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Prevalence, Intensity, Longevity, and Persistence of *Anisakis* sp. Larvae and *Lacistorhynchus tenuis* Metacestodes in San Francisco Striped Bass

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ABSTRACT

Thirteen hundred and seventy-three striped bass, *Morone saxatilis*, were collected from the San Francisco Bay-Delta area to correlate host diet with parasitic infections and to determine the prevalence, intensity, longevity, and persistence of larval *Anisakis* sp. nematodes and the metacestode *Lacistorhynchus tenuis*. There is an increase in the prevalence and intensity of *Anisakis* sp. and in the intensity of *L. tenuis* with increase of age of the host. These increases are probably related to the diet and the persistence of the parasites. The infections of both species are overdispersed. San Francisco Bay striped bass are an incompatible host for both species of parasites. Degenerated *Anisakis* sp. will remain in the host for at least 8 months and *L. tenuis* metacestodes for 22 months. The occurrence of several other species of parasites and a tumor are also reported.

INTRODUCTION

Striped bass, *Morone saxatilis*, is a popular sportfish in the San Francisco Bay, CA, area. Anglers have often reported the presence of parasites in the mesenteries and muscle of striped bass and questioned the public health aspects of the parasitic infections. The purpose of this study was to determine the prevalence (no. hosts infected/no. hosts examined), intensity (total no. parasites/no. infected hosts), longevity (time parasites remain alive), and persistence (time degenerated parasites are detectable) of the two most commonly seen parasites: the metacestode *Lacistorhynchus tenuis* (Cestoda) and the larval nematode *Anisakis* sp. (probably *A. simplex*).

MATERIALS AND METHODS

Collection

Thirteen hundred and seventy-three striped bass were collected from the San Francisco Bay-Delta area between June 1979 and December 1983 by hook and line, gill net, and otter trawl. Fish were frozen or Formalin-fixed and autopsied for parasites and stomach content analyses at Long Marine Laboratory, University of California, Santa Cruz.

Aging

The age of the fish was determined by scale ring counts by the California Department of Fish and Game and the use of growth curves.

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Diet Analysis

The stomach contents of the fish were analyzed to determine possible correlations between diet and parasite infections. Stomach contents of 831 striped bass collected between January and September 1981 from San Pablo Bay and Suisun Slough were examined for possible intermediate hosts. The Index of Relative Importance (IRI) of food items was determined by methods suggested by Cailliet (1976). The young-of-the-year (YOY) and most of the 1-yr-olds had similar diets, hence were combined for analysis. The age groups for diet analysis were: YOY and 1-yr-old (10 to 230 mm SL); subadult females and adult males (2 to 3 yr); and adults (4+ yr).

Statistical Analysis

The coefficient of dispersion (overdispersed distribution) was determined to indicate possible clumping in parasite distributions, hence the possible need for nonparametric analysis (Sokal and Rohlf 1969). Within each age class seasonality did not significantly change the prevalance or intensity of the parasitic infections. Therefore, all seasons were combined within each age class (ANOVA, regression analysis).

Serial Infections

Serial infections were performed to determine whether nematode larvae can be transferred from fish to fish. The striped bass used in both infection experiments were YOY hatchery fish provided by the California Department of Fish and Game, Elk Grove, CA. The third stage larval *Anisakis* sp. used were from bocaccio, *Sebastes paucispinis*. The fish were force-fed (Wootten and Smith 1975) with washed larvae (Tanaka and Torisu 1978). Fifty larvae were fed to each of six striped bass. As a control, four YOY yellowtail rockfish, *Sebastes flavidus*, were infected in a similar manner.

Longevity and Persistence

Striped bass collected from the field were observed to have degenerated larval nematodes in their mesenteries and tissues. The purposes of this experiment were to determine how long the larval *Anisakis* sp. remain alive in striped bass, therefore potentially harmful to humans, and to determine the persistence of dead larvae in the mesenteries and muscle. The third stage *Anisakis* sp. larvae used were prepared as above but were from sablefish, *Anoplopoma fimbria*. To insure that all fish were infected with equal numbers of larvae, 25 larvae were inserted into the coelomic cavity through a small cut on the sides of 178 striped bass. This wound was sealed with a nontoxic biological glue, Histoacryl (Tri-Hawk, Los Angeles, CA). Previous tests showed that striped bass reacted similarly to larvae infected by this technique, to those force-fed, and to those seen in field fish. The hosts were periodically autopsied during a 33-wk period.

RESULTS

Diet Analysis

The fullness of the stomachs and the percent IRI for the dominant food item or items are given for each age class. No stomachs contained larvae or metacestodes (Fig. 1).

Anisakis sp.

Host reaction.—The larval *Anisakis* from field fish were found on the mesenteries and internal organs. Rarely were they found in the muscle tissue. Most larvae were dead or degenerating with dark brown cuticles. The larvae were often seen as solid, round masses of fibrous tissue. When several larvae were in close proximity in the mesenteries, they were often encapsulated to form a fibrous "raft." In field fish with high intensity infections, numerous degenerated larvae were found embedded in the posterior end of the stomach (Fig. 2).

