PARASITES OF THE GRUNION, *LEURESTHES TENUIS* (AYRES)

by

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INTRODUCTION

The grunion, *Leuresthes tenuis* (Ayres), has been the subject for several papers (13, pp. 1-27; 3, pp. 1-51; 4, pp. 49-54; 14, pp. 1-166; 15, pp. 409-420) but only Pearse (10, pp. 332-333) has mentioned a grunion parasite. He described a new species of parasitic copepod, *Caligus olsoni*, which I had submitted to him for identification in connection with the preliminary stages of this study.

This work was undertaken in an effort to determine the numbers and kinds of helminths and arthropods which parasitize grunion during their breeding season. Some of the data appear to corroborate the conclusions of Walker (15, p. 420) that the grunion populations are relatively static, at least during the spawning season.

MATERIALS AND METHODS

On 29 occasions between June 1949 and August 1954 from 8 localities between San Clemente, Orange County, California and

Estero Beach, Bahia de Todos Santos, Baja California (fig. 1) 1977 grunion were collected at night on the various beaches in accordance with the laws of the State of California. The freshly collected fish were taken to the laboratory and refrigerated as soon as possible until detailed examinations could be made. For certain collecting periods of the 1954 season at least 20 fish as collected were placed individually into plastic bags. This permitted an accurate count of the incidence of external parasites for a considerable number of specimens.

During the 1954 season collections from 4 localities were made on consecutive run periods. This was done in order to be able to compare the incidence of grunion parasites at different beaches. The beaches and collection dates were San Clemente, Orange County, California, May 5; Estero Beach, Bahia de Todos Santos, Baja California, May 20; South Pylon, San Diego Bay, California, June 3; and Coronado Strand, San Diego County, California, June 19 (fig. 1). From each collection, 10 representative fish of each sex were chosen for examination.

The fish were examined first for external parasites including those found in the gills and in the mouth. An opening was made into the space surrounding the anterior end of the dorsal aorta and trematodes were recovered when present. The viscera were exposed and examined for coelomic parasites. The various portions of the gut were usually examined individually for parasites. The brain case and brain of considerable numbers of fish

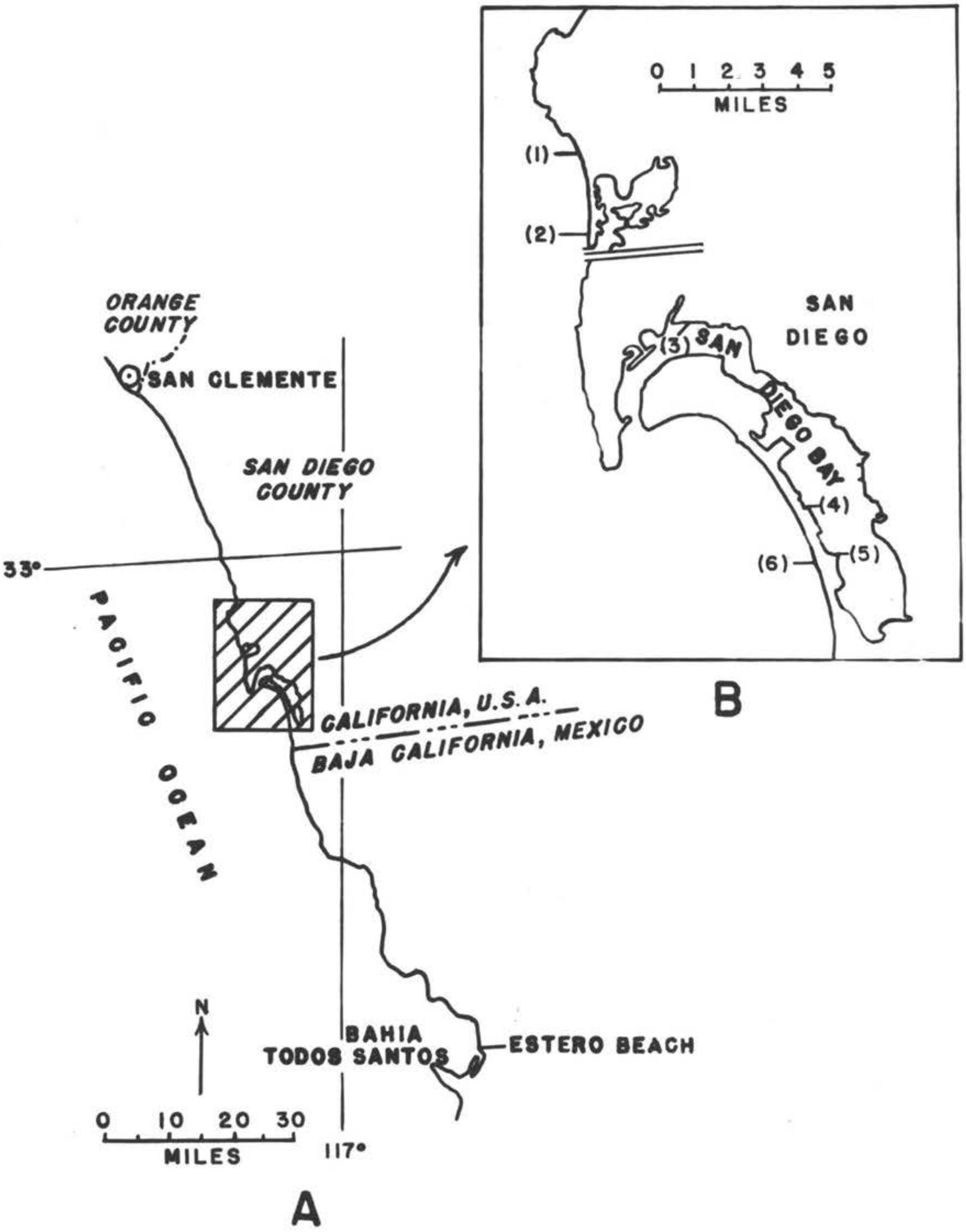

Figure 1. Maps showing beaches on which grunion, Leuresthes tenuis (Ayres), collections were made. Insert B represents the slant-line area of A. (1) = Pacific Beach; (2) = Mission Beach; (3) = 1/2 mile west of the Institute of Aeronautical Science; (4) = 3 miles southeast of Hotel del Coronado; (5) = South Pylon; and (6) = Coronado Strand.

were examined. Some fish were digested in pepsin-HCl mixture in order to recover encysted larval stages after the method of Nolan and Bozicevich (7, p. 652).

Five caspian terns, Hydroprogne caspia, which were hatched out in the laboratory were fed larval parasites from the grunion. The birds lived only a few days. As soon as possible after death the birds were examined and parasites were recovered. Adult Galactosomum humbargari Park were found to have developed. Trematodes and larval tapeworms were fixed in alcohol-formalin-acetic acid mixture or in Bouin's fluid. The nematodes were placed into hot 70% ethyl alcohol, and the copepods and isopods were placed into 70% ethyl alcohol.

The flatworms were stained in Mayer's carmalum or Delafield's hematoxylin. Nematodes were cleared and mounted in Turtox CMC-10 or glycerin jelly. Copepods were mounted in either diaphane or Turtox CMC-10.

