX (a TTX analogue) could be detected, whereas in *S. lobatus*, 0.42 µg/g of TTX was measured in the mucus of the skin (Nuñez-Vázquez et al., 2000). This may explain the higher diversity of ectoparasites such as *N. melleni*, *L. simplex*, and *Trichodina* spp. on the skin of *S. annulatus*.

From the life cycles described for digeneans, the ones found in this study should have been ingested as larval stages within an intermediate host. Clearly, conditions of lagoons (Teacapan) favor digeneans in general. The concentration of calcium carbonate in the water, the warm temperature, and the high productivity favor the development of dense mollusk populations (Scholz et al., 1994). The intermediate host for *L. vibex* is the bivalve mollusk, *Laevicardium mortonii* (Conrad, 1830) (see Stunkard, 1978), the presence of which determines the abundance of this parasite in the fish. The presence of *H. longisinosum* can also be associated with the consumption of mollusks, which act as intermediate hosts of the metacercaria for this species.

Based on data available for the life cycles described for *Phyllodistomum* spp., it is possible that metacercariae of *P. mirandai* encyst within the mollusks, or metacercariae may encyst inside the tail of a free-swimming cercaria (Rahkonen, 1990). In either case, the fish are orally infected, and therefore the higher prevalence in Teacapan than in Mazatlan is probably caused by the difference in availability of food at each locality. That Teacapan is a spawning ground for *S. annulatus* suggests that parasites are more readily consumed during this time.

The lepecreadiid *B. plicitum* has a "typical" life cycle with cercariae that emerge from gastropods and then penetrate a range of invertebrate and vertebrate intermediate hosts, such as carnivorous fish (Watson, 1984; Koie, 1985). The first intermediate hosts for Lepocreadiidae are restricted to just 3 superfamilies of mollusks, Conoidea, Muricoidea, and Rissooidea (Cribb et al., 2001), which are all well represented in the sampling areas (van der Heiden and Hendrickx, 1982).

The relative risk analysis showed no relationship between the presence of any of the species of parasites analyzed and size of the fish. In most fish, the number of parasite species increases regularly with the size of the host (Noble et al., 1963), but this is best seen in long-lived fish. The frequency of exposure to the intermediate host may be more significant to endoparasitism of fish. The absence of a relation between the number of *B. plicitum* per fish and the host length agrees with observations that this parasite species in *S. testudineus* relates to ecological factors such as exposure frequency to intermediary hosts and longevity of the parasite (Boucher, 1974). As a general rule, endoparasites seem to accumulate in top-predator fish, whereas monogenean ectoparasites accumulate on large-bodied fish living in groups or on fish with a high population density (Sasal et al., 1997; Morand, 2000; Morand et al., 2000). This is true for *H. ecuadori*, which has a high prevalence in Teacapan, where the fish are found in high population density.

The indices of richness were similar, 5 for Mazatlan and 6 for Teacapan. There is little information on species richness indices for platyhelminths in marine fish, but according to studies on coral reef fish, these seem to be common values (Lo et al., 1998) and are within the range reported for other species of marine fish (Rhode et al., 1998). The specific richness indices estimated in this study are lower than published values from temperate regions. Kennedy (1995) suggested that parasite communities in the tropics are not richer than those in

temperate regions, where most of the studies have been carried out. Results of this study agree with the predictions suggested by Kennedy (1995).

The assessment of the platyhelminth assemblage of *S. annulatus* from the 2 main capture localities in northwest Mexico is 1 of the first contributions to the knowledge about the parasite fauna of this important fish.

We thank Juan Sarmento for his help in collecting the fish from Teacapan. Also, we thank Ana Rivas Salas, Roberto Contreras, and María Amparo Rodríguez Santiago for their help with the collection of parasites and also for help from the library of the Instituto de Ciencias del Mar y Limnología de la Universidad Autónoma de México, Unidad Académica de Mazatlán. We thank Ellis Glazier and Neil Duncan for editing English. This study was supported by a grant from the Consejo Nacional de Ciencia y Tecnología (CONACyT), México. No. 31621B awarded to E.J.F.-Á.

