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Heavy infections of *Anisakis simplex* (Nematoda: Anisakidae) larvae in the muscle of maturing chum salmon: a preliminary report

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Heavy infections of *Anisakis simplex* (Nematoda: Anisakidae) larvae in the muscle of maturing chum salmon: a preliminary report

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Abstract

Heavy infections with 3rd-stage larvae of *Anisakis simplex* (sensu strico) were observed in the muscle of maturing chum salmon caught in the central Bering Sea (53-54ºN, 180º) and the Chitose River, Hokkaido, Japan. In adult chum salmon returning to the Chitose River, the abundance of *A. simplex* larvae was less than 20 parasites/fish in 2002 and before, while it increased rapidly for 4 consecutive years since 2003, reaching to 160 parasites/fish in the 2006 fall run season. A high increase of the parasite infections was also observed in maturing chum salmon caught in the central Bering Sea in June 2006. The complex life cycle of *A. simplex* includes paratenic crustacean hosts and final cetacean hosts especially mink whale. The unusual mass infection of *A. simplex* may reflect some changes in the North Pacific ecosystems. This is also a concern for human health, because *A. simplex* larvae occasionally cause gastric anisakiasis when humans consume the infected fish. Further investigations are required to assess the infection levels of *A. simplex* in Pacific salmon and other hosts in various areas.

Introduction

Nematode larvae of *Anisakis simplex* complex (*A. simplex* sensu stricto, *A. pegreffii* and *A. simplex* C) were recorded from various species of marine fishes and squids, including chum salmon (*Oncorhynchus keta*) (Urawa 1986; Sugawara et al. 2004). Adults of *A. simplex* infect the stomach of marine mammals, especially cetaceans. Mink whale (*Balaenoptera acutorostrata*) is a major final host of *A. simplex* in the western North Pacific Ocean (Kuramochi et al. 1996). The eggs are released from the digestive tract of final hosts into seawater, and after hatching in the sea the 3rd-stage larvae infect small crustaceans, especially euphausiids such as *Euphausia pacifica* and *Thysanoessa longiceps* (Shimazu and Oshima 1972). The larvae transit to fish, squid or whales, which feed the infected crustaceans. The nematodes remain in 3rd-stage larvae in crustaceans, fish or squids which serve as paratenic hosts, while they develop to adult stage in cetaceans after consuming the paratenic hosts.

In general, the number of *A. simplex* larvae has a positive correlation with body size or ocean age of host fishes such as walleye pollock (*Theragra chalcogramma*)(Konisi and Sakurai 2002) and common mackerel (*Scomber japonicus*)(Otsuru 1968). However, adult chum salmon which returned to the Chitose River in Hokkaido did not show significant increase in the number of *A. simplex* larvae with their ocean age, suggesting that the infection period of *A. simplex* was limited for Japanese chum salmon (Urawa 1986; Sugawara et al. 2004).

In Pacific herring (*Clupea pallasii*), walleye pollock and common mackerel, the larvae mainly infected to the visceral organs (Itagaki and Ishimaru 1967; Otsuru 1968; Saito et al. 1970). In chum salmon, however, *A. simplex* larvae appeared mainly in the muscle (Urawa 1986; Sugawara et al. 2004). Anisakid nematodes are known to cause human anisakiasis. Chum salmon has high risk as low food, because of frequent occurrence of *Anisakis* larvae in the muscle (Urawa 1986). We have conducted annual monitoring for infection levels of anisakid larvae in chum salmon since 2001 (Sugawara et al. 2004). The recent inspections have shown an unusual increase of the infection level of *A. simplex* larvae in maturing chum salmon in the Bering Sea and the Chitose River, Hokkaido, Japan. Thus we have made a preliminary report on the present status of *A. simplex* infections in chum salmon.