All of the drawings are original and were made with the aid of a camera lucida.

DATA

Trematoda

Monogenetic fluke. Specimens of a monogenetic fluke belonging to the family Microcotylidae have been sent to Emmett W. Price who is preparing a description of this species. By letter he has stated that this form will be assigned to a new genus closely related to but not identical with the present genus Heteraxine. This undescribed form is illustrated by figure 3, plate I. As many as 8 were recovered from the gills of 1 grunion.

Asymphlodora atherinopsidis Annereaux (fig. 5, pl. I) was confirmed as the correct identification for this trematode by Harold W. Manter. This species was recovered from the intestine of the grunion. The single original specimen from which this species was described (2, pp. 249-255) was taken from the jack-smelt, Atherinopsis californiensis, at Stinson's Beach in central California, therefore this constitutes new host and distribution records. The anterior portion of the intestinal caeca and esophagus were apparently not evident in the specimen from the jacksmelt for they were neither described nor illustrated. The specimens from the grunion show that the esophagus is very short or lacking and that the intestine branches immediately behind the pharynx.

Lepocreadium pyriforme (Linton) (fig. 4, pl. I). My material seems to fit the species description (5, pp. 84-87) fairly well. According to Harold W. Manter, in a personal communication, "Your species may be new. It is similar ... to L. retrussum Linton, 1940 and L. pyriforme (Linton, 1899) Linton, 1940 (especially his fig. 49) but Linton had more than one species, I think, in both of these cases." I collected this material from the stomach of the grunion, although all but 1 of the specimens studied by Linton were from the intestine. This is the first time this species has been reported from the Pacific Coast of North America and is a new host record.

Galactosomum humbargari Park (figs. 7 and 8, pl. I). Cysts of this form were recovered from the coelom of the grunion and were fed to the caspian tern, Hydroprogne caspia, and recovered as young adults no more than 4 days later. Any variations in size from the type specimens (9, pp. 360-365) probably are the result of the age of the respective specimens and are not significant in my opinion. The identification of this material was confirmed by Walter E. Martin. As I have found no previous description of these cysts, a description is included here. Cyst: (fig. 8, pl. I) oval, about 3/5 as wide as long, with a resistant thick wall enclosing a coiled worm which when stained shows well defined gonads. In the space surrounding the worm are what appear to be excretory granules. Measurements of 14 cysts were: average length, 0.387 (0.325-0.470) mm; width, 0.228 (0.210-0.250) mm; thickness of cyst wall, 0.015 (0.013-0.018) mm.

Strigeid metacercariae (fig. 9, pl. I) were found in cyst-like structures on the surface and in the ventricles of the brain of the grunion. The "cyst" consists of an outpocketing of the dura that encloses 1 to many diplostomula whose movement seems to be restricted to a very small space. Ernest J. Hugghins and Lawrence R. Penner, in personal communications, suggest that these belong to the family Cyathocotylidae and possibly to the genus Mesostephanus. Penner noted that they may represent the metacercaria of Mesostephanus microbursae the adults of which are found in the pelican in southern California. Feeding experiments will be necessary to prove the identity.

Larval distome (fig. 6, pl. I). Not enough adult characteristics are shown in flukes recovered from around the anterior portion of the dorsal aorta and once in a superficial hepatic blood vessel to assign them to any particular group. They appeared very active and were not found encysted.

Cestoda

Larval tetraphyllidean (fig. 10, pl. I). Up to at least 170 tetraphyllidean plerocercoids have been recovered from the intestine of an individual grunion. The absence of hooks on the holdfast organ would place these in the family Phyllobothriidae. A variety of larvae resembling in one way or another the present specimens have been classified as Scolex pleuronectis (16, pp. 229-231). Feeding experiments would be required to determine the species. The plerocercoids were very active and assumed a variety of shapes while extending and inverting the anterior end. The light area in the body of the one figured represents the space occupied by the holdfast organ when it is inverted.

Nematoda

Spirocamallanus pereirai (Annereaux) (figs. 11, 12 and 13; pl. I). A single male specimen was obtained from the intestine indicating that this species is not common in the grunion. Annereaux (1, pp. 299-303) described this species from the intestine of the jacksmelt, Atherinopsis californiensis, on the basis of 3 adult worms, one of which was a male, taken at Bolinas Bay, California. The specimen in my collection agrees with the original description very well except that mine is over twice as long and other measurements, with the exception of body width, are proportionately greater. This specimen is the second collection of this species, both from California fishes belonging to the family Atherinidae; and is the second record of the genus in North America. The generic name Spirocamallanus was proposed by Olsen in 1952 (8, pp. 196-197) for certain species removed from the genus Procamallanus.

Larval Contracaecum sp. (figs. 14, 15 and 16; pl. I). These immature nematodes are found in the coelom and partially embedded in the liver and other visceral organs. Paul V. Gustafson and Leland S. Olsen have both confirmed the generic designation. The species cannot be determined from the material available. Lengths of the specimens varied from 1.8 mm to 6.4 mm. Some individuals lived in the refrigerator 60 hours following the death of the grunion.

Larval nematode (figs. 17, 18 and 19; pl. I). Two specimens of a second larval roundworm much larger than Contracaecum were recovered from the coelom of two fish. Both worms were apparently lost in the mail when they were sent to Dr. Clark P. Read, of the Johns Hopkins University, for they were not received by him and consequently have not been identified.

Copepoda

Argulus melanostictus Wilson (figs. 20, 21, 22, 23 and 24; plate II) is an arguloid copepod found beneath the fins on the occasions when it was taken directly from the fish. The identification was confirmed by Paul L. Illg. The only two records (18, pp. 776-777; 19, p. 565) are of females taken by plankton tow, one in Monterey Bay, California, and the other in the Gulf of Thailand, thus, the present specimens from the grunion represent the first host records. The female specimens from grunion differ enough from those in the previous collections to make it necessary to include the following comparison. The present specimens do not have strongly divergent lobes of the carapace; so slender an abdomen nor an integument raised into minute irregular knobs like pebbled leather; or as many segments in the supporting rods as in the Thailand specimens nor do they have the same shaped respiratory tracts: the posterior one in the grunion is J-shaped instead of elongate-ovate as in the others in which the posterior curved portion may have been obscured by eggs. They lack a well developed claw on the anterior margin of the second segment of the first antenna as in the Thailand specimens, instead they have a weak anterior claw resembling the one in the Monterey specimens. They are lacking a large acute spine on the ventral surface of the first antenna as in the Thailand specimens but have a blunt spine as do the Monterey forms. They do not have a narrow basal plate on the second maxilla as in the Monterey specimens but a broader plate as do the ones from Thailand; they lack a tiny claw at the tip of the second maxilla as did the ones from Monterey (not described in ones from Thailand) but have two claws present which were perhaps overlooked in the earlier ones. It would appear from these comparisons that the specimens from grunion are somewhat intermediate in morphology between the two previous collections. Table I summarizes the measurements and number of eggs present in 13 female Argulus melanostictus from the grunion.

The males and larval stages of this species have never been described therefore the following descriptions are included.

Table I. Summary of measurements and numbers of eggs present for 13 female Argulus melanostictus collected from the grunion, Leuresthes tenuis. All measurements are in millimeters.

