BIOLOGY AND FISHERY OF THE "TITI" SHRIMP **XIPHOPENAEUS RIVETI** ON THE PACIFIC COAST OF COLOMBIA, SOUTH AMERICA

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by

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ABSTRACT

The commercial importance of this species in Colombia is reflected in landings of about four million pounds (tail weight) in 1971, having been increasingly reported in the last few years as demand and price increased. Analysis of the fishery indicated the necessity for management by limiting the number of vessels before depletion would become apparent. Biology of the species, based on monthly samples taken during survey fishing, gave conversion factors of 1.62 for tail weight to total weight and 0.61 for total weight to tail weight. Length-weight, etc., relationships indicated that males gained more weight with increase in size than females, but the latter grew to much larger sizes. Maxima for carapace length were 26 and 35 mm, respectively, in the samples. Average monthly growth in females was estimated at 2.9 mm carapace length. First maturity in males was reached at a carapace length of 15 mm; maturity was continuous thereafter, as shown by presence of spermatophores. In females, first maturity was observed at 17 mm cl, but data on their reproductive cycles indicates that they mature and spawn up to four times over the period indicated by the range of carapace length observed. Their gonads were rated as juvenile, immature, maturing, and mature, based on sizes of ovaries and ova, the largest ova being 0.25 mm in diameter before spawning. High percentages with large ova in each monthly sample indicated frequent spawnings, probably numbering five times a year for the population.

Procercoids of cestodes parasitized principally the hepatopancreas. Food organisms were observed to be primarily other crustaceans, polychaetes and pelecypods. The sex ratio was biased in favour of females. This is interpreted to be due to a gear selection or preference of/for larger shrimp. With regards to bathymetric distribution, 5-10 m and mostly in near-shore locations were favoured, and some adults, as well as juveniles, were found within estuaries. Recruitment appeared to occur four times annually, based on length frequency samples.

The thesis further examines the taxonomy of the genus and the species and morphology details of X. riveti are given. However, no final decision is made concerning the separation of X. riveti from X. kroyeri.

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INTRODUCTION

The "titi" shrimp (Xiphopenaeus riveti Bouvier) is one of the most abundant species in the commercial catches on the Pacific coast of Colombia. It is caught at the same time as Penaeus (L) occidentalis, P. stylirostris, P. vannamei, Trachypenaeus similis pacificus, T. byrdi, T. faoea, Protrachypene precipua and occasionally with Palaemon (Nematopalaemon) colombiensis.

In 1953, the beginning of the shrimp industry, the "titi" was not reported in the landing statistics. However, in 1966 the companies located on the Pacific coast began to export this shrimp to the United States.

This exportation provided the reason for the growing economic importance of the species. Previous to this many captains took part of the catch for private use and "under the table" sales, but in 1969 higher pay was provided for these men, giving them the incentive to land the entire catch at the shrimp companies in which they were employed.

For these reasons, as well as an intensified fishing effort the figures of landings have increased from a few thousand pounds in 1958 to 3,834,000 tail-pounds in 1971. This exceeded the landings of the "langostino" or white shrimp (Penaeus (L) occidentalis, P. stylirostris and P. vannamei) which reached 2,359,000 tail-pounds in 1971.

The amount produced by the artisan fishery does not reach an appreciable percentage, but some companies, such as those located in Tumaco and Guapi, buy from the artisan fishermen even the smallest quantities (i.e., two kg) in order to increase the company's production.

The economic importance that this resource represents in this country is implicit in the recent increase in its exports. For example, in 1971 the exports of this species reached 2,168,360 tail-pounds with a value of U.S. $864,475. Therefore, a scientific study of its biological cycle, its trophic relationship and its population dynamics, is of fundamental importance in order to maintain this resource at a rationally exploited level.

Some work previous to this paper that had been done were the following: Smith in 1885 described the genus Xiphopenaeus. In 1907 Bouvier described the species riveti from some specimens collected by Rivet in Paita, Peru. Burkenroad in 1936 reviewed the genus and made some criticisms of Bouvier's observations on X. riveti, concluding that it was a varietal form of X. kroyeri.

In Brazil, however, work has been done on the sexual maturity (Borges, 1947), fishery biology (Neiva and Wise, 1963), population dynamics (Santos, et al., 1968) and reproduction (Santos, et al., 1971) on its counterpart, the sea bob, Xiphopenaeus kroyeri, of the Atlantic.

The "titi" shrimp has a distribution range from the northeastern portion of Mexico to Paita, Piura, Peru (Perez, E., 1970).

MATERIALS AND METHODS

The present work was done in the Marine Science Center of Buenaventura with the support of the United Nations Development Program (FAO) and the Instituto de Desarrollo de los Recursos Naturales Renovables, INDERENA, of the Colombian Government. The monthly sampling started in January 1969, and was continued to February 1970.

In order to carry out objectives a local fishing vessel was chartered monthly for eight or ten days to occupy statipns north or south of Buenaventura at depths of 5 (9 m), 10 (18m), 20 (37 m), 30 (55 m) and 40 (73 m) fathoms. During this study the "titi" shrimp was caught at 97 of the 280 stations (Fig. 1) at depths between 3 and 30 fathoms. Approximately 1,400 specimens were studied in detail from the monthly samples collected during the cruises. To determine frequency distributions, carapace lengths of 9,319 specimens and total lengths of 4,503 specimens were measured. This study, undertaken along the Pacific coast of Colombia (encompassing 1,300 km) gives preliminary information on the natural history and population dynamics of the "titi" shrimp. Also, taxonomy, sexual maturity, food, parasitism, sex ratio, growth, fishing areas, statistics of catch and effort and commercial landings were studied.

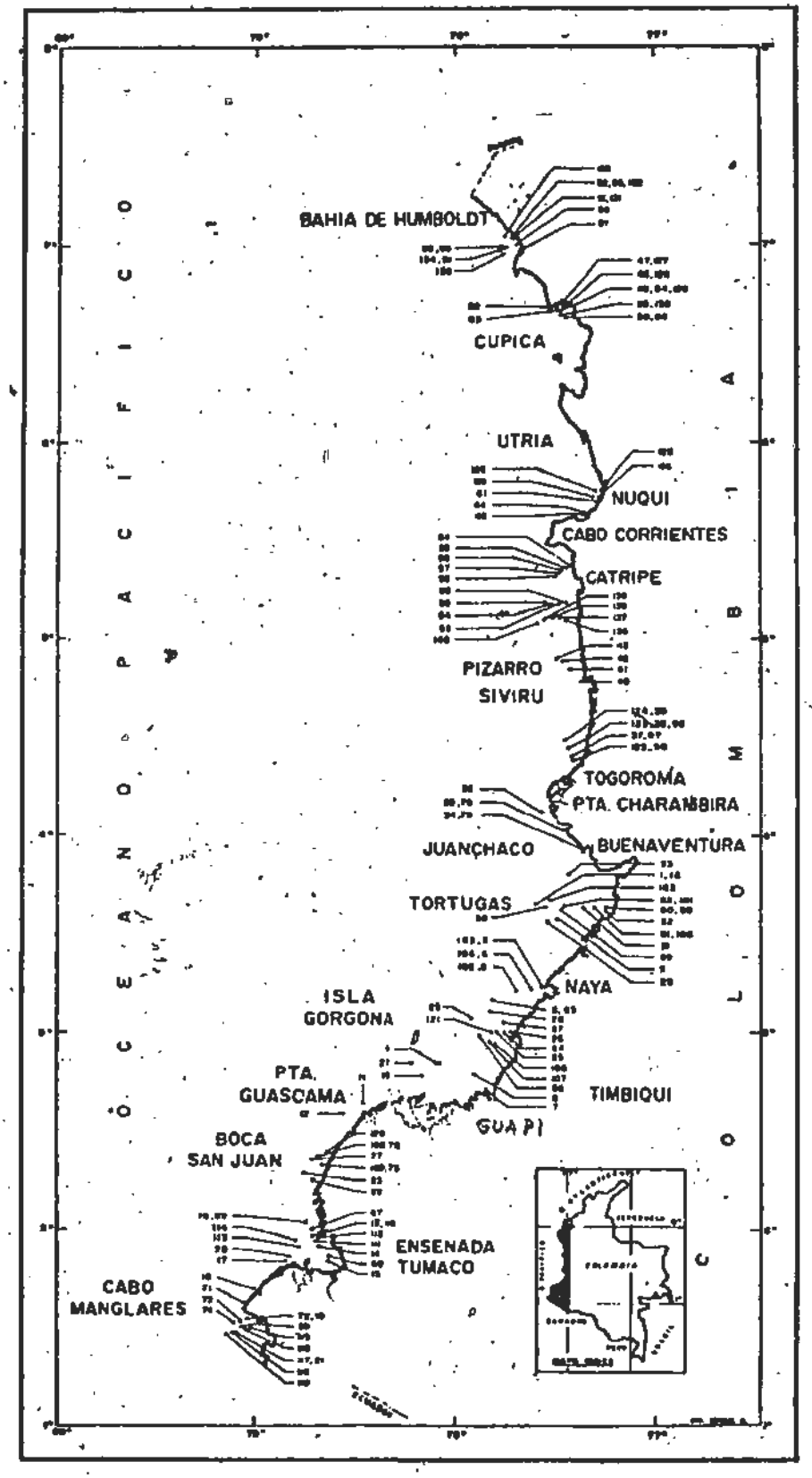

Fig. - 1. Map of the Pacific Coast of Colombia showing fishing stations and place names used in the text.

Population Sampling

Sampling for each zone north and south of Buenaventura was bimonthly. Samples for biological analysis were collected by the author aboard the shrimp vessel M/V "Cacique" (for 12 months) and on the R/V "Choco" (January, 1970).

Trawling was done for one hour at each station. The captain always tried to maintain the same depth. He followed the method of fishing used by fishermen in these waters turning in a wide circle in each area. Once the total catch was aboard, the commercial species of shrimps, fish and crabs were separated. The total catch of "titi" was weighed with a spring balance. From the total catch a random sample was taken and put in a one-gallon jar with sea water and formalin (10%). If the catch was large enough, some of it was stored in cloth bags or cardboard boxes in the refrigerated hold to calculate later in the laboratory conversion factors from tail weight to total weight.

Hydrography

At the end of each haul, water samples were taken from near the bottom using Nansen bottles for temperature and salinity determinations. A common mercury thermometer with an accuracy of $\pm 0.5^{\circ}C$ was used for determining surface temperatures, and a reversing thermometer for the bottom temperatures. For the water transparency

a Secchi disc was used. In some of the stations, two types of bathythermographs were used, one for depths to 30 fathoms and the other for 40 fathoms or deeper.

In the laboratory, from the samples that were preserved in gallon jars, all were measured for length of carapace, then about 50 specimens were chosen randomly. From these, 30 were selected for biological analysis because not all of the preserved specimens were in suitable condition for such analysis. Often, irregularities of preservation and rigidity caused damage to the rostrum or telson. For each specimen (about 1,400) the following data were taken: carapace length, total length, total weight, sex, sexual maturity (females), size of the ova, stomach contents, parasites, presence of spermatophores (males and females) and shell hardness.