Prevalance and intensity.—The prevalence and intensity of larval nematode infections in striped bass begin to increase at 4 yr and continue to increase throughout the life of the host. The mean to variance ratios (year classes 3 to 8+ are: 1.3, 14.2, 58.8, 33.7, 49.9, 39.5, respectively) show the infections to be increasingly overdispersed with time (Fig. 3).

Serial infection.—Autopsies showed that after 5 wk, two of six striped bass were infected by one and four larvae, respectively. Although the larvae from the striped bass responded weakly to tactile stimuli, the cuticle had darkened, resembling the dead larvae recovered from field-captured striped bass. In contrast, three of the four rockfish were infected with an average of four larvae. The larvae from the rockfish were more active, and the cuticle was flesh colored, similar to larvae from field-collected *Sebastes paucispinis* and other fish hosts.

Figure 2.—Cross section of posterior end of stomach with embedded larval nematodes.

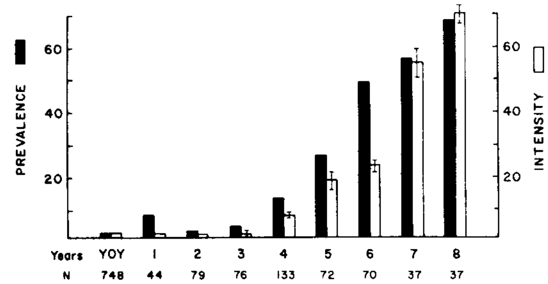

Figure 3.—Prevalence and intensity of larval nematodes compared with age of host. Bar = standard error.

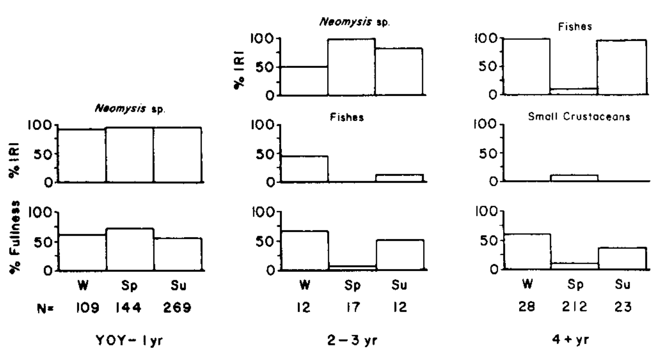

Figure 1.—Stomach content analysis of striped bass in the three major age groups in winter (W), spring (Sp), and summer (Su).

Longevity and persistence.—At the end of 2 wk most larvae had been encapsulated into a fibrous "raft." In the following 31 wk, in addition to the "raft," one to five larvae were recovered in the coelom or attached to the mesenteries. These larvae usually responded weakly to tactile stimuli, but became progressively darker and weaker with time (Fig. 4).

Figure 4.—*Anisakis* sp. larvae encapsulated in fibrous "raft."

Lacistorhynchus tenuis

Host reaction.—Moser, Sakanari, Wellings, and Lindstrom (1984) described the inflammatory response of the striped bass to these "rafts." The metacestodes from field fish appeared degenerated. The outer surface of the blastocyst was brown and the metacestode was a hardened mass. Often, the metacestodes, similar to the nematode larvae, were encapsulated into fibrous "rafts."

Prevalance and intensity.—During the first year the prevalence of larval cestode infections reached 81.6% and remained approximately at this level throughout the year. However, the mean intensity of infection slowly increases with the age of the host. The mean to variance ratios (age classes YOY to 8+ are: 14.4, 23.2, 38.9, 9.2, 48.6, 36.7, 59.3, 51.2, 73.0, respectively) indicate the infections were increasingly overdispersed with time (Fig. 5).

Persistence.—Four field fish kept in the laboratory for 22 mo still retained their dead metacestodes and "rafts."

Other Parasites and a Tumor

Occasionally other helminth parasites were encountered during autopsies. However, because of the overall goal of this study and the method of preservation of field fish, no attempt was made to quantify these helminths. Parasites reported from the San Francisco Bay-Delta include: Acanthocephala—*Southwellina* (D. Woodbury[3]); Cestoda—Tetraphyllidae larvae, in mesenteries,

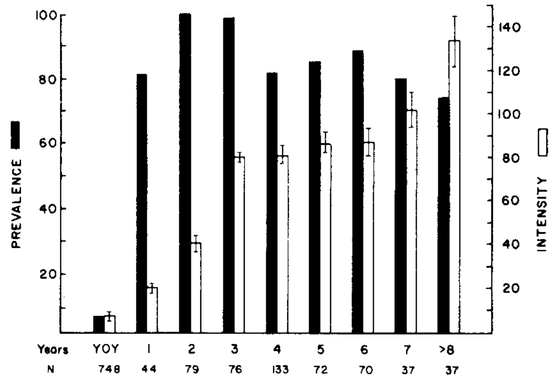

Figure 5.—Prevalence and intensity of metacestodes compared with age of host. Bar = standard error.

