AN ABSTRACT OF THE THESIS OF

Allyn Gregory Johnson (Name of student) for the Master of Science (Degree)

in Fisheries (Major) presented on May 11, 1967 (Date)

Title: BIOLOGY OF THE RATFISH, HYDROLAGUS COLLIEI (LAY AND BENNETT)

Abstract approved: Howard F. Horton

In the fall and winter of 1965, 1966, and 1967, 298 ratfish (180 males, 118 females) were collected off the Pacific coast of Oregon and Washington and examined for food habits, parasites, growth relationships and a method of age determination. The following food organisms were found to be the most important in the collection; Pandalus, Crago, Musculus, Amphissa, Pecten, and Brisaster. Two occurrences of cannibalism were found in ratfish collected off Cape Arago, Oregon.

The parasite Gyrocotyle occurred in from 29.2% to 65.8% of the ratfish from the four collections made off Oregon. The copepod, Acanthochondria sp., was found attached to the pelvic claspers of seven male ratfish from Cape Arago, Oregon.

Age appears to be related to body length, with females growing faster and to a larger size than the males.

The eye lens weights (wet and dry), vertebral radii, and body weights were compared to body lengths (S-V). General equations for body weight-body length (S-V) relationships (metric system) are Log weight = Log -4.3217 + 3.0546 Log length for the males and Log weight = Log -4.1692 + 2.9720 Log length for the females.

No accurate method of determining age of the ratfish was found, although the body parts examined showed an increase in size with increase in body length. Ridges on the posterior side of the upper dental plate offer a promising indicator of age, but the relationship could not be confirmed.

BIOLOGY OF THE RATFISH, *HYDROLAGUS COLLIEI* (LAY AND BENNETT)

by

ALLYN GREGORY JOHNSON

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1967

APPROVED:

Associate Professor of Fisheries

in charge of major

Professor of Fisheries

Robert M Storm

Professor of Zoology

Dean of Graduate School

Date thesis is presented May 11, 1967

Typed by Joanne Wenstrom for Allyn Gregory Johnson

ACKNOWLEDGMENTS

I would like to express my gratitude to my major professor, Dr. Howard F. Horton, Associate Professor of Fisheries, for the encouragement, advice, assistance, and resources extended to me during this investigation. Without his help this study could not have been completed.

Special thanks are extended to personnel of the Fish Commission of Oregon. Messrs. James Meehan and Gary Milburn were particularly helpful in obtaining the ratfish needed to make this study more complete.

I would also like to express my appreciation for the help given to me by the following people: Dr. Carl E. Bond, Professor of Fisheries, for his advice and review of the thesis; Dr. Raymond D. Simon, Professor of Fisheries, for instruction in microtechniques and for use of a cryostat; Dr. Scott W. Overton, Professor of Statistics, for direction in the statistical analyses and use of a computer program; and Dr. Raymond E. Millemann, Associate Professor of Fisheries, for guidance in the study of the parasites.

In addition to the above, I wish to thank all those people in the various departments of Oregon State University and the University of Washington who in one way or another helped me in this investigation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

BIOLOGY OF THE RATFISH, HYDROLAGUS COLLIEI (LAY AND BENNETT)

INTRODUCTION

The ratfish, Hydrolagus colliei (Lay and Bennett), is a member of the class Chondrichthyes, order Chimaeriformes, and family Chimaeridae (American Fisheries Society, 1960). Distributed from Alaska to northern Baja California (Koratha, 1960), this species is the only chimaeroid fish on the Pacific Coast of North America. Although of little economic value, ratfish commonly are caught in the trawls of commercial fishermen and are considered to be a nuisance. Conversely, ratfish are an important source of food for fishes of economic import such as the soupfin shark, Galeorhinus zyopterus Jordan and Gilbert, (Nakatsu, 1957), the spiny dogfish, Squalus acanthias Linnaeus, (Alverson and Stansby, 1960), and the Pacific halibut, Hippoglossus stenolepis Schmidt, (Thompson, 1915).

This study was conducted to increase the general knowledge on the biology of the ratfish so that man will better be able to understand its place in nature. The subjects investigated were food habits, parasites, length-weight relationships, and methods of aging this primitive fish. Most specimens studied were collected off the coast of Oregon by otter trawl in the fall of 1965 and 1966, and the winter of 1967. Laboratory analyses were conducted on the campus of

Oregon State University during the 1966-67 academic year.

At present little information has been collected on the food habits of the ratfish. Olsson (1896) reported the following organisms from the digestive tract of 16 Chimaera monstrosa; mollusks (Cyprina islandica, Leda, and Venus), decapods, annelids (chetapodes-nereides), amphipods, echinoderms, and polyps. Legendre (1944) extended the above list to include additional mollusks (Anomia, Pecten, Cardium, Breccinum, Fusus, and Scalaria). Dean (1906), in his exhaustive study of chimaeroid development, stated that Chimaera (Hydrolagus) colliei feed on small isospondylous fishes, opisthobranchs, annelids, crustaceans, mollusks, squids, nudibranchs, sand, and gravel. He also commented that ratfish voided their food between capture and landing, which increased the difficulty of obtaining an accurate, representative list of foods ingested.

The few morphometric studies of the ratfish that I found were descriptive or histological in nature. Sanford, Clegg, and Bonham (1945) published an analytical study of the liver oil and vitamin A content of 35 ratfish captured off Tatoosh Island, Washington. These factors were related later to the size and sex of ratfish by Pidlaoan (1950). Halstead and Bunker (1952) described the venom apparatus and anatomy of the dorsal spine of ratfish. They concluded that the venom of H. colliei is not very potent, and that it is doubtful if this ratfish is capable of inflicting fatal injuries to man. They could find

no correlation between length of the dorsal spine and age (body length). A macro- and microscopic study of the histology of the digestive tract of 12 Hydrolagus colliei was conducted by Clothier (1957).

Stanley (1961) performed a morphometric study on the genital systems of Hydrolagus colliei. He found that:

1. The most accurate measurement of the body length was from the tip of the snout to the anterior edge of the anus (S-V), because the attenuated tip of the tail was missing in many specimens.
2. The ratio of female to male ratfish collected off Lopez Island, Washington, from August, 1959, to February, 1961, was 2:3.
3. The largest female obtained was 31.5 cm (S-V) and the largest male was 24.5 cm (S-V).
4. Summer was the peak reproductive period, although 1/3 of the females were sexually active at any time during the year. The adult males were sexually active throughout the year.
5. Sexual maturity was obtained at 24 to 25 cm (S-V)for females and 18.5 to 20.0 cm (S-V) for males.
6. The size at hatching from the egg capsule was 30 to 40 mm (S-V) for females and 41 mm (S-V) for males.

Several studies have been conducted on the parasites of Hydrolagus colliei. Wardle (1932) reported that most ratfish are infected with a pair of Gyrocotyle urna, which he suggested represented twin survivors of a mass infection. The twins occur opposite each other in the anterior region (spiral valve) of the intestine. Occurrence of more than two Gyrocotyle in one ratfish is unusual, but does happen. Lynch (1945) studied the taxonomy and morphology of Gyrocotyle urna and concluded that the genus should be divided into G. urna and G. fimbriata.

Koratha (1960) examined two Hydrolagus colliei from Cedros Island, Baja California, and found: One monogenean from the gills, two digeneans (Otodistomum sp.) and one cestode from the intestine, one hirudinean (Branchellion sp.) from the skin surface, and three copepods (Chondracanthus epacthes) from the gills. Another parasite reported on the gills of ratfish from Washington waters is Octobathrium leptogaster (Bonham, 1950).

METHODS

Source of Specimens

The ratfish used in this study were collected from the following five locations, four of which are shown in Figure 1:

1. Cape Blanco to the mouth of the Rogue River, Oregon, where 44 ratfish were collected by the Fish Commission of Oregon on March 20 and 21, 1967. These specimens were captured by trawl at a depth ranging from 50 to 110 fathoms.
2. Cape Arago to the mouth of the Umpqua River, Oregon, where 35 ratfish were collected by the Fish Commission of Oregon on February 20 to 22, 1967. These specimens were captured by trawl at a depth ranging from 50 to 110 fathoms.
3. Newport, Oregon, where 189 ratfish were purchased from the New England Fish Company. These fish were captured on October 4, 1965, by otter trawl between Loran chart blocks 2200 and 2300 (approximately 25 miles west of Newport) at a depth of 110 to 120 fathoms.
4. Astoria, Oregon, where 24 fish were collected by the Fish Commission of Oregon in November, 1966. These ratfish

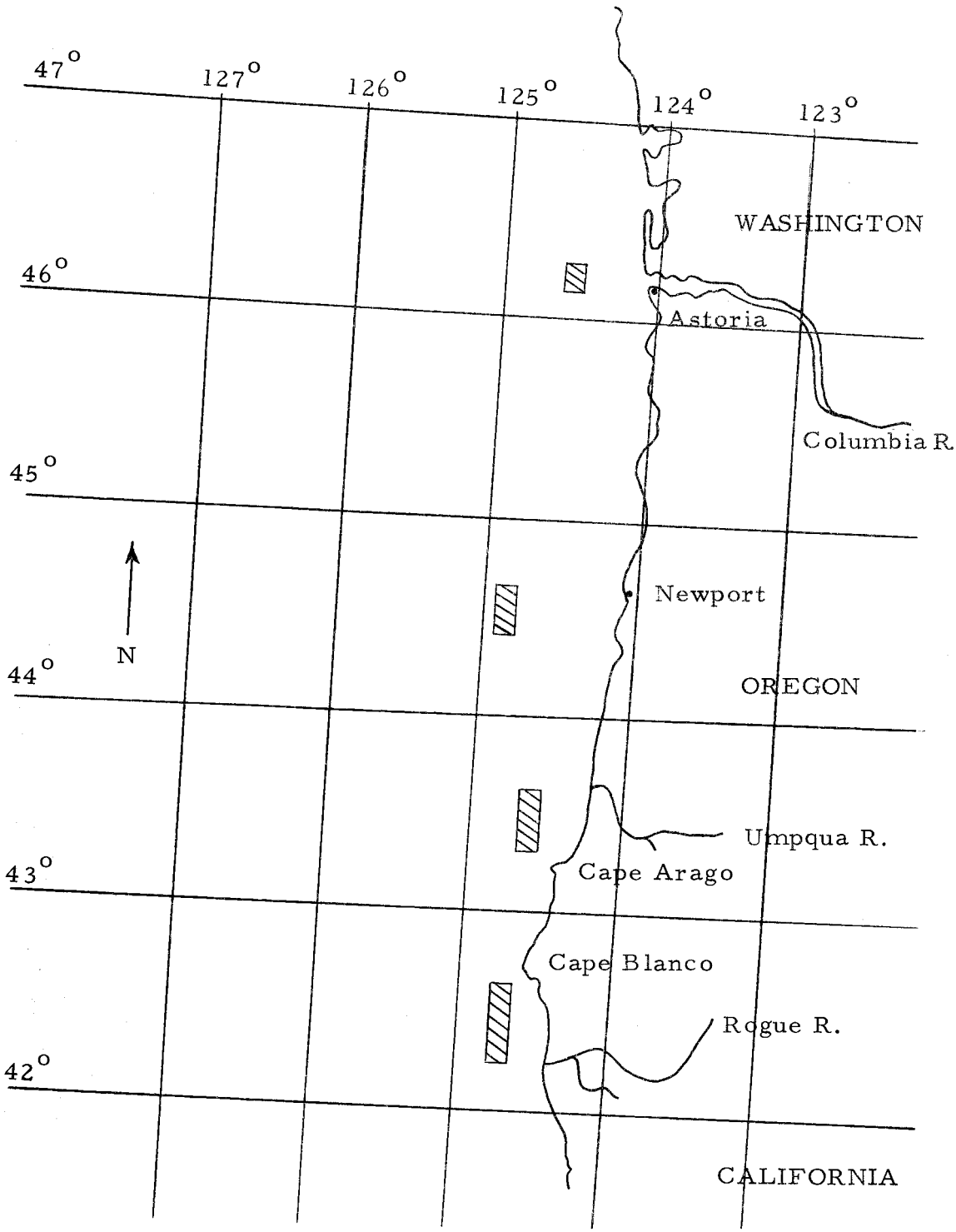


Figure 1. Map of the areas where ratfish were collected along the coast of Oregon. Cape Blanco, March, 1967; Cape Arago, February, 1967; Newport, October, 1965; and Astoria, November, 1966.

were captured by trawl at a depth of about 33 fathoms off the mouth of the Columbia River.

5. Puget Sound, Washington, where the author caught four ratfish by hook and line during August and September, 1965. One fish was captured off the lighthouse at Makitteo at a depth of 10 fathoms, and three were hooked 1/4 mile north of Eagle Point, Sekiu, Washington, at a depth of 70 fathoms.

The Newport collection was frozen until time for examination. Specimens collected off Cape Blanco, Cape Arago and Astoria were placed directly into 10% formalin. Ratfish collected in Puget Sound were examined fresh.

Examination Procedure

The following procedure was used for the examination of all ratfish except the Puget Sound collection. Because of the small sample, fish from Puget Sound were used for parasite and food content analyses only.

1. Sex was determined by examination of the reproductive organs.
2. Snout-vent (S-V) length in millimeters was measured from the tip of the snout to a line perpendicular to the anterior edge of the anus.
3. Total weight was measured in grams.

4. All structures were examined for the presence of external and internal parasites using a check sheet recommended by Dr. R. E. Millemann.[1]

5. Dental plates, left and right eye lens, dorsal spine, alimentary canal, left pectoral fin, and a section of the vertebral column just posterior to the dorsal spine were removed and placed in 10% formalin for further examination.

Procedure for Weighing Eye Lenses

The wet and dry weight of each eye lens from the Newport and Astoria collections was determined to the nearest ten thousandth of a gram on a Mettler analytical balance. For wet weight determinations, lenses were stored in 10% formalin for one month, removed and blotted, and immediately weighed. The lenses were then dried at 80 C for 82 hours and reweighed. The 82-hour drying period was determined from a curve of weights of ten lenses which were dried at 80 C and weighed at progressive time intervals. The 82-hour period assured 99% evaporation of liquids before the lenses began to disintegrate visibly after 90 hours drying time (Figure 2).

---

[1] Associate Professor of Fisheries, Department of Fisheries and Wildlife, Oregon State University, Corvallis.

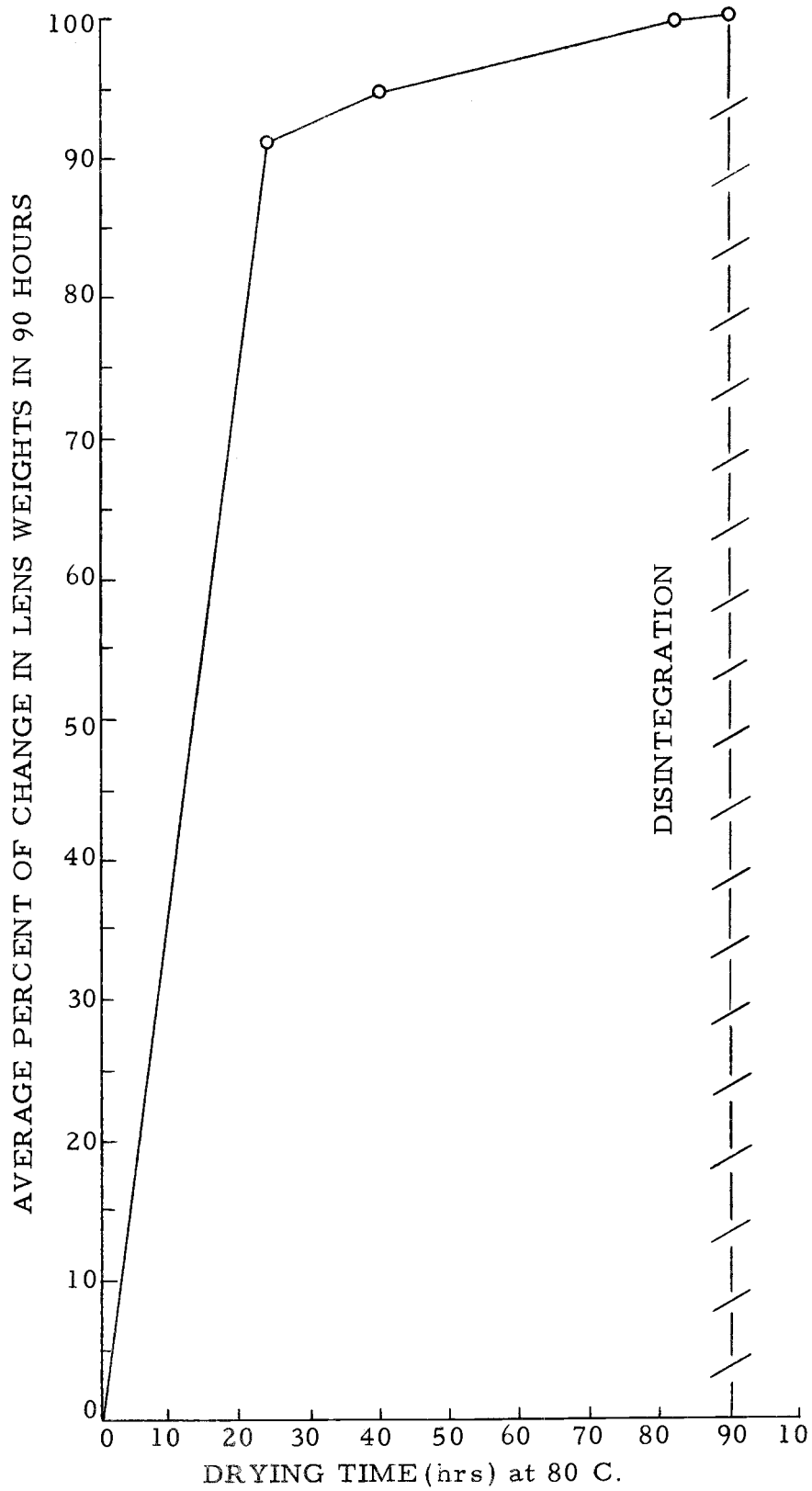


Figure 2. Average percent of change in 10 eye lens weights in 90 hours, before disintegration of lenses began, in relation to drying time at 80 C.