Lengths and Weights

Lengths

Total and tail lengths were measured on a measuring board graduated in millimeters. The total length was taken from the tip of the rostrum to the posterior extremity of the telson. The tail length was measured from the anterior edge of the first abdominal segment to the posterior-end of the telson. The carapace length was measured with a Vernier Caliper with an accuracy of ±0.05 mm, and was taken from the posterior edge of the eye socket to the mid dorsal edge of the carapace.

Weights

To obtain total and tail weights the specimen was shaken to rid it of excess water. Then, with an electric Sauter type balance with an accuracy of ±0.1 g, the weight was obtained.

Sex Determination

Sex determination was made simply by observing the presence of a thelycum in females and a petasma in males.

Sexual Maturity

Sexual maturity was only taken for females. With a dissection needle, a portion of the ovary was taken, generally from the central part located between the cephalothorax and the abdomen. This was placed in water in a Petri dish with a black background in order to observe the size of the ova with a stereoscopic microscope. Four stages of maturity were identified: juveniles, immature, maturing and mature. The ova were measured in a water drop on a rules with a millimeter scale.

Sex Ratio

Sex ratio was estimated taking as a base the number of females present each month (Kubo, et al., 1959).

Stomach Contents

Once the stomach was dissected out, it was put in water in a Petri dish and observations were made under a stereoscopic microscope.

Parasitism

For a study of the incidence of parasites, five specimens were randomly taken from each station sample; the carapace length was measured and the sex determined. The observations were made in the cephalothoracic cavity only.

Conversion Factor from Tail Weight to Total Weight

In order to obtain a conversion factor, 3,000 g of whole shrimp in good condition were weighed on an Eiko balance with an accuracy of ± 50 g. The tails were removed and the total tail weight was obtained on the same balance.

Graphs

Frequency distribution graphs of total and carapace lengths were made from monthly samples. For total length, they were grouped in 3 millimeter classes and for carapace length, one millimeter classes. This was done for both sexes.

To calculate length and/or weight relationships, the least squares formula was used.

Estimation of Growth

For estimating the parameters of growth, the method described by Dos Santos and Da Costa (1964) was followed. In this method, the representative monthly modes of a length frequency

distribution are plotted against the lengths (Fig. 15). Then, the monthly modes of one month are plotted against the modes of next month and curves are adjusted (Fig. 16).

To show growth in a graphic form, the von Bertalanffy growth curve was utilized:

$$Lt = L\infty \left(1-e^{-k\,(t-t_o)}\right)$$

where: Lt : length of individuals with age t

$L\infty$: is the maximum asymptotic carapace length that a specimen would attain under specific conditions

K : is the relative rate of approach to $L\infty$

t_o : is the theoretical age at zero carapace length

In the present study, the female carapace length frequency distirbutions of samples taken aboard the M/V "Cacique" were used.

Estimation of Recruitment

Specimens up to 18 mm carapace length (85 mm total length) fished on the fishing grounds through the time of sampling were considered as recruits.

In order to make an estimation of recruitment during the time of this study, two methods were used: first, the shifting of

the modes less than 18 mm carapace length in the graphs of length frequency distirubiton, and second, the same data were expressed in percentage and plotted against months of observation.

Statistics

Landings

In Buenaventura, the "titi" shrimp is landed "heads-off", while in Tumaco and Guapi the majority of the shrimp landed is "heads-on". These two fishing areas are close to the factories and fishing trips have a duration of one day, therefore allowing "heads-on" shrimp to be landed. For this reason, most of the landings were converted to tail weights using 0.61 as the conversion factor.

In order to estimate the catch per unit effort the master fishermen in Buenaventura were interviewed. These interviews were conducted using the following headings: ship name, fishing areas, depths, species composition and catches. These records were not obtained daily, nor from all the master fishermen. Much of the data was not reliable. In order to avoid discrepancies, a Catch Record Book was prepared which was distributed to the captains, but the result was negative because many of them changed vessels and others did not make entries due to negligence.

The statistical data of the total landings were obtained from 1968 to 1971 from the receipts that each company recorded for each vessel. Before 1968 there were data compiled by Perez (1963)

and Palacios (Ms, 1967) but these were not utilized for the estimation of catch per unit of effort because they were not reliable, since, as was explained before, the catches of the "titi" shrimp were not all landed.

As measurements of fishing effort the number of effective hours of fishing, the number of vessel-months and the number of trips that all the vessels of the Pacific shrimp fleet made each year were utilized.

The term "vessel-months" means the total annual amount of the number of vessels which operated monthly, that is, which fished at lease once during a month.

TAXONOMY

Nomenclature

Scientific valid name:

Xiphopenaeus riveti Bouvier, 1907, Extrait du Bulletin d'historie naturelle. No. 2, p. 113.

Taxonomy

Affinities

Suprageneric (to section Penaeidae after Waterman and Chace, 1960, vol. 1, p. 24).

Phylum Arthropoda

Class Crustacea

Subclass Malacostraca

Series Eumalacostraca

Superorder Eucarida

Order Decapoda

Suborder Natantia

Section Penaeidae

Family Penaeidae

Subfamily Penaeinae

Generic name:

Genus: Xiphopenaeus Smith, 1885. Proc. U.S. Nat. Mus. p.188; Burkenroad, 1934. Bull. Amer. Mus. Nat. Hist. 68(2), p.102.

Genotype:

The first generic description was that of Smith (op. cit.):

The genus, which had been united with Penaeus by Miers and Kinsley (and was not referred to by Bate), was apparently a valid one. It differed from the three genera already defined in the great length of the fourth and fifth pereaeopods, of which the propodi are multiarticulate and flageliform, as in Benthoecetes. (This is characteristic of the female as well as the male). It agreed with Penaeus and Parapenaeus and it differed from Hymenopenaeus in the form of the mandibular palp. It agreed with Parapenaeus and Hymenopenaeus and differed from Penaeus in the short and unsegmented endognath of the first maxilla and in having no branchiae on the fourteenth somite; and it agreed with Hymenopenaeus and differed from Penaeus and Parapenaeus in the long flagella of the antennulae. The branchio-epipodal formula was the same as in Parapenaeus constrictus. In the type species, the epipod of the maxilliped was prolonged in a slender but not segmented tip, and there were exopods at the bases of all the pereiopods.

The following generic description was that of Burkenroad (op. cit.):

The genus is confined to America. It is distinguishable from Trachypenaeus by the multiarticulate dactyls of the last two pairs of thoracic legs, the long antennular flagella, and the absence from the carapace of the adult of a transverse suture; Alcock, 1906, had erroneously stated that the transverse suture was present. This structure is, however, present in three preadults of X. riveti about 25 mm in length and it is faintly indicated in somewhat larger individuals of X. kroyeri. The rostrum loses its distinctive styliform appearance in the preadults, and is quite similar to that of Trachypenaeus, while the number of joints of the dactyls is reduced. An additional difference between Xiphopenaeus and Trachypenaeus is supplied by the telson, which is completely unarmed in the former. The basis of the external maxillipeds is unarmed; the basis and the ischium of the first legs only are armed. The first pleopod of the female lacks a rudimentary endopod such as is perceptible in Trachypenaeus similis and many other Penaeidae. Xiphopenaeus resembles section two of division one of Trachypenaeus in the single, transverse opening of the unpaired picket of its thelycum.

Species name:

The type specimen is presumed to be located in the Museum d'historie naturelle, Paris, France.

Type locality:

Paita, Piura, Peru.

Diagnosis:

X. riveti is illustrated in Figure 2. Bouvier showed a drawing of the cephalothorax only in his original description.

The following diagnosis is translated from the original French given by Bouvier (op. cit.):

Xiphopenaeus riveti sp. nov.

This species shows all the Xiphopenaeus characteristics described by Smith (1885) with a branchial formulae similar to that of X. kroyeri Heller, which was formerly the only species of the genus.

	Pereiopods					Maxillipeds		
	V	IV	III	II	I	III	II	I
Pleurobranchiae	0	0	1	1	1	1	0	0
Arthrobranchiae	0	1	2	2	2	2	2	0
Epip. and Podob.	0	0	Ep.	Ep.	Ep.	0	Ep.+1	Ep.
Exopodites	1	1	1	1	1	1	1	1

The characters which distinguish the present species from X. kroyeri are the following: 1. The median-dorsal carina of the carapace, instead of being very slight, is more pronounced although obtuse. 2. The rostrum is notably shorter than the carapace and on the other hand reaches the height of its incurved part. 3. The convex part of the rostral carina is rather less pronounced than in X. kroyeri and has four teeth instead of five, the anterior or fifth tooth remaining rudimentary. 4. The inferior antennular flagellum equals at most one-quarter and not one-half of the superior flagellum. 5. The dorsal carina of the fourth abdominal segment ends in a small point as well as that of the next segments.

There is a narrow and deep longitudinal furrow in the gastric region; the exopodites of the second and third maxillipeds are of the same length similar to those of X. kroyeri, but are relatively wider. The last articulation of the antennal peduncle is medium in length and does not reach the middle of the scale.

In brief, this species has close affinity with X. kroyeri, but it is more typical of the description of the genus Xiphopenaeus. It replaces X. kroyeri on the west coast of America. Xiphopenaeus kroyeri is common in Brazil and the Antilles (West Indies). It was described from two adult females which measured a little more than 170 mm from the tip of the rostrum to the extremity of the telson.

The thelycum is a wide shield truncate posteriorly that occupies the space between the two pairs of legs. It is composed of two parts, separated by a deep transverse sulcus convex in front. Its anterior part is a narrow transversal band with a median crest.

Objective Synonym:

Xiphopenaeus kroyeri riveti Bouvier; Rioja, 1942, Estudios carcinologicos. XII. - Anales Inst. Biol. XIII, No. 2, p. 680. Mexico.

Rioja described the petasma, the appendix masculina and the sternites of the last segments of the thorax of two males 130 and 90 mm in length.

Key for the Species:

Loesch and Avila, 1964, Bol. Cient. Tec. Vol. 1, No. 2, p. 4. Ecuador. Perex, F. I., 1970, Inst. Invest. Biol. Pesq. Serie Divulgacion. Mexico. Instr. (3): 50.

Taxonomic Status:

Xiphopenaeus riveti is a morphospecies.

Vernacular Names:

Xiphopenaeus riveti is known as "titi" in Salvador, Nicaragua, Panama, Colombia and Ecuador; sometimes its vulgar name is associated with the genus Protrachypene and Trachypenaeus (Lindner, 1957; Croker, 1967). "Bobalon" shrimp and "siete barbas" in Mexico;

"brown shrimp" together with Protrachypene precipua, Trachypenaeus byrdi and T. faoea in Costa Rica, and in Nicaragua "camaroncillo" in the Gulf of Fonseca or "chacalin" (Lindner, 1957; Croker, 1967; Perez, F., 1970).

Morphology

External Morphology

See also diagnosis by Bouvier (p. 27).