Total length	Carapace Length	Carapace Width	Abdomen Length	No. of eggs
9.6	5.3	5.5	3.25	87 ±
9.2	5.6	5.4	3.05	79 ±
9.05	5.2	5.2	2.85	81 ±
8.0	4.75	4.85	2.6	36 ±
7.9	4.95	4.8	2.45	40 ±
7.4	4.3	4.5	2.25	31 ±
5.9	3.75	3.9	1.7	20 ±
5.85	3.7	3.5	1.7	16 ±
5.25	3.1	3.0	1.45	5
4.85	2.9	2.9	1.25	5
4.8	3.0	3.0	1.4	4
2.75	1.9	1.75	0.8	0
2.75	1.9	1.7	0.85	0

Argulus melanostictus male (figs. 21 and 22, pl. II). The body is a cream color with the dorsal surface almost entirely covered with small circular or elliptical black spots randomly spaced and varying considerably in size from 0.01 mm to 0.1 mm.

The carapace is about as wide as long; the posterior lobes are bluntly rounded, somewhat divergent and reaching the second pair of swimming legs; leaving the second, third and fourth thoracic segments almost entirely visible in dorsal view. The sinus between the lobes is about 1/6 the carapace length. The cephalic area is broadly rounded anteriorly and slightly wider than long. The compound eyes are of medium size, far forward and well separated. Each lateral area contains two respiratory tracts, the anterior one is smaller and nearly circular, and the posterior one is J-shaped. The segments of the thorax are about equal in length. The abdomen is about twice as long as wide and half as long as the carapace; the posterior sinus is 1/2 of the abdomen length; the anal laminae are basal; the posterior lobes are narrow, uniformly tapered and acutely pointed. The testes are elongate-elliptical and reach a little past the base of the posterior sinus. On the first antennae there is a broad knob on the posterior margin of the second segment; the lateral claw is long and slender, its curve nearly reaching the tip of the 3-segmented flagellum; the ventral median spine is broad and blunt; the spine at the base is fairly large. The second antenna is 4-segmented, the basal segment is as long as the other 3 segments combined and armed on its ventral surface with a large acute spine. The suction cups are well separated and about 1/4 of the carapace width. The 60 to 65 supporting rods are fairly regular, each made up of from 12 to 18 segments more or less imbricated and tapering distally. The proximal segments are crescentic discs becoming circular toward the distal end. The second maxillae are stout and 4-jointed; the basal plate is broad with short blunt teeth; roughened areas appear on the basal plate, the distal end of the second segment and on the anterior portions of the third and fourth segments; the terminal segment is tipped with a small club-shaped process and two small claws. The anterior pair of post-maxillary spines, which are short and blunt like the ones on the basal plate, are at the base of the second maxillae near the midline on a broad prominence bearing blunt scaley spines. The posterior pair of post-maxillary spines are slenderer and more pointed. The two anterior pairs of swimming legs have flagella and the boot-shaped natatory lobe on the coxa of the fourth swimming leg is short and bluntly rounded. On the posterior side of the third swimming leg a thin-walled voluminous sac extends nearly the length of the coxa and part of the basis. Dorsally the opening of the socket extends at least 2/3 the length of the sac. On the fourth leg the peg is composed of a triangular lamina with the tip directed laterally and the base quite broad. Length to 4.95 mm. Table 2 presents a summary of the measurements of 10 males collected from the grunion.

Table 2. Summary of measurements of 10 male Argulus melanostictus collected from the grunion, Leuresthes tenuis. All measurements are in millimeters.

Total length	Carapace Length	Carapace Width	Abdomen Length
4.95	3.0	3.0	1.25
4.9	2.95	3.05	1.3
4.7	2.85	2.75	1.25
4.5	2.6	2.8	1.2
4.3	2.4	2.7	1.25
4.2	2.5	2.5	1.1
3.6	2.2	2.05	1.05
3.5	2.1	2.0	1.05
3.3	2.05	1.95	0.95
2.25	1.5	1.3	0.65

Argulus melanostictus third stage larva (fig. 23, pl. II). A larva comparable to the third stage as described by Meehean (6, pp. 471-472) was collected on June 28, 1953 at South Pylon, San Diego Bay, California from 1 of 75 grunion. On the basis of larval studies summarized by Meehean this larva would apparently be from 5 to 8 days old. The carapace is about as wide as long; the posterior lobes are broadly rounded, reaching the third pair of swimming legs, leaving most of the second, the third and fourth thoracic segments entirely visible in dorsal view, the sinus between them is about 1/4 the carapace length. The cephalic area is broadly rounded anteriorly. The abdomen is almost as wide as long, and about 1/3 the carapace length; the posterior sinus is about 1/4 the abdomen length. The first maxilla is tipped with a serrated spine and the framework of the suction cup is faintly seen within the basal segment. The basal segment of the second maxilla has 3 blunt spines and is tipped with the fingerlike process and two spines characteristic of the adult. No spinules were evident on the ventral surface. Total length, 1.11 mm. Carapace, 0.73 mm long, 0.75 mm wide. Abdomen, 0.26 mm long.

Argulus melanostictus fifth stage larva (fig. 24, pl. II). A larva comparable to the fifth stage as described by Meehean (6, p. 472) was collected on May 20, 1954 at Estero Beach, Baja California. It was one of 19 of these copepods from 593 grunion in that particular collection. On the basis of larval studies summarized by Meehean this larva would apparently be from 10 to 12 days old. The carapace is slightly longer than broad; the posterior lobes are rounded, just reaching the groove between the second and third thoracic segments, leaving most of the second, and the third and fourth segments entirely visible in dorsal view, the sinus between the lobes is about 1/5 of the carapace length. The abdomen is almost twice as long as wide and a little more than 1/3 the carapace length; the posterior sinus is a little more than 1/3 the abdomen length. The first maxilla is tipped with a serrated spine, the serrations of which are not so distinct as in the third stage larva. The two suction cups, with a diameter of 0.125 mm, have 65 and 67 rods, each with a basal pedestal and about 7 segments, the proximal ones of which are crescentic discs becoming circular at the distal end as in the adult. The 3 blunt teeth on the basal segment of the second maxilla are much more prominent than in the third stage larva. The post-maxillary spines are as in the adult. The undersurface has spinules on the anterior and lateral areas as well as on the thorax. Total length, 1.75 mm. Carapace, 1.15 mm long, 1.09 mm wide. Abdomen, 0.44 mm long.

Bomolochus sp. (figs. 25 and 26, pl. II). This material has been sent to J. H. Stock who is describing these copepods as a new species close to B. soleae Claus as redescribed by Stock (12, pp. 1-5) and B. decapteri Yamaguti (20, pp. 1-8). In a personal communication Stock has indicated that the closest ally is no doubt B. decapteri from which it differs by having the outer-edge spines of the exopods of legs 2 to 4 not serrated but tipped only with a seta, and an incurvation of the 3rd joint of the exopods (fig. 26, pl. II). These copepods are commonly found on the inner surface of the operculum and amongst the gills.

