Biogeography **10.**
17–22. Aug. 20, 2008

Unusual Heavy Infection with *Acanthochondria priacanthi* (Copepoda, Chondracanthidae) on Adult Sailfin Sandfish *Arctoscopus japonicus* from the Pacific Ocean off Southwestern Hokkaido

Kazuya Nagasawa[1]* and Yoshiyuki Takaya[2]

[1] Graduate School of Biosphere Science, Hiroshima University,
1-4-4 Kagamiyama, Higashi-Hiroshima, Hiroshima, 739-8528 Japan

[2] Hokkaido Mariculture Fisheries Experiment Station,
1-156-3 Funami, Muroran, Hokkaido, 051-0013 Japan

Abstract. Adult sailfin sandfish *Arctoscopus japonicus* sampled in the coastal Pacific Ocean off southwestern Hokkaido were found to be heavily infected with the chondracanthid copepod *Acanthochondria priacanthi* Shiino, 1964 in December 2007. This finding is completely different from previous observations that fish from the same region were almost free from the parasite. Mean abundance of the copepod in 2007 was up to 770-fold higher than that recorded in 1999, and a current sharp increase in the copepod population is suggested for the ocean surveyed.

Key words: Parasite, copepod, *Acanthochondria priacanthi*, sailfin sandfish, *Arctoscopus japonicus*, heavy infection.

Introduction

The sailfin sandfish *Arctoscopus japonicus* (Steindachner, 1881) is distributed in the Sea of Japan, Sea of Okhotsk and western North Pacific Ocean (Okiyama, 1970, 1990) and is one of the most important commercial fish in northern Japan (Ochiai & Tanaka, 1986). The fish are caught as adults using set nets and gill nets in coastal waters and as immature fish with bottom trawls in offshore waters. Since the stock abundance of the species has been extremely reduced in Japanese waters, various activities, including fisheries management, seedling production, and release of hatchery-reared juveniles, have been conducted in order to recover the fish resource (*e. g.* Sugiyama *et al.*, 2002; Tomoda *et al.*, 2006).

*Corresponding author: ornatus@hiroshima-u.ac.jp

For experimental seedling production at the Hokkaido Mariculture Experiment Station, Muroran, we collected adult sailfin sandfish in the North Pacific Ocean off southwestern Hokkaido in 2007 but unexpectedly found that these fish were very heavily infected with the chondracanthid copepod *Acanthochondria priacanthi* Shiino, 1964. This finding was completely different from previous information that fish in this region were quite rarely infected with the copepod (Yanagimoto & Konishi, 2004). Thus, we made detailed observations on the occurrence of the copepod on sailfin sandfish from coastal Pacific waters of southwestern Hokkaido. The results are reported herein.

Materials and Methods

A total of 239 *Arctoscopus japonicus* were sampled at three locations (Noboribetsu, Muroran, and Shikabe) in the North Pacific Ocean off southwestern