Size Relationships

This is a small commercial species: the carapace length in males (3,360 specimens) ranging from 12 to 28 mm in length, and in females (5,959 specimens) from 12 to 40 mm. The rostrum in the males (for 9 specimens ranging from 17 to 20 mm in carapace length) was between 19 to 22 mm in length; and in the females (for 17 specimens ranging from 19 to 26 mm in carapace length) was between 21 to 32 mm in length. The length for the sixth abdominal somite in the males (9 specimens) ranged from 10 to 12 mm, and in the females (17 specimens) from 8 to 12 mm. The longer antennular flagellum when intact was 198 mm in length for one male with 19 mm carapace length; in the females for one specimen with 32 mm carapace length the longer antennular flagellum reached 270 mm length.

Main Characteristics

The carapace covers the cephalothorax and carries an upcurved rostrum which is longer than the carapace. The rostral formula was

$\frac{4 - 7 + 1}{0}$ although most of the specimens (ca. 99%) had the following: $\frac{5 + 1}{0}$ spines. In front of the epigastric spine were 8 to 16 setae. Between each pair of the next spines were intercalated 20 to 34 setae. Ventrally, from the second to the fourth dorsal spine, there were as many as 50 setae. The carapace had prominent hepatic and antennal spines and a strong spine as the base of the antennal scale.

The first pereiopods were the smallest (the fifth pair being the longest). Its basis and ischium had a strong spine at their distal part. On the internal and external sides they had tufts of setae. The propodus had six tufts of setae on the inner side of the palm.

The second pereiopods were larger than the first with a few tufts of setae and the propodus and dactylus were large with straight tips.

The third pereiopods were toothed on the inner faces of the propodus and dactylus (the first and second pereiopods also); the merus and carpus were slender. The ischium of the fourth and fifth pereiopods had the same length, and in the fifth the merus and carpus were larger than in the fourth. The ischium in the fourth and fifth pereiopods was one-sixth larger than that of the fourth. The carpus of the fifth pereiopod was one-third larger than that of the fourth.

The dactyli of the fourth and fifth pereiopods were almost equal in size.

The exopod of the first pleopod reaches the hepatic spine of the carapace. In females there are no endopods while in males they are transformed into a petasma. All the rest of the pleopods had a setose endopod which reached half the length of the exopod.

The first three somites of the abdomen were smooth; all the other somites had a dorsal crest and a terminal spine. The pleura were rounded and setose ventrally. The sixth somite ventrolaterally had a spine at the posterior end. The telson was a little longer than the sixth somite. On the dorsal side of the telson there was a fissure near the posterior end and it terminated in a single point. The telson also was setose. The external edges of the exopods of the uropods were straight and without setae and were rounded at the end.

Some other features shown in Figures 2 and 3 are the following:

a) The maxillulae (Mx1) had three lobes: two endites which had apical setae; the second endite had eight plumose setae at its base and three bristles on its median portion. The endopod had setae on the anterior, posterior and lateral portions.

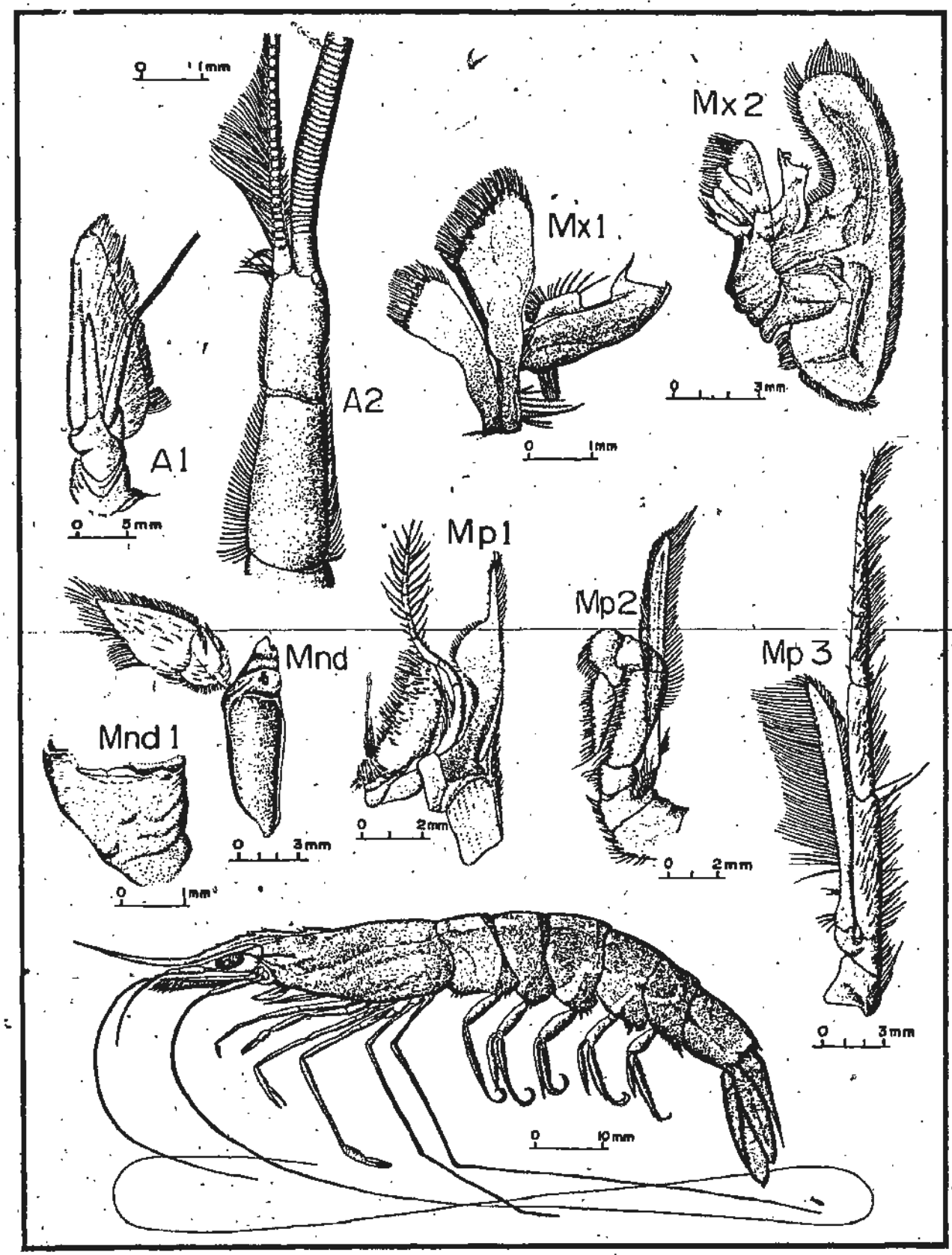

FIG. 2. Xiphopenaeus riveti A_1, antenna; A_2, antennule; Mx_1 maxillula; Mx_2, maxilla; Mnd_1 detail of mandible; Mnd, mandible Mp_1 first maxilliped; Mp2, second maxilliped; Mp3 third maxilliped.

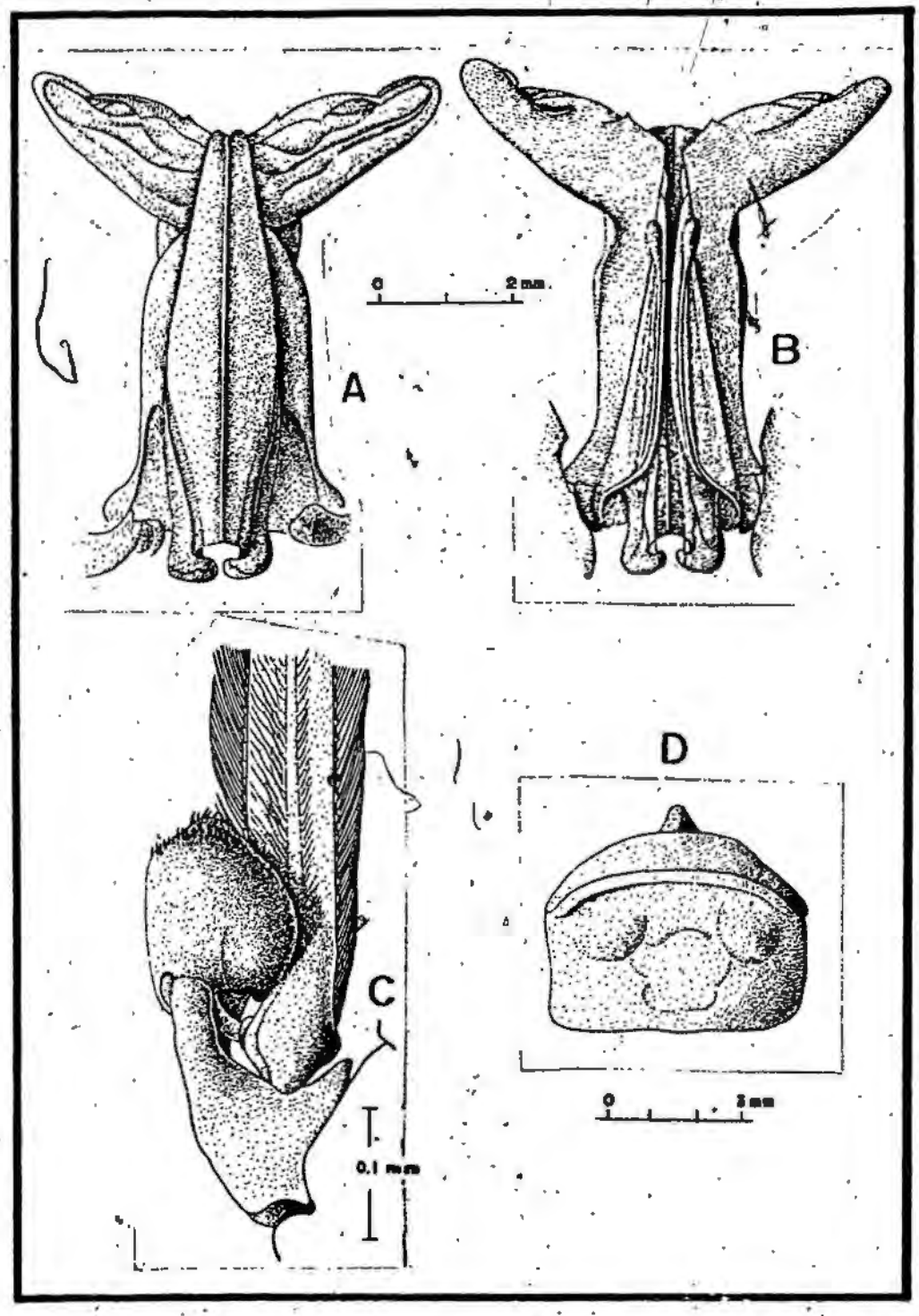

FIG. 3. Xiphopenaeus riveti a. Petasma, posterior view; b. Petasma, anterior view; c. Appendix masculina; d. Thelycum.

b) The maxillae (Mx2) had two setose endites in its apical portion; tne endopod had some apical setae. The scaphognathite had a fringe of setae.

c) The mandible(Mnd) had calcified incisor and mandibular processes (Mnd 1) and a lamellar palp which was in two sections and fringed with setae.

d) The setose endopod of the first maxilliped (Mp1) was longer than the exopod and formed by five portions.

e) The endopod of the third maxilliped (Mp3) was divided in five parts also.

f) The setose exopods of the second (Mp2) and third (Mp3) maxillipeds had sawtooth edges.

g) The petasma was T-shaped. The lateral projections had sawtooth edges.

h) The appendix masculina was setose on its ventral portion.

i) The thelycum had a transverse suture towards its anterior end separating it into two parts externally.