Materials and Methods

Adult chum salmon returning to the Chitose River, a tributary of the Ishikari River System in the Japan Sea coast of Hokkaido in the fall of 2004-2006 were caught to inspect for parasites (Table 1). In addition, maturing chum salmon were caught in the central Bering Sea in June 2006 (Morita et al. 2006). After measuring fork length and body weight and collecting scales for the age determination, the fish samples were immediately frozen until inspections. At the laboratory of National Salmon Resources Center, the defrosted whole muscle and visceral organs of sample fish were examined by candling methods to count the number of larvae and record the infection sites in each host fish. The level of parasitic infections was evaluated according to Margolis et al. (1982):

Prevalence = percentage of infected fish in a sample,

Abundance = mean number of parasites per fish examined.

Results and Discussion

Anisakid nematode larvae were recorded in all samples of chum salmon caught in the central Bering Sea and Chitose River. Most (98%) of anisakid larvae were found in the muscles surrounding the visceral organs. The nematodes (n=60) were identified as *A. simplex* sensu stricto based on the nucleotide sequence of ITS1-5.8S rRNA-ITS2 region (H. Yokoyama, personal communication).

In adult chum salmon returning to the Chitose River, the abundance of *A. simplex* larvae was increased year by year, reaching to 160 parasites/fish in 2006 (Table 1). The annual increase of *A. simplex* infections occurred in all age groups. Sugawara et al. (2004), who examined adult chum salmon in the Chitose River, reported that the abundance of *A. simplex* larvae was 19.9 parasites/fish in 2001, 9.5 parasites/fish in 2002, and 30.3 parasites/fish in 2003. Urawa (1986) also observed the similar infection levels (13-14 parasites/fish) in the same population in 1982 and 1986. Thus, the abundance of *A. simplex* larvae was less than 20 parasites/fish in 2002 and before, while it increased rapidly for 4 consecutive years since 2003 (Fig. 1).

In maturing chum salmon caught in the central Bering Sea in June 2006, the abundance of *A. simplex* larvae was 99 parasites/fish (Table 1), which was much higher than the previous records (7.9-16.5 parasites/fish in the summer of 2002 and 2003; Sugawara et al. 2004). Genetic stock identification study suggested that more than half of maturing chum salmon in the central Bering Sea were Japanese origin (Urawa 2000). It might be possible that the abundance of *A. simplex* larvae became almost double in Japanese chum salmon during the homing migration after June 2006. Andrievskaya (1957) reported that the stomach contents of chum salmon in the western North Pacific Ocean contained 16% of euphausiids such as *Thysanoessa longipes*, *T. irermis*, *T. raschii*, and *Euphausia pacifica*, all which were known as the transport host of *A. simplex*. As assumed by Urawa (1986) and Sugawara et al. (2004), maturing chum salmon might be markedly infected with *A. simplex* larvae when they fed euphausiids during their spawning migration.

On the other hand, the high increase of *A. simplex* infections in maturing chum salmon in the central Bering Sea suggests that frequent *Anisakis* infections also occurred before the spawning migration from the Bering Sea. The complex life cycle of *A. simplex* includes the paratenic crustacean hosts and final cetacean hosts especially mink whale. The unusual mass infections of *A. simplex* may reflect some changes in the North Pacific ecosystems.

Sushi and sashimi have become popular in many parts of the world. The mass infection of *A. simplex* larvae is also a concern for human health, because the parasites occasionally cause gastric anisakiasis when humans consume the infected fish. Further investigations are required for Pacific Rim scientists to assess the infection levels of *A. simplex* in Pacific salmon and other hosts in various areas.

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Table 1. Prevalence and abundance of *Anisakis simplex* larvae in maturing chum salmon caught in the Bering Sea and Chitose River, Hokkaido, Japan.