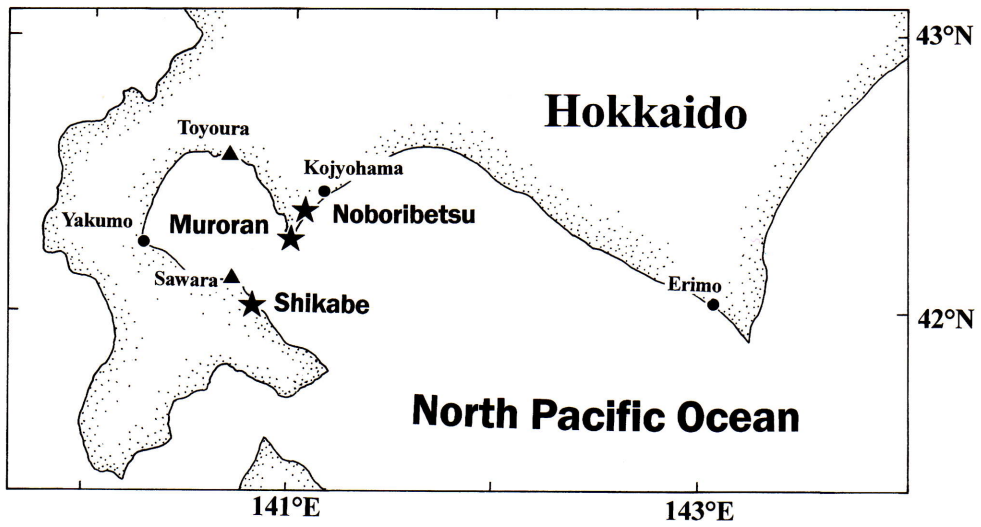

Fig. 1. A map of southern Hokkaido, showing locations where sailfin sandfish *Arctoscopus japonicus* were collected. ★: locations in the present study; ●: locations off which Yanagimoto & Konishi (2004) sampled the fish in 1999; ▲: locations off which the fishermen captured the fish infected with *Acanthochondria priacanthi* in 2007.

Hokkaido on December 6–16, 2007 (Fig. 1). The fish were caught using set nets and gill nets installed in coastal waters. They were brought to the laboratory within a day of capture and individually examined for total length (TL, mm), body weight (g) and the presence of *Acanthochondria priacanthi*. Otoliths were removed from the fish for subsequent age determination. The copepods found were fixed and preserved in 70% ethanol. Voucher specimens are deposited in the crustacean (Cr) collection at the National Science Museum, Tokyo, Japan (NSMT-Cr 17988). The terms, prevalence (the proportion of infected fish of a given species in a sample as a percentage), mean abundance (the mean number of parasites per host examined in a sample), and habitat (a typical local environment in which parasites occur) are used according to the definitions of Bush *et al.* (1997).

Results

Acanthochondria priacanthi was found in various parts of the host, including the inner surface of the operculum, the floor and roof of the buccal cavity, the wall of the branchial cavity, the gill arches, and the chin (Fig. 2). Both prevalence and mean abundance of the copepod were constantly high, ranging from 79.9–100% and from 7.87–15.40, respectively, at three locations (Table 1). There was a marked difference in infection level between age-0 fish and the older fish (age-1 to age-3): age-0 fish showed the lowest prevalence and mean abundance. The maximum number of copepods (47) per infected host was recorded from an age-2 female fish (207 mm TL).

Discussion

Acanthochondria priacanthi had been a rare parasite of sailfin sandfish in the ocean where we sampled the fish (Yamagimoto & Konishi, 2004). Just eight years before our research (November 1999), infection levels of *A. priacanthi* on adult sailfin sandfish remained quite low at two sites (Kojyohama and Yakumo, see Fig. 1) near our sampling locations, being 8.00% and 2.35% in prevalence and 0.09 and 0.02 in mean abundance, respectively (Yanagimoto & Konishi, 2004). When we compare these infection data with the data from our study, mean abun-

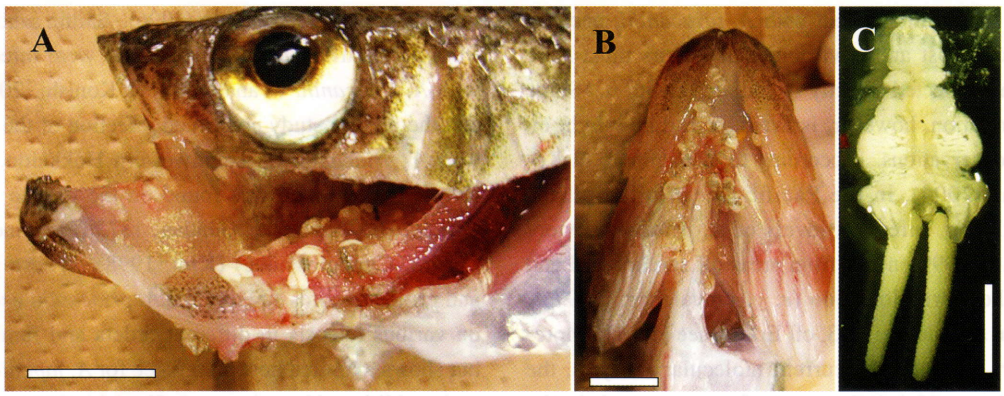

Fig. 2. Sailfin sandfish *Arctoscopus japonicus* (A, B) infected with *Acanthochondria priacanthi* (C). The fish were collected in the coastal North Pacific Ocean off Muroran, Hokkaido, on December 6, 2007. A: part of the left operculum was removed to show the infection with *A. priacanthi* in the buccal and branchial cavities and on the gill arches; B: the chin infected with *A. priacanthi*; C: a gravid female with a pair of egg sacs, whole body, ventral view. Scale bars: 10 mm in A and B; 2 mm in C.