DISTRIBUTION

Xiphopenaeus riveti was originally described from Paita, Peru (Bouvier, 1907). Rioja (1942) made observations on two specimens from the Gulf of California. Lindner (1957) and Croker (1967) gave the geographic distribution as between Mexico and Ecuador. The distribution of X. riveti is therefore in the "Pacific Panamic zoogeographic province" which begins in the Gulf of California to the northeast of Mexico and extends southward to the north of Peru, comprising a length of shore line of more than 4,500 nautical miles (Olsson, 1961).

Details of Distribution

Loesh and Avila (1966) say that they did not capture X. riveti in the estuary of Data, Ecuador, "although many of them are present in the sea at a few miles from its mouth". They caught nine specimens in the estuary of the Moro. They concluded that this shrimp showed preference for the zone at the mouth of the estuary. Croker (1967) (based possibly on Loesh and Avila's paper) said that the "tiger" shrimps spent a great part of their lives in lagoons and estuaries, while the "pomadas" and "titis" did not enter the estuarine waters. My observations indicate that X. riveti may be found in the estuaries but its presence could be due to tidal influences.

Adults

Adults were found between depths of less than five to ten fathoms, but once it was captured at twenth to thirty fathoms.

Length Frequency Distributions

The four length frequency distribution graphs (Figs. 4, 4A, 4B and 4C) were used to estimate the major periods of recruitment during the sampling year and also to find some evidence of fishing pressure on the stocks. The graphs were derived from two stocks of shrimps divided into two parts south and north of Buenaventura.

In order to assist with these estimations, arbitrary vertical lines were drawn at lengths of 18 and 28 mm (carapace length) for females, and at 18 and 22 mm for males. These lines separated two size groups, the small and large sizes, as well as the modal size of the monthly frequency.

Recruitment

Recruitment was defined as "enlisting newcomers to an adult population consisting of potential breeders" (Wynne-Edwards, 1967, p. 486).

Recruitment was indicated by the relatively numerous small shrimps (juveniles) during the last months of 1969 (October, November, and December) and at the beginning of 1970 (January and February) (Figs. 4, 4A, 4B and 4C).

In general, it was found that a displacement of the mode occurred shifting to the left of the modal size throughout the year of sampling. This would indicate that a large number of shrimp, of small and medium sizes, were recruited to the fishing grounds periodically.

If recruitment was continued for a period of three to four months, and if it can be presumed that growth in tropical waters is rapid, a modal displacement to the right side of the distribution or the presence of various modes would occur. Once the recruitment was over, it was anticipated that the size range would decrease because the shrimps that were growing were being fished and also because there were none or very few shrimps entering the population. This was found for the months of March and May in females from the north, and in June and December south of Buenaventura.

Although the picture was not as clear for males, due to the narrower length range, the same was found to occur in March north of Buenaventura.

If the shrimps with large sizes to the right of the arbitrary lines, 28 mm for females and 22 mm for males, were considered, it could be seen that this group was smaller in October 1969 and in February 1970. All other months were found to have this group present but in a greater proportion than in the above months. Therefore, it could

be said that during 1969 and the beginning of 1970 recruitment occurred during five months, from October 1969 to February 1970[1].

Fishing Pressure

Another factor to be considered was that of fishing pressure which reduced the numbers of shrimps. The net mesh size tends to be selective and to some extent it captures larger sizes and allows juveniles to escape. This implies that there is a tendency to reduce the shrimp sizes, in spite of the rapid growth of these shrimps. Therefore, the mode has a tendency to shift to the left, or to a smaller size group. This could also occur in periods of high recruitment because the proportion of small shrimps would be greater.

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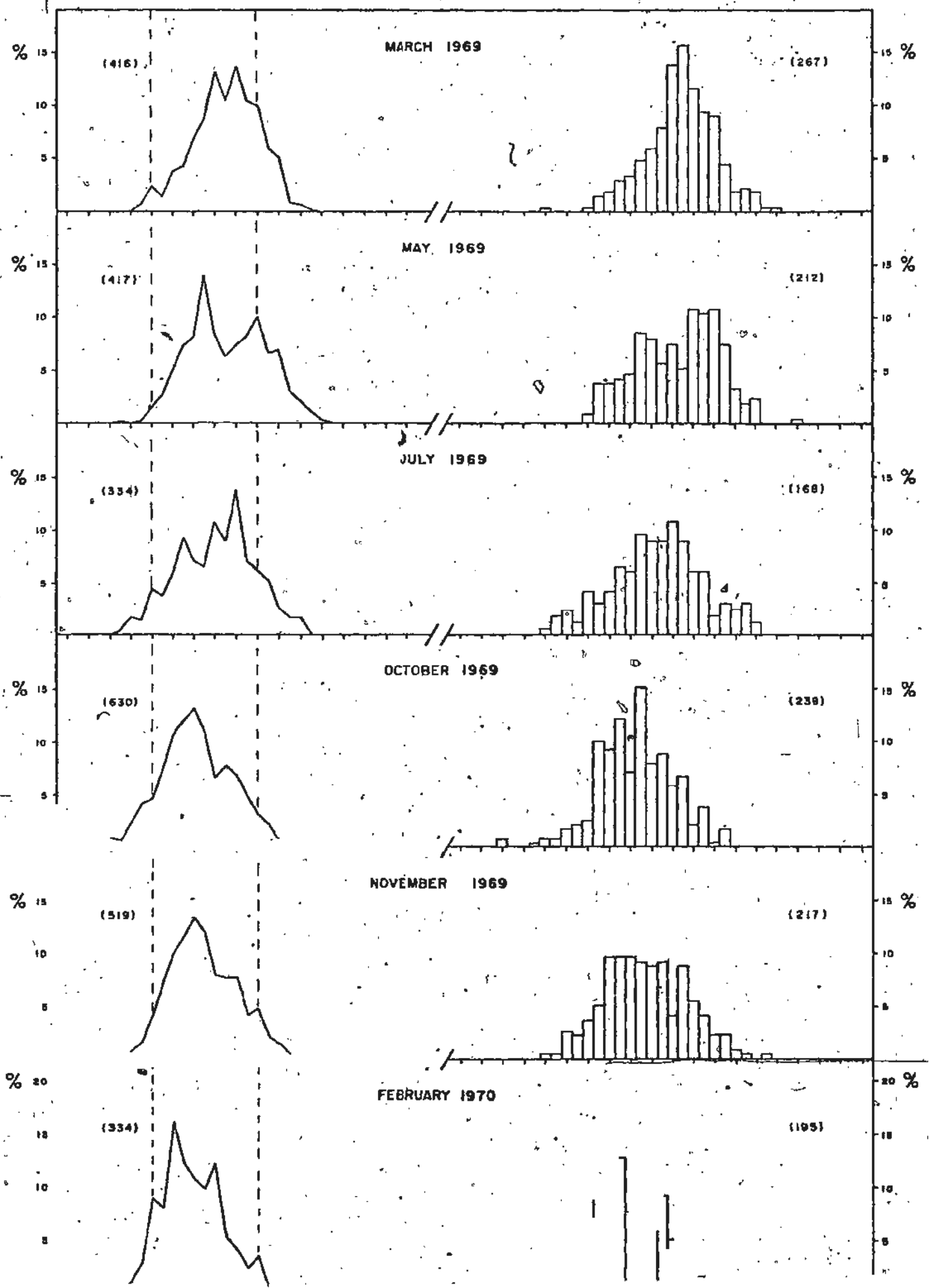
[1] See also another approach to recruitment on p. 100.


MARCH 1969
(416)
(267)
MAY 1969
(417)
(212)
JULY 1969
(334)
(168)
OCTOBER 1969
(630)
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NOVEMBER 1969
(519)
(217)
FEBRUARY 1970
(334)
(195)
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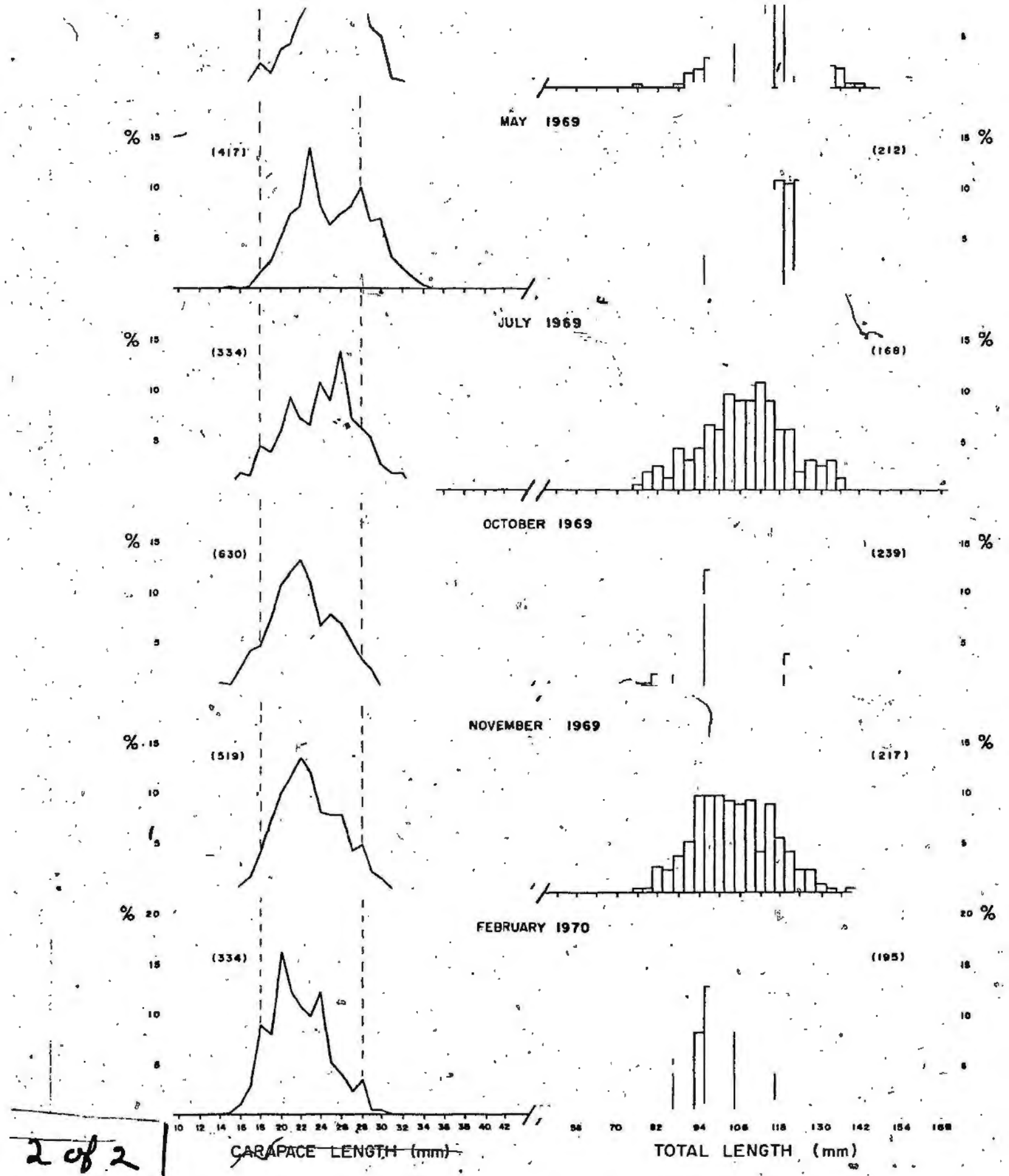

