HELMINTH PARASITES OF PORPOISES OF THE GENUS *STENELLA* IN THE EASTERN TROPICAL PACIFIC, WITH DESCRIPTIONS OF TWO NEW SPECIES: *MASTIGONEMA STENELLAE* GEN. ET SP. N. (NEMATODA: SPIRUROIDEA) AND *ZALOPHOTREMA PACIFICUM* SP. N. (TREMATODA: DIGENEA)

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ABSTRACT

Parasite frequencies in 72 spotted porpoise, *Stenella graffmani* (Lönnberg, 1934), and 19 spinner porpoise, *S.* cf. *S. longirostris* (Gray, 1828), are reported and analyzed with respect to age of host. In addition to the new nematode *Mastigonema stenellae* gen. et sp. n. from the fore stomach of *S. graffmani* and the new fluke *Zalophotrema pacificum* sp. n. from the pancreatic duct of *S. graffmani* and *S.* cf. *S. longirostris*, parasites reported include *Anisakis simplex, Halocercus delphini, Crassicauda* sp., *Campula rochebruni, Tetrabothrium forsteri, Strobilocephalus triangularis, Phyllobothrium delphini*, and *Monorygma grimaldii*. Irreversible lesions in the ventral region of the skull due to infection of the air sinuses by a *Crassicauda*-like nematode were more frequent in skulls of calves of *S. graffmani* than in skulls of subadults and adults (129 specimens total), indicating that the parasite, or a condition correlated with its occurrence, is a significant factor in natural mortality of the spotted porpoise in the eastern tropical Pacific.

Porpoises of the genus *Stenella* are of great importance to the U.S. tropical tuna fishery (Perrin, 1969, 1970a). Yellowfin tuna associate with porpoise schools in the eastern Pacific, and the fishermen make use of this association in locating and capturing the tuna. Despite this economic importance, little is known of the ecology of the porpoises. Parasites have been previously reported from *Stenella longirostris, S. roseiventris, S. coeruleoalba, S. attenuata*, and *S. graffmani* (Dailey and Brownell, 1972). These reports have usually been from a small sample and did not include numbers of parasites per animal or percentage of sample infected. This report deals with two members of the genus in the eastern tropical Pacific: the spotted porpoise and the spinner porpoise. The taxonomy of the genus is currently in a chaotic state. Spinner porpoises from the eastern Pacific have been referred by recent authors to *Stenella microps* (Gray, 1846) and to *S. longirostris* (Gray, 1828)—Perrin and Hunter (1972). The spotted porpoise *S. graffmani* (Lönnberg, 1934) was described from Acapulco, but Rice and Scheffer (1968) recently referred all spotted porpoises to *S. dubia* (G. Cuvier, 1812), a decision that does not reflect a concensus of current opinion (Perrin, 1970b; Mitchell, 1970; Caldwell et al., 1971). We here refer the spotted porpoise examined to *S. graffmani* and the spinner porpoise tentatively to *S. longirostris*. The "eastern" and "whitebelly" spinner porpoises (Perrin, 1972) are considered to be geographical variants within one species and are not treated separately. This usage is provisional pending the results of current taxonomic investigations.

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MATERIALS AND METHODS

We examined 72 specimens of *S. graffmani* and 19 of *S.* cf. *S. longirostris* (11 eastern and 8 whitebelly). These were collected during the course of investigations of morphology and reproduction. We collected parasites as we prepared skeletons of the animals for use as museum specimens. Capture data and museum numbers are presented in Appendix Tables 1 and 2. Also, we examined 67 skulls of spotted porpoise and 29 of spinner porpoise from museum collections, for bone damage caused by nematode infection. The museum specimens were from the eastern tropical Pacific and are listed below. Abbreviations used are: AMNH, American Museum of Natural History, New York; LACM, Los Angeles County Museum; SDMNH, San Diego Museum of Natural History; USNM, United States National Museum, Washington, D.C.

S. graffmani: AMNH130216, LACM27412, 27413, 27419, 27420, 27421, 27422, 27425, 27426, 27427, 27428, 27429, 27431, 27434, 31362, 31431; SDMNH20637, 21199; USNM-261427, 261428, 261429, 261430, 261431, 261432, 261433, 261434, 395264, 395265, 395266, 395267, 395268, 395615, 395616, 395617, 395618, 395926, 395927, 395928, 395929, 395935, 395936, 395937, 395938, 396027, 396029, 396034, 396037. The following LACM specimens, identified by field numbers, had no museum numbers when examined: GDF42, GDF57, MI563, RLB404, RLB500, WAW42, WAW51, WAW55. The following specimens, identified by field numbers are in the research collection at the Southwest Fisheries Center (SWFC below), La Jolla, Calif: CV160, JSL88, JSL89, JSL90, JSL95, RICE65-1, RICE66-3, WFP7, WPSG-01, WPSG02, WPSG03.

S. cf. *S. longirostris:* LACM27414, 27423, 27424, 27428, 27430, 27432, 27433; SDMNH-21200, 21427; USNM395269, 395270, 395271, 395272, 395273, 395274, 395275, 395930, 395931, 395932, 395933, 395934, 396030, 396032, 396035; LACM field numbers GDF56, RLB238, RLB405, WAW43, WAW50, WAW-52, WAW53, WAW54, WAW58, WAW60; SWFC field numbers CV240, CV241, CV245, RICE65-149, RICE67-102.

While rough-cleaning the porpoise carcasses for skeletal preparation, we examined the blubber, mesenteries, peritoneum, musculature, blowhole region, maxillary sinuses, mammary glands, and viscera (esophagus, stomachs, heart, lungs, liver, spleen, kidneys, gonads, intestine) for larval and adult parasites. We searched 3-m lengths of the intestine at the duodenal end, mid-length, and posterior end. Counts of cysts in the blubber should be considered as relative indices; we did not examine all the blubber carefully. We filled out a data form for each carcass indicating precisely which areas had been checked for parasites. All worms and cysts were fixed in Lavdowsky's (Formalin[3]-Acetic acid-Alcohol) or Bouin's fluid and stored in 70% ethanol. Cestode, trematode, and acanthocephalan whole mounts were stained with celestine blue B or Semichon's carmine. Specimens were sectioned singly or in situ at 6, 8, and 10 μ and stained with Mayer's hematoxylin and eosin Y or Mallory's trichrome. All material except nematode whole mounts were dehydrated in ethanol, cleared in xylene, and mounted in Piccolyte. Nematodes were cleared and mounted in glycerine. Drawings were made with the aid of a drawing tube. Measurements are given in millimeters unless otherwise stated. Average measurements are given with ranges in parentheses.

THE PARASITES

Counts of parasites collected are tabulated in Appendix Tables 1 and 2.

Nematoda

Anisakis simplex **(Rudolphi, 1809, det. Krabbe, 1878)**

This nematode was the most frequent parasite collected during this study. The taxonomic criteria used in identification of these specimens were those presented by Davey (1971) in his revision of the genus *Anisakis*. *A. simplex* was found in the stomachs of both host species and represents a new host report for both *S. graffmani* and *S. longirostris*. Anisakids have been previously reported from other species of *Stenella* (Delyamure, 1955; Kagei et al., 1967; Zam, Caldwell, and Caldwell, 1971; Dailey and Brownell, 1972).

[3] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Halocercus delphini Baylis and Daubney, 1925

This parasite has been reported previously from the genus *Stenella* by Zam et al. (1971). They found three of 17 *S. plagiodon* (Cope, 1866) taken off the Florida coast infected with *H. delphini*. This report represents a new host record from *S. graffmani* and *S. longirostris*. Infections occurred in bunches with the anterior ends of the parasites embedded in capsules found outside of the bronchial walls (Figure 1). The body of each parasite lies in the bronchiole oriented in an anterior direction, never towards the apex of the lobe, similar to the orientation described for *Skrjabinalius cryptocephalus* (see Delyamure, 1955).