Examination of Alimentary Canals

Alimentary canals from all ratfish collected were removed from the preservative and opened along their entire length. The contents were washed into a glass stacking dish and identified.

Preparation of Vertebral Sections

Each section of cartilaginous vertebral column from ratfish collected off Newport was removed from its preservative and cut into three 0.25 mm cross sectional slices. These slices were placed between glass slides and examined by use of a microprojector. The projected radius (12X) of the centrum at a 90 degree angle to the apex of the neural arch was measured to the nearest millimeter. The three sectional radii from each ratfish were averaged.

Preparation of Structures for Age Analysis

Twenty-seven ratfish (8 males and 19 females) representing peaks in the length frequency distributions of the Cape Blanco and Newport collections were examined for growth structures indicative of age. Sections of the dorsal dental plate, base of the dorsal spine, base of the pectoral fin, and vertebral column were decalcified by the following procedure: (1) Remove extraneous tissue from the object. (2) Place in 30% formic acid for 12 hours to remove calcium.

(3) Remove from formic acid and place in a saturated solution of lithium carbonate in 70% ethanol to neutralize the acid.

After decalcification the materials were sectioned with a cryostat at -25 C to obtain 20-micron sections. The sections were placed on glass slides and stained with a Delafield's haematoxylin stain and then mounted with glucose.

The straining was accomplished by passing the sections systematically through the following solutions: Water, Delafield's haematoxylin stain, 35% acid-alcohol, lithium carbonate in water (to blue), and glucose. After the sections were mounted, they were examined under compound and binocular microscopes for growth structures.

Analysis of Data

My search for a method of determining the age of ratfish was based on the assumption that as fish increase in age, there is a corresponding increase in body length. Therefore, most measurements of body structures were compared to body length. Most statistical analyses of body length-body weight and body length-eye lens weight relationships were performed on a Control Data 3300 computer utilizing program FISH 6669 in the Department of Statistics at Oregon State University.

RESULTS

Length-Weight Relationship

The results of the analysis of body length-body weight relationship for the Newport collection are given in logarithms in Figure 3. The R^2 values of 0.87 for males and 0.97 for females indicate the goodness of fit of the lines plotted to the actual data. In Figures 4 and 5, the body weights are compared to body lengths in five millimeter intervals for males and females, respectively, in the Newport collection. As shown in these figures, there was a high degree of correlation of weight on length. The maximum length of the males was about 230 mm, while the maximum length for the females was about 290 mm. These three figures are based on my largest collection of specimens, comprising 189 ratfish collected off Newport, Oregon, on October 4, 1965. Five fish in this collection were mutilated and not fit for this analysis.

When the length-weight relationships for females from the Cape Arago, Newport, and Astoria collections were compared to each other and to a collection made off Tatoosh Island, Washington, by Sanford, Clegg, and Bonham (1945), there was good agreement among the relationships (Figure 6).

The mean body weight is compared to body length in 10 mm

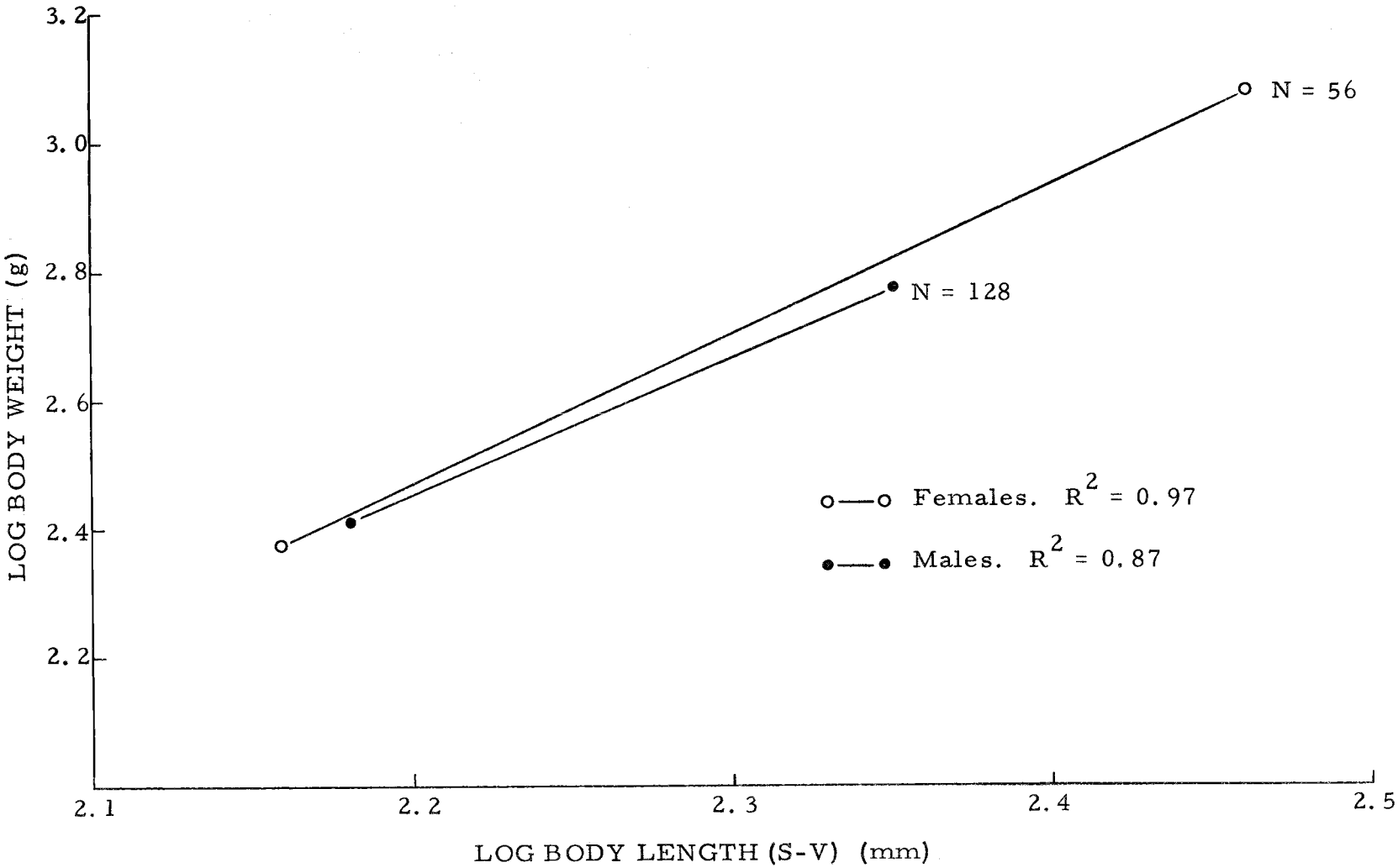


Figure 3. Length-weight relationship of male and female ratfish collected off Newport, Oregon, October, 1965.

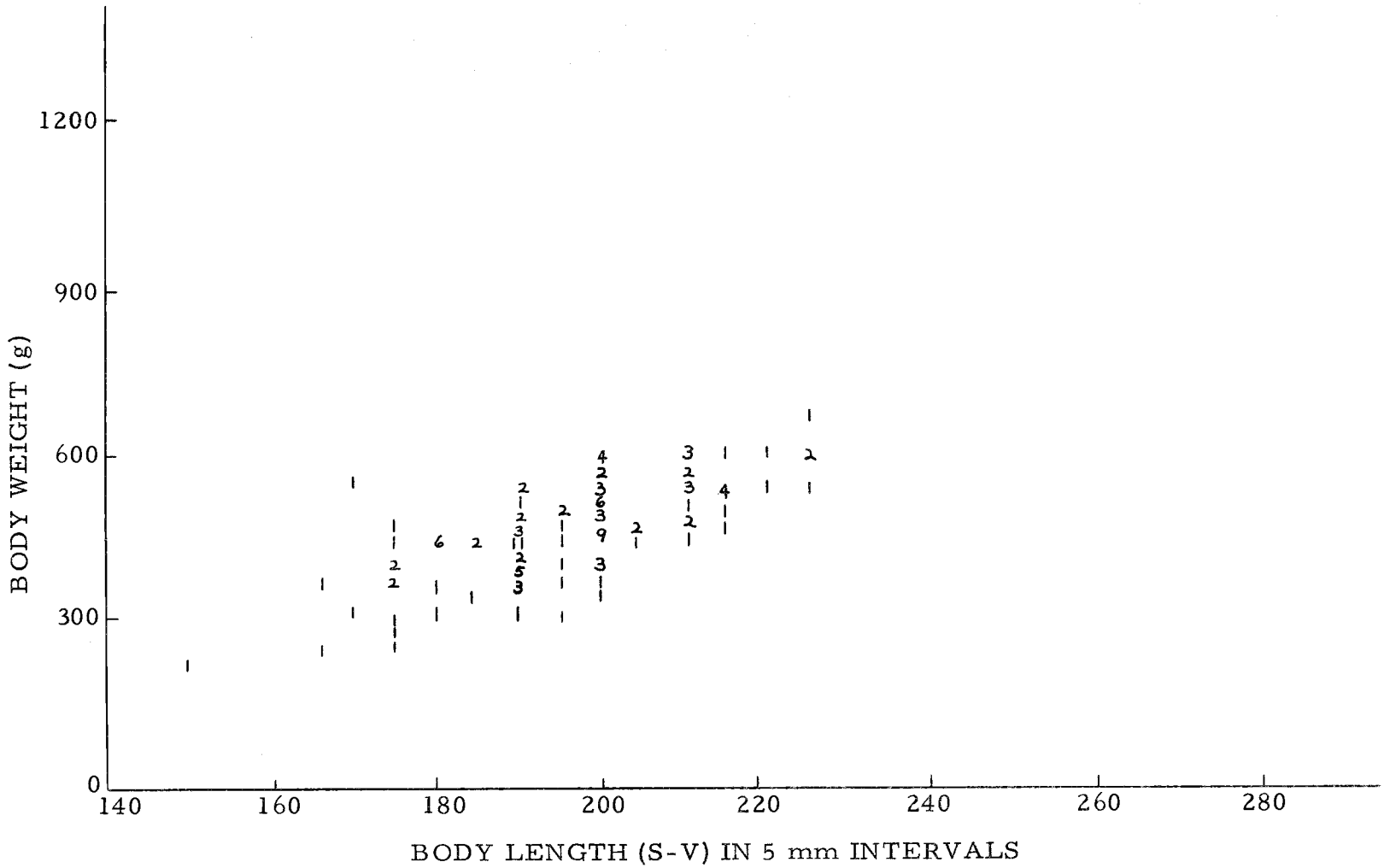


Figure 4. Length-weight relationship for 128 male ratfish collected off Newport, Oregon, October, 1965.

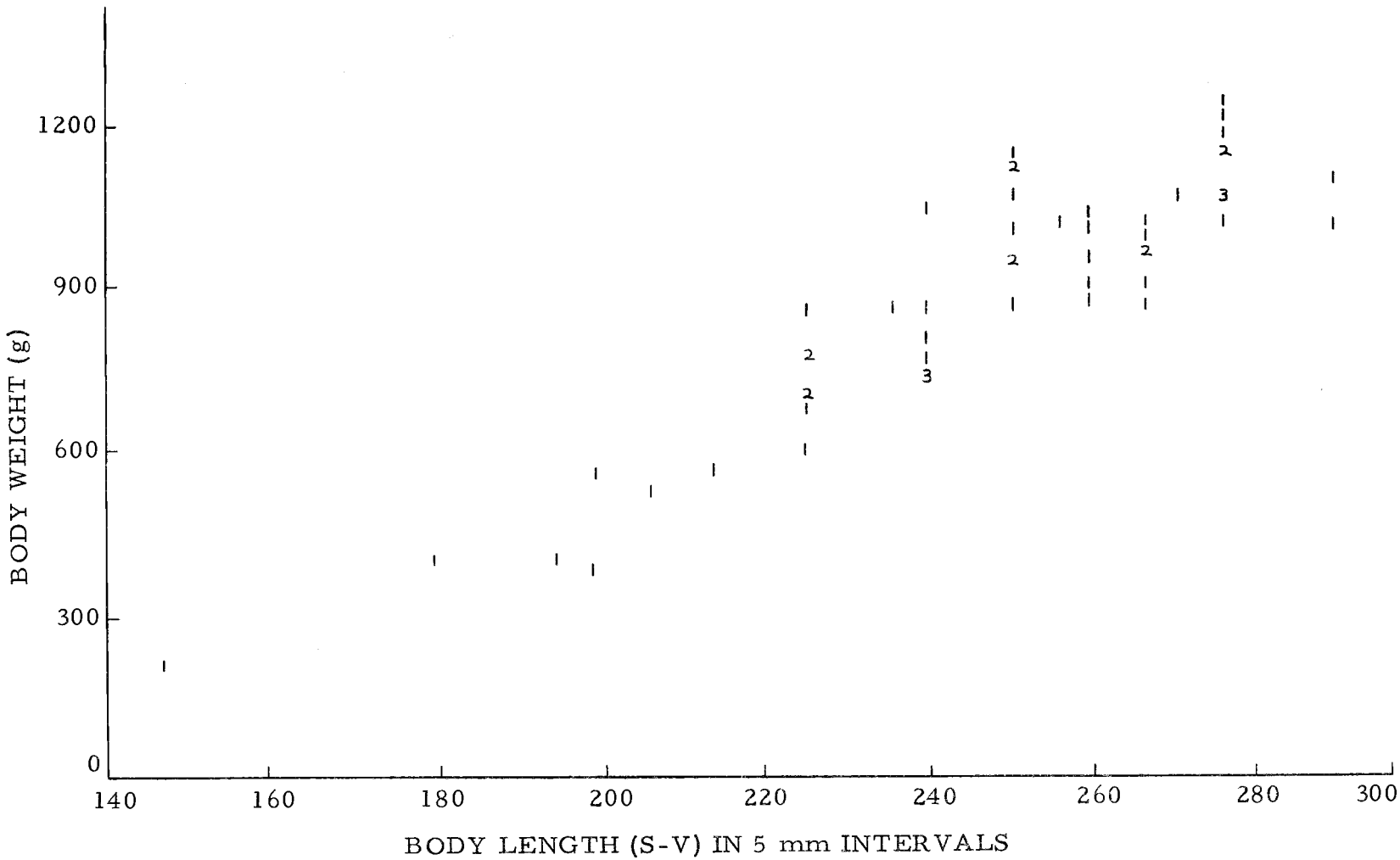


Figure 5. Length-weight relationship for 56 female ratfish collected off Newport, Oregon, October, 1965.

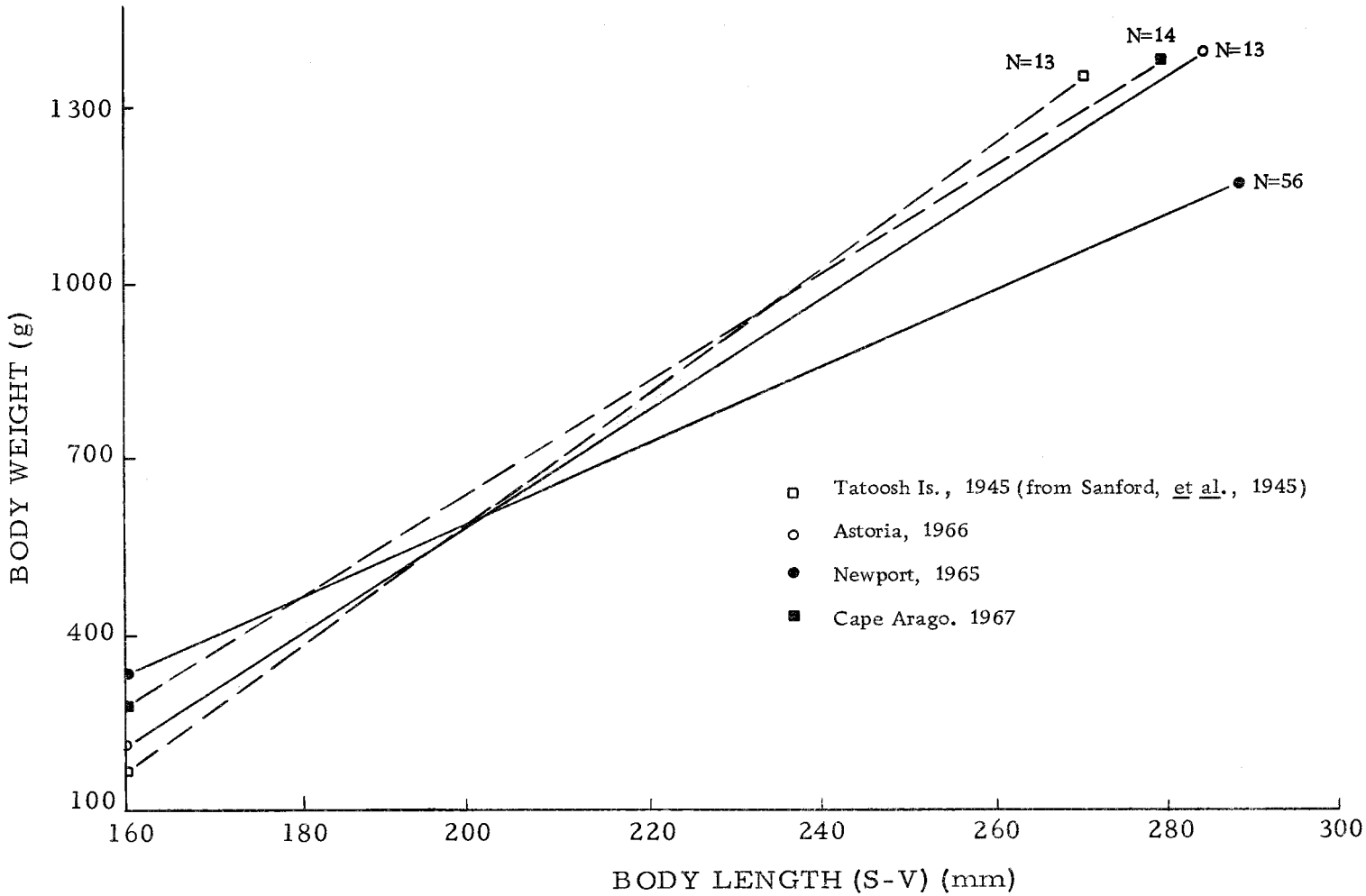


Figure 6. Comparison of length-weight relationships of female ratfish collected off Oregon and Washington.

intervals for male and female ratfish collected off Cape Blanco, Cape Arago, Newport, and Astoria in Figure 7. Figures 8 and 9 show the range and plus or minus one standard deviation of the mean of the body weight in relation to body lengths, in 10 mm intervals, for the males and females, respectively, from these same collections.