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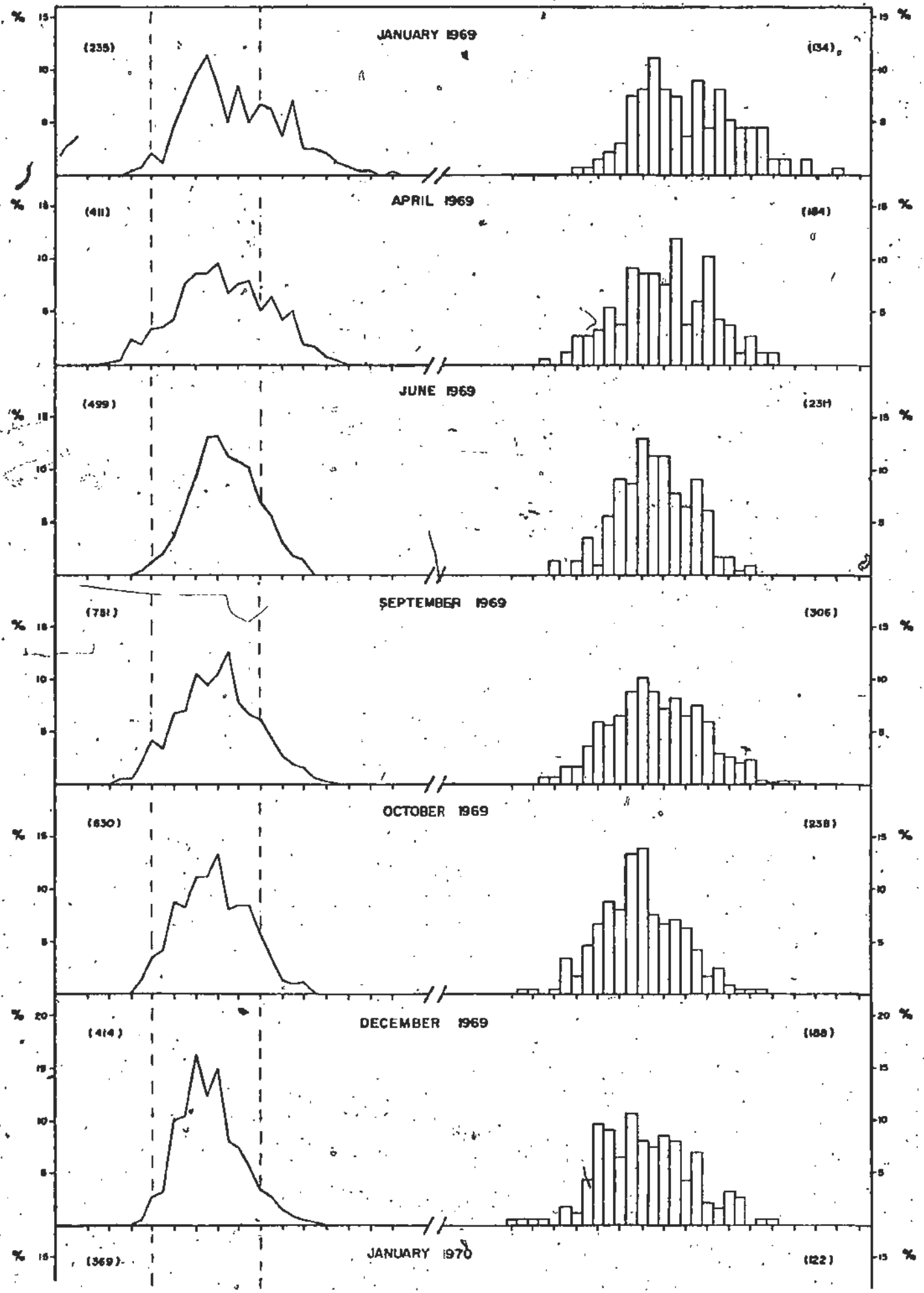
FIG. 4. Xiphopenaeus riveti Carapace and total length frequency distributions of females North of Buenaventura.

1 of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(235)
(134)
APRIL 1969
(411)
(184)
JUNE 1969
(499)
(231)
SEPTEMBER 1969
(781)
(306)
OCTOBER 1969
(630)
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DECEMBER 1969
(414)
(188)
JANUARY 1970
(369)
(122)
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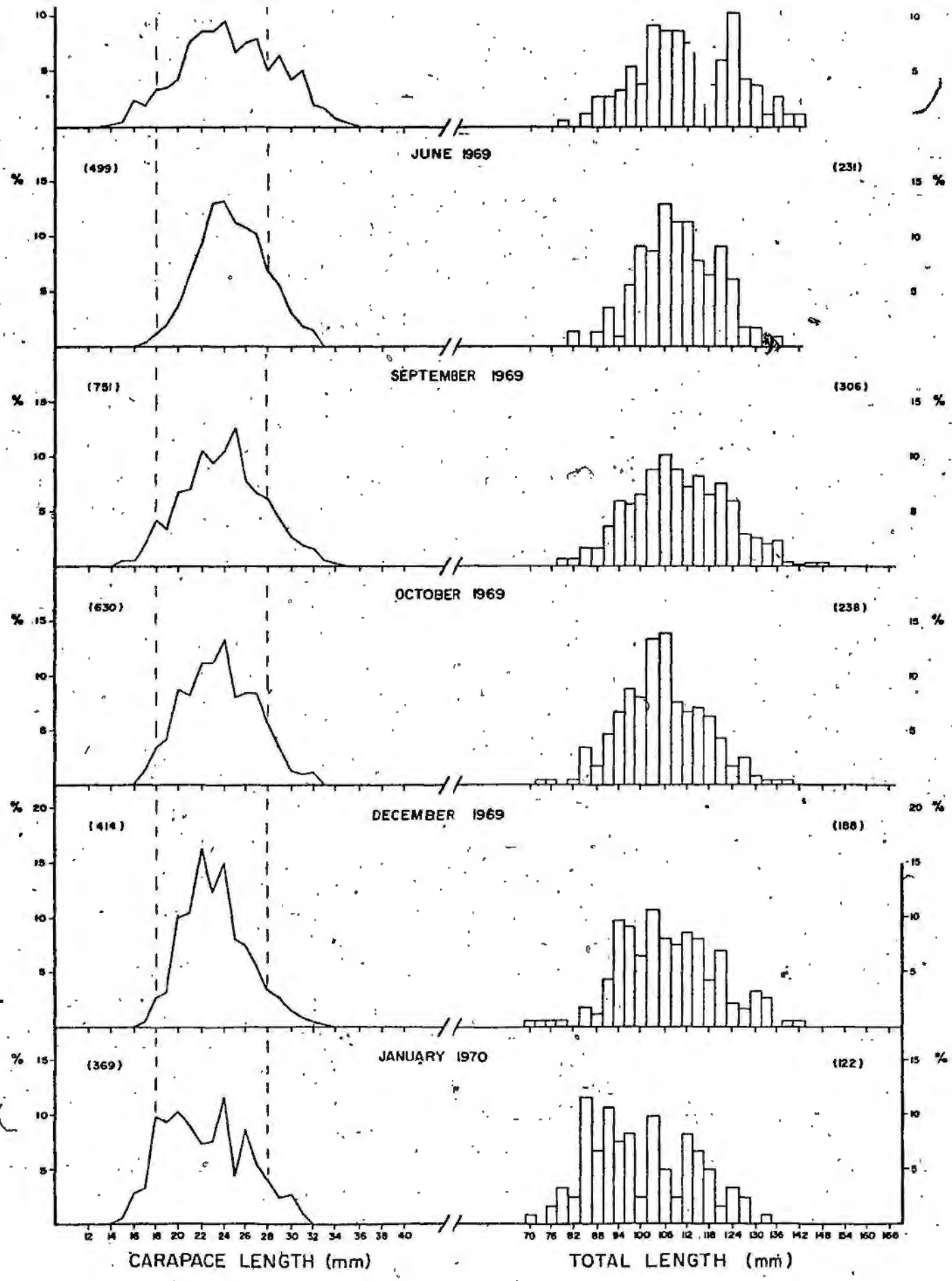
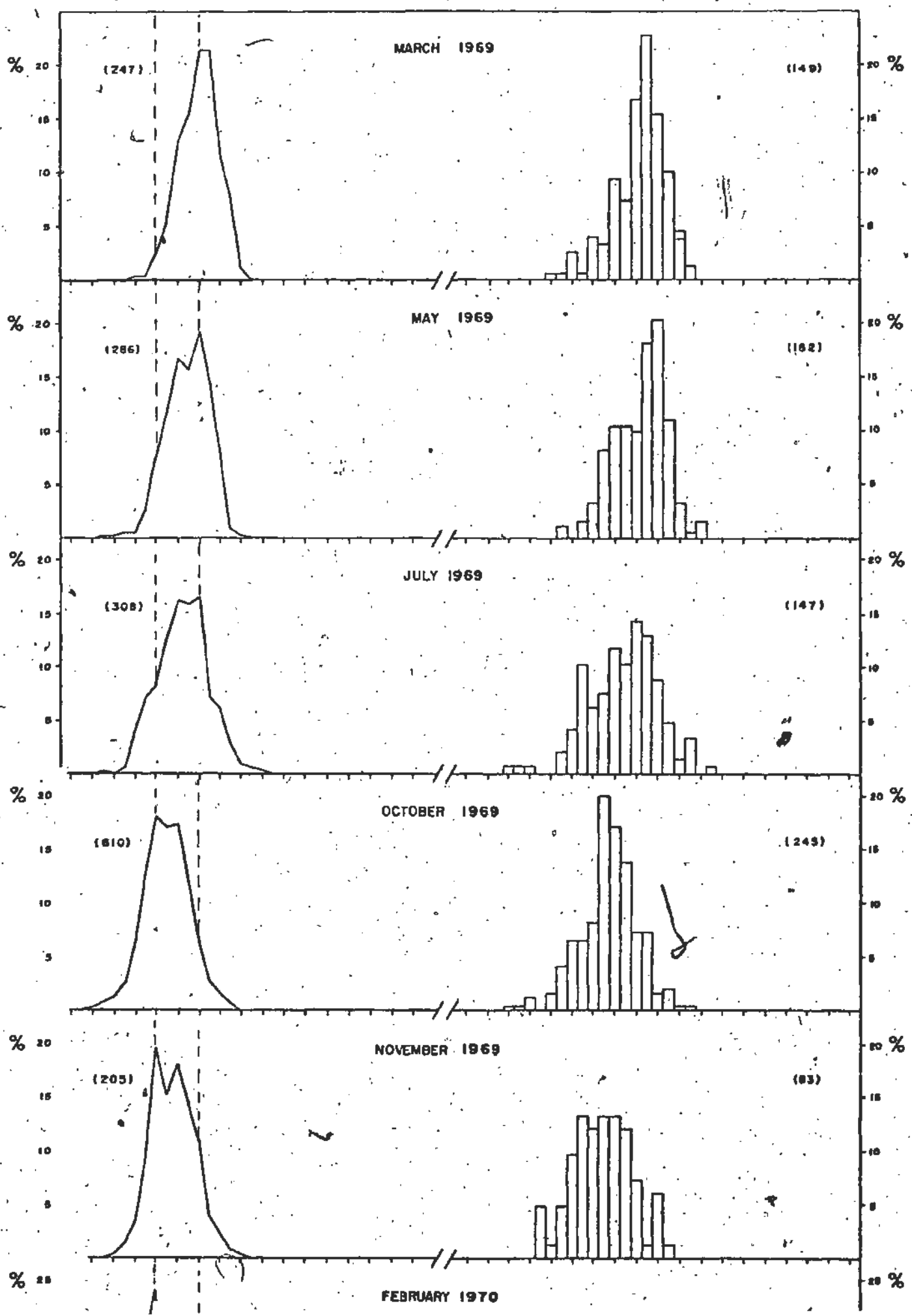