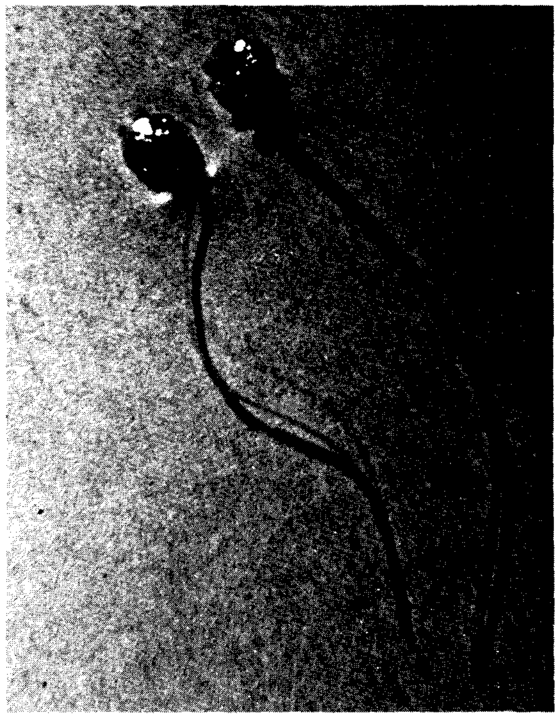


FIGURE 1.—*Halocercus delphini* with anterior end embedded in capsule. (X7)

Mastigonema stenellae gen. et sp. n. (Nematoda: Spiruridae)

This nematode is described from three female specimens taken from the forestomachs of two *S. graffmani* (both recovered prior to present study) and one *S. longirostris*.

Mastigonema gen. n. (Ascaropsinae)

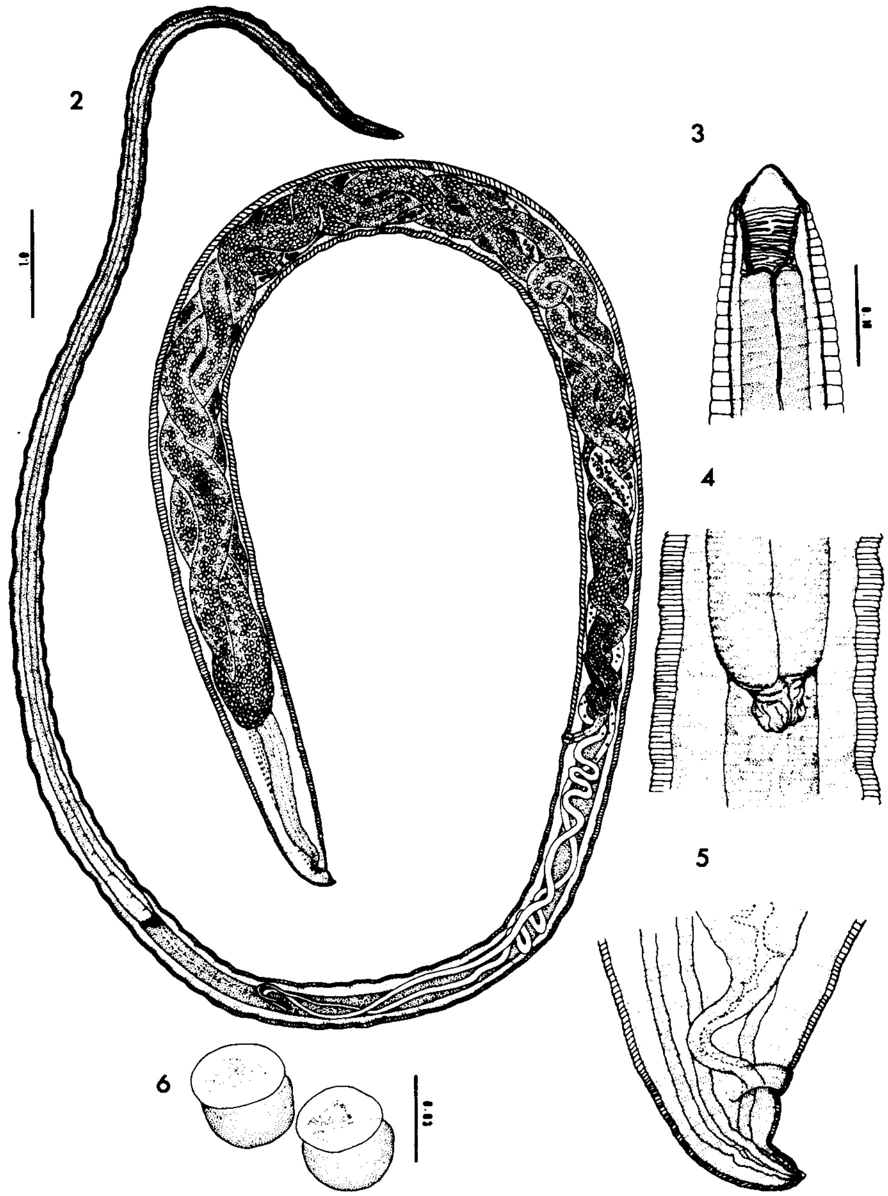
Mouth with two unlobed lips. Cervical cuticle not inflated or flanged. Buccal capsule cylindrical, with few connecting, annular, thickenings. Esophagus long, not divided into anterior and posterior portions; valve of typical spiruroid form. Females prodelphic, ovaries postesophageal. Vulva in middle third of body. Cuticle transversely striated. Oviparous. Parasites of Cetacea.

Mastigonema stenellae sp. n. (Figures 2-6)

With characters of the genus: body whip-shaped, with thin anterior and enlarged posterior portions. Stoma triangular; two large lips. Buccal capsule reinforced with connecting rings, cervical papillae present, eggs with enlarged cap.

Female: 25.5 (23.5-28.5) long by 1.2 in maximum width, 7.0 from posterior end. Buccal capsule 0.054 long, tapering from 0.045 wide at anterior to 0.032 at esophageal junction. Nerve ring 0.281 from anterior end, surrounding esophagus. Esophagus 8.5-11.7 long, widening at approximately 2.59 from anterior end. Ovaries directed anteriorly then reflexing sharply. Vulva muscular, 16.64 from anterior, vagina vera 0.13 long by 0.086 wide, vagina uterina 0.81 long by 0.11 wide. Eggs 0.034 long by 0.032 wide, with swollen cap slightly larger than bottom portion. Anal lip large, anus 0.22 from posterior tip. Tail conical with large mucron.

Hosts: *Stenella graffmani, S. longirostris.*
Location: Forestomach.
Locality: Eastern tropical Pacific Ocean; holotype from *S. longirostris* collected at approximately lat 8°N, long 107°W.
Type specimens: USNM Helminth Collection holotype female No. 72159, paratype No. 72160.
Remarks: A search of the literature indicates this is the first report of a spirurid



FIGURES 2-6.—*Mastigonema stenellae* sp. n.: 2. Entire worm. 3. Cephalic region, showing annular thickenings. 4. Esophageal-intestinal valve. 5. Caudal region. 6. Eggs, showing enlarged caps.

nematode parasitizing a marine mammal. The general body shape of this nematode is similar to that seen in *Vasorhabdochona cablei* Martin and Zam, 1967, *Trichospirura leptostoma* Smith and Chitwood, 1967, and *Freitasia teixeirai* Baruš and Coy, 1965. However, the structure of lips and buccal capsule place it in the subfamily Ascaropsinae rather than with the rhabdochonids. Of the genera in this subfamily it most closely resembles the genus *Pereirai* Cuocolo, 1943. It differs from *Pereirai* in the following characteristics; lips are unlobed, cuticular flange is lacking, buccal capsule has few annular thickenings, esophagus not divided into anterior and posterior portions, and vulva in posterior half of body.