Table 1 contains the basic data from program FISH 6669 on the length-weight relationships of the ratfish presented in this thesis.

Food Habits and Parasites

The results of the food habits study are given by collection in Tables 2 (Newport), 3 (Astoria), 4 (Cape Arago), and 5 (Cape Blanco). These data are presented in the numerical and the frequency of occurrence methods. The Cape Blanco ratfish were divided into two length groups (40-70 mm and 115-120 mm S-V) in order to obtain a better idea of the food habits of the young of the year represented by the smaller length group.

A photograph of representative food organisms from the alimentary canals is presented in Figure 10. All these specimens, except Aphrodita sp., were removed from the canals of ratfish. Aphrodita sp. is presented as two specimens; one (left) that had not been eaten and the other (right) that was removed from the canal of a ratfish.

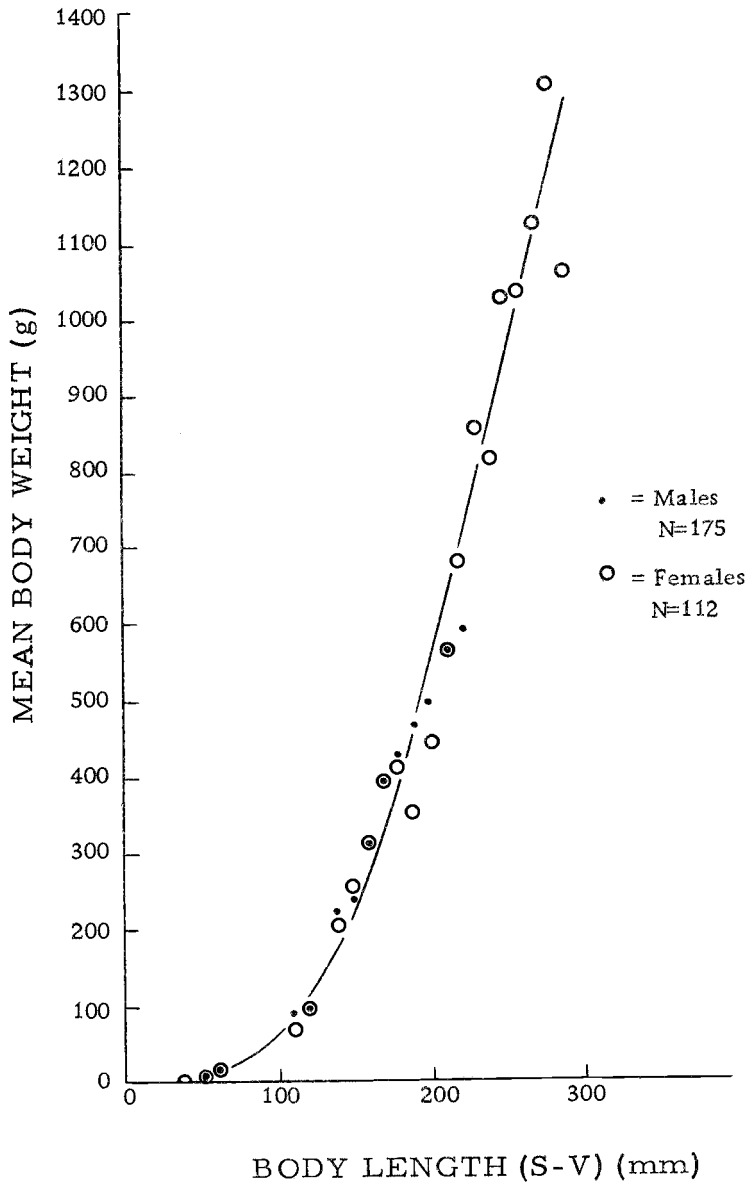


Figure 7. Mean body weight compared to body length in 10 mm intervals for male and female ratfish collected off Cape Blanco, Cape Arago, Newport and Astoria, Oregon, 1965 - 1967.

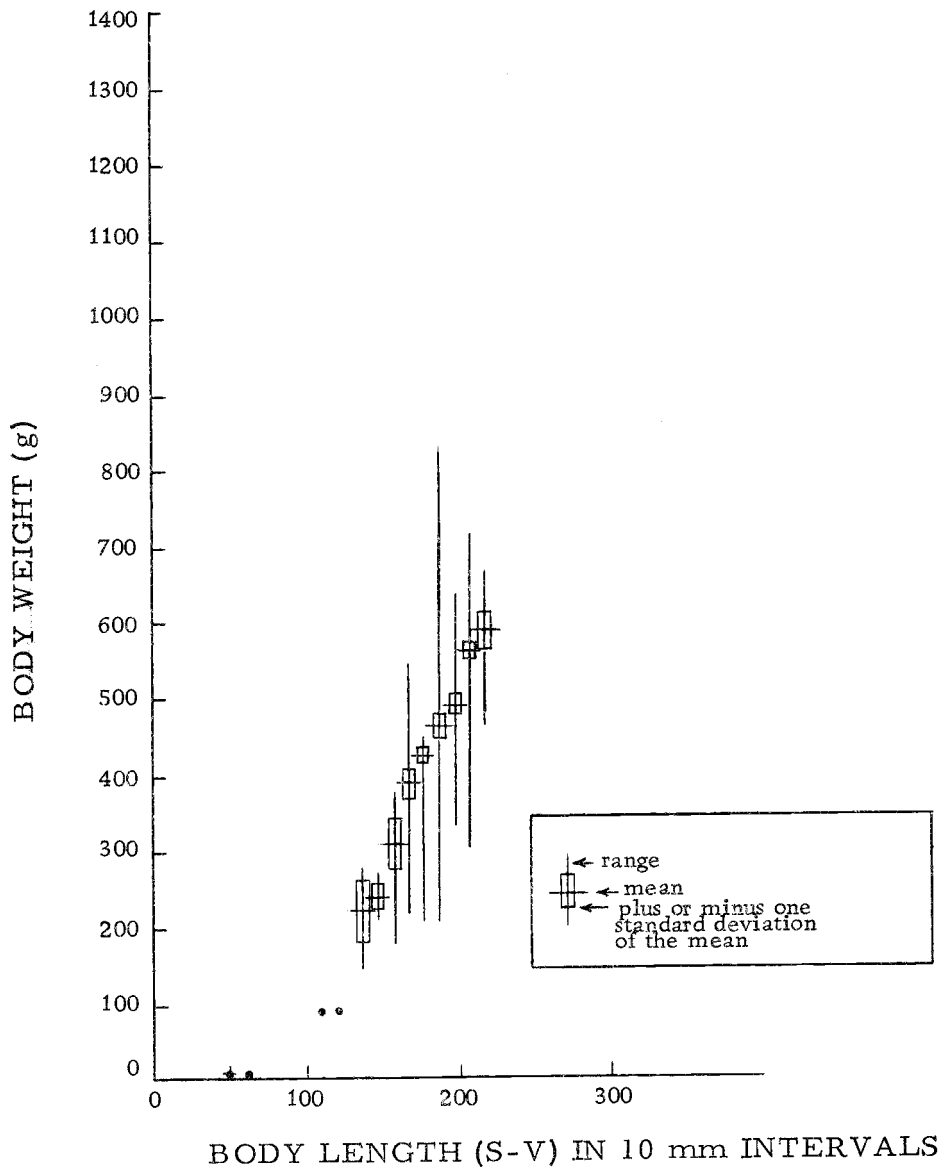


Figure 8. Range and plus or minus one standard deviation of the mean of body weight in relation to the body length (S-V) in 10 mm intervals for 175 male ratfish collected off Cape Arago, Cape Blanco, Newport, and Astoria, Oregon, 1965-1967.

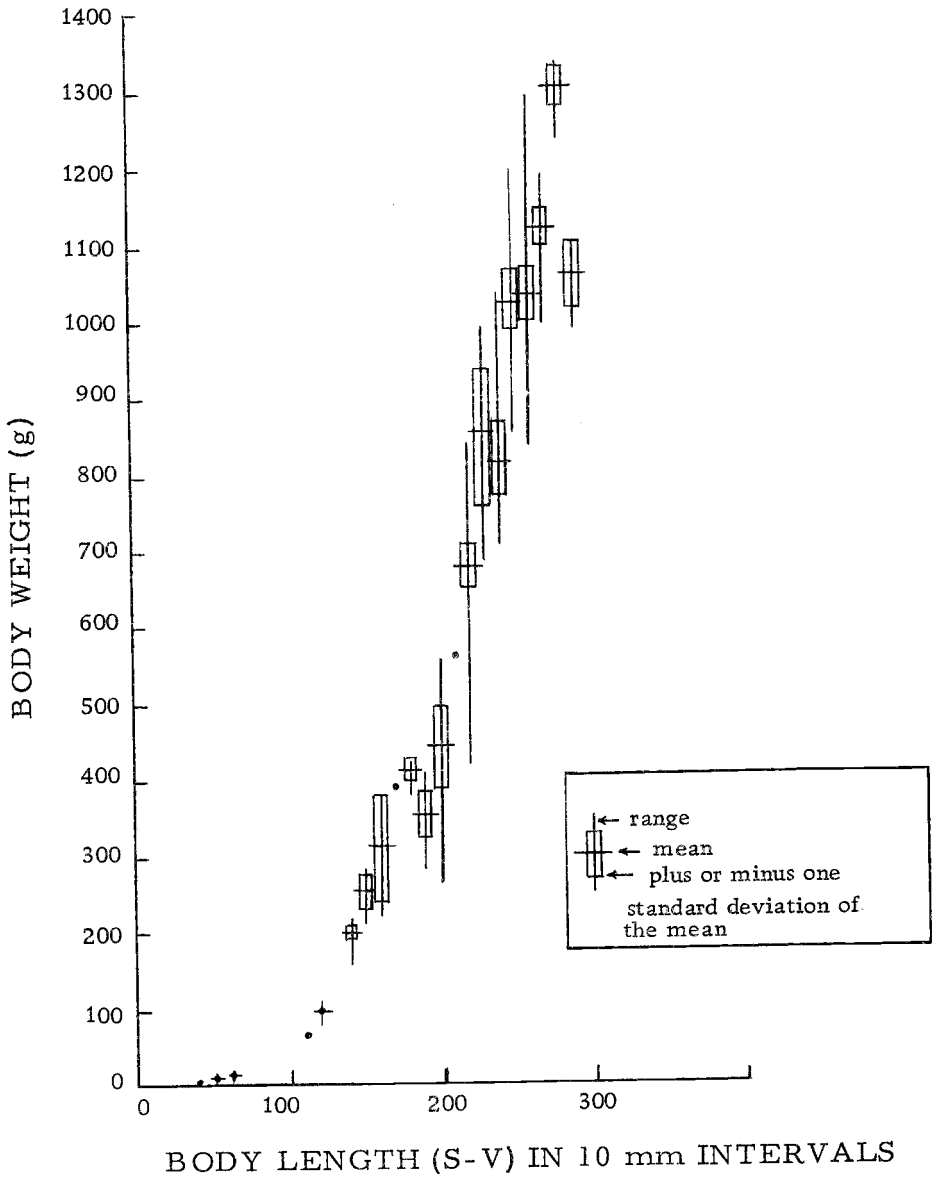


Figure 9. Range and plus or minus one standard deviation of the mean of the body weight in relation to the body length in 10 mm intervals for 112 female ratfish collected off Cape Arago, Cape Blanco, Newport, and Astoria, Oregon, 1965-1967.

Table 1. Results of program FISH 6669 (Control Data 3300) for length-weight relationships[1] of ratfish collected along the coast of Oregon during 1965, 1966, and 1967.

Sex[2]	Locations[3]	Y BAR[4]	X BAR[5]	RSQ[6]	SSX[7]	SSY[8]	LOG A	B	KFL[9]	SAMPLE SIZE
M	N	2.6525	2.2836	0.8748	0.0355	0.1695	-2.0168	2.0447	6.31	128
F	N	2.8459	2.3614	0.9652	0.0936	0.6223	-3.1384	2.5336	5.68	56
M	A	2.6378	2.2981	0.2270	0.0096	0.0405	0.3849	0.9803	5.81	13
F	A	2.8232	2.3669	0.9110	0.0550	0.8691	-6.3055	3.8569	5.24	13
M	T	2.2535	2.1526	0.9938	0.4804	4.5103	-4.3217	3.0546	6.32	175
F	T	2.4289	2.2201	0.9887	1.0844	9.6877	-9.1692	2.9720	5.83	112

[1] Basic length-weight equation: $\text{LOG } Y = \text{LOG } A + B (\text{LOG } X)$

[2] F = Females, M = Males

[3] N = Newport, A = Astoria, T = composite of Newport, Astoria, Cape Arago, and Cape Blanco collections.

[4] Y BAR = $\bar{Y}$ = mean of Y's. Y's are logs of body weight of fish in 5 mm length categories.

[5] X BAR = $\bar{X}$ = mean of X's. X's are logs of body length of fish in 5 mm length catagories.

[6] RSQ = R^2 = Coefficient of determination.

[7] SSX = Sum of the squares of the deviations of the X (length) observations about $\bar{X}$.

[8] SSY = Sum of the squares of the deviations of the Y (weight) observations about $\bar{Y}$.

[9] KFL = Coefficient of condition = weight/ a (length)^n (metric system).

Table 2. Food organisms occurring in the alimentary canals of 154 ratfish[1] (Hydrolagus colliei) collected off Newport, Oregon, October 4, 1965.

Organism[2]	Canals in which organism occurred		Total organisms found in canals[3]	
	Number of canals	Percent of canals	Number of organisms	Percent of organisms
Phylum Annelida				
Aphrodita sp.	8	3.8	8	0.7
unidentified	1	0.5	1	0.1
Phylum Mollusca				
Amphissa sp.	68	32.9	989	86.6
Musculus sp.	43	20.8	48	4.2
Yoldia sp.	6	2.9	6	0.5
Leptopecten sp.	2	1.0	2	0.2
Dentalium sp.	6	2.9	6	0.5
Phylum Arthropoda				
Livoneca sp.	8	3.8	8	0.7
unidentified amphipod	2	1.0	2	0.2
Crago sp.	28	13.5	32	2.8
unidentified shrimp	5	2.4	10	0.9
Cancer magister	1	0.5	1	0.1
unidentified crab	1	0.5	1	0.1
Phylum Echinodermata				
Brisaster sp.	21	10.1	21	1.8
Phylum Chordata				
Teleostomi	6	2.9	6	0.5
Unidentified				
animal matter	1	0.5	1	0.1
Totals	207	100.0	1142	100.0

[1] The canals of 30 additional ratfish collected off Newport, Oregon, were empty of ingested matter and were not included in this analysis.

[2] Sand occurred in 6 canals and mud was present in 18. These materials were not included in the calculations.

[3] Fragments (less than one-half an animal) were recorded as one individual.

Table 3. Food organisms occurring in the alimentary canals of 22 ratfish[1] (Hydrolagus colliei) collected off Astoria, Oregon, November, 1966.

Organism	Canals in which organism occurred		Total organisms found in canals[2]	
	Number of canals	Percent of canals	Number of organisms	Percent of organisms
Phylum Annelida				
Aphrodita sp.	1	3.6	1	2.4
Phylum Mollusca				
Amphissa sp.	5	17.7	12	29.3
Musculus sp.	6	21.4	9	22.0
Searlesia sp.	1	3.6	1	2.4
Phylum Arthropoda				
Pandalus sp.	10	35.8	13	31.8
Cancer sp.	1	3.6	1	2.4
Phylum Echinodermata				
Strongylocentrolus sp.	1	3.6	1	2.4
Brisaster sp.	1	3.6	1	2.4
Phylum Chordata				
Teleostomi	2	7.1	2	4.9
Totals	28	100.0	41	100.0

[1]The canals of two additional ratfish collected off the mouth of the Columbia River were empty of ingested matter and were not included in this analysis.

[2]Fragments (less than one-half an animal) were recorded as one individual.

