Identification of parasitic nematode larvae, *Sulcascaris sulcata*, in the calico scallop, *Argopecten gibbus* (Linnaeus), and the surf clam, *Spisula solidissima*

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Larval anisakid nematodes from scallops (*Pecten* sp.) were placed in the genus *Paranisakis* when first described. Similar nematodes, often dark brown to black, were observed in surf clams, *Spisula solidissima*, harvested in nearshore waters of Virginia and Maryland, and brought to our laboratories by concerned representatives of the seafood industry. Cooperative efforts by State (regional), Federal, and university investigators revealed that the discoloration was due to a new species of the haplosporidan protozoan, *Urosporidium spisuli* Perkins, Zwerner and Dias, 1975, parasitic in nematodes present in surf clams but not in scallops. Studies, including scanning electron microscopy, showed that the nematodes were developing stages of *Sulcascaris sulcata* (Rudolph) which parasitizes the green and loggerhead sea turtles, *Chelonia mydas* and *Caretta caretta*, respectively. Unparasitized nematodes dissected from Florida scallops and Virginia clams were not infective for rats and *S. sulcata* is presently not considered to be of public health significance. The recent finding of *S. sulcata* in another Florida mollusc, *Hunter's banded tulip shell snail* (*Fasciolariella lilium hunteria*), indicates that the larval nematode may parasitize a wide range of molluscan hosts. Transmission of the nematodes from Queensland scallops (*Amusium balloti*) to turtles (*C. caretta*) resulted in their development to adults in Australia. In North America, transmission of larval nematodes from calico scallops to Maryland terrapin turtles (*Malaclemys terrapinae*, not reported as a natural host) resulted in survival for 21 days in the turtles' stomachs without maturation.

Les nématodes larvaires anisakidiens chez des coquilles (*Pecten* sp.) ont été placés, premièrement décrits, dans le genre *Paranisakis*. Les nématodes semblables, souvent bruns foncés à noirs en couleur, ont été observés chez les « palourdes de ressac » (*Spisula solidissima*), qui sont capturés dans les eaux littorales de Virginie et de Maryland et apportés à nos laboratoires par de concernés représentants de l'industrie des produits de la mer. Les efforts coopératifs par les investigateurs des états (régionaux), du gouvernement fédéral et des universités ont révélé que la décoloration était par suite d'une nouvelle espèce du protozoaire haplosporidien, *Urosporidium spisula* Perkins, Zwerner et Dias, 1975, qui est un hyperparasite chez les palourdes de ressac mais pas chez les coquilles. Les études, y compris les études du microscope électronique balayant, ont montré que les nématodes développaient des stades de *Sulcascaris sulcata* (Rudolph) qui est parasitaire dans les tortues de mer vert et

**Introduction**

Representatives of the seafood industry in Maryland and Virginia called our attention in 1974 to worm-like organisms in commercially processed surf clams, *Spisula solidissima*, that had been harvested from nearshore waters of Maryland and Virginia. The possibility that the organisms could contaminate seafood products and render them unsuitable for human consumption, or cause temporary cessation of processing operations, presented several problems which required immediate attention. A workshop attended by participants from the seafood industry and by Federal, State (regional), and university scientists met at the Oxford Laboratory on 23 January 1975, to share in the free exchange of information, and to plan a multidisciplinary study to identify the organism and determine whether it presented a potential hazard to human health. Prior to the first meeting in January, it had already been determined that many of the nematodes were parasitized by a haplosporidan hyperparasite (Perkins et al., 1975), and that the nematodes had a superficial resemblance to *Paranisakis*, an anisakid nematode from scallops reported by Cobb (1930). Continued study showed that the nematodes correctly belonged to the genus *Sulcascaris* which contains only one known species, *S. sulcata* (Rudolphi). Adults of *S. sulcata* parasitize the green turtle, *Chelonia mydas*, and the loggerhead turtle, *Caretta caretta*, thus explaining why only larval stages have been recovered from shellfish (Lichtenfels et al., 1978). Further research, to be reviewed in the following paragraphs, has led to two important conclusions concerning the presence of *S. sulcata*: (1) the nematodes are not parasitic in warm-blooded vertebrates and do not present a recognized health hazard; and (2) whole nematodes or nematode fragments are extraneous materials which must not be present in processed clam meats in excess of the limits established by law.

**Nematode identification**

Extensive morphological studies, which employed scanning and transmission microscopy in addition to conventional methodologies, confirmed that the excretory pore of the nematode was located at the base of ventral interlabium rather than at the level of the nerve ring (Lichtenfels et al., 1978) as previously noted in serial sections examined by Gibson and Taylor (1976). The correct identification of larval anisakids from surf clams and scallops as *S. sulcata* thus resolved a taxonomic problem with parasitic nematodes which previously had been identified as belonging to the genera *Paranisakis*, *Parrocaecum*, or *Paranisakiopsis*. Historically, all identifications had been based on descriptions of larval stages from molluscs since hosts for adult stages were unknown. Although infection experiments to attempt the transfer of larvae to marine turtles have not been attempted in the United States, Sprent (1977) in Australia recovered adult *S. sulcata* from laboratory-reared turtles which had been infected with larvae recovered from sea scallops, *Amusium balloti* (Bernardi). Our preliminary studies (unpublished) have shown that larvae from calico scallops, *Argopecten gibbus* (Linnaeus), may survive for at least 21 days in the stomach of the Maryland terrapin, *Malaclemys terrapininae*. Further research is necessary to determine whether *S. sulcata* larvae are able to mature in species of turtles other than *C. mydas* and *C. caretta*. Lichtenfels et al. (1980) recently recovered larvae from Hunter’s banded tulip, *Fasciolaria lilium hunteria* (G. Perry), in Florida and provided a list of 11 species of marine molluscs which are known to act as intermediate hosts for the parasite.