Crassicaudidae Skrjabin et Andrews, 1934

Crassicauda sp. A single infection of this tissue nematode was found in the 78 animals examined (1.3%). The worms were in the abdominal muscle adjacent to the mammary gland of *S. longirostris*. A large abdominal cyst was also found in the same area. Sections revealed large numbers of *Crassicauda* sp. eggs as well as portions of the female worm (Figure 7). Entire worms were not recovered so specific identification was not possible. However, egg

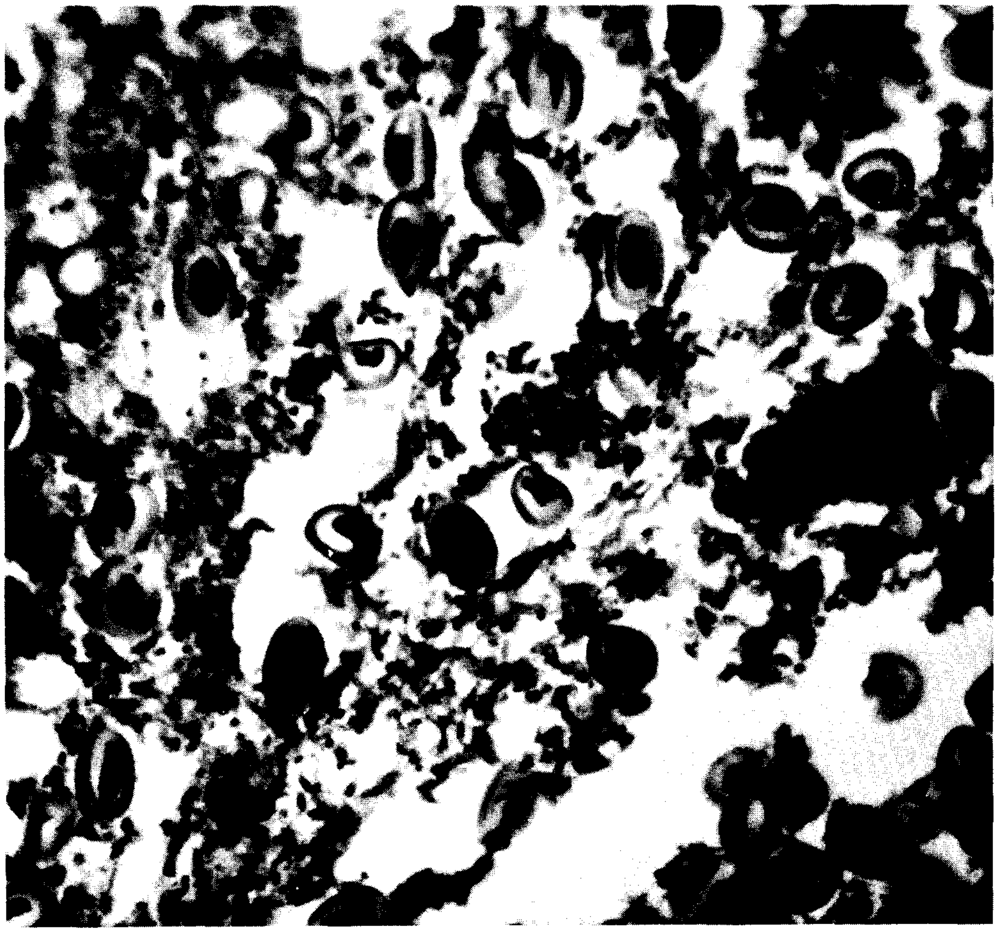


FIGURE 7.—Section through abdominal cyst with *Crassicauda* eggs. (X150)

measurements resemble those given for *C. grampicola* by Johnston and Mawson (1941) from Risso's porpoise, *Grampus griseus* (Cuvier, 1812), taken at New South Wales, Australia.

Another single specimen with *Crassicauda* affinities was recovered by James G. Mead, University of Chicago, Department of Anatomy, while dissecting the head of a *S. graffmani*. The worm was taken from the pterygoid air sinus. The pterygoid bone was eroded in the region in which the specimen was found. We assume that extensive bone damage found by us in other specimens we examined (Figure 8) was also caused by infestations of this nematode, although, judging from the published literature, the possibility cannot be dismissed that more than one species is involved. Reysenbach de Haan (1957) reported *Stenurus globicephalae* Baylis and Daubney, 1952, in the sinuses and cava tympani of the pilot whale, *Globicephala melaena* (Traill, 1809). Norris and Prescott (1961) collected "large quantities of a nematode (*Stenurus* sp.)" from the lateral air sinus of a dall porpoise, *Phocoenoides dalli* (True, 1885). Tomilin and Smyshlyayev (1968) reported that a "nematode *Stenurus minor* attacks the hearing organs of the Black Sea porpoise *Phocaena* and by clogging the cavity around the earbone may kill its host or severely complicate its existence." Brodie (1971) reported *Crassicauda* sp. as a middle ear parasite of the white whale, *Delphinapterus leucas* Pallas, 1776, in Cumberland Sound, Baffin Island. Yamada (1956) examined skulls of approximately 80 false killer whales, *Pseudorca crassidens*, from a stranded group of approximately 150 and found "basket-like" lesions in the pterygoid region of 40 skulls. He ascribed the damage to parasitic infection, "most probably by nematodes," and stated that such damage is a common occurrence in *Grampus* and *Globicephala* in Japanese waters.

Trematoda

The trematodes recovered during this study are represented by two genera known from marine mammals and three specimens of one genus that has been found in teleost hosts.

***Zalophotrema pacificum* sp. n.**
(Figures 9 and 10)

Description: Based on measurements from 26 specimens. With characteristics of the genus. Body elongate. Dorsoventrally flattened, 10 mm (8.3-12.6) long by 1.7 mm (1.4-2.0) wide. Cuticle spinose. Oral sucker 535 μ (398-592) long by 575 μ (439-673) wide; opening slightly subterminal. Pharynx pyriform, 494 μ (398-541) long by 314 μ (255-367) wide. Intestinal cecum bifurcates immediately caudad to pharynx with each lateral branch dividing into short anterior and long posterior portions. Both anterior and posterior cecal branches contain numerous diverticula; anterior branch terminating lateral to posterior edge of oral sucker, posterior branch terminating near posterior end of body. Excretory pore terminal. Acetabulum 600 μ (520-710) in diameter, located approximately mid-body. Cirrus unarmed. Testes large, lobed, in tandem and extending posterior to equatorial third of body. Ovary pretesticular, lobed, 333 μ (235-418) long by 477 μ (310-765) wide. Mehlis's gland posterior and dorsal to ovary. Uterus coiled, preovarian. Genital pore just preacetabular. Vitellaria follicular, occupying entire anterior half of body from level of genital pore to shoulder region of ceca, extending posterior from genital pore in lateral bands to posterior end of body. Eggs, oblong, operculate, round in cross-section, mean measurements of 20 eggs, 61 μ long by 42 μ wide.

Hosts: *Stenella longirostris*, *Stenella graffmani*.

Location: Pancreatic duct.

Locality: Eastern tropical Pacific Ocean; holotype from *S. graffmani* collected at lat 12°5'N, long 93°18'W.

Type specimen: USNM Helm. Coll. No. 72158.

Remarks: Currently there are three species in the genus *Zalophotrema* (Stunkard and Alvey, 1929): *Z. hepaticum* Stunkard and Alvey, 1929, described from the bile ducts of a California sea lion, *Zalophus californianus* (Lesson, 1828), at the New York Aquarium; *Z. curilensis* Gubanov, 1952, from the bile ducts of