Caligus olsoni Pearse (fig. 27, pl. II) was first collected by me in 1950 and turned over to A. S. Pearse who described the material and established type male and female specimens (10, pp. 332-333). This appears to be a common external parasite. Up to 6 have been taken from 1 grunion.

Clavellopsis sp. (fig. 28 and 29, pl. II) a lernaeopodoid copepod was taken from the roof of the mouth and the gill arches of the host fish. Only 7 female specimens of these were discovered and two of these were from the same fish. Paul L. Illg was unable to assign a specific name to these copepods, which, perhaps, represent an undescribed species of the genus Clavellopsis as described by Wilson (17, pp. 686-687). The color is yellowish white. The cephalothorax is thick, cylindrical and somewhat longer than the trunk. The head is not enlarged, is squarely truncated anteriorly, and is without a dorsal carapace. The trunk is pear shaped, nearly as wide as long, and without posterior ridges or processes. The first antennae are with an enlarged base, and the last joint is tipped with 1 long and at least 4 short spines. The second antennae are biramose, with the exopod fairly long, 1-jointed, and bluntly rounded; the endopod is shorter, 2-jointed, and tipped with a short conical spine. The mouth tube is broadly conical, projecting in front of the anterior margin, but not so far as the second antennae. The first maxillae are bipartite, the palp is small and equipped with 2 setae. The second maxillae are swollen and fused throughout their length. The bulla is funnel shaped. The maxillipeds have a rather stout basal joint bearing a short spine on its medial surface and the slender terminal claw is armed on its inner margin with an accessory spine. The egg strings are ellipsoidal, about the length of the trunk, with the eggs arranged in 6 or 7 longitudinal rows each with about 7 eggs. Maximum and minimum measurements are based on 4 specimens. Cephalothorax, 3.5 mm to 2.4 mm long, and 0.63 mm to 0.43 mm wide. Trunk, 1.72 mm to 1.15 mm long, and 1.25 mm to 0.9 mm wide. Egg strings, 1.3 mm long, and 0.96 mm wide.

Isopoda

Nerocila californica Schioedte and Meinert (fig. 30, pl. II) male and intermediate forms have been found on the grunion. When these specimens were first shown to Robert J. Menzies in 1952 he considered them to be the first examples of stages other than female to be collected of these protandrous isopods. Since then he has found them on other small fishes in the San Diego area (personal communication).

Livoneca californica Schioedte and Meinert (fig. 31, pl. II) females were recovered from the gill chamber with no more than one found in a single fish. The gills in the infested gill chamber were much reduced in size. Robert J. Menzies has confirmed this identification. Richardson (11, p. 260) reports this species as far south as San Pedro, California where it was found in the "shiner".

Incidence of Parasitism

Tables 3 and 4, and figure 2 include data on the incidence of the species of parasites infecting grunion. All of the collection dates are within the spawning period of the fish for collections were made only at the time of the grunion "runs", as these spawning occasions are called.

Table 3 shows the total incidence of all parasite species according to locality. Because of the variation in numbers of fish examined from different localities the average number of parasites is listed so as to give a standard of comparison. Nine of the 16 species reported in this study (monogenetic trematode, Asymphlodora atherinopsidis, Galactosomum humbargari metacercaria, larval distome, strigeid metacercaria, tetraphyllidean plerocercoid, larval Contracaecum sp., Bomolochus sp., and Caligus olsoni) were present at all localities from which fish were examined for them. The only flatworm not represented in the above list is Lepocreadium pyriforme for it was absent in the 2 fish examined from Pacific

Table 3. The total incidence of parasites in all grunion, <u>Leuresthes</u> <u>tenuis</u> (Ayres), examined, according to locality. A = number of parasites; B = number of grunion examined; C = average number of parasites per fish expressed to the nearest tenth.

					SAN DIEGO BAY					
		SAN CLEMENTE	PACIFIC BEACH	MISSION BEACH	1/2 MI. WEST INSTITUTE OF AERONAUTICAL SCIENCES	3 MI. SE HOTEL DEL CORONADO	SOUTH PYLON	CORONADO STRAND	ESTERO BEACH	TOTAL
MONOGENETIC TREMATODE	A	34	5	103	2	3	42	73	24	286
	B	20	2	125	11	8	65	95	20	346
	C	1.7	2.5	0.8	0.2	0.4	0.6	0.8	1.2	0.8
<u>ASYMPHLODORA ATHERINOPSIDIS</u>	A	11	3	59	5	13	181	64	12	348
	B	20	2	67	20	13	168	56	20	366
	C	0.5	1.5	0.9	0.2	1.0	1.1	1.1	0.6	1.0
<u>LEPOCREADIUM PYRIFORME</u>	A	7	—	39	94	—	1120	83	9	1352
	B	20	2	23	20	—	133	55	20	273
	C	0.3	—	1.7	4.7	—	8.4	1.5	0.4	5.0
<u>GALACTOSOMUM HUMBARGARI</u> METACERCARIA	A	46	15	51	7	1	176	189	204	689
	B	20	2	20	8	8	92	55	20	225
	C	2.3	7.5	2.5	0.9	0.1	1.9	3.4	10.2	3.1
LARVAL DISTOME	A	281	—	—	2	—	48	83	160	574
	B	20	—	—	8	—	85	55	20	188
	C	14.0	—	—	0.2	—	0.6	1.5	8.0	3.1
STRIGEID METACERCARIA	A	8	—	53	—	—	2	7	11	81
	B	20	—	14	—	—	32	10	20	96
	C	0.4	—	3.8	—	—	0.1	0.7	0.5	0.8
TETRAPHYLLIDEAN PLEROCERCOID	A	213	—	133	72	55	1343	1039	101	2956
	B	20	—	14	11	13	68	55	20	201
	C	10.6	—	9.5	6.5	4.2	19.7	18.9	5.0	14.7
<u>SPIROCAMALLANUS PEREIRAI</u>	A	—	—	—	1	—	—	—	—	1
	B	20	2	67	20	13	168	55	20	365
	C	—	—	—	—	—	—	—	—	—
LARVAL <u>CONTRACAECUM</u> SP.	A	6	1	3	3	—	40	31	5	89
	B	20	2	63	11	—	122	45	20	283
	C	0.3	0.5	—	0.3	—	0.3	0.7	0.2	0.3
UNIDENTIFIED LARVAL NEMATODE	A	—	—	—	1	—	—	1	—	2
	B	20	2	63	11	—	122	45	20	283
	C	—	—	—	0.1	—	—	—	—	—
<u>ARGULUS MELANOSTICTUS</u>	A	—	—	—	—	1	6	1	19	27
	B	136	2	155	8	265	641	98	613	1918
	C	—	—	—	—	—	—	—	—	—
<u>BOMOLOCHUS</u> SP.	A	33	4	25	11	10	148	120	30	381
	B	20	2	38	12	14	185	95	20	386
	C	1.6	2.0	0.7	0.9	0.7	0.8	1.3	1.5	1.0
<u>CALIGUS</u> <u>OLSONI</u>	A	34	—	201	1	1	153	27	10	427
	B	136	—	155	8	4	641	98	613	1655
	C	0.2	—	1.3	0.1	0.2	0.2	0.3	—	0.3
<u>CLAVELLOPSIS</u> SP.	A	—	—	1	—	—	3	1	2	7
	B	20	2	38	8	—	18	28	20	134
	C	—	—	—	—	—	0.2	—	0.1	0.1
<u>NEROCILA CALIFORNICA</u>	A	—	—	1	—	—	36	—	—	37
	B	20	2	38	12	14	620	95	20	821
	C	—	—	—	—	—	0.1	—	—	—
<u>LIVONECA CALIFORNICA</u>	A	—	—	—	2	1	2	1	—	6
	B	20	2	38	12	14	245	55	20	406
	C	—	—	—	0.2	0.1	—	—	—	—

Table 4. Incidence of parasitism in the grunion, Leuresthes tenuis (Ayres), of various lengths from 4 localities. Vertical axis represents standard length of the fish in millimeters. Horizontal axis represents numbers of parasites. Included are parasites which occurred in at least 5 of the host fish.