Table 4. Food organisms occurring in the alimentary canals of 22 ratfish[1] (Hydrolagus colliei) collected off Cape Arago, Oregon, February 20-22, 1967.

Organism	Canals in which organism occurred		Total organisms found in canals[2]	
	Number of canals	Percent of canals	Number of organisms	Percent of organisms
Phylum Mollusca				
Amphissa sp.	2	5.7	14	17.0
Musculus sp.	4	11.4	5	6.1
Pecten sp.	4	11.4	7	8.5
Phylum Arthropoda				
Livoneca sp.	2	5.7	17	20.8
Pandalus sp.	12	34.4	26	31.8
Phylum Echinodermata				
Brisaster sp.	3	8.6	3	3.7
Strongylocentrolus sp.	1	2.8	1	1.2
Phylum Chordata				
Chimaeridae	2	5.7	2	2.4
Teleostomi	5	14.3	7	8.5
Totals	35	100.0	82	100.0

[1] Canals of an additional 13 ratfish were empty of ingested matter and were not included in this analysis.

[2] Fragments (less than one-half an animal) were recorded as one individual.

Table 5. Food organisms occurring in the alimentary canals of 30 ratfish[1] (Hydrolagus colliei) collected off Cape Blanco, Oregon, March 25-26, 1967.

Organism	Canals in which organism occurred		Total organism found in canals[2]	
	Number of canals	Percent of canals	Number of organisms	Percent of organisms
Ratfish 40-70 mm (S-V)				
Phylum Annelida				
unidentified	4	9.0	9	11.5
Phylum Mollusca				
Amphissa sp.	1	2.3	1	1.3
Amygdalum sp.	1	2.3	2	2.6
Cardiomya sp.	14	31.8	27	34.5
Dentalium sp.	1	2.3	1	1.3
Phylum Arthropoda				
Livoneca sp.	1	2.3	1	1.3
Pandalus sp.	22	50.0	37	47.5
Totals	44	100.0	78	100.0
Ratfish 115-120 mm (S-V)				
Phylum Annelida				
Aphrodita sp.	1	8.3	1	5.3
Phylum Mollusca				
Musculus sp.	3	25.0	4	21.0
Calliostoma sp.	1	8.3	1	5.3
Amygdalum sp.	4	33.3	7	36.8
Phylum Arthropoda				
Pandalus sp.	2	16.8	5	26.3
Chionectes sp.	1	8.3	1	5.3
Totals	12	100.0	19	100.0

[1]The canals of 10 additional ratfish were empty of ingested matter and were not included in this analysis.

[2]Fragments (less than one-half an animal) were recorded as one individual.

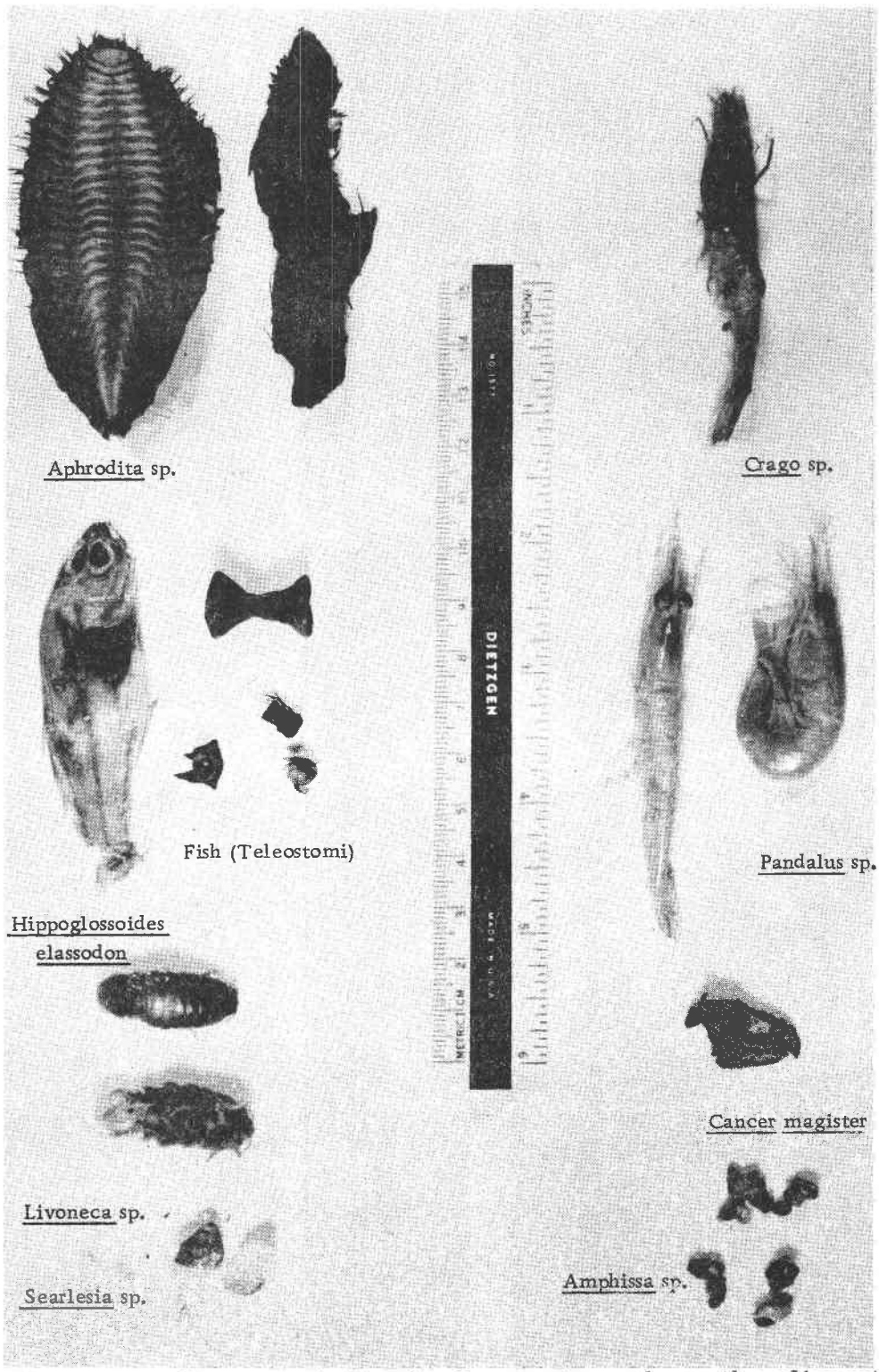


Figure 10. Representative food organisms from the alimentary canals of ratfish collected off the coast of Oregon, 1965-1967.

A taxonomic list of all food organisms identified from the 287 ratfish collected off Oregon and Washington is presented in Table 6. I was able to identify all food organisms except one piece of matter from an individual in the Newport collection.

The parasites found on or in ratfish were Gyrocotyle urna, G. fimbriata, a fungus, and the copepod, Acanthochondria sp. Table 7 is a listing of the Gyrocotyle found in the four collections of ratfish from the coast of Oregon. The unidentified fungus occurred in 29.2% of the ratfish collected off Newport. The fungus was located on the peritoneal surface of the intestine. Figure 11 is a photograph of Acanthochondria sp. These copepods were found attached to the ends of the pelvic claspers of seven males from the Cape Arago collection.

Sex and Age Determination

The determination of the sex of ratfish was accomplished by examining the reproductive organs. Sex could have been determined accurately by the presence or absence of the frontal, abdominal and pelvic claspers. The males possess these claspers and the females do not (Figures 12 and 13). Figures 14, 15 and 16 show the development and location of the claspers on males and the oviducal openings on females. The development of these structures can be used to separate ratfish into three age groups; young, immature, and adult. The

Table 6. Taxonomic list[1] of food organisms identified from the alimentary canals of 287 ratfish (Hydrolagus colliei) collected off Oregon and Washington during 1965, 1966, and 1967.

Phylum Annelida
Class Polychaeta
Aphrodita sp.
Phylum Mollusca
Class Gastropoda
Amphissa undata
Amygdalum sp.
Yoldia limatula gardneri
Musculus sp.
Leptopecten sp.
Hinnites or Pecten sp.
Cardiomya pectinata
Calliostoma sp.
Searlesia dira
Class Scaphopoda
Dentalium pretiosum
Phylum Arthropoda
Class Crustacea
Livoneca sp.
Crago franciscorum
Pandalus jordani
Orchestia sp.
Cancer magister
Chionectes tanneri
Balanus sp.
Phylum Echinodermata
Class Echinoidea
Brisaster sp.
Strongytocentrolus sp.
Phylum Chordata
Hippoglossoides elassodon
Esopsetta jordani
Spirinchus dialatus
Hydrolagus colliei

[1] After Barnes (1965)

Table 7. *Gyrocotyle* found in 283 ratfish (*Hydrolagus colliei*) collected off the coast of Oregon, 1965-1967.

Location	Total number of *Gyrocotyle*[1]			Number of ratfish examined	Percent infection[2]
	G. fimbriata	*G. urna*	Unidentified		
Newport	50 (34)	62 (39)	38 (25)	184	53.2 (60.0)
Astoria	8 (7)	-- --	-- --	24	29.2 (31.8)
Cape Arago	40 (23)	-- --	-- --	35	65.8 (79.4)
Cape Blanco	18 (11)	4 (2)	-- --	40	30.0 (35.4)

[1]Number in parenthesis is the number of ratfish infected.

[2]Number in parenthesis is the percent infection when the completely empty, that is neither food nor parasites were present, alimentary canals are not included.

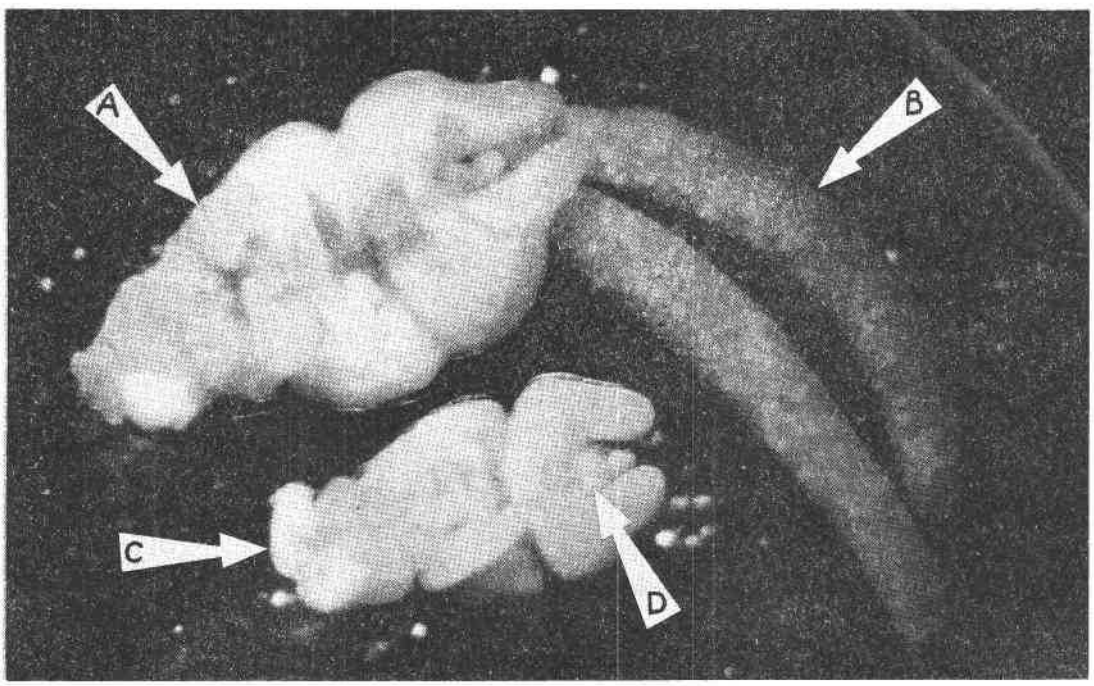


Figure 11. The copepod, Acanthochondria, showing (A) an adult female, (B) the paired egg sacs of the adult female, (C) a female without egg sacs, and (D) a pygmy male located between the lobes of the trunk of the female (11X actual size).

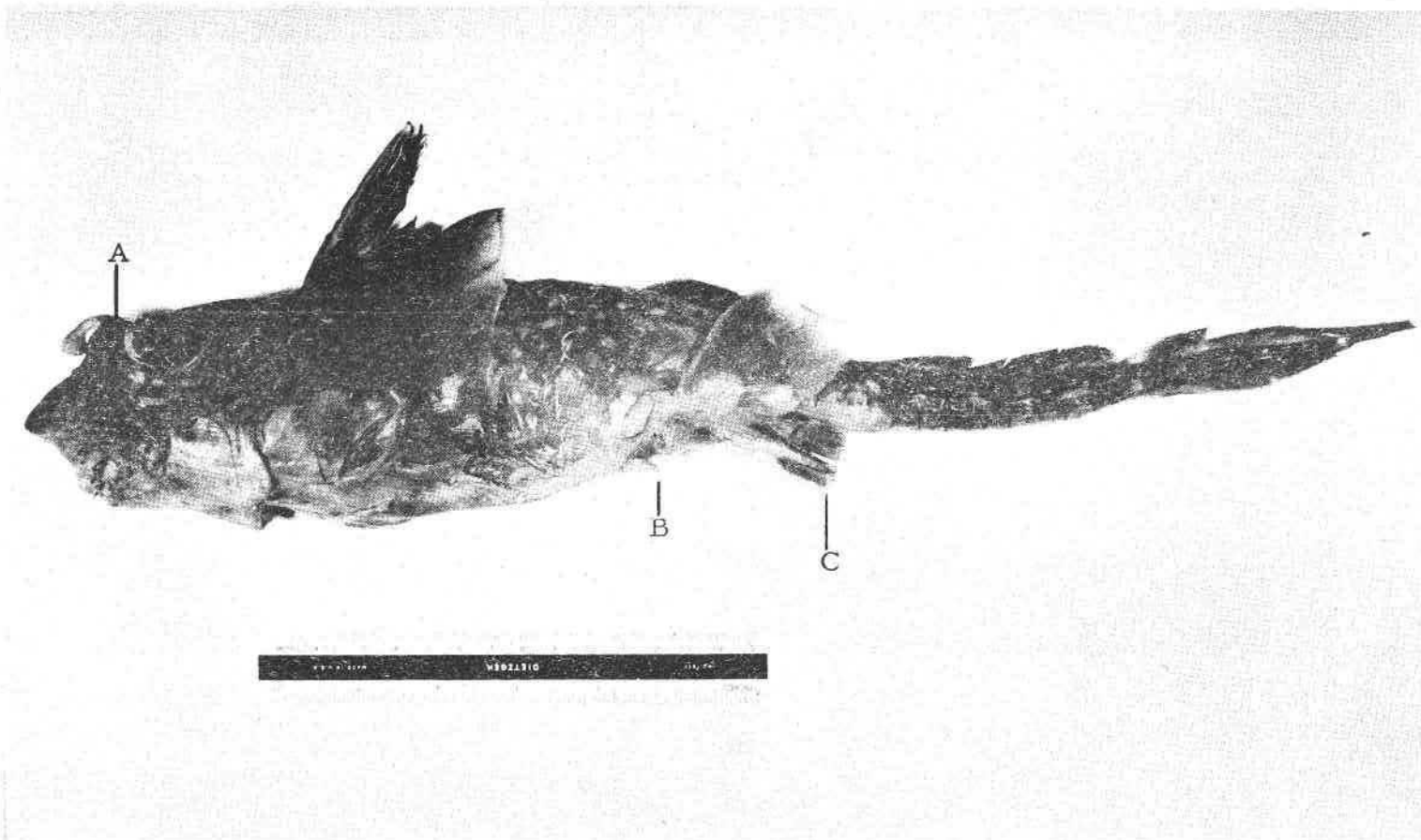


Figure 12. Adult male ratfish (Hydrolagus colliei) showing the location and appearance of the (A) frontal clasper, (B) abdominal claspers, and (C) pelvic claspers.