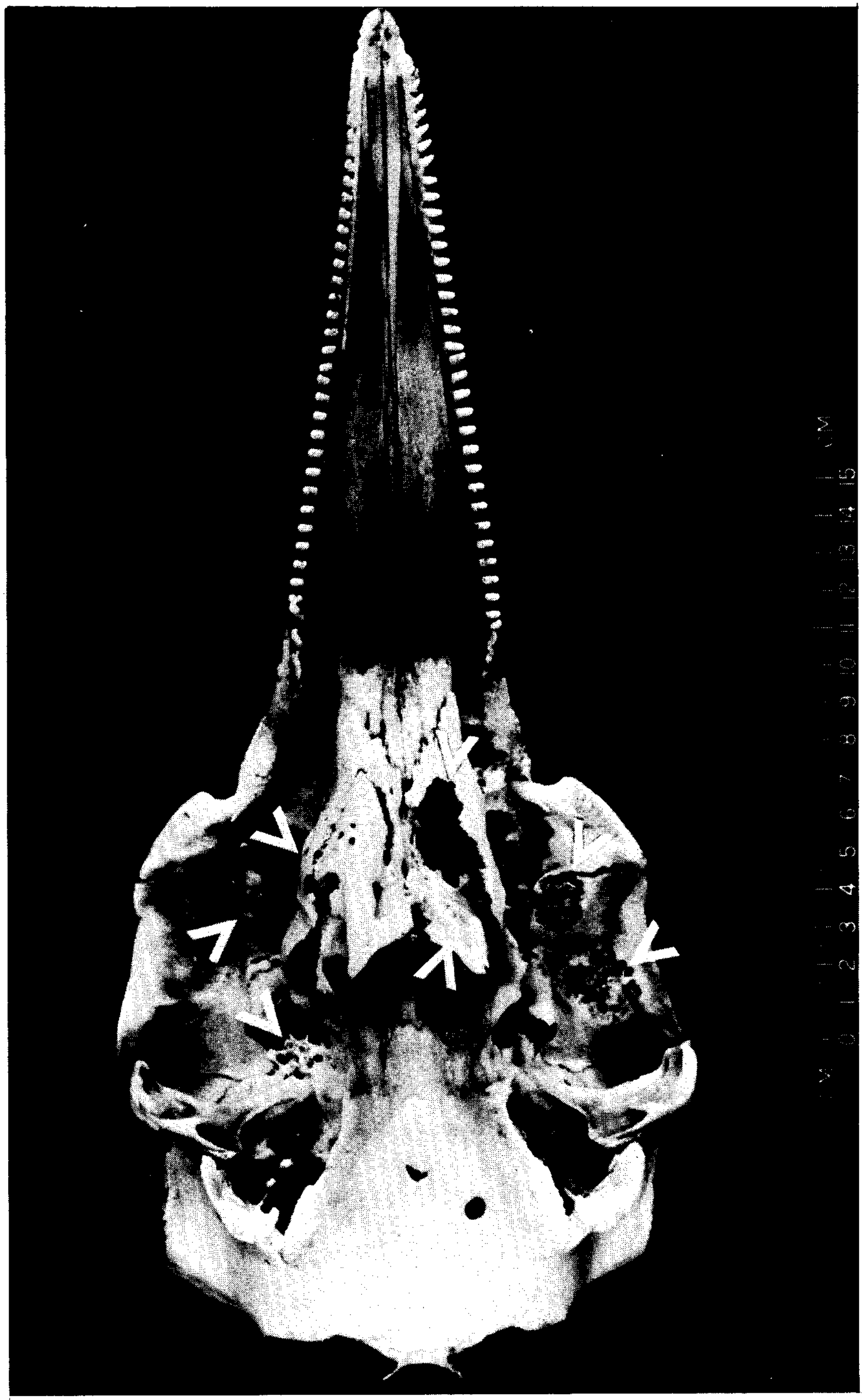
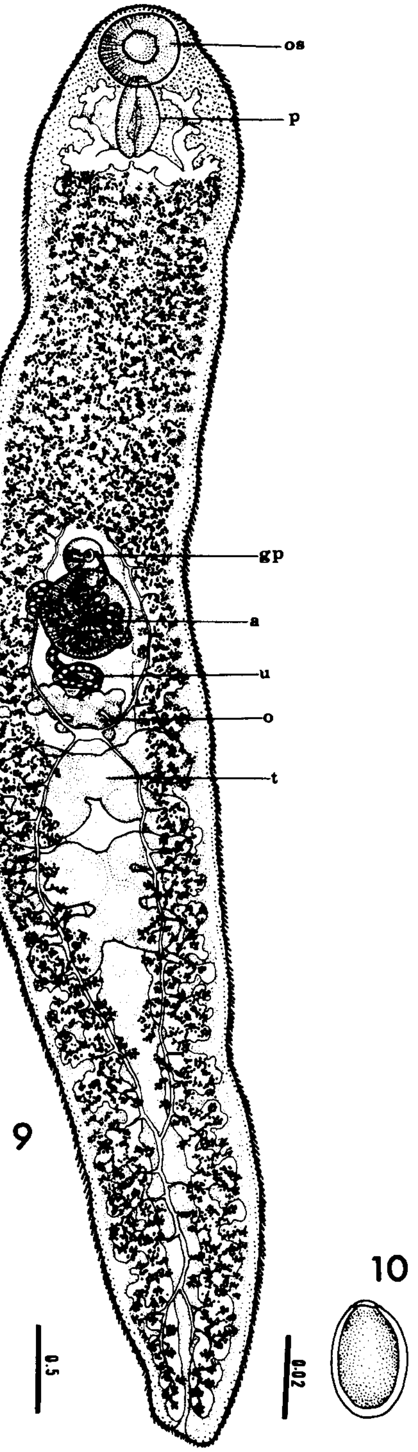


FIGURE 8.—Ventral view of skull of spotted porpoise, *Stenella graffmani*, showing bone lesions (arrows).



a sperm whale, *Physeter catodon* L; and *Z. lubimowi* Petrov and Chertkova, 1963, from the liver of a southern sea lion, *Otaria byronia* (Blainville, 1820) at the Moscow Zoo. *Zalophotrema pacificum* sp. n. can be easily separated from the three previously described species. *Z. lubimowi* differs from all other species in the genus in that it does not have confluent vitellarian fields anteriorly. *Z. curilensis* differs from *Z. pacificum* by larger body size (18-22.5 mm long by 5-7 mm wide) as well as the acetabulum being larger than the oral sucker. *Z. pacificum* sp. n. is most similar to *Z. hepaticum* in general body shape but differs in the following characteristics: body width (*Z. hepaticum* 3.0-3.6 mm wide), sucker ratio (in *Z. hepaticum* oral sucker almost twice as large as acetabulum while in *Z. pacificum* sp. n. suckers are approximately same size), ratio of distance between suckers to body length (*Z. hepaticum* 1:13, *Z. pacificum* sp. n. 1:2.5), distribution (percentage) of preacetabular vitellaria (*Z. hepaticum* nearly twice as large as those of Z. pacificum sp. n.), and egg size (75 μ long by 50 μ wide in *Z. hepaticum*).

Campula rochebruni (Poirier, 1886) Bittner et Sprehn, 1928

This parasite was recovered from the stomachs and hepatopancreatic ducts of three (two *S. graffmani* and one *S. longirostris*) of 78 (3.9%) animals examined. This is a new host record for this parasite and represents the first report from the genus *Stenella*. *C. rochebruni* was originally described from *Delphinus delphis* L. in European waters.

Incidental Trematodes

Three specimens of the genus *Hirudinella*

FIGURES 9-10.—*Zalophotrema pacificum* sp. n. 9. Entire worm, ventral view; 10. egg. Abbreviations used: a - acetabulum; gp - genital pore; o - ovary; os - oral sucker; p - pharynx; t - testis; u - uterus.

Garsin, 1730, were recovered from the forestomachs of three hosts (two *S. longirostris* and one *S. graffmani*). Members of this genus are commonly parasites of teleost fishes and were probably ingested with a meal of fish and not established parasites of these hosts.

Cestoda

Tetrabothrium forsteri **(Krefft, 1871) Fuhrmann, 1904**

This cestode was recovered from the intestine of over 50% of the examined hosts and occurred in both *S. graffmani* and *S. longirostris*. This is the first report of this parasite from either of these hosts. *T. forsteri* (Krefft, 1871) was first described by Krefft (1871) under the name of *Taenia forsteri* from *Delphinus delphis* L. (= *D. forsteri*) caught off the coast of New Zealand and later transferred to the genus *Tetrabothrium* by Fuhrmann (1904). A complete review of the literature on this species is given by Delyamure (1955).