FIG. 4 A. Xiphopenaeus riveti Carapace and total length frequency distributions of females South of Buenaventura.

2 of 2


MARCH 1969
(247)
(149)
MAY 1969
(286)
(182)
JULY 1969
(308)
(147)
OCTOBER 1969
(810)
(245)
NOVEMBER 1969
(205)
(83)
FEBRUARY 1970
%

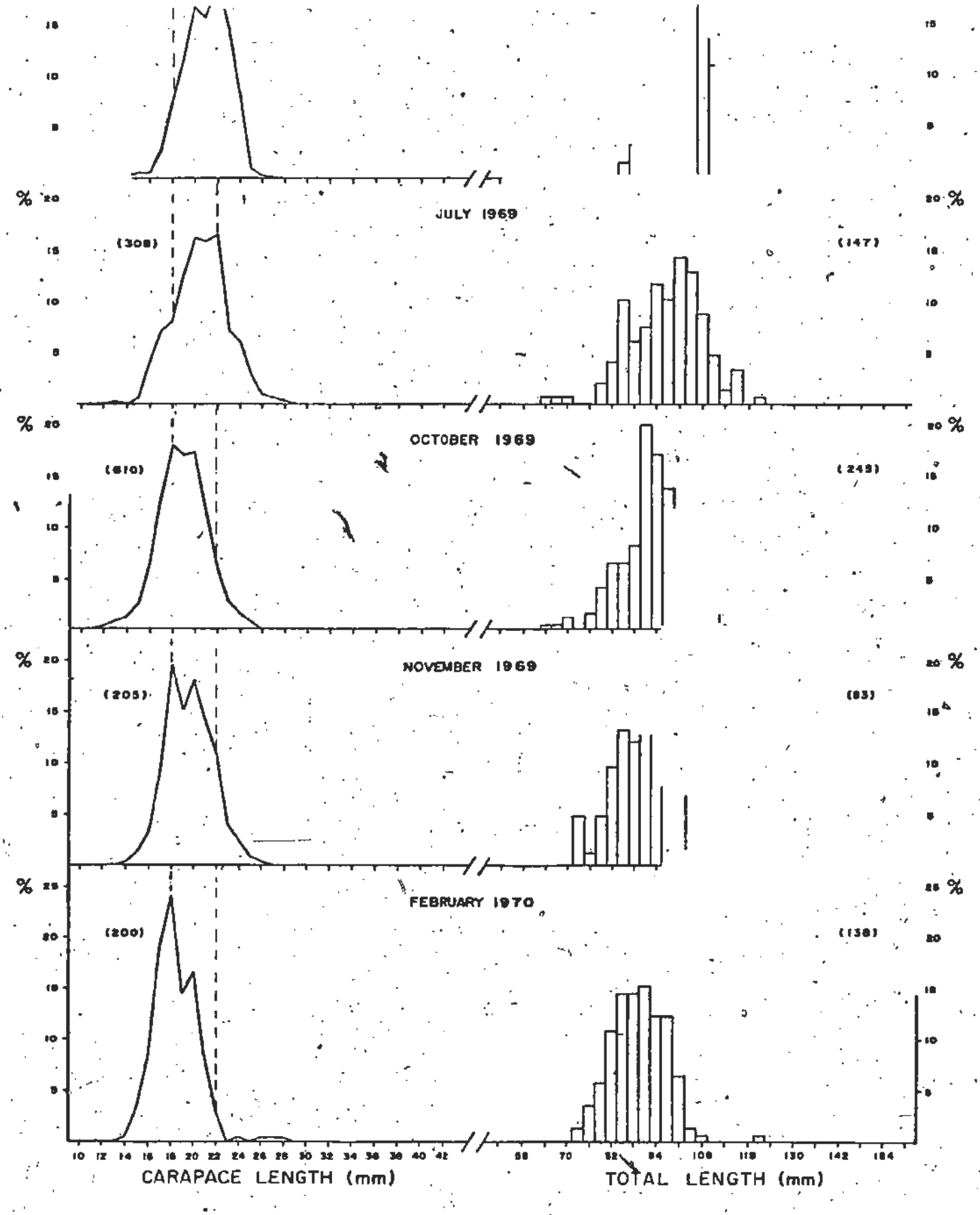


FIG. 4 B. Xiphopenaeus riveti Carapace and total length frequency distributions of males North of Buenaventura.

2 of 2

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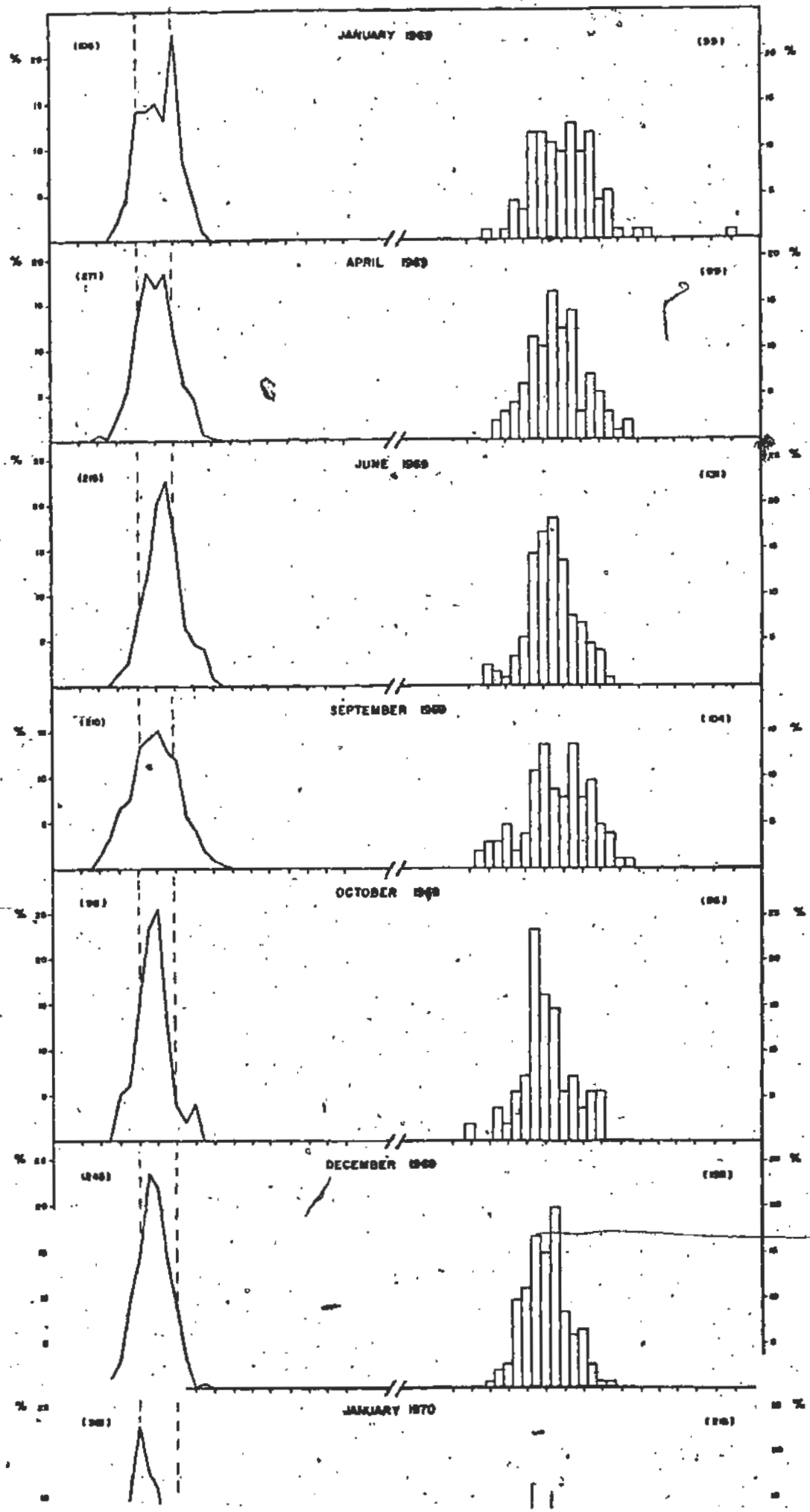
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JUNE 1969
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OCTOBER 1969
DECEMBER 1969
JANUARY 1970