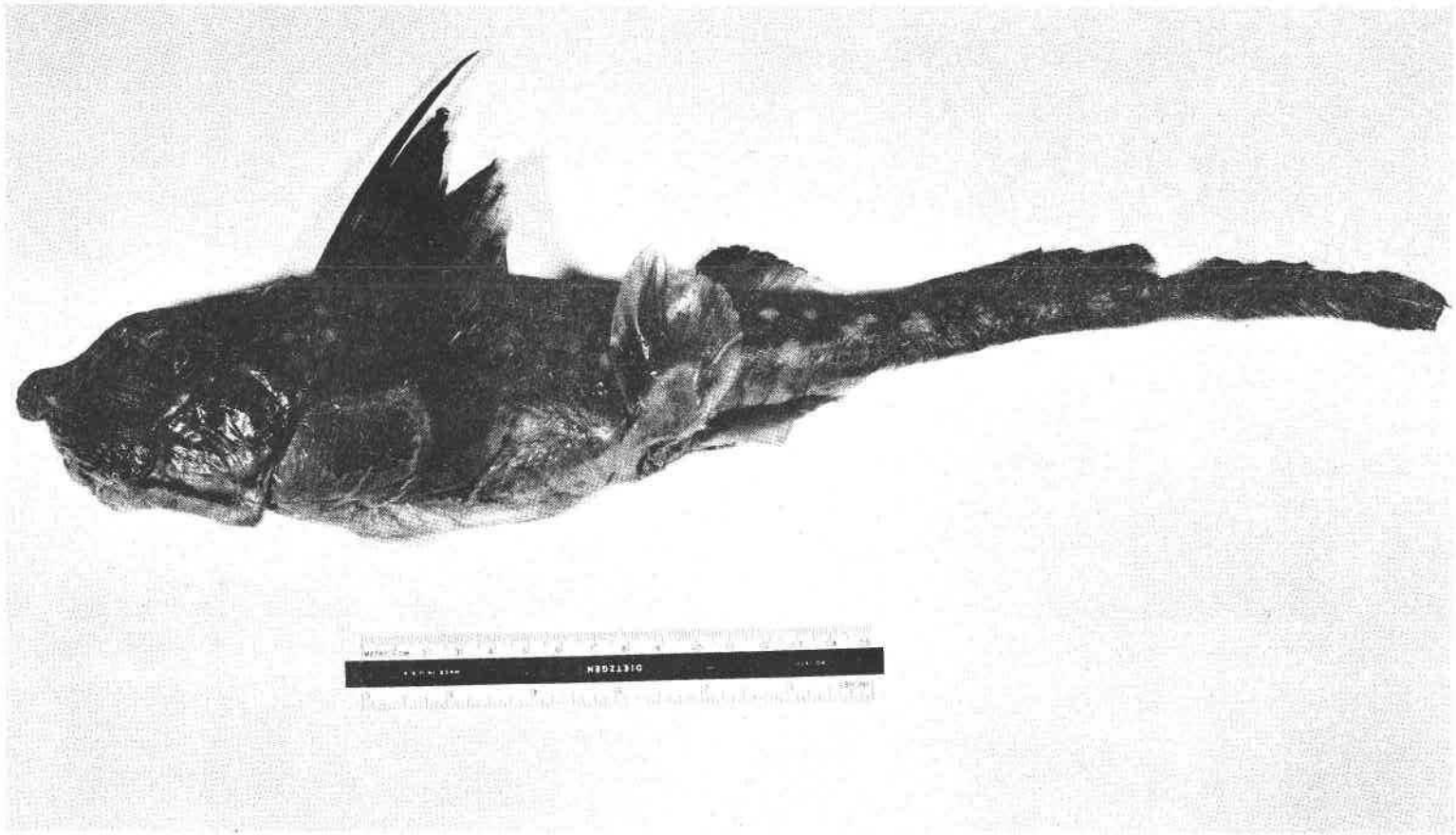


Figure 13. Adult female ratfish (Hydrolagus colliei).

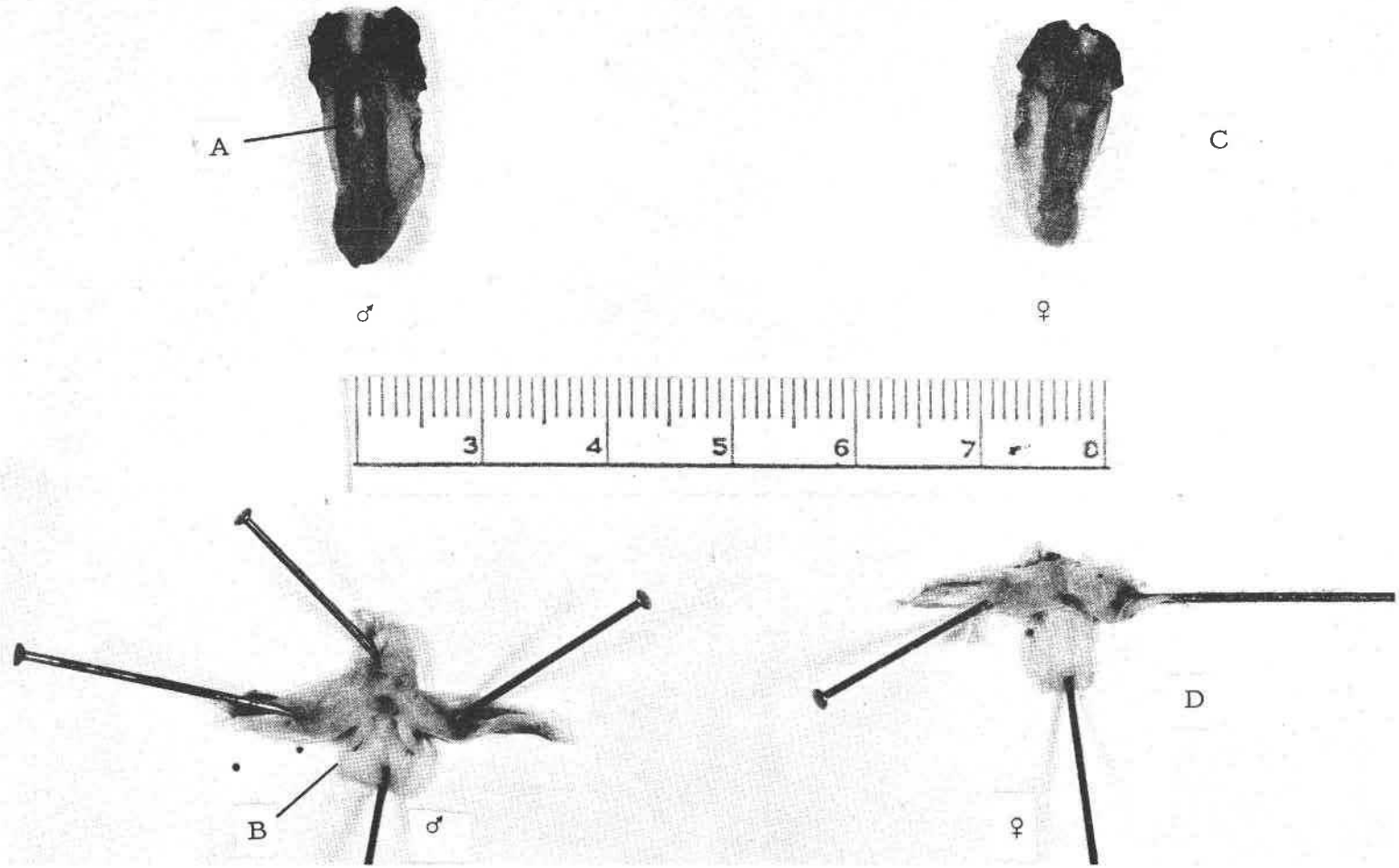


Figure 14. Regions of young ratfish showing (A) the frontal clasper streak and (B) the small pelvic claspers of the male, and (C) the lack of the frontal clasper streak and (D) the absence of the oviduct opening in the female.

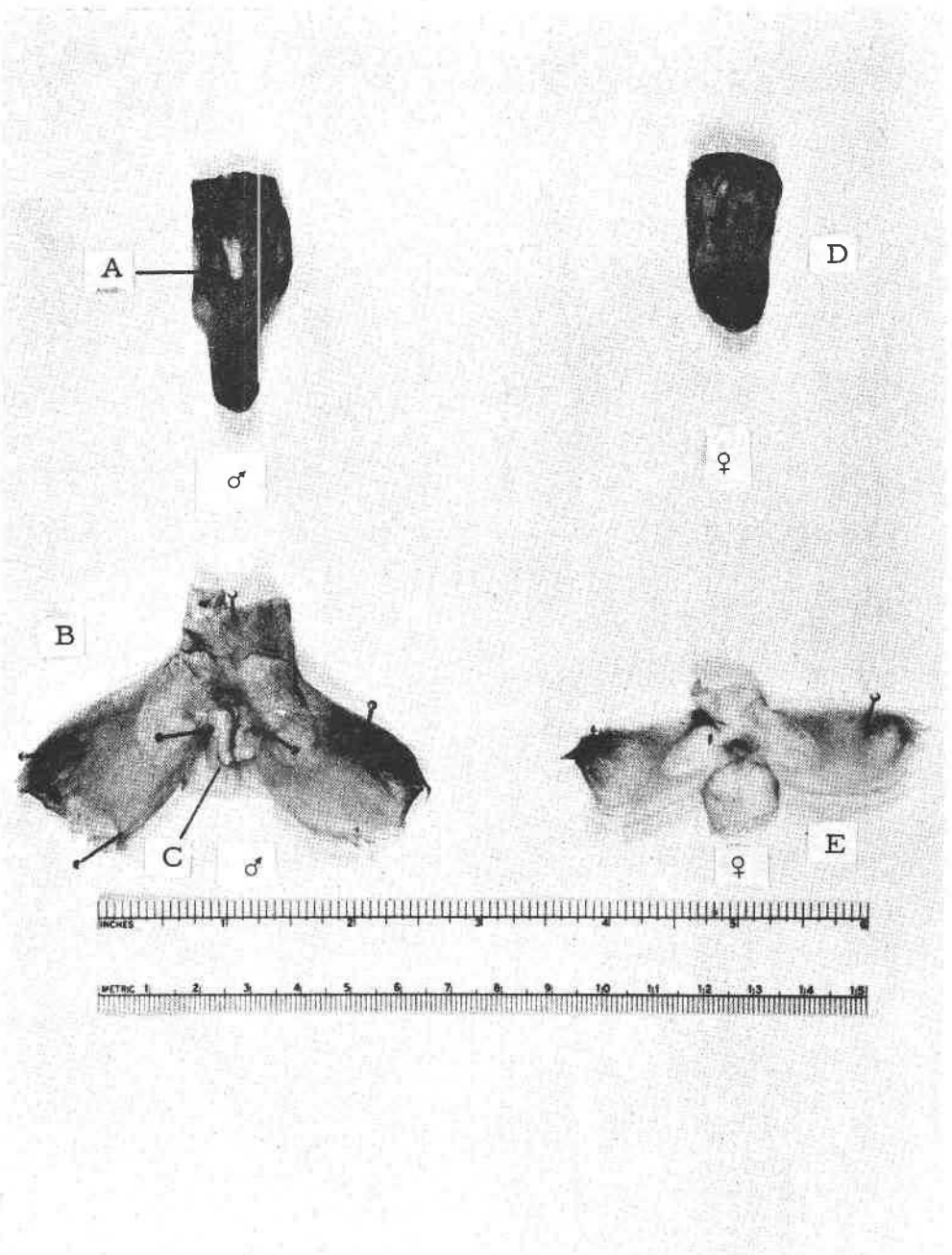


Figure 15. Regions of immature ratfish showing (A) the frontal clasper, (B) the abdominal clasper openings and (C) the pelvic claspers of the male, and (D) the absence of the frontal clasper and (E) the presence of the small openings to the oviducts of the female.

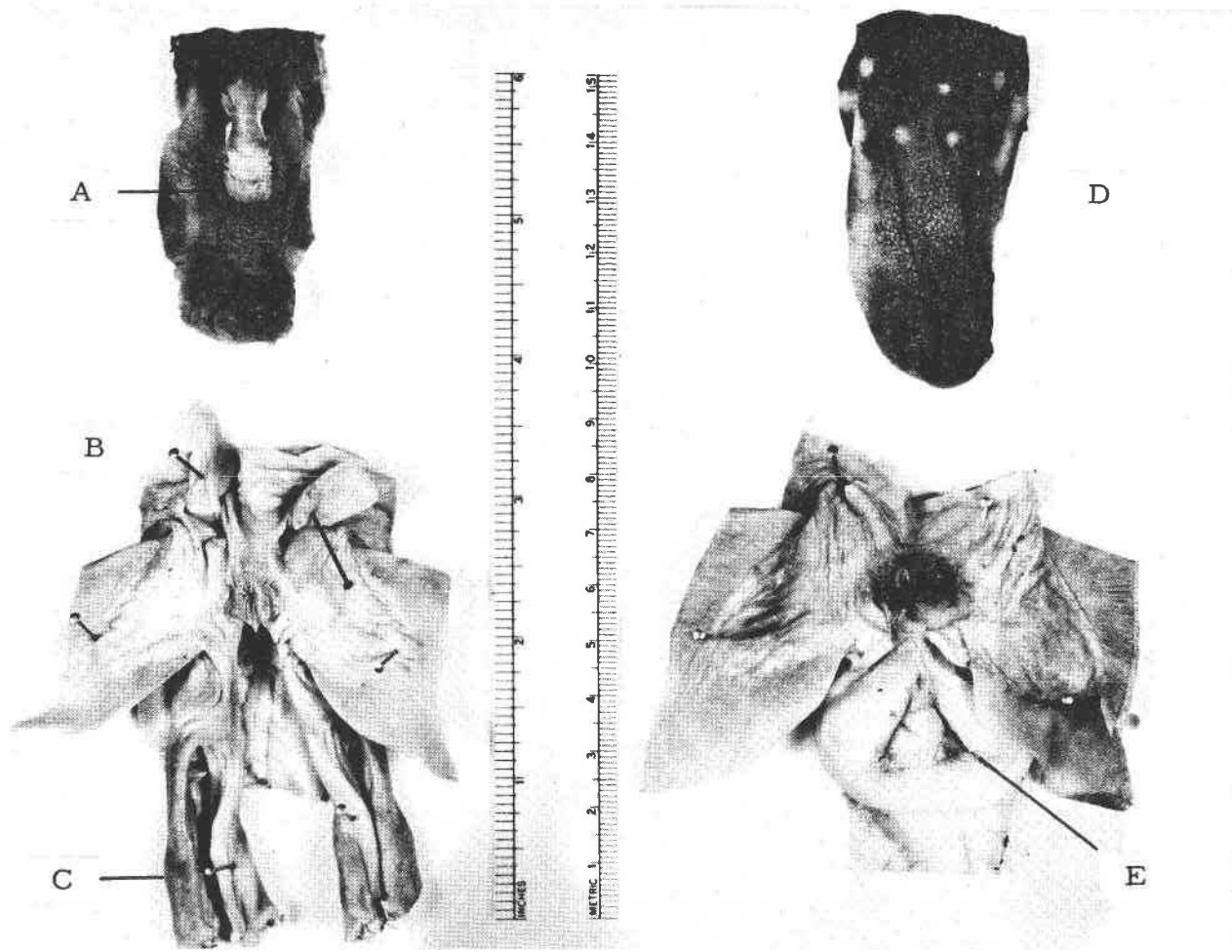


Figure 16. Regions of mature ratfish showing (A) the frontal clasper, (B) the abdominal claspers and (C) the pelvic claspers of the male, and (D) the absence of the frontal clasper and (E) the presence of well developed openings to the oviducts in the females.

ends of the pelvic claspers of immature males are not perforated, while those of the adults appear to be perforated. The openings of the oviducts of young females are not visible; those of the immatures are small; and those of the adults are open, elongated, and swollen.

The length frequency distribution of the Cape Blanco and Newport collections are presented in Figure 17 for the males and Figure 18 for the females. In both of these figures, I have assigned an arbitrary age scale, at the top of the graphs, based on the peaks of the length frequencies. The Cape Blanco collection contributed the ratfish less than 140 mm in length and those over 140 mm were obtained from the Newport collection.

When the eye lens weights (wet and dry) were compared to body length (S-V) for the Newport collection, the weight of the lenses of the males showed a higher correlation with body length than did those of the females (Figures 19 and 20, and Table 8). The R^2 values shown in these figures indicate the degree of correlation.

When the enlarged (12X) vertebral radii of ratfish from the Newport collection were compared to body length (S-V), there was a slight increase in size of the vertebrae with increasing length. There was, however, considerable variation in radii measurements within the body length groups of ratfish (Figures 21 and 22).

On the posterior side of the upper dental plate, there are ridges. The number of these ridges was compared to the body

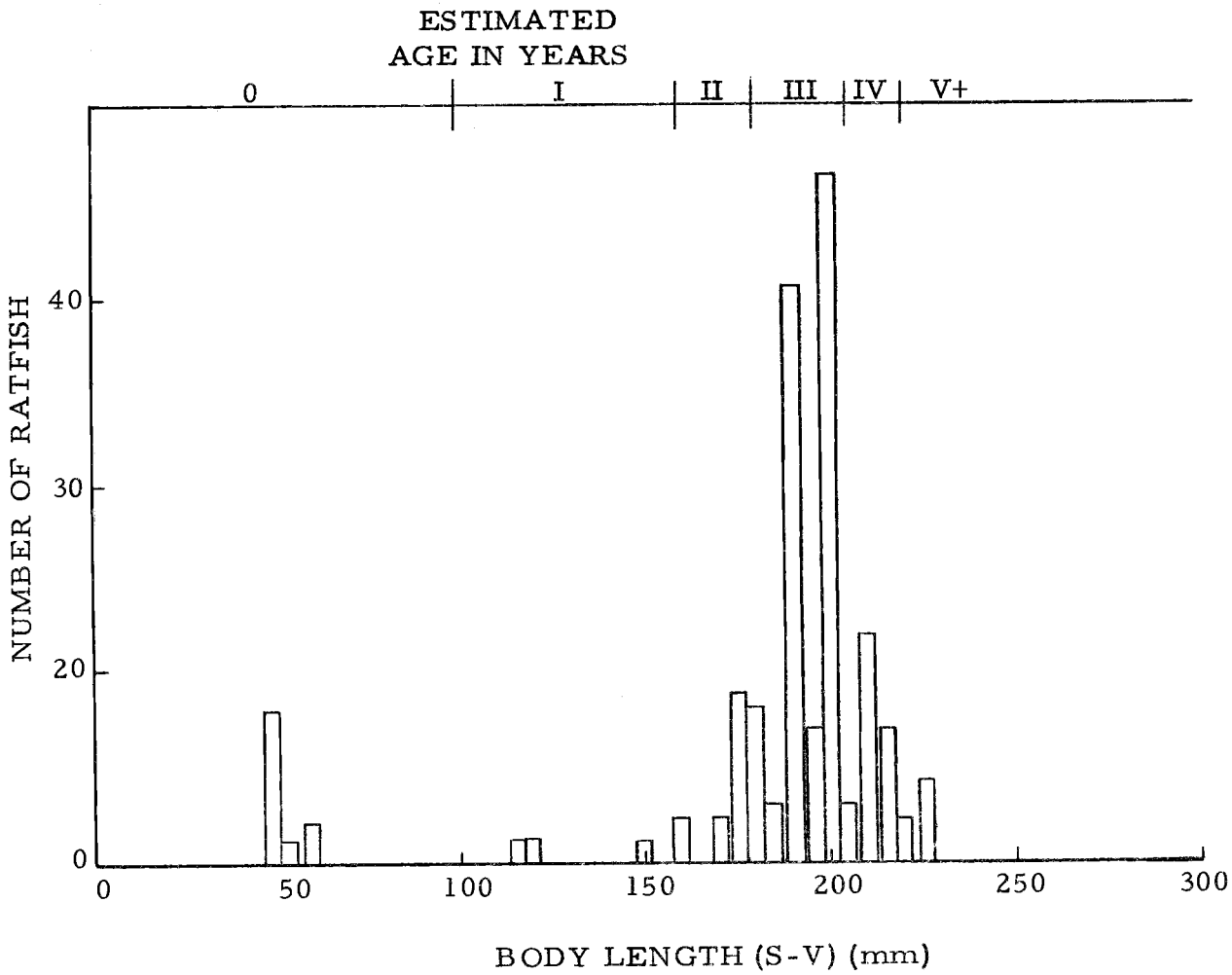


Figure 17. Estimated age of male ratfish collected off Cape Blanco and Newport, Oregon, 1957-1967, based on the distribution of body length frequencies in 5 mm intervals.