Strobilocephalus triangularis **(Diesing, 1850) Baer, 1932**

This tetrabothriid has a complex taxonomic history that is covered by Delyamure (1955). The parasite apparently anchors its scolex in the colon wall when small and grows inside a fibrotic capsule formed by the host (Figures 11 and 12). This is the first report of this parasite from the genus *Stenella*. It has been reported from the Pacific Ocean by Baer (1955), who described material taken from an unidentified dolphin captured in the waters of the Marshall Islands. There are numerous reports of the parasite from Atlantic Ocean hosts (*Hyperoodon ampullatus*) (Forster, 1770) (= *H. rostratus*), *Mesoplodon bidens* (Sowerby, 1804), *Lagenorhynchus acutus* (Gray, 1828), *Steno bredanensis* Lesson, 1828 (= *S. frontatus*), *Delphinus* sp. (Delyamure, 1955).

Phyllobothrium delphini **(Bosc, 1802) and *Monorygma grimaldii*** **(Moniez, 1881) Baylis, 1919**

These larval cestodes were recovered from

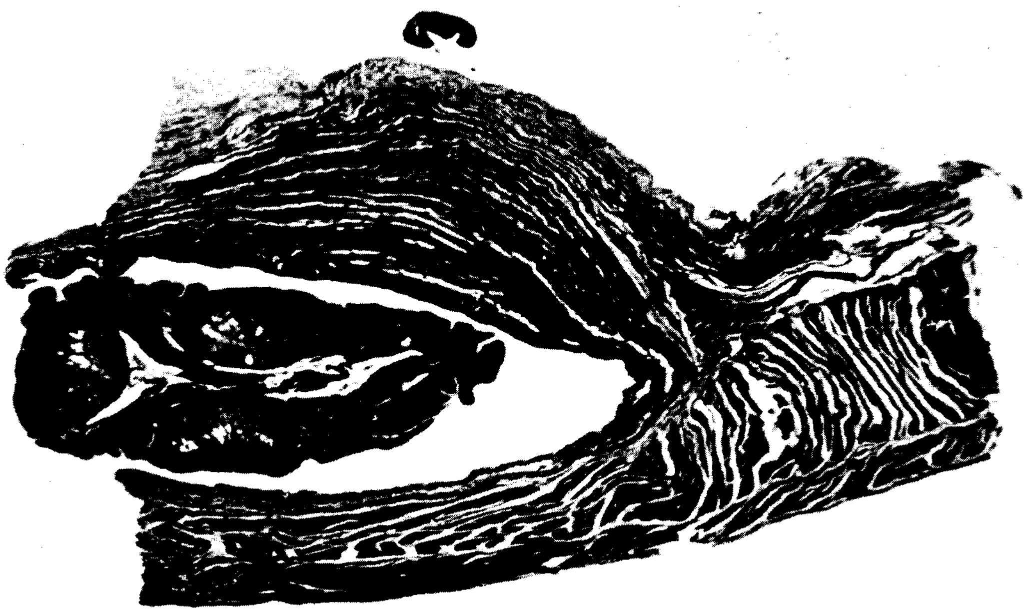


FIGURE 11.—Section through the capsule and scolex of *Strobilocephalus triangularis* from the rectum of *S. graffmani*. (X10.5)

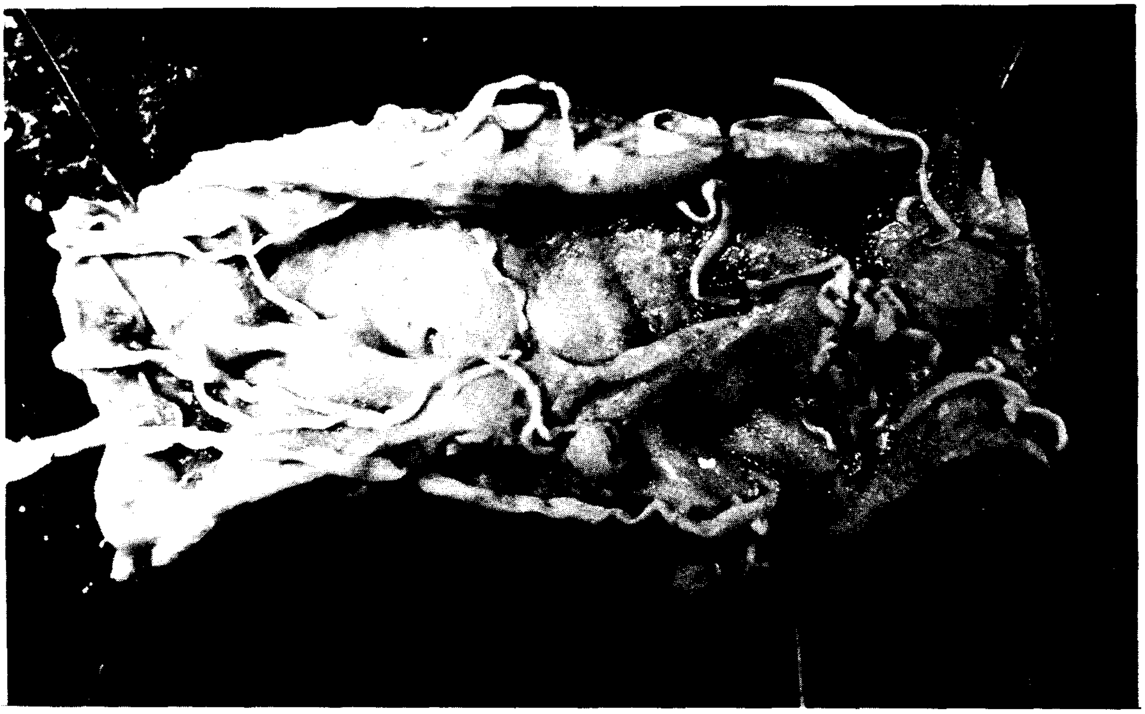


FIGURE 12.—*Strobilocephalus triangularis* attached in rectum of *Stenella graffmani*. (X1)

a large proportion of the animals examined. The history of these worms has been discussed by Delyamure (1955), Dollfus (1964), Williams (1968), and Dailey and Brownell (1972). *P. delphini* was always found in the blubber and *M. grimaldii* in the mesenteries.

PARASITE LOAD RELATIVE TO AGE OF HOST

The availability of data for a large sample of porpoise specimens, especially of *S. graffmani*, dissected in relatively uniform manner provides an unique opportunity to examine infection relative to age of the host for certain of the more frequently encountered parasite species. We discuss only the parasite species for which patterns of infestation are apparent in the data.

Spotted Porpoise, *Stenella graffmani*

The sample of *S. graffmani* examined may be divided into four age classes on the basis of total length, the developmental pattern categories defined by Perrin (1970b) and degree of sexual maturity (Figure 13). Females were classified as adult by the presence of corpora of ovulation in the ovaries and males by presence of spermatogenesis in the seminiferous tubules, as determined by histological examination. Sixty-one of the 72 specimens were collected during a 1-month period, and the first three modes probably represent discrete reproductive cohorts. Analysis below of parasitism relative to age is in terms of the four age classes, except as noted in the case of the *Crassicauda*-like nematode in the air sinuses.

The percent infection for *Anisakis* in *S. graffmani* shows increase with age of the host (Figure 14), but very large numbers of worms were found only in subadults, and the parasite number frequency distribution for that class is obviously skewed to the right. The inference to be drawn is that either some reduction in number of worms occurs in a heavily infected porpoise as it matures, due to the life cycle

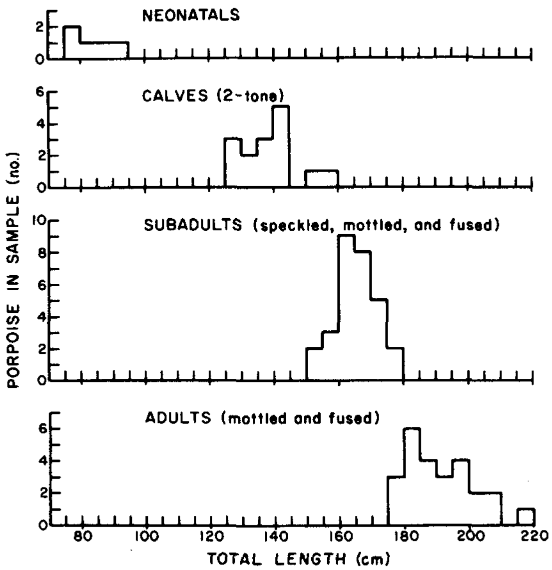


FIGURE 13.—Frequency distributions of total length, by age class, of spotted porpoise, *Stenella graffmani*, included in sample examined for parasites.