dances (9.99 at Noboribetsu, 15.40 at Muroran, 14.48 at Shikabe) on adult fish (age-1 to age-3 fish combined) were 111- to 770-fold higher than those recorded for 1999. Further, fishermen who had been engaged in commercial fishing of sailfin sandfish at Sawara (see Fig. 1) discovered fish heavily infected with *A. priacanthi* for the first time in their catch in June 2007 (Dr Teruhiko Awakura, *pers. comm.*). Similarly, fish infected with many copepods were found by fishermen working at Toyoura and Muroran (see Fig. 1) in early December 2007. It is, thus, very likely that the infection level or population size of *A. priacanthi* changed markedly in 2007 off southwestern Hokkaido, and if this is the case, the copepod must have increased enormously in number there.

At present, it is very difficult to clarify what factors contributed to the observed, sudden heavy infec-

Table 1. Occurrence of *Acanthochondria priacanthi* on sailfin sandfish *Arctoscopus japonicus* collected at three locations in the coastal Pacific Ocean off southwestern Hokkaido in December 2007.

Sampling site	Fish age (year)	No. of fish examined	Total length (mean, mm)	Prevalence (%)*1	Mean abundance (range)*2
Noboribetsu	0	40	80–101 (91)	30.0	0.50 (0–4)
	1	36	142–193 (158)	83.3	11.22 (0–39)
	2	102	162–245 (213)	98.0	9.63 (0–47)
	3	1	224 (224)	100	2.00 (2)
	Subtotal	179	80–245 (175)	79.9	7.87 (0–47)
Muroran	–*3	20	178–233 (197)	100	15.40 (1–42)
Shikabe	1	13	138–180 (152)	92.3	13.15 (0–30)
	2	27	169–234 (200)	100	15.11 (2–45)
	Subtotal	40	138–234 (184)	97.5	14.48 (0–45)
	Total	239	80–245 (178)	87.0	9.60 (0–47)

*1 Percentage of infected fish.
*2 Mean number of copepods per fish examined.
*3 Age was not determined, but the fish examined were all adults.

tion of sailfin sandfish with *A. priacanthi*, because various host and environmental factors must have been connected directly or indirectly with it. Some information, however, is available to throw light on our observations. According to Yanagimoto & Konishi (2004), in the Pacific Ocean off southern Hokkaido, infection levels of *A. priacanthi* were high in 1999 on fish from areas off southcentral and southeastern Hokkaido (*e. g.* prevalence: 78.97%, mean abundance: 3.53, off Erimo, see Fig. 1). Moreover, based on the current molecular analysis, the sailfin sandfish is known to form one stock in the Pacific waters off southern Hokkaido (Yanagimoto, 2004; Shirai *et al.*, 2006, 2007). Therefore, in addition to a sharp, enormous increase in the copepod population itself off southwestern Hokkaido in 2007, another possibly contributing factor could be that fish from other Pacific regions (*e. g.* those off Erimo) have expanded their distribution.

A similar sudden increase in infection level has been reported for the pennellid copepod *Pennella* sp., a parasite of the Pacific saury *Cololabis saira* (Brevoort, 1856), in the western North Pacific Ocean and adjacent seas (Nagasawa, 1984; Nagasawa *et al.*, 1985, 1988). In this case, the parasite appeared suddenly in 1981, kept infection levels high for three years from 1982–1984, but almost disappeared in 1985 (Nagasawa *et al.*, 1988). Since we have as yet little information on the population biology of parasitic copepods in wild fish populations, continuous monitoring of the infection level of *A. priacanthi* on sailfin sandfish is desirable to clarify the change in population size and geographical distribution of the copepod off the coastal Pacific waters of Hokkaido.