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Gastrointestinal Helminths of Cuvier's Beaked Whales, *Ziphius cavirostris*, From the Western Mediterranean

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ABSTRACT: We examined the gastrointestinal helminth fauna of 2 Cuvier's beaked whales, *Ziphius cavirostris*, stranded on the Spanish Mediterranean coast. Information regarding intestinal parasites of this species is provided for the first time. Six helminth taxa were identified. Thirty type II larvae of the nematode *Anisakis* sp. were found in the stomach and the intestine of both hosts; 2 type I larvae of *Anisakis* sp. were found in the intestine of 1 host. One juvenile of the acanthocephalan *Bolbosoma vasculosum* was found in the intestine; the metacestode *Scolex pleuronectis* was found mainly in the terminal colon and the anal crypts of both hosts; adult cestodes of *Tetrabothrius* sp., which may represent a new species, were collected from the duodenum of 1 host. Composition of the intestinal parasitic community is similar to that of

other oceanic cetaceans, which mostly include species of *Bolbosoma* and tetrabothriids (Cestoda).

Parasitological information regarding Cuvier's beaked whales, *Ziphius cavirostris*, is very limited. There are reports of *Phyllobothrium delphini* in the blubber, 3 species of *Anisakis* in the stomach, and 1–3 species of *Crassicauda* in the kidneys (Raga, 1994; Mignucci-Giannoni et al., 1998; Paggi et al., 1998). No intestinal parasite has been reported, which is obviously interesting from a diversity and evolutionary viewpoint (see Aznar et al., 2001). A major problem, however, is that most parasitological studies do not provide explicit information about the

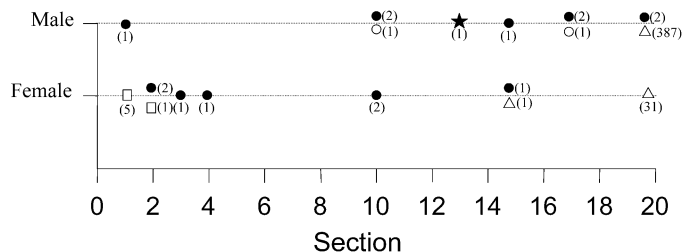


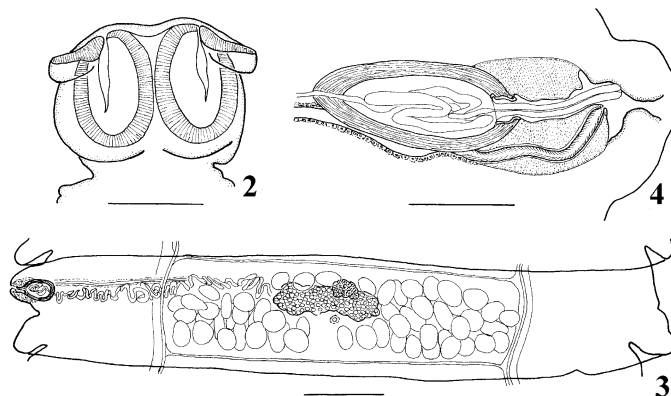
FIGURE 1. Position of helminth species in the intestine of 2 *Ziphius cavirostris* from the Western Mediterranean. The intestine was divided in 20 sections of equal length. Type I larvae of *Anisakis* (open circle), type II larvae of *Anisakis* (solid circle), *Tetrabothrius* sp. (open square), *Scolex pleuronectis* (open triangle), *Bolbosoma vasculosum* (solid star). Numbers in parentheses indicate the number of worms collected.

organs analyzed, and therefore it is unclear whether the intestine of this species is free of parasites or whether this organ has never been examined for parasites. As far as we are aware, only 1 survey reports that intestines of 5 animals were analyzed, and no parasite was found (Mignucci-Giannoni et al., 1998). In this article, we report on the gastrointestinal helminths found in 2 Cuvier's beaked whales stranded in the Spanish Mediterranean and provide, for the first time, information on intestinal parasites.

An immature female (3.83 m) of Cuvier's beaked whale was stranded on 25 February 1996, in Chilches (39°47'N, 00°09'W), and an immature male (5.10 m) was stranded the following day in Pinedo (39°24'N, 00°19'W), Comunitat Valenciana, Spain. Both animals were in good condition (Code 2, sensu Geraci and Lounsbury, 1993). The stomachs and the intestines from both animals were available for examination and were stored in a freezer. After thawing, the contents of the forestomach, main stomach, connecting channel + pyloric stomach, and duodenal ampulla were flushed through a sieve (0.2-mm mesh); the solid contents were collected in a petri dish and examined separately with a stereomicroscope. Each intestine was divided into 20 sections of equal length, and the contents of each section were examined using the same procedure. The length of the intestine was 1,336 cm (female) and 1,964 cm (male). Parasites were washed in physiological saline and then fixed and preserved in 70% ethanol. Adult cestodes were stained with iron acetocarmine (Georgiev et al., 1986). Mature proglottids of *Tetrabothrius* sp. were transversely hand-sectioned by razor blade (Hoberg, 1987) to facilitate examination of genital ducts. Nematodes, acanthocephalans, and metacestodes were cleared in lactophenol. Vouchers were deposited at the Natural History Museum of London, U.K. Accession numbers: *Anisakis* L4 larva type I, 2003.9.9.1; *Anisakis* L3 larva type II, 2003.9.9.2; *Anisakis* L4 larva type II, 2003.9.9.3; *S. pleuronectis*, 2003.9.9.4–7; *Tetrabothrius* sp., 2003.9.23.1–2.