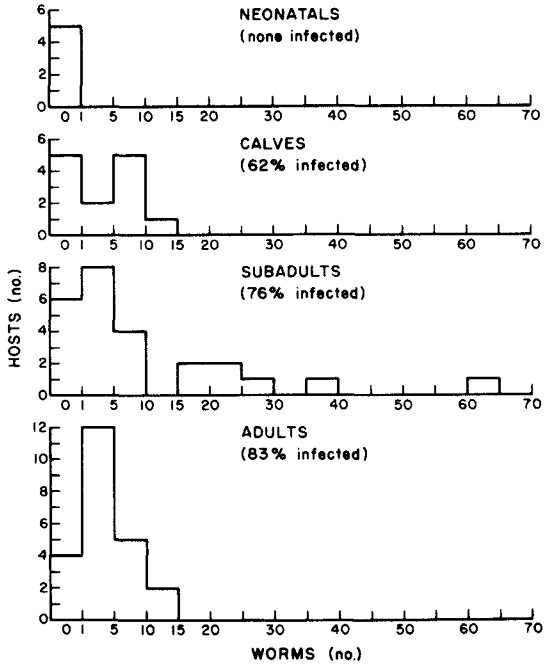


FIGURE 14.—Frequency distributions of levels of infection by *Anisakis* in four age classes of *Stenella graffmani*.

of the parasite and/or to possibly differential feeding habits of young and mature porpoise, or heavily infected individuals die before attaining maturity.

The case of the *Crassicauda*-like parasite in the air sinuses of *S. graffmani* certainly provides the most dramatic instance of infection varying with age. As stated above, the sinuses were not searched during dissection of most of the porpoise specimens, and only one specimen of the *Crassicauda*-type was recovered. Direct evidence, however, is provided of heavy infection by the areas of bone erosion on the lower surfaces of the skull (as illustrated in Figure 8). Given this circumstance, we expanded the series of porpoise specimens examined to include skeletal specimens in various museum collections. In all, 129 skulls of spotted porpoise from the eastern tropical Pacific were examined (see Materials and Methods). Since correlated data on size, reproductive condition, and color pattern were not available for most of the museum specimens examined, it was necessary to use other criteria of age for those specimens. The fetal and neonatal skulls examined were all from specimens we dissected. Those of the remaining skulls that were museum specimens were relegated to the three categories of calves, subadults, and adults by criteria of cranial features, using the sample of skulls from specimens we dissected to correlate these features with total length, sexual maturity, and color pattern. Museum skulls were assigned to the calf class when in condylobasal length, telescoping of facial elements, and closure of occipital sutures, they had not reached the adult condition. Skulls exhibiting adult length, telescoping, and occipital closure were divided into adults and subadults by the criterion of presence or absence of distal fusion of the premaxillary and maxillary bones of the rostrum. Rough correlation of the onset of fusion with attainment of sexual maturity was found among the skulls from specimens for which external data were also available (Table 1. Errors in classifying subadult skulls as adult and vice versa are approximately equal. Results of examination of the 129 skulls for bone damage (Table 2) demonstrate clearly that the rate of infection is very much higher in

TABLE 1.—Incidence of distal fusion of pmx (premaxillary) and mx (maxillary) bones in specimens of *Stenella graffmani*.

Age class[1]	Examined	Pmx and mx fused	Error in classification
Subadults	31	6	19.4%
Adult	21	18	14.3%

[1] As determined by criterion of total length, color pattern, and sexual maturity.

TABLE 2.—Lesions of the ventral side of the skull in *Stenella graffmani*, presumably due to infection by a *Crassicauda*-like nematode.

Age class	Range of condylobasal length	Examined	Lesions present
	(mm)		
Nearterm fetuses and neonatals	209-236	10	0
Calves	302-359	18	8 (44.4%)
Subadults	356-446	45	5 (11.1%)
Adults	360-466	56	4 (7.1%)
Total		129	17 (13.2%)

calves than in subadults or adults. What is more, the most severely damaged skulls were those of calves. Such extensive damage is certainly irreversible, in that if repaired, traces would still be apparent in the form of bone callouses, depressions, or altered shape of bone elements. No such traces were found in any of the adult skulls examined, although we searched for them carefully. We conclude, therefore, that heavy damage is indicative of a probably morbid condition and that parasitism or a correlated condition is a significant factor in natural mortality of the spotted porpoise in the eastern tropical Pacific.

The patterns of infection relative to age by cysts of the cestodes *Monorygma* and *Phyllobothrium* (Figure 15) closely resemble each other, with little or no occurrence before subadulthood and 100% occurrence and greatest numbers in adults. As these are larval forms, the cysts presumably would have to be ingested by predators of the porpoise in order for the life cycles of the parasites to progress. Killer whales, *Orcinus orca*, have been observed by Perrin to prey on spotted porpoise, and sharks of several species have been observed to feed on dead and injured spotted porpoise during tuna fishing operations (Leatherwood, Perrin, Garvie, and La Grange, manuscript).[4] Killer whales and/or sharks are therefore possible candidates for terminal hosts of these two cestodes, although adult Tetraphyllidea have only been found in elasmobranchs. However, a life cycle involving a warm blooded intermediate host serving a cold blooded definitive host has not been previously demonstrated.

The two nonlarval cestodes, *Tetrabothrium forsteri* (Figure 16) and *Strobilocephalus triangularis* (Table 3), exhibit different patterns of occurrence, more like those of the nematodes, occurring with greatest numbers and frequencies in calves in the case of *T. forsteri* and in calves and subadults in the case of *S. triangularis*. This was especially striking for *S. triangularis*. In the two calves and two subadults with extremely heavy infections, the last meter of the intestine was all but blocked and swollen to three or four times its normal diameter. No adult examined was found to be infected with *S. triangularis*.

Spinner Porpoise, *Stenella* cf. *S. longirostris*

The smaller sample of spinner porpoise was divided into three age classes on the basis of length and sexual maturity, with subadults again defined as immature animals of adult size. Despite the small number of data for the spinner (Appendix Table 2), some differences are apparent between the patterns of infection for this species and for *S. graffmani*. For *Anisakis*, the specimen with the greatest number of worms (CV285) was a large adult female, which contrasts with the finding for *S. graffmani*, in which heaviest infections occurred in subadults. Bone erosion suggesting severe infection of the ventral air sinuses by a nematode was encountered in only 1 skull (of a subadult) of 53 examined. The parasite specimen was not recovered, precluding identification, but the damage was similar to that caused by the *Crassicauda*-like nematode in *S. graffmani*.

[4] Leatherwood, J. S., W. F. Perrin, R. L. Garvie, and J. C. La Grange. Observations of sharks attacking porpoise (*Stenella* spp.). (Unpubl. manuscr.)