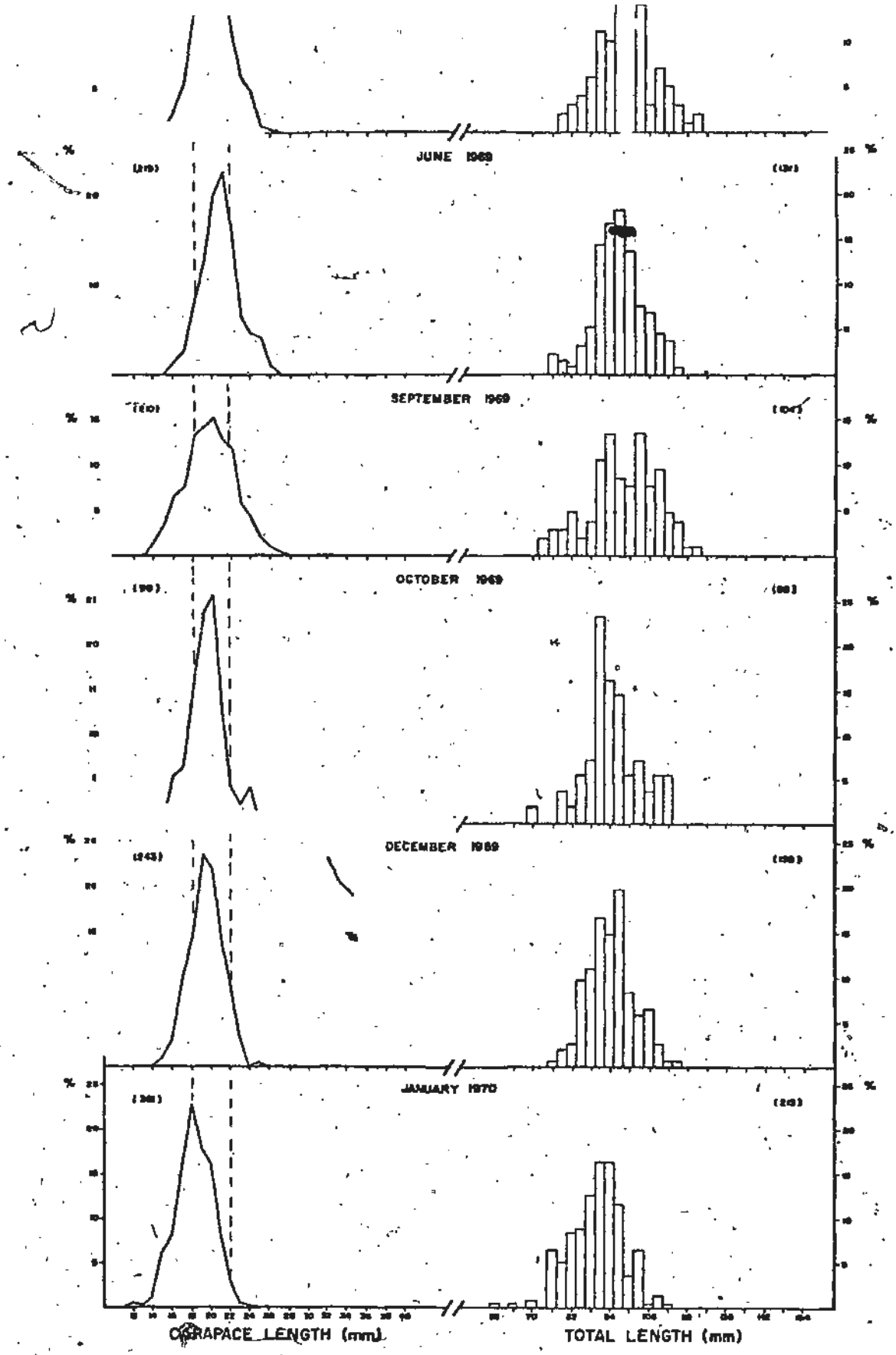

FIG. 4 C. Xiphopenaeus riveti Carapace and total length frequency distributions of males South of Buenaventura.

2 of 2

BIOLOGY

Length and/or Weight Relationships

The following morphometric relationships were obtained for males and females separately, as well as a combination of the sexes:

Total length:	Carapace length
Total weight:	Tail weight
Total weight:	Carapace length
Total weight:	Total length
Tail weight:	Carapace length

The calculated equations are shown in Table I with their respective correlation coefficients. The graphs for these equations are shown also in Figs. 5 to 14.

Total Length - Carapace Length Relationship

The total length - carapace length relationship was obtained for 471 males and 792 females, ranging in the former between 13 to 27 mm in carapace length, and in the latter between 12 to 35 mm in carapace length.

Males always showed a greater increase in total length than females, thus, for each millimeter of increment in carapace length, males increased 3.8 times in total length. In females the relationship was 3.5 times (Fig. 5).

TABLE I. Length and/or weight relationship equations for X. rivoti from the Pacific Coast of Colombia, 1.969. Graphs to illustrate these equations are in Figs. 4 - 14. (ToL = total length, CL = carapace length, TaW = tail weight, ToW = total weight).

Relationship	Sex	Equation	Correlation Factor	C.L. Range mm	No.of specimens
ToL/CL	M	$ToL = 3.798\ CL + 17.795$	0.993	13-26	471
ToL/CL	F	$ToL = 3.518\ CL + 21.64$	0.995	15-33	792
ToL/CL	M + F	$ToL = 3.521\ CL + 22.119$	0.985	13-33	1263
ToW/TaW	M	$ToW = 1.554\ TaW + 0.062$	0.992	14-26	458
ToW/TaW	F	$ToW = 1.790\ TaW - 0.501$	0.997	15-35	777
ToW/TaW	M + F	$ToW = 1.799\ TaW - 0.602$	0.997	14-35	1254
ToW/CL	M	$ToW = 0.0028\ CL^{2.521}$	0.991	13-27	454
ToW/CL	F	$ToW = 0.0011\ CL^{2.780}$	0.985	14-36	790
ToW/CL	M + F	$ToW = 0.0033\ CL^{2.444}$	0.997	13-36	1254
ToW/ToL	M	$ToW = 1.016 \times 10^{-6}\ ToL^{2.894}$	0.988	64-124 *	472
ToW/ToL	F	$ToW = 1.626 \times 10^{-7}\ ToL^{3.292}$	0.994	64-145 *	799
ToW/ToL	M + F	$ToW = 3.03 \times 10^{-7}\ ToL^{3.160}$	0.998	64-145 *	1271
TaW/CL	M	$TaW = 0.00106\ CL^{2.688}$	0.984	13-27	464
TaW/CL	F	$TaW = 0.00134\ CL^{2.563}$	0.990	14-36	790
TaW/CL	M + F	$TaW = 0.00206\ CL^{2.436}$	0.995	13-36	1254

* Total length.

For males and females combined (1,263 specimens), the relationship was more near to that of the females shown separately. The increment in total length was 3.5 times the carapace length (Fig. 6).

Total Weight - Tail Weight Relationship

The total weight - tail weight relationship obtained from the averaged weights of 777 females indicated that the increment in total weight had a direct relationship of 1.790 times, on the average, for each gram of increase in tail weight.

In 458 males the increase in total weight was 1,554 times, on the average, for each gram of increase in the weight of the tail. Females had the greatest range in weight (1 - 11.5 g for tail weight and 1 - 18.5 for total weight). Furthermore, they showed a greater increase in total weight for each interval of tail weight, than males (Fig. 7).

For all the specimens (1,254 males and females, with an increase of one gram in tail weight the total weight increased by 1.799 times, on the average (Fig. 8).

Total Weight - Total Length Relationship

The total weight - total length relationship calculated from 472 males ranged from 64 to 121 mm total length and from 799 females ranged from 64 to 145 mm total length. In males a greater

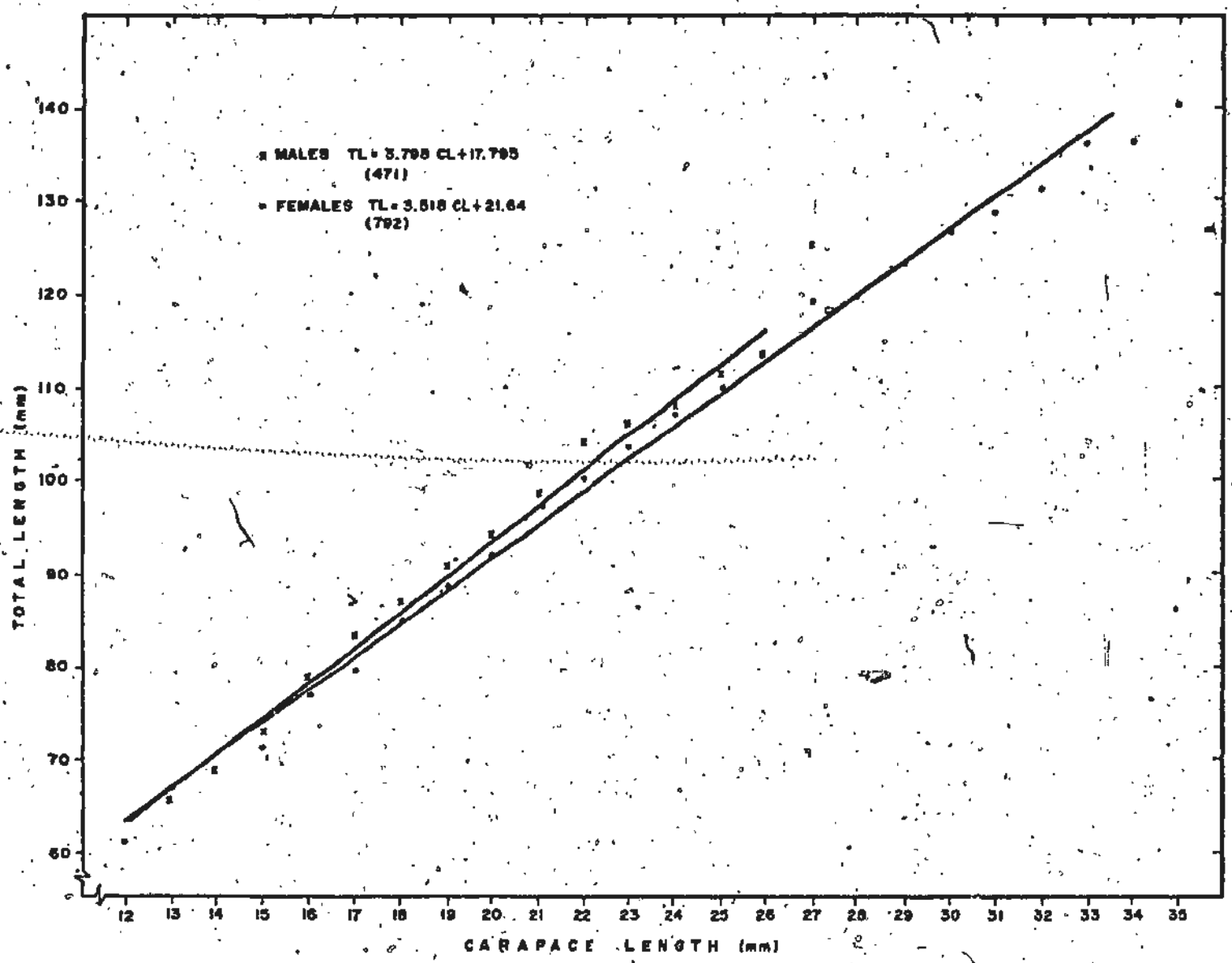

FIG. 5. Total length-carapace length relationship in male and female Xiphopenaeus riveti