Six helminth taxa were found (see distribution in intestine in Fig. 1). Type II larvae of *Anisakis* (sensu Berland, 1961) were collected from both animals. In the female, 4 L3s were present in the stomach and 5 L3s and 2 L4s throughout the intestine. In the male, 8 L3s and 5 L4s were found in the stomach, and 5 L3s and 1 L4 occurred throughout the intestine. According to Mattiucci et al. (2002), type II *Anisakis* includes 2 species that are indistinguishable at the larval stage, i.e., *A. physeteris* and *A. brevispiculata*, with the former being the only species that has been identified in Cuvier's beaked whales (Rodríguez, 1958; Kagei, 1969; Mattiucci et al., 2001). This suggests that Cuvier's beaked whales may share a similar diet as the main definitive host, the sperm whale, *Physeter macrocephalus* (Mattiucci et al., 2001). On the other hand, 2 type I larvae (L4) of *Anisakis* sp. were collected from the intestine of the male whale. This morphotype includes 5 species, i.e., the 3 sibling species of the *A. simplex* species complex (*A. simplex* s.s., *A. simplex* C, and *A. pegreffii*), *A. typica*, and *A. ziphidarum*, which cannot be identified at the larval stage (Mattiucci et al., 2002). All these species, except the *A. simplex*, have been reported from Cuvier's beaked whales (Rodríguez, 1958; Kagei, 1969; Paggi et al., 1998).

Six scolices and numerous strobilar fragments, including those containing pregravid proglottids, were available from the intestine of the female whale. The scolex occurred in sections 1–2, but strobila extended up to the intestinal section 8 (Fig. 1). Total biomass was 208.6 g.



FIGURES 2–4. *Tetrabothrius* sp. from *Ziphius cavirostris*. 2. Scolex. 3. Detail of a transverse section through the genital atrium showing male and female terminal ducts as seen from the posterior. 4. Mature proglottid. 2 and 3: Bar = 500 μ m; 4: Bar = 100 μ m.

Biomass from section 1 to 8 was: 119.8, 20.2, 11.9, 10.3, 7.6, 10.5, 14.6, and 13.8 g, respectively. These worms were identified as belonging to *Tetrabothrius* Rudolphi, 1819. Because no species of this genus has been reported from Cuvier's beaked whales, a brief description of the material found follows. Measurements and counts are given as the range, with the mean and the number of measurements taken (n) in parentheses. Unless otherwise stated, measurements are in micrometers.

Scolex (Fig. 2) rectangular, maximum width of scolices in correct dorsoventral position in slide in posterior part of bothridia, 0.96–1.09 mm (1.01 mm, n = 3) wide; when scolices are not in dorsoventral position, their diameter 1.16–1.27 mm (1.23, n = 3). Bothridia longitudinally elongate, cup shaped, 608–688 \times 436–504 (550 \times 458, n = 10), with strongly developed musculature. Each bothridium provided with single highly muscular auricle. Apical organ concave. Neck very long, at least 40 mm. The longest strobilar fragment available, 485 cm, consisting from premature to pregravid proglottids. Maximum width at pregravid proglottids, 4.9–5.2 mm. Proglottids wider than long at all developmental stages. Genital pores unilateral, situated on well-expressed protuberance. Genital ducts passing between longitudinal osmoregulatory canals. Testes 55–78 (63, n = 20) in number, distributed dorsally in 1–3 layers in median field, may slightly overlap longitudinal osmoregulatory canals; single testes overlapping ovary and vitellarium (Fig. 3). Vas deferens thin walled, highly convoluted. Cirrus sac from round to oval, 178–196 \times 143–162 (185 \times 156, n = 20), thick walled; containing highly convoluted internal vas deferens (Fig. 4). Male canal straight, 65–85 (73, n = 20) long, without sphincter. Cirrus cylindrical, unarmed, when fully evaginated 75–122 (n = 3) long, with diameter at base 13–15 (14, n = 10). Ovary compact to slightly lobed, transversely elongate, 590–662 (635, n = 20) wide, in preequatorial region of proglottids. Vitellarium rounded or with irregular shape, slightly lobed, anteroventral to ovary, 179–262 (234, n = 20) wide. Vagina as straight or slightly curved canal; opening in atrium ventrally to orifice of male canal; diameter of lumen 24–32 (28, n = 20). Uterus transversely elongate, its ends passing beyond longitudinal osmoregulatory canal. Mature eggs and oncospheres (with developed embryonic hooks) not observed.