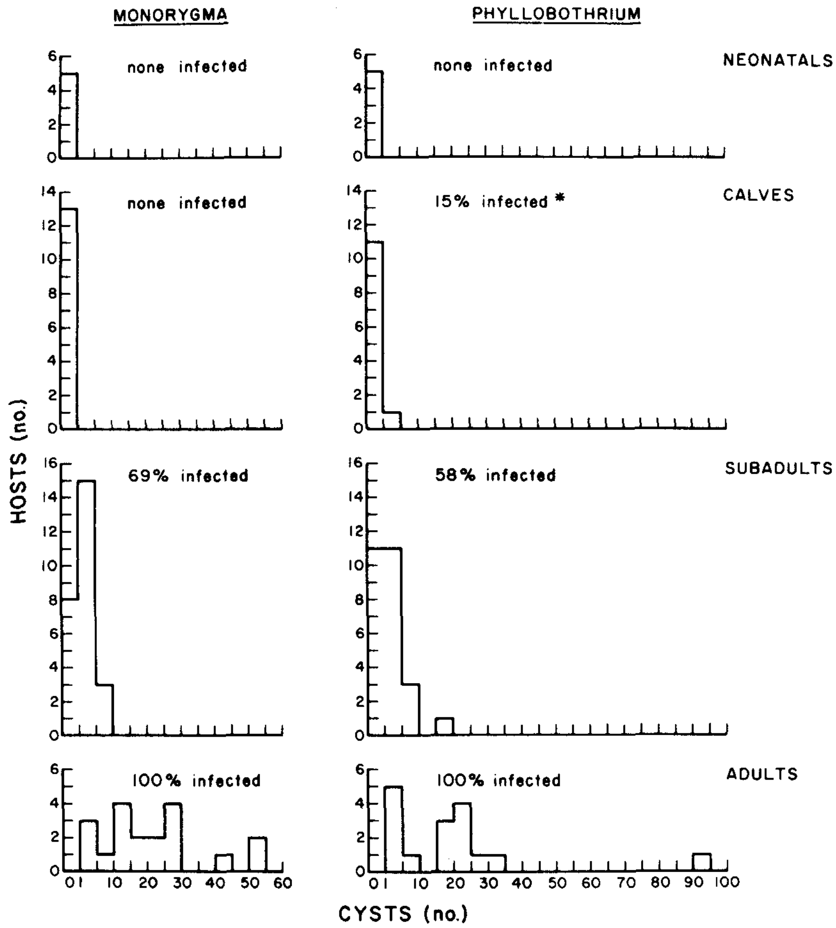


FIGURE 15.—Frequency distributions of levels of infection by cysts of *Monorygma grimaldii* and *Phylobothrium delphini* in four age classes of *Stenella graffmani*.

Infection by cestode cysts showed the same pattern as in *S. graffmani*, except that one adult specimen was found to be free of *Phyllobothrium* cysts. Also, as in *S. graffmani*, calves were most heavily infected with *T. forsteri*, and *Strobilocephalus triangularis* was encountered only in an immature specimen, a calf.

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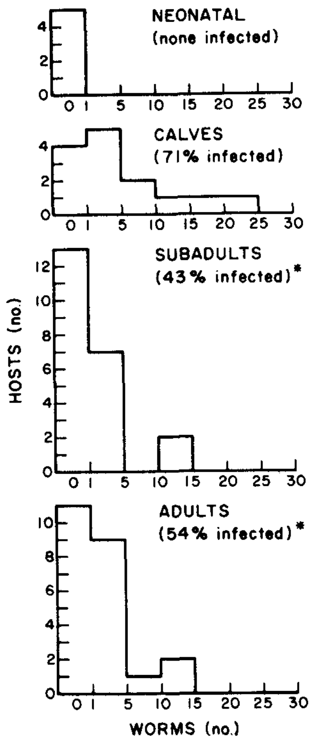

FIGURE 16.—Frequency distributions of levels of infection by *Tetrabothrium forsteri* in four age classes of *Stenella graffmani*.

TABLE 3.—*Strobilocephalus triangularis* in *Stenella graffmani*.

Age class	Examined	Infected
Neontals	5	0
Calves	14	3 (21.4%)
Subadults	26	3 (11.5%)
Adults	23	0
Total	68	6 (8.8%)

Los Angeles County Museum; Joseph R. Jehl, Jr., San Diego Museum of Natural History; and Charles O. Handley, Jr., U.S. National Museum, kindly made materials in their charge available for study.

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APPENDIX TABLE 1.—Parasites in *Stenella graffmani*.

Host						Parasites noted										
Field number	Museum number of skeletal specimen[1]	Collection number or locality[2]	Length (cm)	Sex	Age class[3]	*Anisakis simplex*	*Halocercus delphini*	*Mastigonema stenellae* sp. n.	*Zalophotrema pacificum* sp. n.	*Campula rochebruni*	*Tetrabothrium forsteri*	*Strobilocephalus triangularis*	*Phyllobothrium delphini*	*Monorygma grimaldii*	*Bolbosoma vasculosum*	*Bolbosoma balanae*
CV259	USNM395276	6	1,676	M	3	0	—	0	0	0	2	0	0	0	0	0
CV260	USNM395277	6	1,750	F	4	1	—	0	0	0	0	0	1	3	0	0
CV261	USNM395278	2	1,657	F	3	1	—	0	0	0	0	0	0	2	1	0
CV262	USNM395279	2	1,646	F	3	20	—	0	0	0	1	1	0	0	0	0
CV263	USNM395328	6	1,759	M	3	35	—	0	0	0	0	0	0	5	0	0
CV264	USNM395329	6	1,716	M	3	0	—	0	0	0	2	0	18	7	0	0
CV265	USNM395330	2	1,954	M	4	1	—	0	0	0	4	0	20	26	0	2
CV266	USNM395331	2	1,681	M	3	1	—	0	0	0	0	+	0	2	0	0
CV267	USNM395332	2	1,787	M	4	2		0	0	0	0	0	18	23	0	0
CV268	USNM395333	2	1,900	F	4	4	—	0	0	0	2	0	—	27	0	0
CV269	USNM395334	2	1,837	F	4	2	—	0	0	0	0	0	—	14	0	0
CV270	USNM395336	2	1,815	F	4	0	—	0	0	0	1	0	5	52	0	1
CV271	USNM395337	2	1,821	F	4	8	—	0	0	0	0	0	—	13	0	0
CV272	USNM395338	2	1,850	F	4	0	—	0	0	0	2	0	25	45	0	1
CV273	USNM395339	2	1,630	M	3	61	—	0	0	0	0	0	0	1	0	1
CV274	USNM395385	6	1,782	M	3	0	—	0	0	0	+	0	0	5	0	0
CV275	USNM395386	6	1,570	M	3	2	—	0	0	0	1	0	8	3	0	0
CV276	USNM395387	6	1,578	M	3	16	—	0	0	0	0	0	0	1	0	0
CV277	USNM395388	2	1,816	F	4	8	—	0	0	0	0	0	5	2	0	1
CV278	USNM395389	6	1,632	M	3	18	—	0	0	0	0	0	2	0	0	0
CV279	USNM395390	6	2,183	M	4	8	—	0	0	0	5	0	27	50	2	0
CV280	USNM395391	6	2,032	M	4	14		0	0	0	5	0	32	14	0	0