MICROCOTYLID TREMATODE

	0	1	2	3	4	5	8
190							1
180				1	1		
170	2		1	2			
160	1	3	3	2	2		
150	5	2	2		1		
140	11	2	2	1		1	
130	4	3	3	3			
120	6	3	1				
110	4	2	2				
100		1					
90	1		1				

LEPOCREADIUM PYRIFORME

	0	1-10	11-20	21-30	31-35	73
190	1					
180	2					
170	4	1				
160	7	4				
150	7	3				
140	8	5	1	3		
130	8	4	1			
120	7	2		1		
110	3	2		2	1	
100					1	
90		1				1

ASYMPHLODORA ATHERINOPSIDIS

	0	1	2	3	4	5	6	8	12
190			1						
180	1				1				
170	2			1		1		1	
160	4	3	3				1		
150	5	1	3		1				
140	10	2	3	1					1
130	6	4		1	2				
120	10								
110	8								
100			1						
90	2								

GALACTOSOMUM HUMBARGARI METACERCARIA

	0	1-10	11-20	21-26	70
190		1			
180		2			
170	1	3			1
160	4	5	2		
150		10			
140	4	8	3	2	
130	2	8	1	2	
120	5	5			
110	4	4			
100	1				
90	2				

STRIGEID METACERCARIA

	0	1	2	3	6	8
190			1			
180	2					
170	5					
160	9					1
150	10					
140	16			1		
130	12				1	
120	10					
110	9	1				
100	1					
90	2					

LARVAL DISTOME

	0	1-10	11-20	21-30	44-68
190				1	
180				1	1
170		5			
160	3	5	1	2	
150	3	4	2		1
140	7	9	1		
130	2	9		1	1
120	3	5	1	1	
110	2	6			
100		1			
90		2			

TETRAPHYLLIDEAN PLEROCERCOID

	0	1-10	11-20	24-32	85-170
190	1				
180	1				1
170	2	2		1	
160	4	5		1	1
150	4	3	1	1	1
140	8	6	1	1	1
130	6	5	2		
120	6	2	2		
110	4	2	1	1	
100	1				
90	2				

LARVAL CONTRACAECUM SP.

	0	1	2	3	5
190	1				
180	1	1			
170	2	3			
160	7	1	1	1	1
150	9	1			
140	15		1	1	
130	9	2	2		
120	7	3			
110	5	3			
100	1				
90	1				

BOMOLOCHUS SP.

	0	1	2	3	4	5	6
190			1				
180				2			
170			2	2			1
160	4	3	4				
150	3	3		2	1		1
140	5	5	3	3	1		
130	3	4	3	1		1	1
120	8		1		1		
110	4	4					
100		1					
90	1	1					

CALIGUS OLSONI

	0	1	2	3	5
190		1			
180		1		1	
170	3	1	1		
160	7	2		1	1
150	6	3		1	
140	11	5	1		
130	11	2			
120	8	2			
110	7				1
100	1				
90	2				

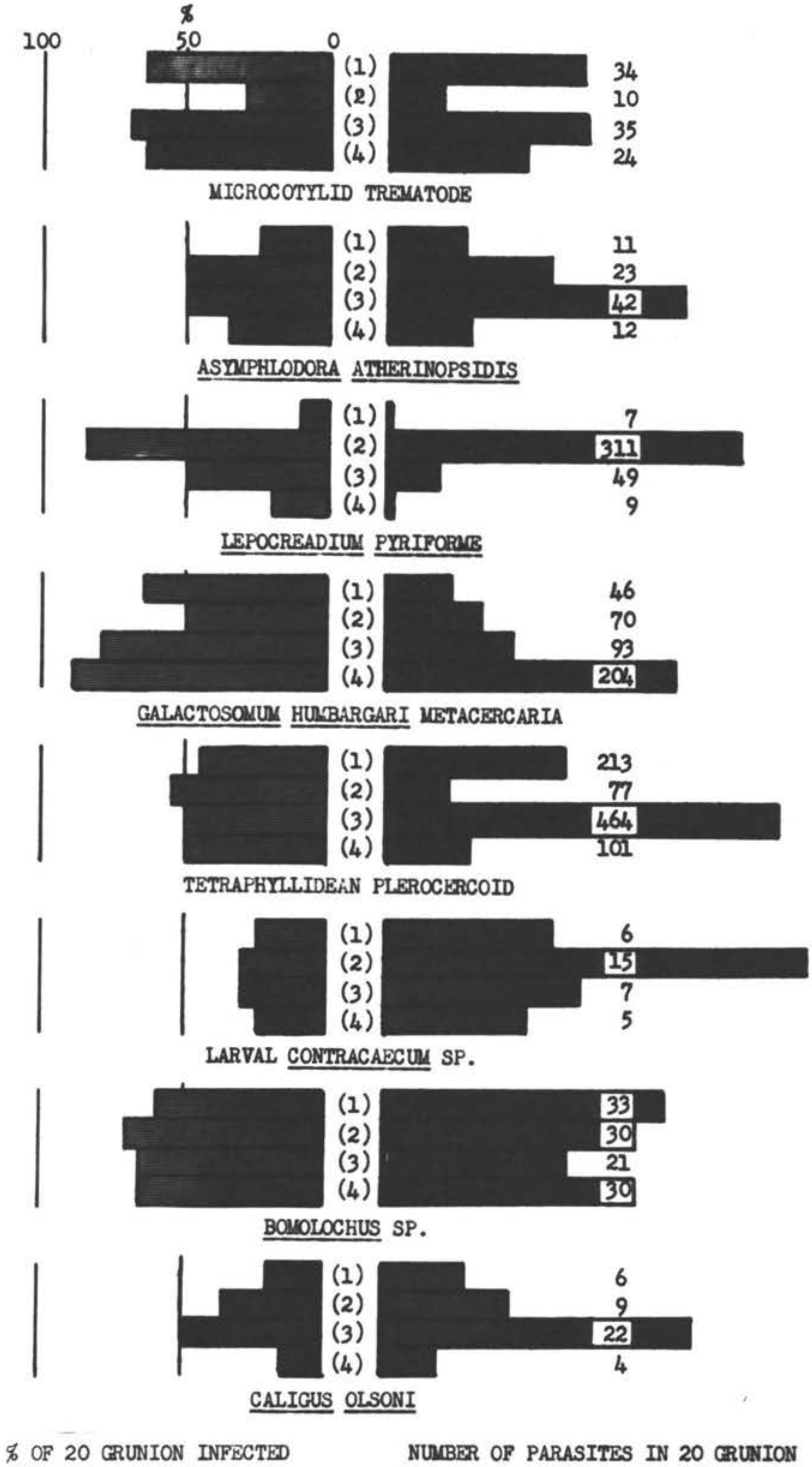

Figure 2. Incidence of 8 species of parasites in 20 grunion, Leuresthes tenuis (Ayres), from each of 4 localities. (1) = San Clemente, Orange County, California, May 5, 1954; (2) = South Pylon, San Diego Bay, California, June 3, 1954; (3) = Coronado Strand, San Diego County, California, June 19, 1954; (4) = Estero Beach, Baja California, May 20, 1954.