Acanthochondria priacanthi was originally described as a new species by Shiino (1964) from the longfinned bullseye *Cookeolus japonicus* (Cuvier, 1829) (as *Priacanthus broops*, Perciformes, Priacanthidae: see Starnes, 1988, for the nomenclature of the species) collected in the Sea of Japan near Sado Island. The copepod was later redescribed by Ho & Kim (1995) from the sailfin sandfish *Arctoscopus japonicus* (Perciformes, Trichodontidae) collected at Kushiro, Hokkaido. Specimens from Kushiro were reported again by Ho & Kim (1996). Sailfin sandfish from northern Honshu and Hokkaido were infected with *A. priacanthi* (Yanagimoto & Konishi, 2004), and the present study confirmed infection of the fish with *A. priacanthi* off southwestern Hokkaido. In Korea, the copepod was found on the tongue sole *Cynoglossus semilaevis* Günther, 1873 (Pleuronectiformes, Cynoglossidae) (Kim, 1998). These past and present records suggest that *A. priacanthi* occurs on various teleosts in different orders and families but shows a limited host preference for *A. japonicus*.

In addition, Yanagimoto & Konishi (2004) suggested that *A. priacanthi* prefers cold waters, because the species infected *A. japonicus* from waters affected by the cold Oyashio current more frequently and heavily than those from waters by the warm Tsushima current. *Arctoscopus japonicus* is mainly distributed in cold subarctic waters (Okiyama, 1990) and *Cynoglossus semilaevis* also occurs in cold shallow waters off Korea and China (Yamada *et al.*, 2007). On the other hand, since *Cookeolus japonicus* is a warm-water species occurring in tropical and subtropical regions (Starnes, 1988), its distribution area does not overlap with those of *A. priacanthi* and the other known hosts. Based on these considerations, *C. japonicus* might be an accidental host for the copepod.

Previously *A. priacanthi* was recorded only from the inner surface of the operculum of the fish (Shiino, 1964; Ho & Kim, 1995). In this study, however, the species was found in the buccal and branchial cavities and on the gill arches and chin, as well (Fig. 1). Some other copepods (*e. g. Salmincola* spp. in the Lernaeopodidae) parasitic on fishes are known to change their habitats with increase in their number on a host (Black *et al.*, 1983; Nagasawa *et al.*, 1995). Thus, it appears that *A. priacanthi* exhibits such habitat changes as well, in cases of heavy infection.

Acknowledgements

We thank the staff of the Hokkaido Mariculture Fisheries Experiment Station for their assistance during the study. We also acknowledge Dr Teruhiko

Awakura, Hokkaisuiko Consultant Corporation, Sapporo, for his provision of useful information on the parasite. Part of the present study was supported by a Grant-in-Aid for Scientific Research (B) (No. 18380116) from the Japan Society for the Promotion of Science.

Literature Cited

Black, G. A., Montogomery, W. L. & Whoriskey, F. G., 1983. Abundance and distribution of *Salmincola edwardsii* (Copepoda) on anadromous brook trout, *Salvelinus fontinalis* (Mitchill), in the Moisie River system, Quebec. *J. Fish Biol.*, **22**: 567–575.

Bush, A. O., Lafferty, K. D., Lotz, J. M. & Shostak, A. W., 1997. Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *J. Parasit.*, **83**: 575–583.

Ho, J.-S. & Kim, I.-H., 1995. *Acanthochondria* (Copepoda: Chondracanthidae) parasitic on fishes of Sado Island in the Sea of Japan, with a preliminary review of the genus. *Rep. Sado mar. biol. Stn, Niigata Univ.*, **25**: 45–67.

———, 1996. Copepods parasitic on fishes of western North Pacific. *Publs Seto mar. biol. Lab.*, **37**: 275–303.

Kim, I.-H., 1998. Cirripedia, symbiotic Copepoda, and Pycnogonida. *Illustrated Encyclopedia of Fauna and Flora of Korea*, **38**. 1,038 pp. Ministry of Education, Seoul. (In Korean).