The present material belongs to the nominate subgenus of the genus *Tetrabothrius* on the basis of the structure of the genital atrium (Temirova and Skryabin, 1978; Hoberg, 1994). Temirova and Skryabin (1978) listed 8 species belonging to this subgenus. Only 2 of them, *T. (T.) curilensis* Gubanov & Delyamure, 1955, and *T. (T.) forsteri* (Kreffit, 1871), are parasites of cetaceans. The former reaches 1.63 m in length and is characterized by 88–96 testes, and the latter is up to 65 mm long and possesses 15–25 testes per proglottid. The present material seems to be unique in this family, with its length about 5 m. In addition, it can be distinguished from the above-mentioned species by the number of the testes.

Unfortunately, the specimens found were fragmented, and all the scolices were separated from the strobila available. Probably because they have been collected from frozen intestines, many parts of the strobila

were deformed. For these reasons, we do not propose a new species, pending collection of new, better-preserved specimens.

Metacestodes of tetraphyllideans, collectively referred to as *S. pleuronectis* (see Skrjabin, 1972), were found in the intestines of both whales (Fig. 1). Worms could not be accurately counted because most of them were difficult to detect and remove from the intestinal tissue (Fernández et al., 2003). Thirty-one specimens were collected from the female and 387 from the male. All specimens had a scolex with 4 monocular bothridia and an accessory sucker. In agreement with previous studies on other Mediterranean odontocetes (Aznar et al., 1994; Agustí et al., 2000; Fernández et al., 2003), 2 morphotypes were recognized. Small plerocercoids were found free along the intestine but were especially common in the mucosa of the terminal colon and rectum, whereas large plerocercoids were found in the anal crypts. The significance of this pattern of habitat selection has been already discussed (see Fernández et al., 2003). *Scolex pleuronectis* had not been reported in beaked whales.

One specimen of the acanthocephalan *Bolbosoma vasculosum* was collected from the intestine (section 13) of the male Cuvier's beaked whale (Fig. 1). The specimen measured 9.7 mm and showed no sign of sexual development. Although *B. vasculosum* is known from many odontocete species, including beaked whales, the specimens have been found almost invariably as juveniles (Raga, 1994). To our knowledge, Harada (1935) is the only author to report adult worms. He found 3 gravid females of *B. thunni* (= *B. vasculosum*, according to Petrochenko, 1958) in the northern bluefin tuna, *Thunnus thynnus*. Yamaguti (1963) reported adult *B. vasculosum* in common dolphins, *Delphinus delphis*, and Sowerby's beaked whales, *Mesoplodon bidens*. However, the first record is probably that of Meyer (1932) and the second that of van Cleave (1953), neither of whom describes adult worms. Costa et al. (2000) speculated that deep-diving odontocetes could be the main definitive hosts for *B. vasculosum*.

In conclusion, 3 helminth taxa are new for Cuvier's beaked whale, i.e., *S. pleuronectis*, *B. vasculosum*, and 1 species of *Tetrabothrius*. Composition of the intestinal parasitic community is similar to that of oceanic cetaceans, which mostly include species of *Bolbosoma* and tetrabothriids (Raga, 1994; Gibson et al., 1998; Mignucci-Giannoni et al., 1998; Baker et al., 2001).

We are very grateful to E. Ferrer, C. Agustí, and other colleagues for their assistance with viscera examination. Dr. A. Kostadinova helped us with cestode identification. Whales were collected thanks to the Agreement between the Conselleria de Medio Ambiente (Generalitat Valenciana) and the University of Valencia. M.F. and F.J.A. benefit from "Ramón y Cajal" contracts from the MCYT of Spain.

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