(this study); Digenea—*Stephanostomum tenue* (D. Woodbury footnote 3), *Lepocreadium californianum* (Edwards and Nahhas 1968); Monogenea—*Cleidodiscus pricei* (Hensley and Nahhas 1975); Nematoda—*Thynnascaris brachyurum* (as *Contracaecum b.*, Hensley and Nahhas 1975), *Spiroxys* sp. larva (Hensley and Nahhas 1975), and *Phocanema* sp. larvae, in mesenteries, (this study); a tumor, in coelom, (this study, Fig. 6, National Museum of Natural History-Registry of Tumors in Lower Animals (NMNH-RTLA) #3173).

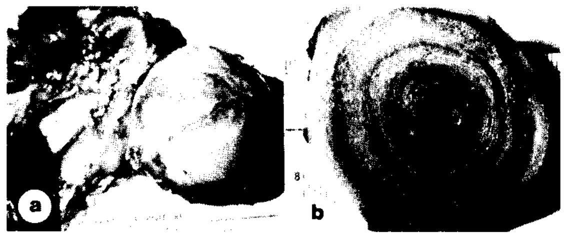

Figure 6.—Tumor a) attached to mesenteries, b) cross section.

DISCUSSION

The food habits of San Francisco Bay-Delta striped bass have been reported by Turner and Kelley (1966), Thomas (1967), Orsi (1971), Moriguchi (1973), Moyle (1976), and Orsi and Knutson (1979). The present study and the above reports show that YOY consume primarily shrimp (*Neomysis* sp. and *Crangon* sp.), amphipods (*Corophium* sp.), and copepods. By the end of the first year the fish begin to switch from feeding on invertebrates to eating fish (striped bass, shad, salmon, flatfish, herring, perch, bait). This trend continues in the subadults. Although adults are primarily piscivorous, striped bass continue to eat some invertebrates, such as crabs. The adults, and perhaps the subadults, reduce their feeding in the spring and early summer during the spawning season.

The life cycle of *Anisakis* sp. usually includes a marine crustacean as the first intermediate host, a fish or squid as the second host, and a marine mammal as the definitive host. The larva of *Anisakis* sp. is well known as a potential hazard to human health if

[3]D. Woodbury, Seasonal Aide, California Department of Fish and Game, 203 Tall Trees Drive, Vallejo, CA 94589, pers. commun. March 1983.

consumed in raw or improperly prepared seafood (Moser, Love, and Sakanari 1984). San Francisco Bay striped bass infected with larval *Anisakis* do not appear to be a major health hazard. Rarely were these larvae found in the muscle tissue. In addition, most of the larvae degenerate in the body cavity after a few weeks. The results of this study suggest that some degenerating larvae and the fibrous "rafts" can persist in striped bass for at least 33 wk. This slow turnover rate of larvae probably contributes to the increase in intensity of infection with time.

Wootten and Smith (1975) showed that trout can be serially infected with *Anisakis* sp. larvae from herring. Many of the fish consumed by striped bass are infected by *Anisakis* sp. larvae (Love and Moser 1983). The serial infection experiments with *Anisakis* sp. larvae may explain the increase in prevalence and intensity as striped bass become more piscivorous at 4 yr. Although numerous fibrous "rafts" were found in the mesenteries and next to the peritoneum of field fish, they did not form open lesions as described for the metacestodes of *L. tenuis* in San Francisco Bay striped bass (Moser, Sakanari, Wellings, and Lindstrom 1984).

The life cycle of *Lacistorhynchus tenuis*, although not completely described, most probably includes the adult in an elasmobranch, such as the leopard shark, *Triakis semifasciata*, common to San Francisco Bay, the procercoid in a crustacean, and the metacestode in fish. *Lacistorhynchus tenuis* metacestodes have been reported worldwide from more than 60 species of hosts (Moser 1983), including striped bass from the east coast and other San Francisco Bay fish, with no apparent harm to the host. However, Moser, Sakanari, Wellings, and Lindstrom (1984) have shown that these metacestodes are pathological to striped bass found in the San Francisco Bay-Delta area.

The sharp rise in prevalence of *L. tenuis* metacestodes in the 1-yr-olds may be related to the movement of this age class from the Delta area into San Francisco Bay where they are more likely to encounter the infected intermediate hosts. The continued increase in the intensity of metacestodes through time may reflect both the acquisition of new metacestodes and their persistence in the host. Preliminary studies (Sakanari, Moser) suggest that metacestodes of *L. tenuis* can be transfered serially from white croaker, *Genyonemus lineatus*, to striped bass. These studies suggest that the prevalence of metacestodes from the YOY to the 1 yr class may also be related to increased piscivory. The increased clumped distribution of parasites with the age of the host may indicate striped bass vary in their susceptibility to these parasites. Some hosts may eliminate the parasites before they can become embedded in the mesentaries or muscle tissue. Striped bass were introduced into San Francisco Bay from the east coast approximately 100 yr ago. The type of incompatibility shown here has not been described between east coast striped bass and their helminth parasites. Current studies are investigating the possibility that the west coast striped bass are immunologically incompatible with the indigenous strain of parasite.

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