Nagasawa, K., 1984. The finding of *Pennella* sp. (Copepoda: Pennellidae) on the saury, *Cololabis saira*, in the western and central North Pacific Ocean and the Okhotsk Sea. *Fish Pathol.*, **18**: 205–208.

Nagasawa, K., Imai, Y. & Ishida, K., 1985. Distribution, abundance and effects of *Pennella* sp. (Copepoda: Pennellidae), parasitic on the saury, *Cololabis saira* (Brevoort), in the western North Pacific Ocean and adjacent seas, 1984. *Bull. biogeogr. Soc. Japan*, **40**: 35–42.

———, 1988. Long-term changes in the population size and geographical distribution of *Pennella* sp. (Copepoda) on the saury, *Cololabis saira*, in the western North Pacific Ocean and adjacent seas. *Hydrobiologia*, **167/168**: 571–577.

Nagasawa, K., Yamamoto, M., Kumagai, A. & Sakurai, Y., 1995. Rediscovery in Japan and host association of *Salmincola carpionis* (Copepoda: Lernaeopodidae), a parasite of wild and reared freshwater salmonids. *Can. J. Fish. aquat. Sci.*, **52** (Suppl. 1): 178–185.

Ochiai, A. & Tanaka, M., 1986. *Ichthyology*, **2** (New Edn). 1,140 pp. Koseisha-Koseikaku, Tokyo. (In Japanese).

Okiyama, M., 1970. Studies on the population biology of the sand fish, *Arctoscopus japonicus* (Steindachner). II. Population analysis (preliminary report). *Bull. Japan Sea reg. Fish. Res. Lab.*, **22**: 59–69 (in Japanese with English abstract).

———, 1990. Contrast in reproductive style between two species of sandfishes (family Trichodontidae). *Fish. Bull.*, **88**: 543–549.

Shiino, S. M., 1964. On two new species of the genus *Acanthochondria* Oakley (Crustacea Copepoda) found in Japan. *Zool. Mededel.*, **34**: 30–36.

Shirai, S., Kuranaga, R., Sugiyama, H. & Higuchi, M., 2006. Population structure of the sailfin sandfish, *Arctoscopus japonicus* (Trichodontidae), in the Sea of Japan. *Ichthyol. Res.*, **53**: 357– 368.

Shirai, S., Goto, T. & Hirose, T., 2007. Sail-fin sandfish (*Arctoscopus japonicus*) collected off the Iwate area in February to March, 2004: evidence that they came from the Sea of Japan. *Jpn. J. Ichthyol.*, **54**: 47–58 (in Japanese with English abstract).

Starnes, W. C., 1988. Revision, phylogeny and biogeographic comments on the circumtropical marine percoid fish family Priacanthidae. *Bull. mar. Sci.*, **43**: 117–203.

Sugiyama, H., Morioka, T., Furunaka, H., Sugishita, S. & Nagakura, Y., 2002. Biological Characteristics and Seedling Production Techniques of Sailfin Sandfish. *Japanese Sea ranching Technique Series*, (8). 113 pp. Japanese Sea Farming Association, Tokyo. (In Japanese).

Tomoda, T., Hotta, K. & Morioka, T., 2006.

Growth, spawning and migration of hatchery-reared Japanese sandfish *Arctoscopus japonicus* released in Nanao Bay and Toyama Bay. *Nippon Suisan Gakkaishi*, **72**: 1039–1045 (in Japanese with English abstract).

Yamada, U., Tokimura, M., Horikawa, H. & Nakabo, T., 2007. *Fishes and Fisheries of the East China and Yellow Seas*. 1,262 pp. Tokai University Press, Hadano. (In Japanese).

Yanagimoto, T., 2004. Geographic population subdivision of the Japanese sandfish, *Arctoscopus japonicus*, inferred from PCR-RFLP analysis on mtDNA. *Nippon Suisan Gakkaishi*, **70**: 583–591 (in Japanese with English abstract).

Yanagimoto, T. & Konishi, K., 2004. *Acanthochondria priacanthi* (Copepoda: Chondracanthidae) as a biological indicator for stock identification of sandfish *Arctoscopus japonicus* (Steindachner). *Fish. Sci.*, **70**: 336–338.

(Accepted February 4, 2008)