APPENDIX TABLE 1.—Parasites in *Stenella graffmani*.—*Continued.*

Host						Parasites noted										
Field number	Museum number of skeletal specimen[1]	Collection number or locality[2]	Length (cm)	Sex	Age class[3]	*Anisakis simplex*	*Halocercus delphini*	*Mastigonema stenellae* sp. n.	*Zalophotrema pacificum* sp. n.	*Campula rochebruni*	*Tetrabothrium forsteri*	*Strobilocephalus triangularis*	*Phyllobothrium delphini*	*Monorygma grimaldii*	*Bolbosoma vasculosum*	*Bolbosoma balanae*
CV281	USNM395392	6	1,739	F	3	27	—	0	0	0	+	0	1	1	0	0
CV282	USNM395393	6	1,740	F	3	2	—	0	0	0	2	0	6	4	0	0
CV283	USNM395394	6	2,021	M	4	5	—	0	0	0	13	0	90	28	0	0
CV284	USNM395395	2	1,927	F	4	0	—	0	0	0	0	0	—	—	0	1
CV286	USNM395397	2	1,647	M	3	0	—	0	0	100+	0	0	3	2	2	0
CV287	USNM395417	2	1,732	M	3	0	—	0	0	0	0	0	4	7	0	0
CV289	USNM395594	2	1,767	M	4	0	0	0	0	0	2	0	3	4	0	0
CV290	USNM395595	2	1,627	F	3	0	0	0	0	0	6	0	0	1	0	0
CV291	USNM395596	6	1,927	F	4	1	—	0	0	0	0	0	24	9	0	0
CV292	USNM395597	2	1,895	M	4	5	0	0	34	5	15	0	—	—	0	0
CV293	USNM395598	6	1,996	M	4	2	—	0	0	0	0	0	5	12	0	0
CV295	USNM395527	6	1,390	M	2	9	0	0	0	0	19	0	0	0	1	2
CV296	USNM395528	2	1,298	M	2	0	0	0	0	0	0	+	0	0	0	0
CV297	USNM395529	6	1,429	F	2	2	0	0	0	0	1	0	0	0	0	2
CV298	USNM395530	2	1,540	M	3	4	0	0	0	0	5	+	0	0	0	0
CV300	USNM395532	6	1,438	M	2	11	0	0	0	0	20+	0	0	0	2	2
CV303	USNM395535	6	1,433	M	2	0	0	0	0	0	4	0	0	0	0	0
CV304	USNM395458	2	862	M	1	0	0	0	0	0	0	0	0	0	0	0
CV305	USNM395459	2	780	F	1	0	0	0	0	0	0	0	0	0	0	0
CV306	USNM395460	6	913	M	1	0	0	0	0	0	0	0	0	0	0	0
CV307	USNM395461	2	803	F	1	0	0	0	0	0	0	0	0	0	0	0
CV308	USNM395466	6	793	F	1	0	0	0	0	0	0	0	0	0	0	0
CV309	USNM395463	6	1,878	F	4	9	0	0	0	0	9	0	21	26	0	0
CV310	USNM395464	2	1,801	M	4	3	0	0	0	0	1	0	21	17	0	0
CV311	USNM395465	6	1,995	M	4	4	0	0	0	0	3	0	18	23	0	0
CV312	USNM395462	2	1,640	F	3	7	0	0	0	0	0	0	1	0	0	0
CV313	USNM395467	2	1,601	M	3	8	0	0	0	0	5	0	0	2	0	0
CV314	USNM395468	2	1,842	F	4	1	0	0	0	0	0	0	+	+	0	0
CV315	USNM395603	2	1,621	M	3	7	+	0	0	0	12	0	3	5	0	0
CV316	USNM395604	2	1,679	M	3	12	0	0	0	0	0	0	1	4	0	0
CV317	USNM395605	2	1,375	M	2	7	0	0	0	0	5	0	0	0	0	2
CV318	USNM395606	2	1,444	F	2	8	0	0	0	0	0	0	0	0	0	0
CV319	USNM395607	6	1,681	F	3	2	0	0	0	0	1	0	5	0	0	0
CV320	USNM395608	2	1,670	M	3	20	+	0	0	0	13	0	7	0	0	0
CV321	USNM395609	2	1,525	M	3	1	0	0	0	0	0	0	1	0	0	0
CV322	USNM395610	6	1,423	F	2	9	0	0	0	0	6	0	0	0	0	0
CV323	USNM395611	2	1,617	M	3	5	0	0	0	0	0	0	4	2	0	0
CV324	USNM395612	6	1,356	F	2	0	0	0	0	0	13	0	+	0	0	0
CV325	USNM395613	6	1,348	M	2	4	+	0	0	0	8	0	1	0	2	2
PQ01	USNM395407	lat ~8°N, long 107°W	1,978	M	4	3	—	0	0	0	0	0	5	18	0	0
PQ02	USNM395408	lat ~8°N, long 107°W	1,590	M	2	7	—	0	0	0	0	+	0	0	0	0
[4]PQ04	USNM395410	lat ~8°N, long 107°W	1,677	F	3	3	—	0	0	0	0	0	2	8	1	0
WFP10	CAS15662	lat ~14°N, long 100°W	1,865	F	4	11	—	0	0	0	0	0	—	—	0	0
WFP11	UCMP86284	lat ~14°N, long 99-108°W	1,304	M	2	—	+	—	—	—	—	+	—	—	—	—
WFP12	MVZ140640	lat ~14°N, long 100°W	1,671	M	3	—		—	—	—	—	0	—	—	—	—
WFP13	UCMP23071	lat ~10°N, long 100°W	1,572	M	3	—	0	—	—	—	—	—	—	—	—	—
WFP19	CAS15663	lat ~10°N, long 100°W	1,536	M	3	—	0	—	—	—	—	—	—	—	—	—
WFP20	MVZ140643	lat ~10°N, long 100°W	1,708	F	3	—	0	—	—	—	—	—	—	—	—	—
WFP3	LACM37549	lat 14°30′N, long 99° 10′W	1,252	F	2	0	0	0	0	0	2	0	0	0	0	2
WFP4	LACM37550	lat 14°30′N, long 99° 10′W	1,260	M	2	0	0	0	0	0	0	0	0	0	0	0

[1] CAS = California Academy of Sciences, San Francisco
LACM = Los Angeles County Museum
MVZ = Museum of Vertebrate Zoology, University of California, Berkeley
USNM = United States National Museum, Washington, D.C.

[2] Locality for collection number 2: lat 12°51′N, long 93° 18′W
Locality for collection number 6: lat 7° 11′N, long 90°32′W

[3] 1 = near term fetus or neonatal
2 = calf
3 = subadult
4 = adult

[4] This specimen also infected with *Crassicauda.*

APPENDIX TABLE 2.—Parasites in *Stenella* cf. *S. longirostris*.

Host						Parasites noted										
Field number	Museum number of skeletal specimen[1]	Collection number or locality[2]	Length (cm)	Sex	Age class[3]	*Anisakis simplex*	*Halocercus delphini*	*Mastigonema stenellae* sp. n.	*Zalophotrema pacificum* sp. n.	*Campula rochebruni*	*Tetrabothrium forsteri*	*Strobilocephalus triangularis*	*Phyllbothrium delphini*	*Monorygma grimaldii*	*Bolbosoma vasculosum*	*Bolbosoma balanae*
CV285	USNM395396	2	1,769	F	4	56	—	0	50+	50+	3	0	27	13	2	0
CV288	USNM395593	6	1,726	F	4	2	—	0	—	—	—	—	+	+	—	—
CV294	USNM395526	6	1,494	F	2	1	+	0	0	0	10	0	8	0	1	0
CV299	USNM395531	2	1,189	M	2	4	0	0	0	0	5	0	0	0	0	4
CV301	USNM395533	2	1,396	F	2	0	0	0	0	0	0	0	0	0	2	0
CV302	USNM395534	2	1,184	M	2	9	0	0	0	0	20+	0	0	0	0	1
PQ03	USNM395409	lat ~8°N, long 107°W	1,571	F	3	8	0	0	0	0	8	0	8	2	2	6
PQ05	USNM395411	lat ~8°N, long 107°W	1,680	F	4	5	—	0	0	0	0	0	13	13	0	0
PQ06	USNM395412	lat ~8°N, long 107°W	1,729	F	4	9	—	1	0	0	0	0	0	4	1	0
PQ07	USNM395413	lat ~8°N, long 107°W	1,761	F	4	9	—	0	0	0	0	0	8	6	1	0
PQ08	USNM395414	lat ~8°N, long 107°W	1,734	M	4	1	—	0	0	0	2	0	7	17	0	0
PQ09	USNM395599	lat ~8°N, long 109°45′W	1,727	M	4	1	0	0	0	0	0	0	21	8	1	2
PQ10	USNM395600	lat ~8°N, long 107°W	1,086	F	2	7	—	0	0	0	0	0	0	0	0	1
PQ11	USNM395601	lat 8°N, long 109°45′W	1,054	F	2	0	—	0	0	0	6	+	0	0	0	1
WFP14	CAS15664	lat ~14°N, long 99-108°W	1,618	F	4	—	+	—	—	—	—	—	—	—	—	—
WFP15	CAS15665	lat ~14°N, long 100°W	1,637	M	4	—	+	—	—	—	—	—	—	—	—	—
WFP21	MVZ140641	lat ~14°N, long 100°W	1,651	M	3	—	+	—	—	—	—	—	—	—	—	—
WFP22	CAS15668	lat ~10°N, long 100°W	1,750	M	4	—	—	—	—	—	—	—	—	—	—	—
WFP6	LACM37551	lat 10°40′N, long 108°40′W	896	F	2	0	0	0	0	0	0	0	0	0	0	0

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[2] Locality for collection number 2: lat 12°51′N, long 93°18′W
Locality for collection number 6: lat 7°11′N, long 90°32′W

[3] 1 = near term fetus or neonatal
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3 = subadult
4 = adult

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