Beach. The remaining 6 species would not appear to be common at any locality where they were found. Of the parasites having an incidence of at least 0.8 individuals per fish, only 1 (Bomolochus sp.) is not a platyhelminth. The larval cestode has the highest incidence with an average of 14.7 per fish while the next highest incidence is an average of 5 individuals of the fluke Lepocreadium pyriforme per fish. The 3 localities within San Diego Bay tend to have higher or lower incidences than the ocean beaches. In all cases the monogenetic trematode, Galactosomum humbargari metacercaria, tetraphyllidean plerocercoid, and strigeid metacercaria had smaller, and Lepocreadium pyriforme had higher averages in the bay than elsewhere. Spirocamallanus pereirai was found only in the bay while Nerocila californica and Livoneca californica each occurred only once outside of the bay.

Figure 2 presents the incidence of 8 species of parasites from 4 localities between San Clemente, Orange County, California and Estero Beach, Baja California. Collections were made on successive grunion run series so that the collection dates fall within a 7 week period. The portion of the figure indicating numbers of parasites illustrates, as does table 3, that parasites of grunion from San Diego Bay had a tendency to occur in either greater or lesser numbers than at ocean localities. The monogenetic trematode and tetraphyllidean plerocercoid are shown to have fewer while Lepocreadium pyriforme and the larval Contracaecum sp. have more individuals per fish in San Diego Bay. In addition, there are shown differences in numbers between ocean localities. At San Clemente and Estero Beach both the percent of fish infected and numbers of Asymphlodora atherinopsidis, Lepocreadium pyriforme, larval Contracaecum sp. and Caligus olsoni per fish are smaller than at the Coronado Strand or South Pylon. For Galactosomum humbargari metacercariae, the percentage of fish infected and numbers of parasites per fish at ocean localities increases from north to south, with 4 times as many parasites present at Estero Beach as at San Clemente. The greatest uniformity is shown by Bomolochus sp. where the percentage of fish infected varies no more than 10%; and with the exception of Coronado Strand the numbers of parasites in 20 fish varies no more than 3.

Table 4 presents the incidence of 10 species of parasites according to the length of the host fish. Each of the 80 fish represented was parasitized by at least 1 species of parasite. In general, the medium length fish tend to have the greatest numbers of parasites. Also, the shortest fish show a greater tendency toward absence of parasites than do the longest fish. The conspicuous exception to this is Lepocreadium pyriforme where the incidence is greater in the shorter fish. For example, the 3 longest fish were negative while the 3 shortest fish were positive. This situation is reversed in the cases of Asymphlodora atherinopsidis, Galactosomum humbargari metacercaria, strigeid metacercaria, and Caligus olsoni where the shortest fish were negative and the longest fish were infected.

DISCUSSION

The review of the individual parasites encountered in this survey makes it very clear that the state of knowledge of the species of these parasitic forms is not adequate to make completely satisfactory identifications. Furthermore, extensive studies of life histories will be necessary before some of these larval forms can be identified.

Tables 3 and 4, and figure 2 include data which suggest that the grunion are rather heavily parasitized with a number of kinds of parasites. This conclusion is the result of the first evidence that has been accumulated on this point.

On the basis of the data available an attempt has been made to give information on the relative abundance of the various parasites of the grunion. In placing the parasites into any one of the categories I have tried to correct for all factors that might give a false picture of the actual conditions.

Abundant:

Galactosomum humbargari metacercaria

Common:

Monogenetic trematode

Lepocreadium pyriforme

Asymphlodora atherinopsidis

Strigeid metacercaria

Larval distome

Tetraphyllidean plerocercoid

Larval Contracaecum sp.

Bomolochus sp.

Caligus olsoni

Occasional:

Argulus melanostictus

Clavellopsis sp.

Nerocila californica

Livoneca californica

Rare:

Spirocamallanus pereirai

Unidentified larval nematode

It would appear from table 3 and figure 2 that the grunion population of San Diego Bay is rather distinct from the populations of San Clemente, Coronado Strand and Estero Beach, otherwise one would expect more uniformity in the percentages of fish infected and the numbers of parasites present. On the basis of adult monogenetic trematodes, larval and adult digenetic trematodes, and isopods there appears to be a greater difference in parasite incidence than would be expected in freely migrating populations. Also, the evidence involving both larval and adult stages of ectoparasites and endoparasites would seem to give evidence that the differences are of more than a short time duration. That lesser differences also exist between ocean localities is evidence to corroborate the work of Walker (15, p. 420) demonstrating by marked fish that the grunion populations are relatively static, at least during the spawning season.

The differences in incidence might be explained on the basis of the distribution of the intermediate hosts but until more is known about life cycles this cannot be done with certainty. In a schooling fish as is the grunion, one could expect relative uniformity in numbers of external parasites as copepods and isopods which might move from host to host and in the monogenetic trematode which requires no intermediate host. This uniformity appears to exist only in the copepod Bomolochus sp. The monogenetic fluke numbers are fairly uniform in the ocean samples but are found in fewer fish and in decreased numbers per fish in the bay. Variation in such factors as salinity, temperature and available oxygen between ocean and bay localities may be responsible.

Table 4 indicates that in most cases the medium length fish, hence probably the middle age group, were more heavily parasitized than either the younger or the older fish. It would seem possible that the smaller and younger fish are still acquiring new parasites and that the larger older fish are losing their parasites due to age resistance or other intrinsic factors. An exception to this is Lepocreadium pyriforme in which the smallest fish have the most parasites. Reasons for this might be that the diet of the youngest fish includes a plankter which is the intermediate host or that the fish develop a resistance at an early age.

SUMMARY AND CONCLUSIONS

1. A survey of parasitism as found in 1977 grunion, Leuresthes tenuis (Ayres), was completed. The collections were made at 8 sites extending from San Clemente, Orange County, California to Estero Beach, Bahia de Todos Santos, Baja California.

2. Sixteen parasitic forms were collected and identified as far as possible. All but Caligus olsoni Pearse, which was originally collected by me, represent new host records.

Trematoda

Undescribed genus and species of

microcotylid

Lepocreadium pyriforme (Linton)

Asymphlodora atherinopsidis Annereaux

Galactosomum humbargari Park metacercaria

Strigeid metacercaria

Larval distome

Cestoda

Unidentified tetraphyllidean plerocercoid

Nematoda

Spirocamallanus pereirai (Annereaux)

Larval Contracaecum sp.