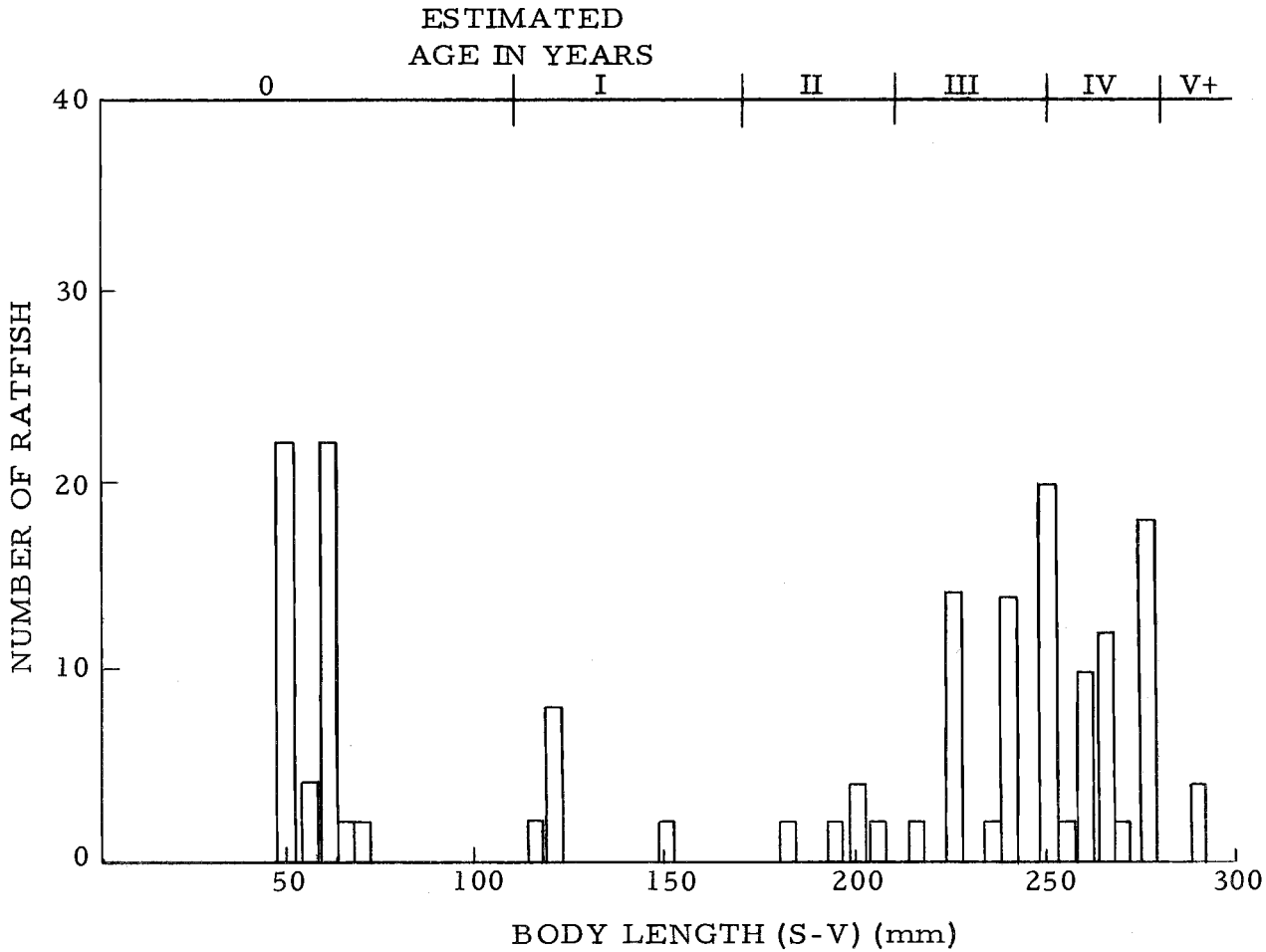


Figure 18. Estimated age of female ratfish collected off Cape Blanco and Newport, Oregon, 1965-1967, based on the distribution of body length frequencies in 5 mm intervals.

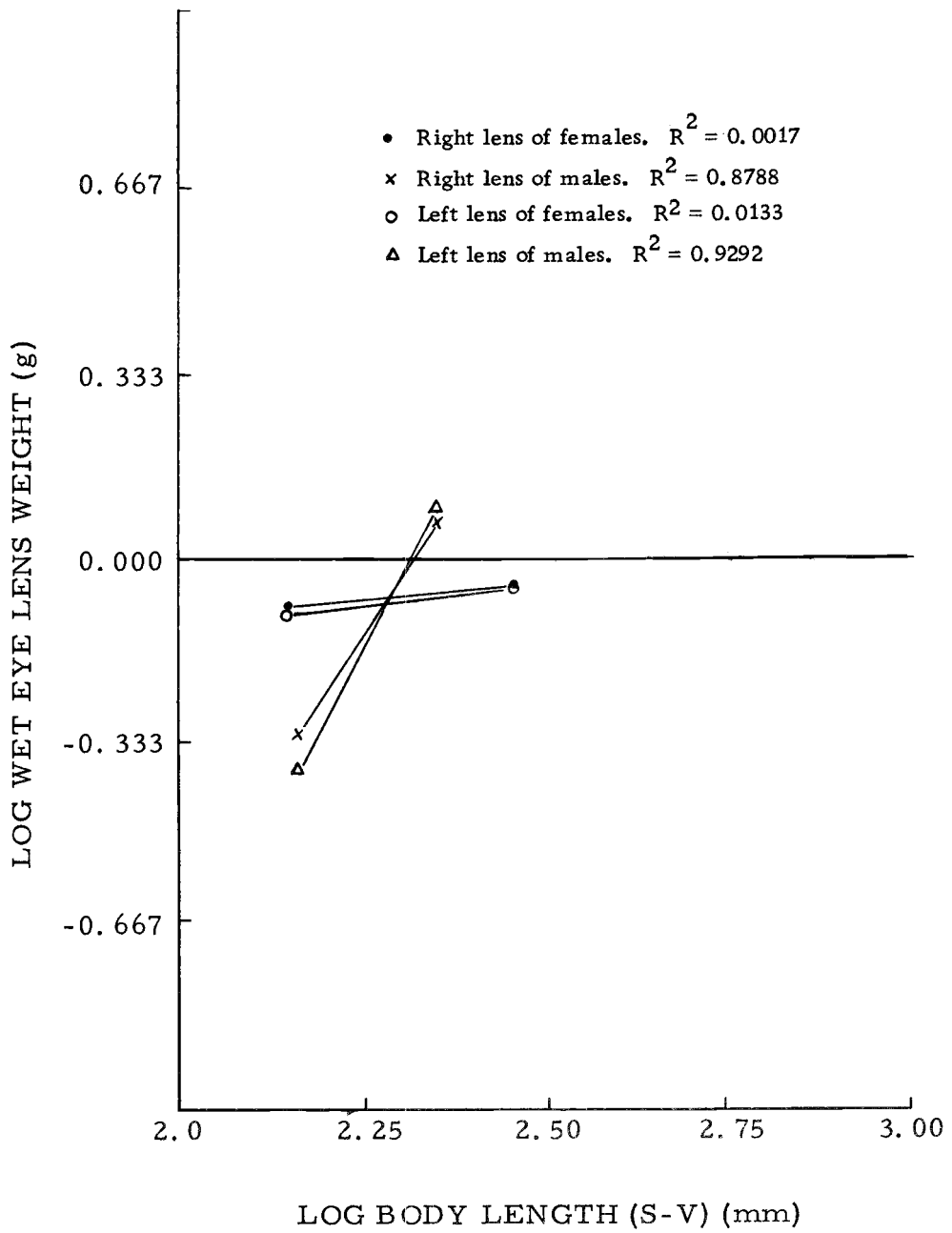


Figure 19. Log wet eye lens weight compared to log body length for ratfish collected off Newport, Oregon, October, 1965.

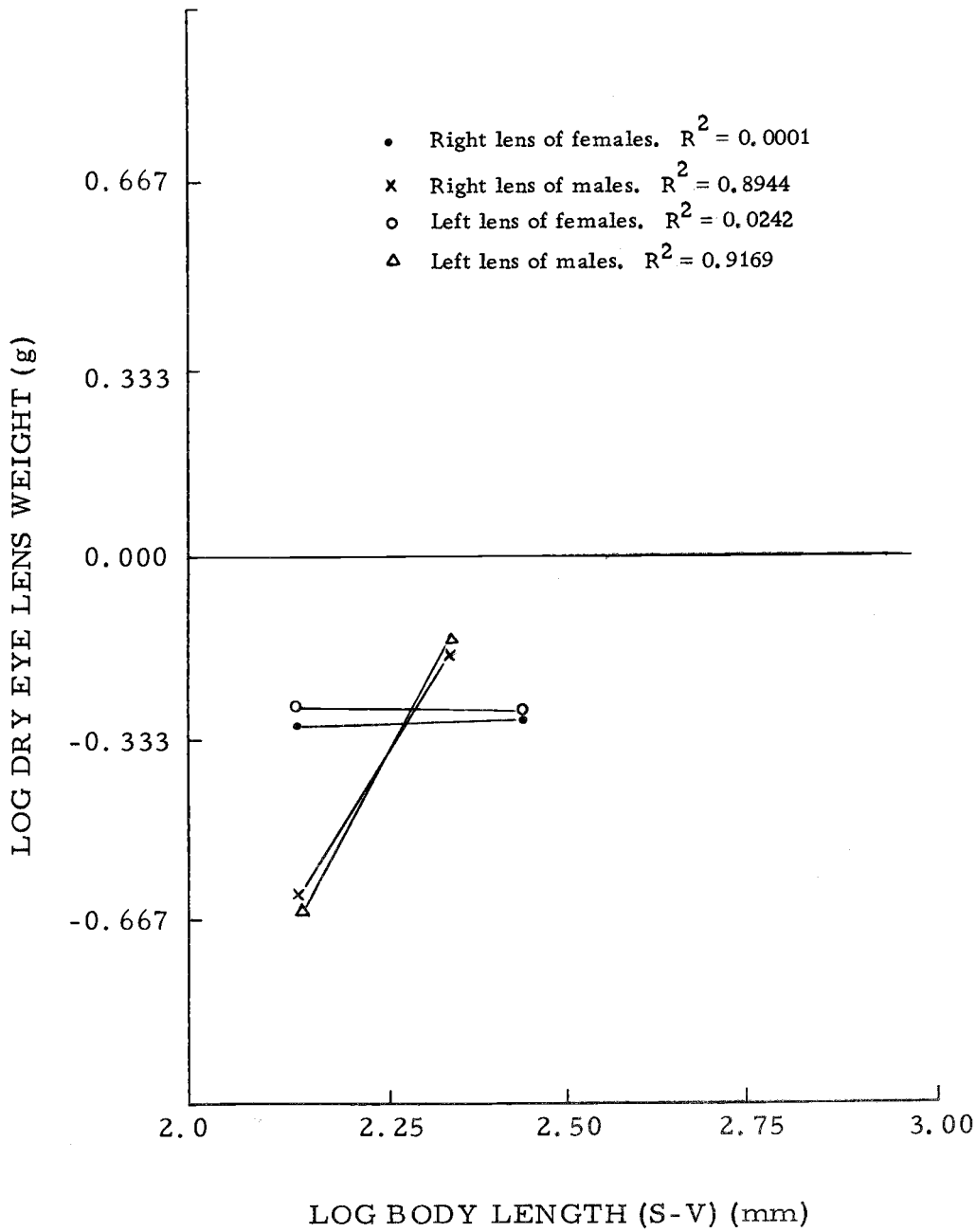


Figure 20. Log dry eye lens weight compared to log body length for ratfish collected off Newport, Oregon, October, 1965.

Table 8. Results of program FISH 6669 (Control Data 3300) for eye lens weight-body length relationships[1] of 189 ratfish collected off Newport, Oregon, October 4, 1965.

SEX[2]	TYPE	Y BAR[3]	X BAR[4]	RSQ[5]	SSX[6]	SSY[7]	LOG A	B
F	Rt. Wet	-0.0592	2.3619	0.0017	0.0936	0.0702	-0.1432	0.0356
M	Rt. Wet	-0.0886	2.2836	0.8788	0.0355	0.2173	-5.3871	2.3201
F	Rt. Dry	-0.3052	2.3619	0.0001	0.0936	0.0603	-0.2877	-0.0074
M	Rt. Dry	-0.3490	2.2836	0.8944	0.3547	0.2739	-6.3503	2.6280
F	Lt. Wet	-0.0606	2.3619	0.0133	0.0936	0.0679	-0.2931	0.0984
M	Lt. Wet	-0.0926	2.2836	0.9292	0.0355	0.3120	-6.6214	2.8590
F	Lt. Dry	-0.2906	2.3619	0.0242	0.0936	0.1456	0.1674	-0.1939
M	Lt. Dry	-0.3530	2.2836	0.9169	0.0355	0.3371	-7.0941	2.9520

[1] Basic equation: LOG Y = LOG A + B (LOG X)

[2] F = Females, M = Males

[3] Y BAR = $\overline{Y}$ = mean of Y's. Y's are Logs of eye lens weights of fish in 5 mm catagories.

[4] X BAR = $\overline{X}$ = mean of X's. X's are Logs of body lengths of fish in 5 mm catagories.

[5] RSQ = Coefficient of determination.

[6] SSX = Sum of the squares of the deviations of the X (length) observations about $\overline{X}$.

[7] SSY = Sum of the squares of the deviations of the Y (lens weight) observations about $\overline{Y}$.

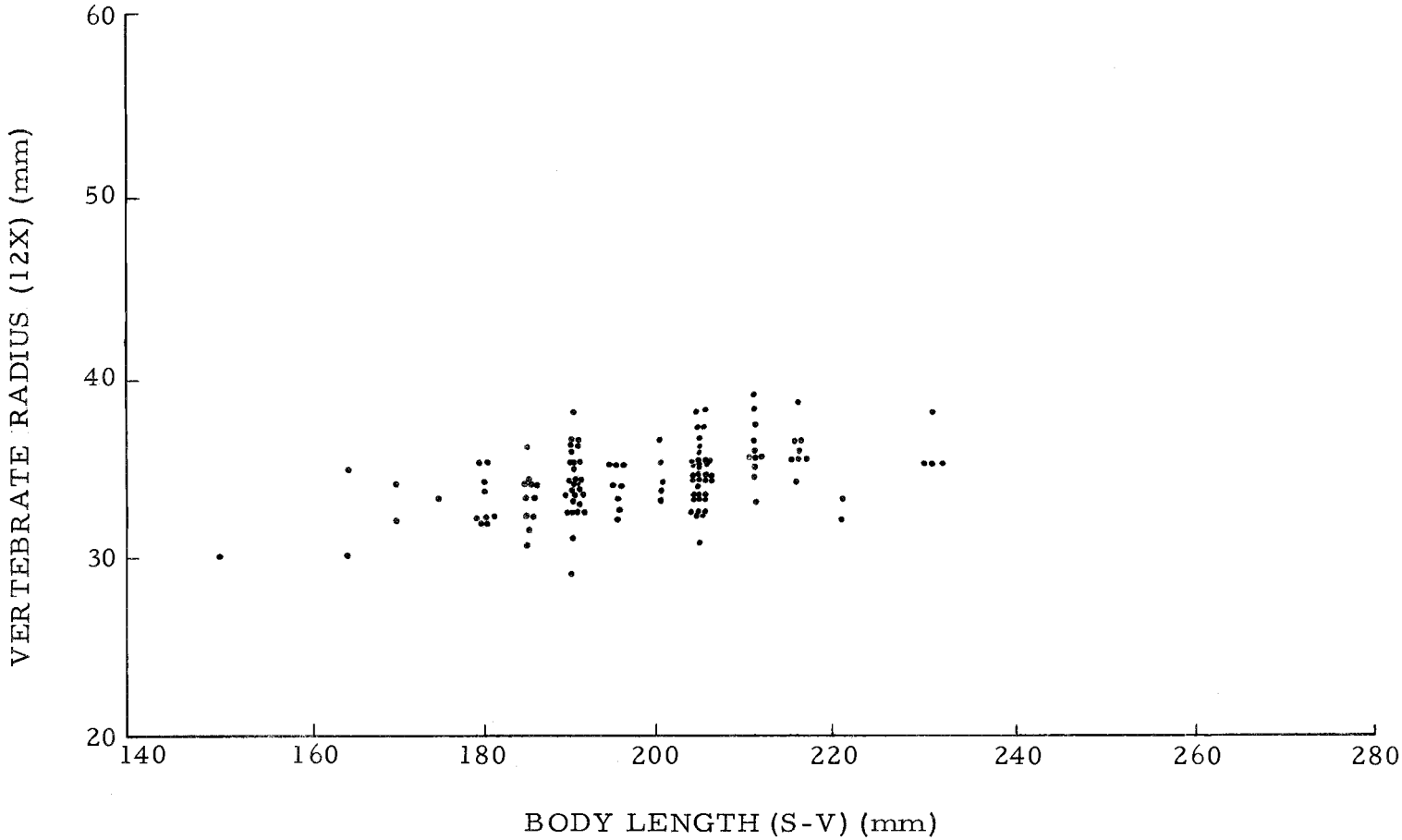


Figure 21. Vertebrae radius compared to body length in 5 mm intervals for male ratfish collected off Newport, Oregon, October 4, 1965.