Location	Date	Chum salmon				*Anisakis simplex* larvae		
		Age	Number of samples	Fork length (cm)	Body weight (g)	Prevalence (%)[*1]	Abundance[*2]	(range)
Chitose River	Oct-04-2004	0.3	20	67.0±3.7[*3]	3185±561[*3]	100	81±52[*3]	(18-192)
		0.4	11	69.8±2.7	3782±475	100	114±83	(24-328)
		total	31	68.0±3.6	3397±599	100	93±66	(18-328)
Chitose River	Oct-21-2005	0.2	6	60.8±2.8	2350±404	100	94±62	(40-197)
		0.3	10	65.0±3.8	2820±471	100	101±59	(21-174)
		0.4	9	69.4±3.3	3633±663	100	143±154	(23-539)
		total	25	65.6±4.7	3000±730	100	114±102	(21-539)
Chitose River	Sep-27 & Oct-11-2006	0.3	7	64.1±2.7	2781±396	100	150±113	(17-327)
		0.4	8	65.8±4.7	3051±722	100	168±98	(23-311)
		total	15	65.0±3.9	2925±589	100	160±102	(17-327)
Central Bering Sea (53-54ºN, 180º)	June-10-2006	-	17	56.8±29.5	2166±333	100	99±94	(11-393)

[*1]Prevalene = number of fish infected/number of fish examined

[*2]Abundance = total number of parasites/number of fish examined

[*3]Mean±SD

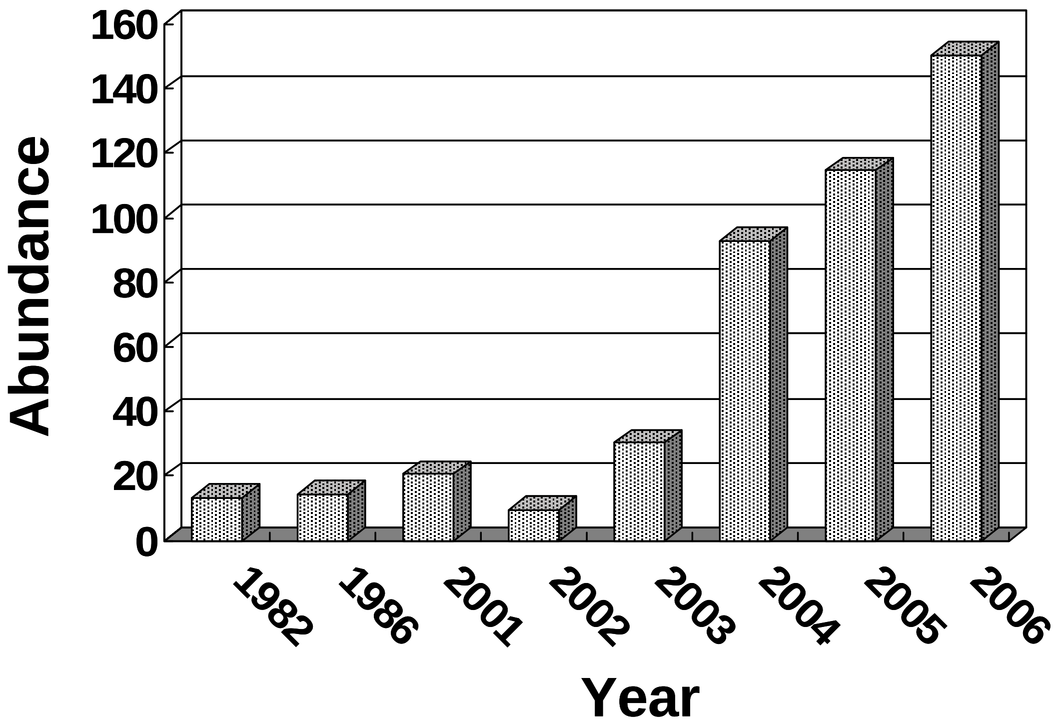

Fig. 1. Annual changes in the abundance of *Anisakis simplex* larvae in adult chum salmon returning to the Chitose River, Hokkaido, Japan. The data before 2004 were cited from Urawa (1986) and Sugawara et al. (2004).