Unidentified Larval nematode

Copepoda

Argulus melanostictus Wilson

Bomolochus sp.

Caligus olsoni Pearse

Clavellopsis sp.

Isopoda

Nerocila californica Schioedte and Meinert

Livoneca californica Schioedte and Meinert

3. Original figures were included to illustrate all parasitic forms encountered.

4. Table 3 included the total incidence of parasites according to kinds, numbers of parasites, number of fish examined, average number of parasites per fish and localities from which the specimens were obtained.

5. Table 4 included the data on the incidence of 10 parasites according to the length of 80 fish from 4 collecting sites.

6. Figure 2 included the incidence of 8 species of parasites at 4 collecting sites.

7. The esophagus and bifurcation of the intestine of Asymphlodora atherinopsidis Annereaux were described.

8. The metacercaria of Galactosomum humbargari Park was described.

9. Male and larval stages of Argulus melanostictus Wilson were described.

10. Male and intermediate stages of Nerocila californica Schioedte and Meinert were reported and illustrated.

11. Parasites were grouped as to whether abundant, common, occasional or rare.

12. Evidence was presented to corroborate the conclusion of Boyd W. Walker that the grunion populations are relatively non-migratory, at least during the spawning season.

BIBLIOGRAPHY

1. Annereaux, Ralph F. A new nematode, Procamallanus pereirai, with a key to the genus. Transactions of the American microscopical society 65:299-303. 1946.

2. ________. Three new trematodes from marine fishes of California. Transactions of the American microscopical society. 66:249-255. 1947.

3. Clark, Frances N. The life history of Leuresthes tenuis, an atherine fish with tide controlled spawning habits. California division of fish and game fish bulletin 10. 1925. 51 p.

4. ________. Grunion in southern California. California fish and game 24:49-54. 1938.

5. Linton, Edwin. Trematodes from fishes mainly from the Woods Hole region, Massachusetts. United States national museum proceedings 88:1-172. 1940.

6. Meehean, O. Lloyd. A review of the parasitic crustacea of the genus Argulus in the collections of the United States museum. United States national museum proceedings 88:459-522. 1940.

7. Nolan, M. O. and J. Bozicevich. The incidence of trichinosis as indicated by post mortem examinations of 1000 diaphragms. Public health report 53:652. 1938.

8. Olsen, Leland S. Some nematodes parasitic in marine fishes. Publications of the institute of marine science 2:173-215. 1952.

9. Park, James T. New trematodes from birds, Plagiorchis noblei sp. nov. (Plagiorchidae) and Galactosomum humbargari sp. nov. (Heterophyidae). Transactions of the American microscopical society 55:360-365. 1936.

10. Pearse, A. S. A new copepod parasite from the grunion. The journal of parasitology 39:332-333. 1953.

11. Richardson, Harriet. A monograph on the isopods of North America. United States national museum bulletin 54. 1905. 727p.

12. Stock, J. H. Bomolochus soleae Claus, 1864 and B. confusus n. sp.: two hitherto confounded parasitic copepods with remarks on some other Bomolochus species. Beaufortia number 24. 1953. 13p.

13. Thompson, Will F. The spawning of the grunion (Leuresthes tenuis). California fish and game commission fish bulletin 3. 1919. 27p.

14. Walker Boyd W. Periodicity of spawning by the grunion, Leuresthes tenuis, an atherine fish. Doctoral dissertation, Los Angeles, University of California, 1949. 166p.

15. ________. A guide to the grunion. California fish and game 38:409-420. 1952.

16. Wardle, Robert A. and James A. McLeod. The zoology of tapeworms. Minneapolis, University of Minnesota Press, 1952. 780p.

17. Wilson, Charles Branch. North American parasitic copepods belonging to the Lernaeopodidae, with a revision of the entire family. United States national museum proceedings 47:565-729. 1915.

18. ________. Parasitic copepods from the Pacific coast. American midland naturalist 16:776-797. 1935.

19. ________. Parasitic copepods in the United States national museum. United States national museum proceedings 94:529-582. 1944.

20. Yamaguti, Satyu. Parasitic copepods from fishes of Japan. Part 1. Cyclopoida, I. Published by the author. 1936. 8p.

PLATE I.

Helminths from the grunion, Leuresthes tenuis (Ayres). All size scale measurements are in millimeters.

Figure 3. Undescribed species and genus of monogenetic fluke from the gills.

Figure 4. Lepocreadium pyriforme (Wilson) from the stomach.

Figure 5. Asymphlodora atherinopsidis Annereaux from the intestine.

Figure 6. Larval distome from around the anterior end of the dorsal aorta.

Figure 7. Galactosomum humbargari Park recovered from the intestine of a caspian tern, Hydroprogne caspia, after laboratory infection with cysts from the grunion.

Figure 8. Galactosomum humbargari Park cyst from the coelom.

Figure 9. Larval strigeid from the brain surface.

Figure 10. Tetraphyllidean plerocercoid from the intestine.

Figure 11. Spirocamallanus pereirai (Annereaux) from the intestine.

Figure 12. Anterior end of Spirocamallanus pereirai (Annereaux) from the intestine.

Figure 13. Posterior end of Spirocamallanus pereirai (Annereaux) from the intestine.

Figure 14. Larval Contracaecum sp. from the coelom.

Figure 15. Anterior end of larval Contracaecum sp. from the coelom.

Figure 16. Posterior end of larval Contracaecum sp. from the coelom.

Figure 17. Unidentified larval nematode from the coelom.

Figure 18. Anterior end of unidentified larval nematode from the coelom.

Figure 19. Posterior end of unidentified larval nematode from the coelom.