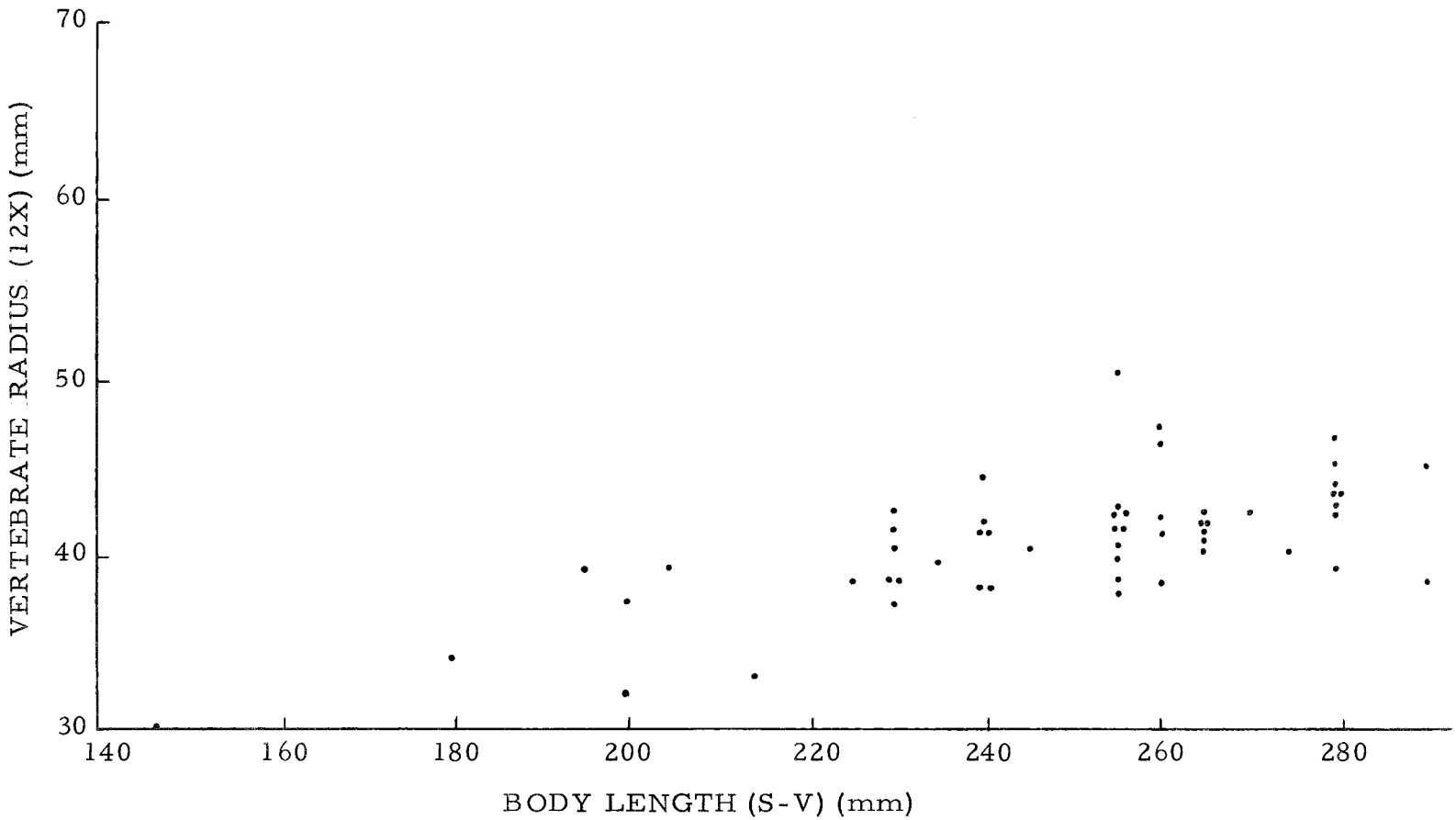


Figure 22. Vertebrae radius compared to body length in 5 mm intervals for female ratfish collected off Newport, Oregon, October 4, 1965.

lengths (S-V) of the ratfish in the Cape Blanco and Newport collections (Figure 23). There is overlap in the number of ridges between the arbitrary age classes presented in Figures 17 and 18, but my sample size was small. With a larger, more complete sample, these ridges may be useful in determining the age of ratfish.

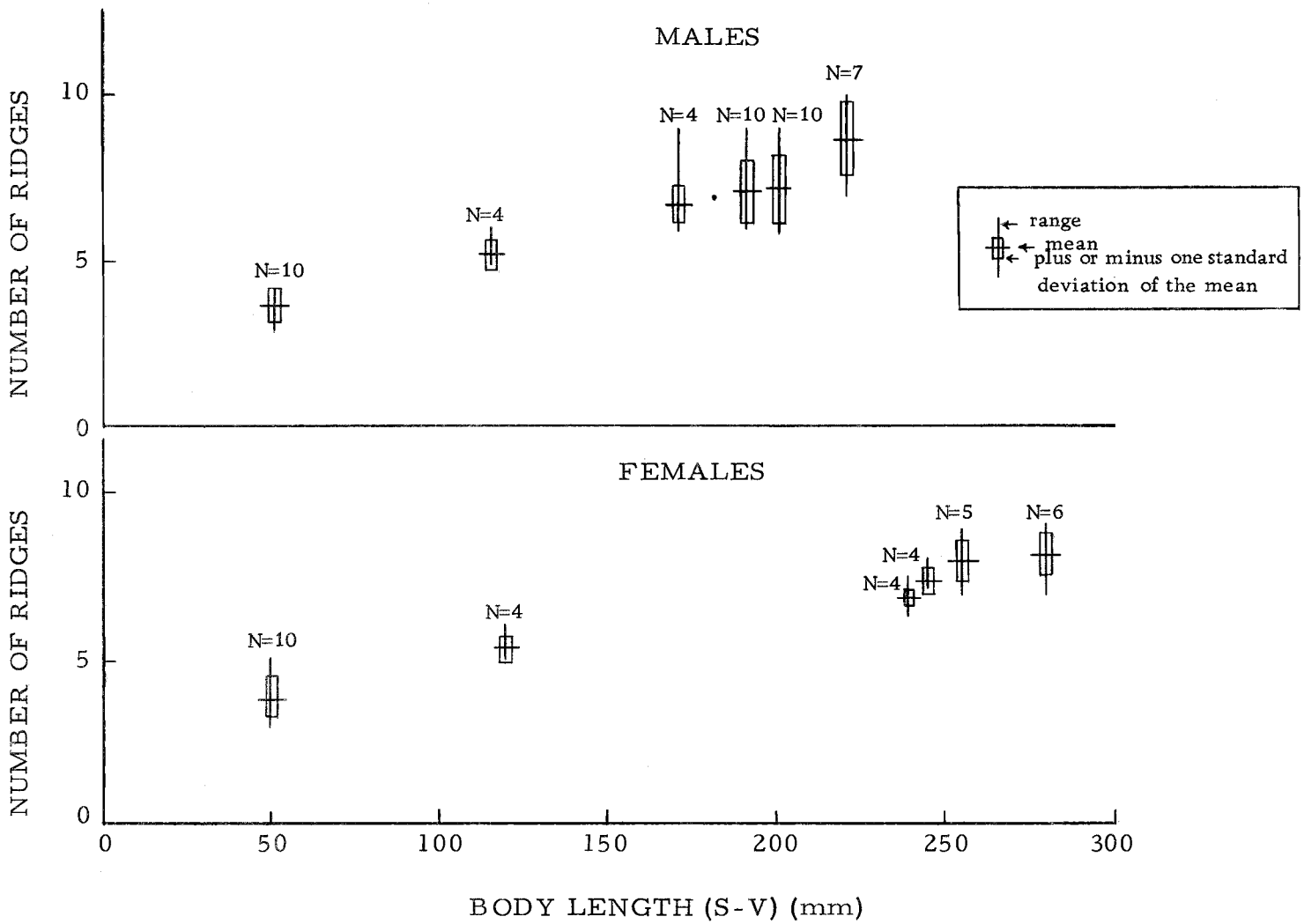


Figure 23. Number of ridges on the posterior side of the upper dental plate compared to body length of ratfish collected off Oregon, 1965-1967.

DISCUSSION

Based on the information presented in Figures 3 through 9, body weight is closely related to body length in ratfish. The length-weight equations describing this relationship for all ratfish collected off the coast of Oregon is Log Y = Log -4.3217 + 3.0546 Log X for males, and Log Y = Log -4.1692 + 2.9720 Log X for females. Coefficients of determination (R^2) for these equations are 0.9938 and 0.9887 for males and females, respectively.

The difference in the slopes of the lines representing the relationship of weight to length in male and female ratfish collected off Newport (Figure 3) is caused by an apparent difference in the rate of growth of the two sexes. This difference in growth rate is illustrated in Figure 24, where the range and median length of male and female ratfish from the Cape Blanco and Newport collections are compared to age estimated from length frequency distributions.

Females from the Newport collection appeared to weigh less at a given body length than did females from collections made off Cape Arago, Astoria, and Tatoosh Island (Figure 6). This difference may have been caused by the method with which the ratfish were preserved. Fish in the Newport collection were frozen and subject to dehydration. Fish in the other collections were preserved in 10% formalin and may have had more fluids in their body cavities than

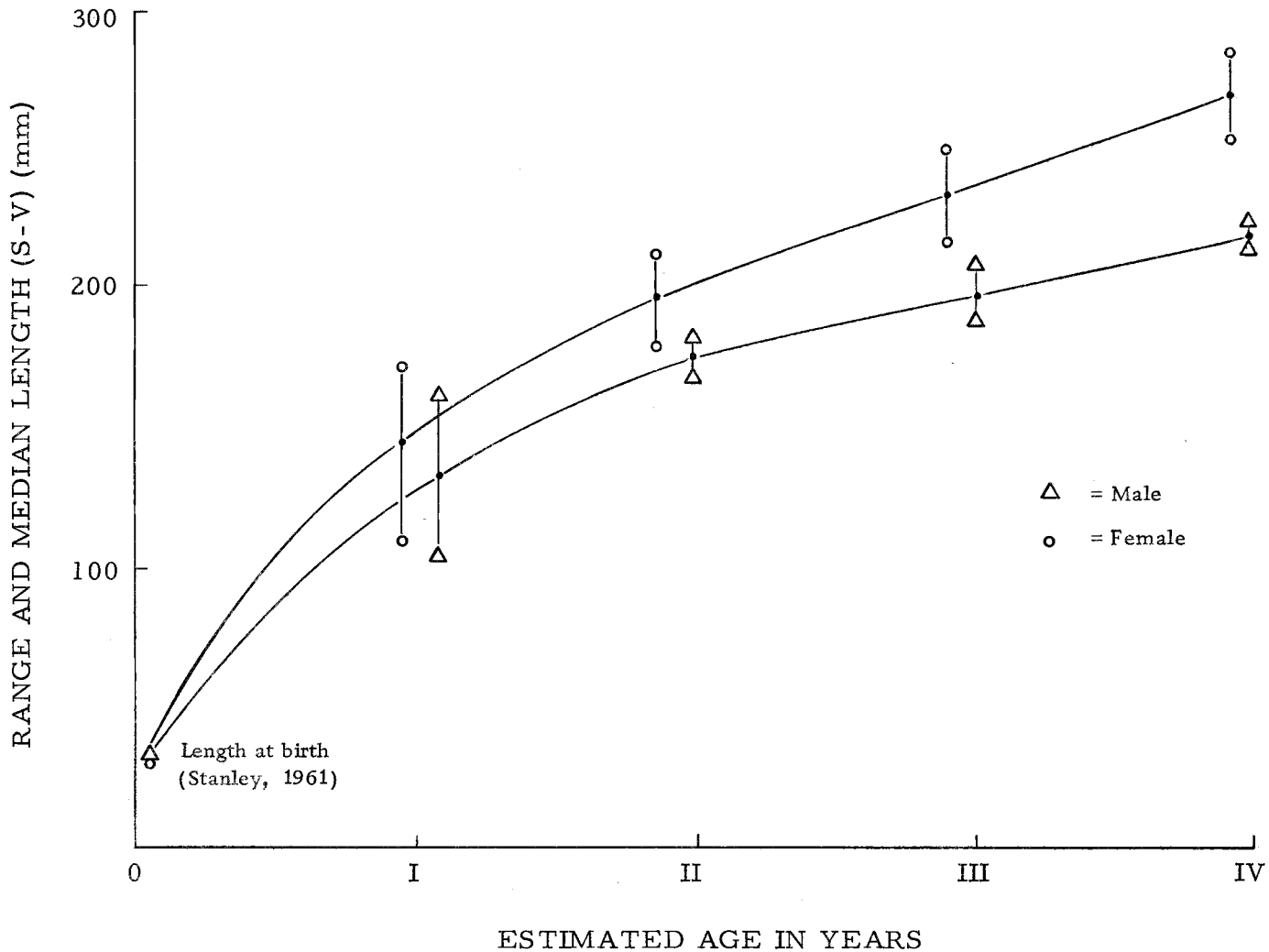


Figure 24. Estimated age-length relationship of male and female ratfish based on analysis of length frequency distributions of the Newport and Cape Blanco collections.

did those specimens which were frozen.

Before I could compare my data on length-weight for females to those of Sanford, et al. (1945), I had to convert the lengths of his fish from snout-insertion of the third dorsal to snout-vent length. On the basis of comparative measurements of 35 ratfish from the Cape Arago collection (Appendix 1), I developed a conversion factor of 1.98, which when divided into snout-insertion of the third dorsal length would yield snout-vent length (metric system). Additional comparative measurements of length from the Cape Blanco collection are presented in Appendix 2.

In Appendix 3, I have plotted the various length measurements in Appendices 1 and 2 in relation to snout-vent length. Inspection of Appendix 3 reveals that the relationship between the different length measurements are not constant. Therefore, I do not believe that any single conversion factor is valid throughout the length range of ratfish. I do believe, however, that the conversion factor of 1.98 was suitable for the length range for which it was used.

The results of the food habits study are presented in the numerical method (number of canals in which the food item occurred) and in the frequency of occurrence method (percentage of the total number of all food items in all canals for each collection). These methods of presenting the results of the food habits are limited in their ability to give an accurate representation of the importance of

the items to the ratfish as food. Wide occurrence in the numerical method does not mean necessarily that the food is of extreme importance, as a single specimen in each canal would give a value of 100%. Large numbers of an organism do not show always its true importance, because one ratfish may have eaten many of the items and the remainder of the ratfish none. Both methods do not give bulk or energy values of the foods. Additionally, only foods resistant to digestion or those ingested just before capture will be suitable for identification.

I did not use a volumetric method of examination because in many of the alimentary canals only shells and fragments remained. Also, some materials, such as the carapaces of shrimp, have a large surface to volume relationship which causes them to displace little water or to float.

An estimation of the relative fullness of the digestive tract was not performed since the alimentary canals are distorted when preserved, thus giving an unrealistic value when measured for volume. The habit of the ratfish of voiding ingested matter between capture and landing often makes volume measurements inaccurate. Dean (1906) commented on this habit, and I have noticed it in ratfish captured by the hook and line method. Also, I have found Gyrocotyle in the mouths of some trawl-caught ratfish, indicating that the contents of the alimentary canal recently had been voided. According

to Lynch (1945), one would normally expect to find Gyrocotyle in the anterior section of the intestine (spiral valve). Considering the above, the following food items seem to be the most important to the ratfish studied; shrimp (Pandalus sp. and Crago sp.), mollusks, (Musculus sp., Amphissa sp. and Pecten sp.), teleostomi, and echinoderms (Brisaster sp.).

In the Cape Arago collection only, ratfish were eaten by ratfish. One egg capsule and a tail were eaten by two large females (280 mm S-V). I am not aware of any previous record of cannibalism in ratfish. Of the teleostomi, flatfish appear to be the most frequently taken by ratfish. The two species found in the ratfish were Hippoglossoides elassodon and Esopsetta jordani.

In the Cape Arago collection, Livoneca appeared to be high in the percentage of the total food organisms when compared to its value in the other collections. The Cape Arago collection contained only two ratfish which had ingested Livoneca, but one contained 15 small (length 2-3 mm) specimens. These isopods were found inside a crushed Brisaster which may have been dead when devoured by the ratfish.