Berry and Cannon (1981) completely described the life history of *S. sulcata* as found in turtles, *C. caretta*, and Queensland scallops, *A. balloti*. The authors found that turtles produce eggs which sink to the bottom of the sea and two molts occur within the eggs to produce free-living third-stage larvae. Third-stage larvae develop within mollusce hosts where they molt to the fourth stage and, upon ingestion by *C. caretta*, molt to adults in 7 to 21 days. The excellent illustrations and discussion provided by Berry and Cannon (1981) represent a major contribution toward understanding the biology, ecology, and life history of *S. sulcata*.

**Identification of the hyperparasite**

The hyperparasite, which gave a dark or black appearance to larval *S. sulcata* in surf clams, was found to be a
new species of protozoan belonging to the order Balanosporida Sprague, 1978. The new organism, Urosporidium spisuli Perkins, Zwerner and Dias, 1975, has been observed only in nematodes from the surf clam and, according to Perkins et al. (1975), the spore stages are killed after 5 to 30 minutes incubation at 100°C. Ultrastructural studies of the spores (Perkins et al., 1977) illustrated surface structures on U. spisuli which served to distinguish them from related U. crescens and U. jiroveci. Surf clams studied at the Virginia Institute of Marine Science by Perkins et al. were harvested from the Atlantic Ocean near Oregon Inlet, North Carolina, False Cape, Virginia, and the Chesapeake Light off the Virginia Capes. Among 894 animals examined, 16% were found to be infected by the protozoan. The brown to black color of diseased nematodes was responsible for the ease with which they were observed in seafood plants during shucking operations. Payne et al. (1980) surveyed surf clams and clam products during 1976 to 1977 and found parasites in only 15 of 1696 nematodes (< 1%), suggesting that perhaps there has been a natural decline in the numbers of nematodes which are affected by hyperparasitism. Further research to monitor the prevalence of infected worms in surf clams throughout the range from which they are harvested is needed to determine the extent of seasonal and annual variations. Such monitoring might provide a means by which inspection agencies could determine when to maximize or minimize their surveillance activities.

Molluscan hosts for larval S. sulcata
Cobb (1930) originally described a "nemic parasite" in scallops belonging to the genus Pecten. He found larval stages only and described them as representing a new species, Paranisakis pectinis. Larvae were found again in the calico scallop, Argopecten gibbus (L.), by Hutton (1964) who named them Porrocaecum pectinis. Cheng (1967) found the same larvae in Atlantic bay scallop, Argopecten irradians (Lamarck). Sprent (1977) compared fourth-stage larvae from stomachs of marine turtles with larvae from Queensland scallops, Amusium balloti (Bernardi), concluded that they were identical, and identified them as Sulcascaris sulcata. At the same time, Lichtenfels (Lichtenfels et al., 1977) examined larvae and adults from loggerhead and green turtles, compared them with larvae from surf clams and calico scallops, and identified them as S. sulcata. Published accounts of parasitism by larval stages of S. sulcata list 11 known mollusc species that are natural intermediate hosts. Lichtenfels et al. (1980) list all previously known hosts and add two new ones from Florida, Hunter's banded tulip shell (snail) and the horse conch. The hyperparasite, U. spisuli, has been found only in one of the 11 species of molluscs, the surf clam, S. solidissima. Further attempts to infect laboratory-reared turtles with larvae from each of the recognized mollusc hosts might provide important information on whether or not larvae from differing sources are infective. Further histological studies should also be of interest to determine whether or not there are differences in the response of host tissues (adductor muscles, gonads, etc.) to infection.

Significance of larval S. sulcata to the seafood industry
The immediate and collective response of the individuals and agencies concerned with the presence of S. sulcata in commercially processed surf clams succeeded in preventing serious financial losses to the industry. Cooperation by the owners of several seafood plants who instructed their employees in collection, preservation, and counting nematodes or nematode fragments on a daily basis provided valuable information on the distribution and abundance of S. sulcata in shellfish harvesting grounds. Thorough investigation by all participants in the study led to the publication of highly significant new information on the identity of the nematodes, the hyperparasites, and on several previously unknown molluscan reservoirs for larval stages. Laboratory experimentation showed that neither the nematodes nor their parasites could survive the high temperatures normally employed during shucking and cooking operations, nor could the nematodes survive at temperatures approximating normal mammalian body temperatures. Extensive research at Food and Drug Administration laboratories showed that the nematodes may survive in turtles but not in laboratory animals that may be experimentally infected with other anisakine species known to be potentially infectious to humans. Presently, neither the nematode nor the protozoan hyperparasite are considered to present a health hazard to mammals. The effect of the nematode on the seafood industry is considered to be minimal as long as high production standards are maintained, and the amount of foreign material per gramme of clam meat does not exceed authorized levels. The early resolution of many important questions resulted from the diverse capabilities of different investigators and the open and free exchange of ideas and information at periodic meetings and workshops.

Although the prevalence of S. sulcata in surf clams, S. solidissima, does not appear to be significant, Lester et al. (1980) found an infection rate of up to 64% in commercial-sized Queensland scallops, A. balloti, and reported that the parasites reduce their commercial value.

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References