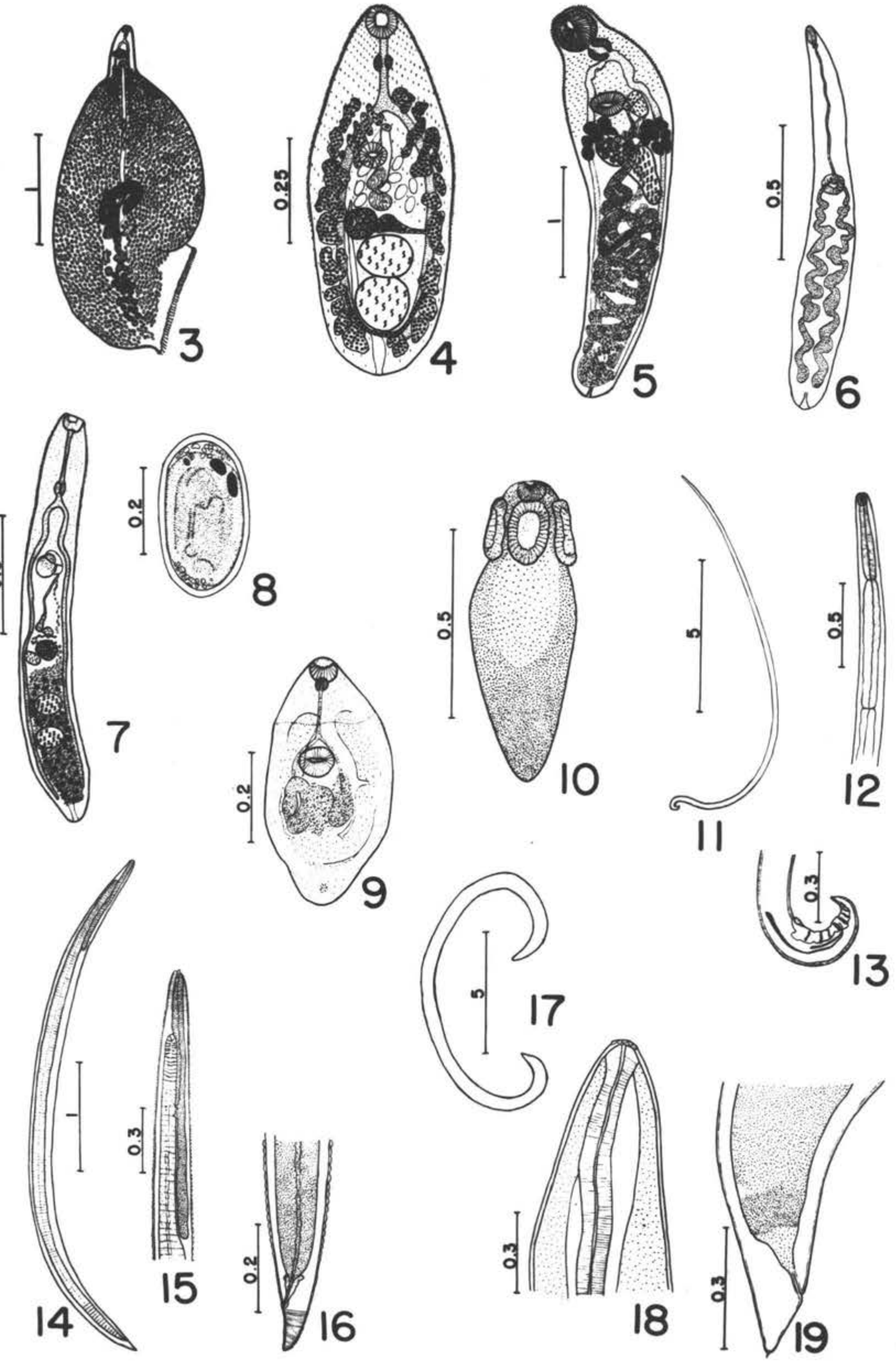
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PLATE II.

Arthropods from the grunion, Leuresthes tenuis (Ayres).
All size scale measurements are in millimeters.

Figure 20. Female Argulus melanostictus Wilson.

Figure 21. Male Argulus melanostictus Wilson

Figure 22. Male accessory apparatus on the 4th and 5th legs of Argulus melanostictus Wilson.

Figure 23. Third stage larva of Argulus melanostictus Wilson.

Figure 24. Fifth stage larva of Argulus melanostictus Wilson.

Figure 25. Female of an undescribed species of Bomolochus.

Figure 26. Exopod of the 3rd leg of an undescribed species of Bomolochus.

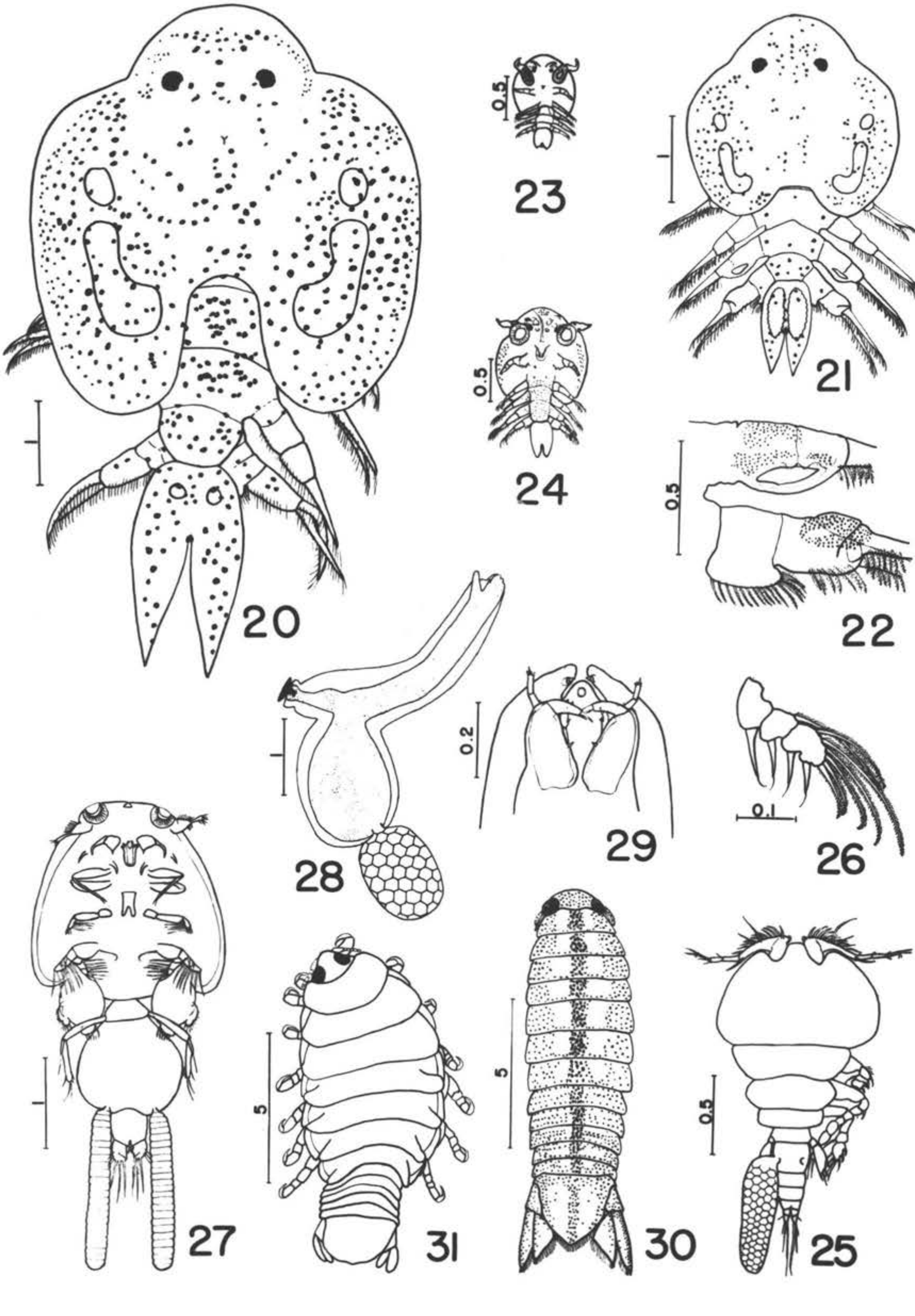
Figure 27. Female Caligus olsoni Pearse.

Figure 28. Female Clavellopsis sp. from the mouth.

Figure 29. Mouth parts of female Clavellopsis sp. from the mouth.

Figure 30. Nerocila californica Schioedte and Meinert.

Figure 31. Livoneca californica Schioedte and Meinert.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