Based on the results of my investigation, the ratfish appears to be an opportunist and feeds on what is available. In general, the young and the adult ratfish ate the same types of food. Dean (1906) mentioned finding seaweed in the alimentary canals of ratfish. I did

not find any plant materials in any of the ratfish I examined.

Of the parasites, both G. fimbriata and G. urna appeared in about equal numbers in the Newport collection, while only G. fimbriata occurred in the Astoria and Cape Arago collections. The percent infection of Gyrocotyle in the young fish from the Cape Blanco collection was 30.0%. I did not find any evidence of mass infection of Gyrocotyle, as suggested by Wardle (1932), in the ratfish I examined. The young fish (50 mm S-V) had from zero to two Gyrocotyle each.

As with the food habits study, the voiding of canal contents by the ratfish interfered with obtaining an accurate estimate of the degree of infection. Gyrocotyle are found lodged in the folds of the spiral valve and do not embed themselves into the intestinal wall, thus they can be expelled by violent intestinal movements.

The unidentified fungus, which occurred in 29.2% of the Newport collection, was not necessarily a parasite as it may have developed between capture and preservation. No visible lesions or other damage was noticed on the body or alimentary canal surfaces of the ratfish in which this fungus was present. The fungus occurred on the peritoneal surface of the intestine. It appeared to be a nonseptate, filamentous type. The fungus growths I examined were white and fuzzy in appearance.

In the Cape Arago collection, 7 of the 21 male ratfish carried

Acanthochondria sp. on their pelvic claspers (Figure 11). Each parasitized fish had from two to eight copepods attached to the ends of its pelvic claspers. The rest of the males, which were not sexually mature, and the females did not carry this copepod. This, to my knowledge, is the first record of the occurrence of Acanthochondria on ratfish. The species appears to be similar, if not the same, as A. compacta (Yamaguti, 1963).

A common method of age determination of fish is to study the distribution of length frequencies. I used this approach on two collections which were combined in order to obtain a larger range of lengths (I was not able to obtain both small and large ratfish in any single collection). The arbitrary age scales expressed in Figures 17 and 18 were based on the peaks in the length frequency distribution of the combined Cape Blanco and the Newport collections. These age scales are subject to the following criticisms: 1. No known-aged fish were available for comparison. 2. The age scales are based on two collections from different locations and time periods. Table 9 summarizes the age scales presented in Figures 17 and 18.

The left and right eye lens weights were compared to each other and to body length (Table 8 and Figures 19 and 20). There was high correlation between eye lens weight and body length for the males but not for the females. Increase in eye lens weight may stop

or be reduced after sexual maturity is reached in the females. Eye lens weight may prove useful in further investigations of age determination of male ratfish since the R^2 values for the males are high. From the results of my study, I do not think the eye lens weights of the females are of much value for age determination as their R^2 values are almost zero.

Table 9. Arbitrary age scales for ratfish (Hydrolagus colliei) based on length frequency distributions of the Cape Blanco and the Newport collections made off the coast of Oregon, 1965 and 1967.

Sex	Length range (S-V) mm	Growth increment	Age
Male	50-100	50	0
	101-160	60	I
	161-180	20	II
	181-205	25	III*
	206-220	15	VI
	221+	--	V
Female	50-110	60	0
	111-170	60	I
	171-210	40	II
	211-250	40	III*
	251-280	30	IV
	281+	--	V

*Sexual maturity is obtained at this age.

The differences between the mean weights of the left and right eye lenses for both males and females are given below at the 95% confidence level.

Wet Weight

Female $\Pr [-0.075 < \mu_1 - \mu_2 < 0.081] = .95$

Male $\Pr [-0.066 < \mu_1 - \mu_2 < 0.068] = .95$

Dry Weight

Female $\Pr [-0.100 < \mu_1 - \mu_2 < 0.114] = .95$

Male $\Pr [-0.033 < \mu_1 - \mu_2 < 0.041] = .95$

These values indicated that the difference between the mean weights of the left and right eye lenses was small, but there was greater variance in the weights of the female lenses than those of the male.

The formulas listed below describe the least-square relation of the vertebra radius to body length. I believe there was too much variation in the vertebral radii, and not enough small ratfish in the sample to merit much confidence in the use of these equations for developing a method of age determination.

Equation: $Y = \overline{Y} + b (X - \overline{X})$

Females $Y \text{ (mm)} = 38.8 + 0.0310 (X-239)$

Males $Y \text{ (mm)} = 33.5 + 0.0402 (X-193)$

These formulas apply to vertebral sections enlarged twelve times their normal size.

In general, there was an increase in the size of the body parts (eye lenses, teeth, vertebral sections, base of the pectoral fins, and

the base of the dorsal spine) with increasing body length. I did not find any areas or zones which were sufficiently correlated with body length to provide a method of age determination. There are, however, ridges on the posterior side of the upper dental plate which may provide an indicator of age. Figure 23 shows the number of ridges compared to body length (S-V). There is overlap between the length groups presented, but a general increase in the number of ridges with body length can be seen. Two problems arise in using this structure as a basis for age determination: 1. No comparison to known-aged fish was possible. 2. The amount of wear on these ridges per unit time is not known.

When I was unable to develop a technique for the determination of age based on the "age dependent" characteristics of individual body structures, I subjected the data to a computer analysis of principal components. In this analysis, seven principal components were calculated. The first two components accounted for 84% of the total variation in all seven variables indicating that 84% of the "information" in all seven was contained in the first two. These two components were then plotted on a graph to determine if any segregation which could be attributed to age could be detected. There was no segregation and the results were considered negative; that is, I was not able to gain any new information on methods of determining the age of ratfish.

SUMMARY

1. The results of the examination of 298 ratfish (Hydrolagus colliei) collected off the Pacific Coast of Oregon and Washington in the fall and winter of 1965, 1966, and 1967 are presented in this thesis.

2. There is a high degree of correlation of body weight on body length in ratfish. Body lengths of the male ratfish ranged from 50 mm (S-V) to 230 mm (S-V), while body lengths of the females ranged from 44 mm (S-V) to 292 mm (S-V).

3. Methods of determining the sex of young and adult ratfish from external structures are illustrated.

4. Ratfish appear to be opportunistic feeders, with the following genera most prevalent in contents of the alimentary canals: Pandalus, Crago, Musculus, Amphissa, Pecten, and Brisaster. A taxonomic list of all food organisms identified is presented in tabular form.

5. Two occurrences of cannibalism were noted in the ratfish collected.

6. Gyrocotyle occurred as parasites in the alimentary canals of from 29.2% to 65.8% of the ratfish collected from the four areas along the coast of Oregon.

7. The copepod, Acanthochondria sp., was found on the pelvic claspers of seven adult males collected off Cape Arago, Oregon, in February, 1967. This is the first known occurrence of this copepod on chimaeroid fishes.

8. Age appears to be related to body length, with females growing faster and to a larger size than males. The eye lens weights (wet and dry), vertebral radii, and body weights were compared to the body lengths (S-V).

9. No accurate method of age determination for ratfish was found, although the body parts examined showed an increase in size with increase in body length of the fish. Ridges located on the posterior side of the upper dental plate offer a promising indicator of age, but more investigation is needed.

10. A review of pertinent literature on the biology of ratfish is presented.

BIBLIOGRAPHY

Alverson, D. L. and M. E. Stansby. 1960. The spiny dogfish (Squalus acanthias) in the Northeastern Pacific. Washington, D. C. 25 p. (U.S. Fish and Wildlife Service. Special Scientific Report--Fisheries no. 447)

American Fisheries Society. 1960. A list of common and scientific names of fishes from the United States and Canada. 2d ed. Baltimore, Waverley Press, Inc. 102 p.

Barnes, R. D. 1965. Invertebrate zoology. Philadelphia, W. B. Saunders Company. 632 p.

Bonham, K. 1950. Some monogenetic trematodes of Puget Sound fishes. In: Studies honoring Trevor Kincaid, ed. by M. H. Hatch. Seattle, University of Washington Press. p. 85-103.

Clothier, G. E. 1957. The histology of the digestive tract of the chimaeroid fish, Hydrolagus colliei (Lay and Bennett). Master's thesis. Corvallis, Oregon State College. 43 numb. leaves.

Dean, B. 1906. Chimaeroid fishes and their development. Washington, D. C. 194 p. (Carnegie Institution of Washington. Publication no. 32)

Halstead, B. W. and N. C. Bunker. 1952. The venom apparatus of the ratfish, Hydrolagus colliei. Copeia (3):128-138.

Koratha, K. J. 1960. Preliminary report on the parasites of a chimaeroid fish from the eastern Indo-Pacific with comments on the phylogenetic significance of parasitic distribution in Holocephali. (Abstract) Journal of Parasitology 46(5, section 2):14.

Legendre, R. 1944. Notes biologique sur Chimaera monstrosa L. Bulletin de le Societe Zoologique 69(1):10-17.

Lynch, J. E. 1945. Redescription of the species of Gyrocotyle from the ratfish Hydrolagus colliei (Lay and Bennett), with notes on the morphology and taxonomy of the genus. Journal of Parasitology 31(6):418-446.

Nakatsu, L. M. 1957. A review of the soupfin shark fishery of the Pacific Coast. U.S. Fish and Wildlife Service, Commercial Fisheries Review 19(12):5-8.

Olsson, P. 1896. Sur Chimaera monstrosa et ses parasites. Memiores de la Societe Zoologique de France 9(5):499-512.

Pidlaoan, N. A. 1950. The vitamin A potency and liver oil yield in the ratfish (H. colliei) of Puget Sound, and the relationship of these factors to size of the fish. Master's thesis. Seattle, University of Washington. 45 numb. leaves.

Sanford, F. B., W. Clegg and K. Bonham. 1945. The ratfish. Fishery Market News 7(11):6-7.

Stanley, H. P. 1961. Studies on the genital systems and reproduction in the chimaeroid fish Hydrolagus colliei (Lay and Bennett). Ph. D. thesis. Corvallis, Oregon State University. 94 numb. leaves.

Thompson, W. F. 1915. A preliminary report on the life-history of the halibut. In: Report on the British Columbia Commissioner of Fisheries for 1914. Victoria, B. C. p. 76-88.

Wardle, R. A. 1932. The cestoda of Canadian fishes. I. The Pacific Coast region. Contributions to Canadian Biology and Fisheries, N. S. 7(18):221-243.

Yamaguti, S. 1963. Parasitic copepoda and branchiura of fishes. New York, Interscience Publishers. 1104 p.

APPENDICES

Appendix 1. Various measurements of length (mm) of 35 ratfish (Hydrolagus colliei) collected off Cape Arago, Oregon, February 20-22, 1967.

Sex[1]	Snout-Vent length	Total Length	Snout-insertion of 3rd dorsal	Snout-origin of 2nd dorsal	Weight (grams)
M	197	468	376	202	736
M	180	445	335	195	453
F	265	360	465	278	1189
M	180	428	310	190	424
M	155	400	301	180	283
M	215	520	486	222	679
M	215	521	425	224	736
F	260	528	520	276	1302
M	165	408	328	175	226
M	210	518	420	222	566
F	180	425	362	190	396
F	260	560	510	276	1302
M	168	415	333	178	396
M	215	522	425	226	679
M	145	342	291	154	283
F	160	405	320	170	396
M	165	403	321	175	396
F	170	415	337	181	396
M	160	408	318	169	220
M	150	360	295	159	226
M	160	407	318	170	198
M	178	422	354	170	453
F	150	355	300	159	225
F	230	545	452	243	1018
F	280	662	551	301	1359
F	280	660	557	300	1415
M	155	367	308	164	226
M	178	420	352	189	226
F	140	331	278	149	226
M	145	344	290	155	169
M	165	390	327	175	396
M	145	345	287	154	226
F	140	330	278	150	169
F	155	366	306	164	283
F	145	344	388	155	226

[1] M = Male, F = Female

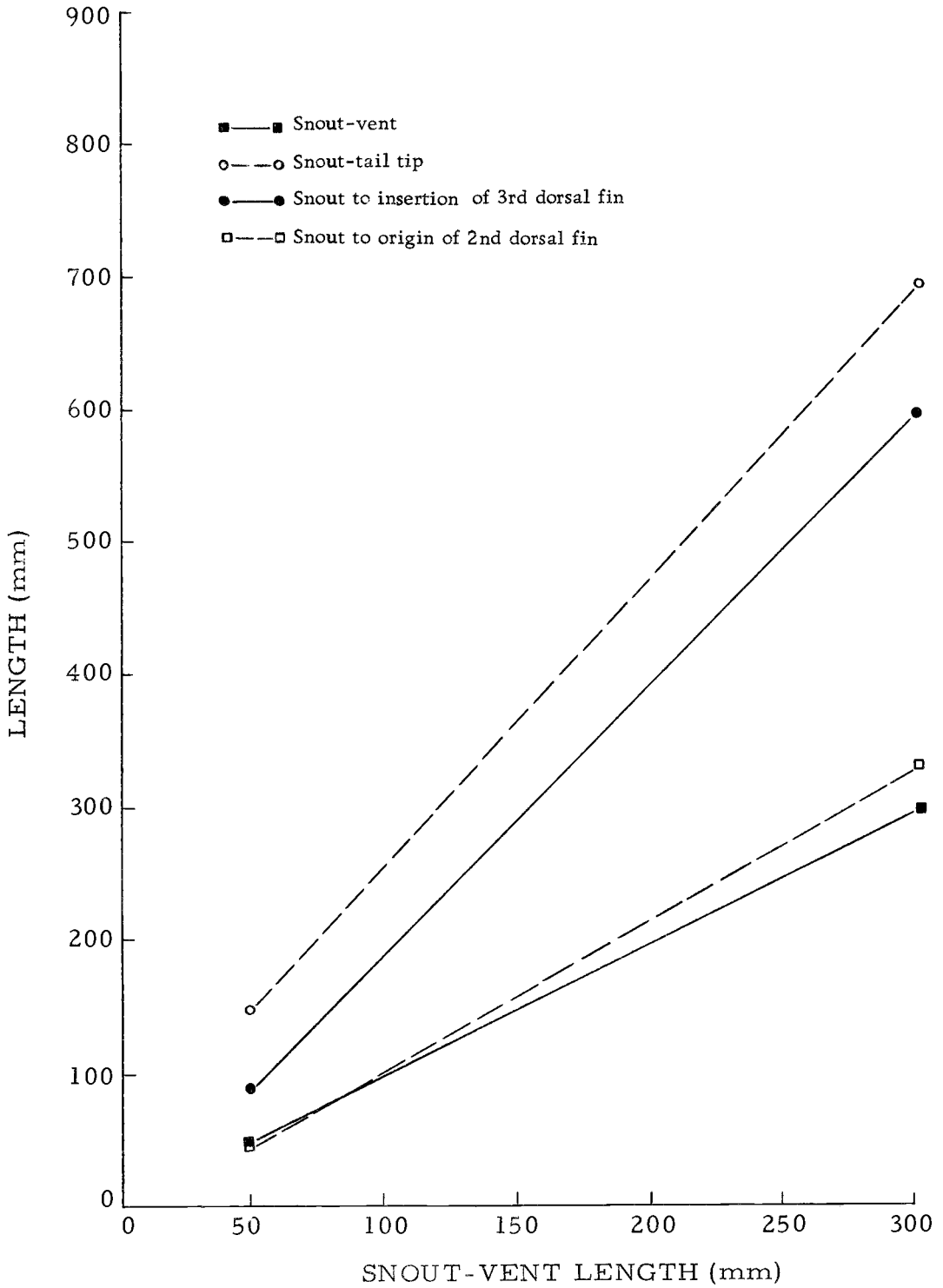
Appendix 2. Various measurements of length (mm) of 44 ratfish (Hydrolagus colliei) collected off Cape Blanco, Oregon, March 25-26, 1967.

Sex[1]	Snout-Vent	Total Length	Snout-insertion of 3rd dorsal	Snout-origin of 2nd dorsal	Weight (grams)
F	51	161	96	53	9.1
M	61	174	110	61	13.2
F	61	175	106	58	12.8
F	58	171	104	57	10.5
M	50	160	96	52	9.0
M	51	140	90	58	6.6
F	58	170	104	57	10.3
F	57	169	104	56	10.2
F	58	170	105	56	10.4
M	56	168	104	56	8.2
F	68	185	118	65	18.7
F	57	169	105	56	8.8
F	56	168	104	56	8.2
F	51	160	96	52	9.0
F	62	176	111	63	14.0
F	57	169	105	56	9.7
M	59	170	106	56	11.6
M	51	161	96	52	9.0
F	63	178	113	65	14.8
F	61	175	110	62	13.2
F	63	179	113	65	15.0
F	64	176	110	62	13.4
F	56	168	104	56	9.6
F	50	160	95	51	9.0
M	50	160	96	52	7.8
M	50	160	96	52	7.5
F	50	160	96	52	7.4
F	50	160	96	52	7.5
M	50	160	96	52	6.5
F	49	160	95	51	7.1
M	50	160	96	52	7.5
M	50	160	96	52	7.2
F	50	163	96	53	7.0
F	50	160	96	52	7.1
F	50	160	96	52	7.2
F	52	163	98	54	7.0
F	50	160	96	52	7.1
M	120	310	200	110	92.5

Appendix 2 (continued)

Sex[1]	Snout-Vent	Total Length	Snout-insertion of 3rd dorsal	Snout-origin of 2nd dorsal	Weight (grams)
M	115	290	203	110	90.0
F	120	296	200	110	108.0
F	115	290	200	111	63.2
F	120	311	201	110	94.3
F	120	310	201	112	106.1
F	120	309	200	110	90.8

[1] F = Female, M = Male



Appendix 3. Various length measurements compared to snout-vent length for ratfish (Hydrolagus colliei) collected along the coast of Oregon, 1967.