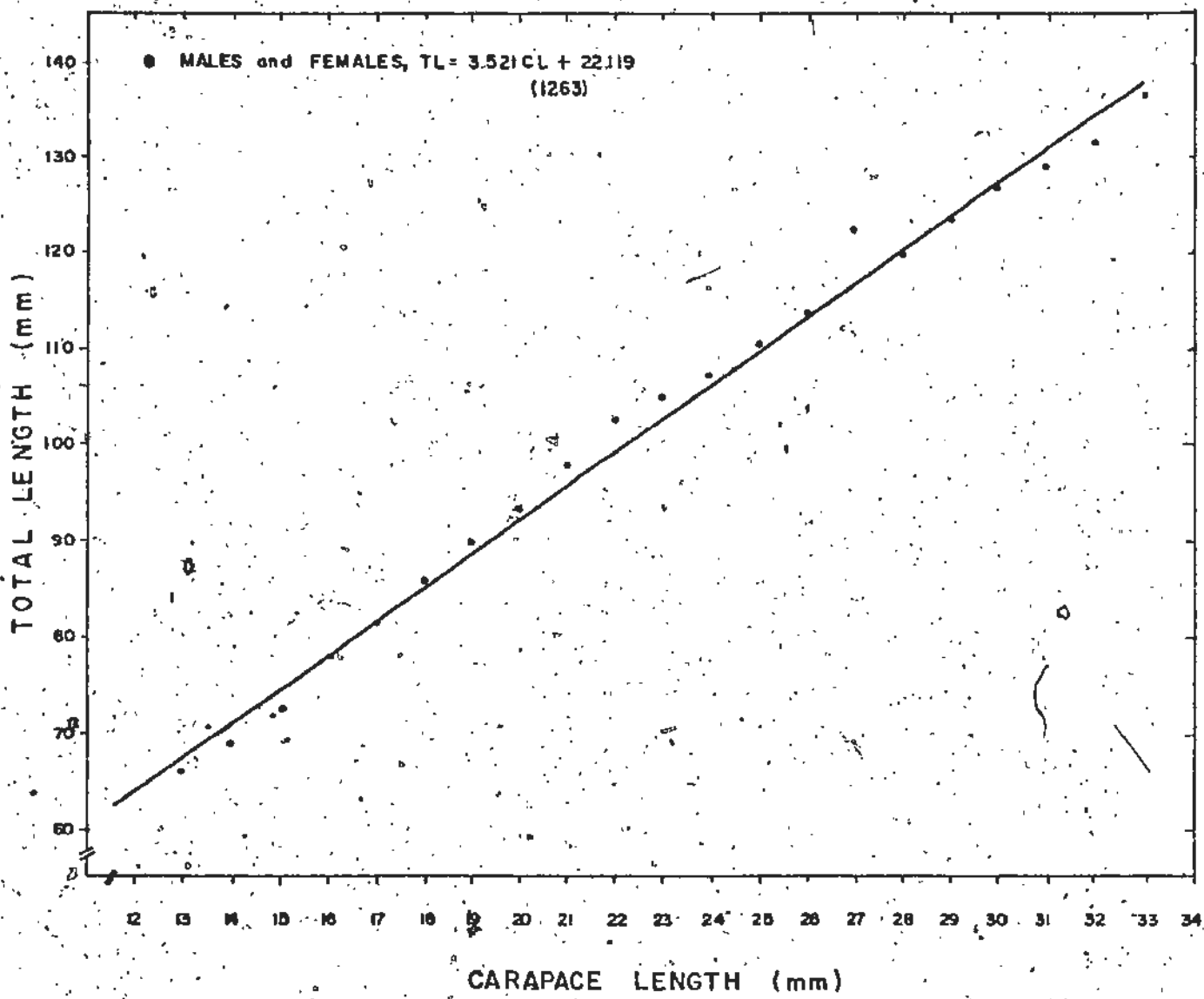

Fig. 6. Total length-carapace length relationship in males and females combined of Xiphopenaeus riveti.

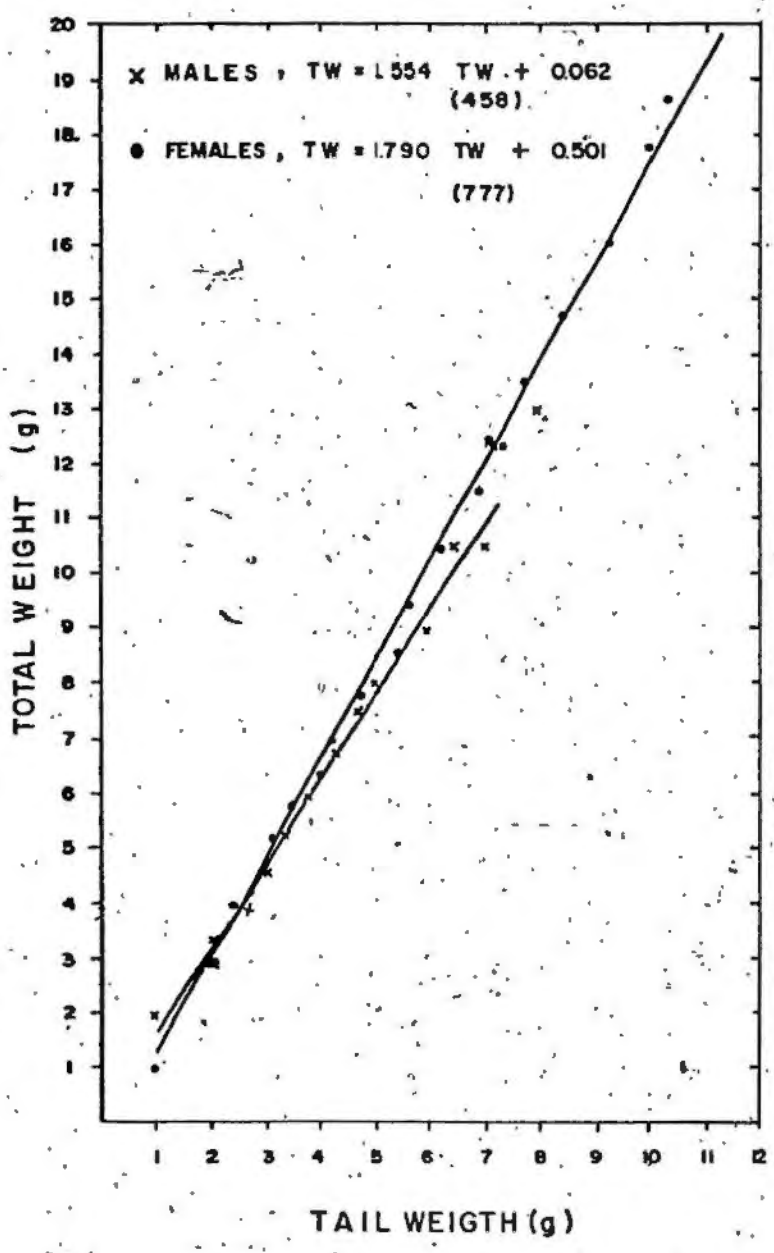

Fig. 7. Total weight-tail weight relationship in male and female Xiphopenaeus riveti.

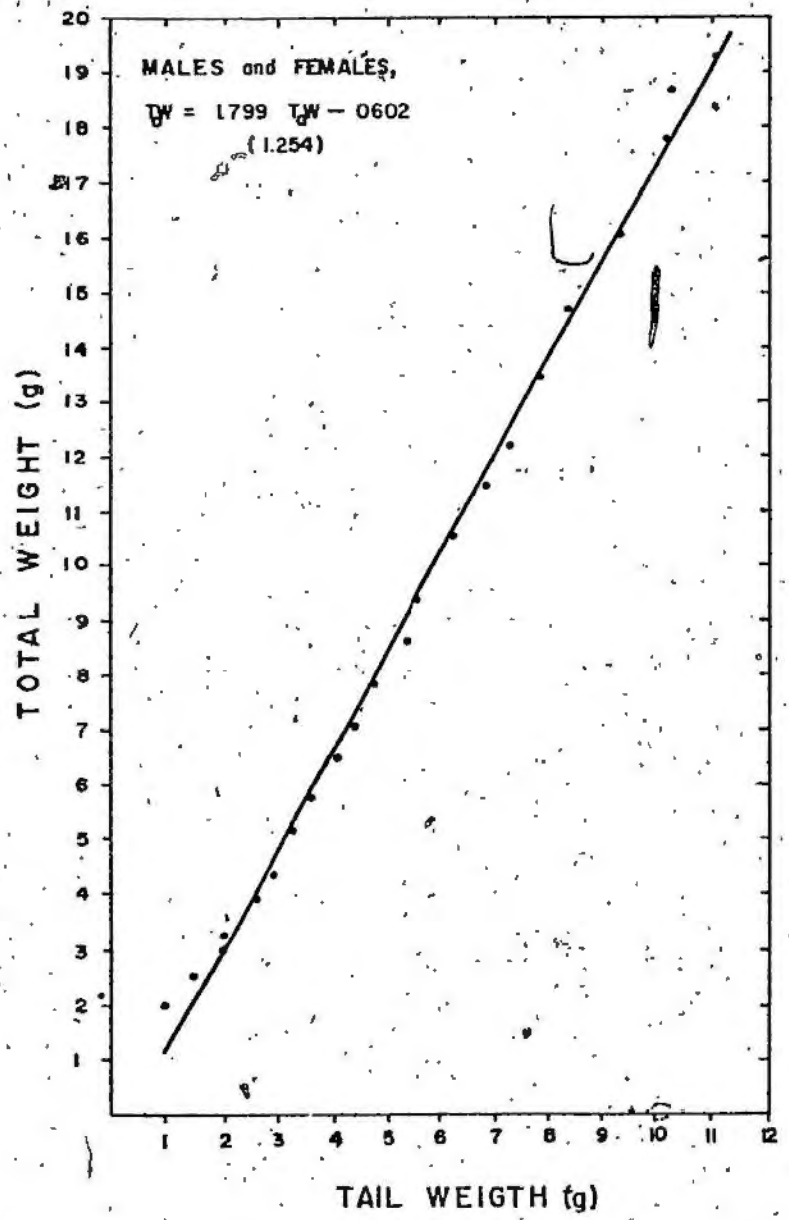

Fig. 8. Total weight-tail weight relationship in males and females combined of Xiphopenaeus riveti .

weight was apparent up to 98 mm in total length. After this length the situation was the reverse, and females began to accelerate in weight faster than males (Fig. 9).

The greatest weight, 21 g, was for one female with 145 mm total length. In males the highest weight was 12 g with 121 mm total length.

For sexes combined (1,271) the constant of allometry was 3.16. After 115 mm total length the increments in total weight were higher than at the lower lengths (Fig. 10).

Total Weight - Carapace Length Relationship

In males, up to 27 mm carapace length, the total weight for their size was greater in females.

The greatest total weight (24 g) was obtained in females with a 36 mm carapace length, but females showed a greater variation than males. Possibly these variations were due to the increase in ovary weight; this was observed at length intervals of 16, 18, 20, 27 and 36 mm carapace length (Fig. 11).

At the minimum sizes for males, there was not a uniform increase in weight. Starting at 18 mm carapace length the increase begins to decelerate as shown from the curve indicating that growth was slowing down (Fig. 11).

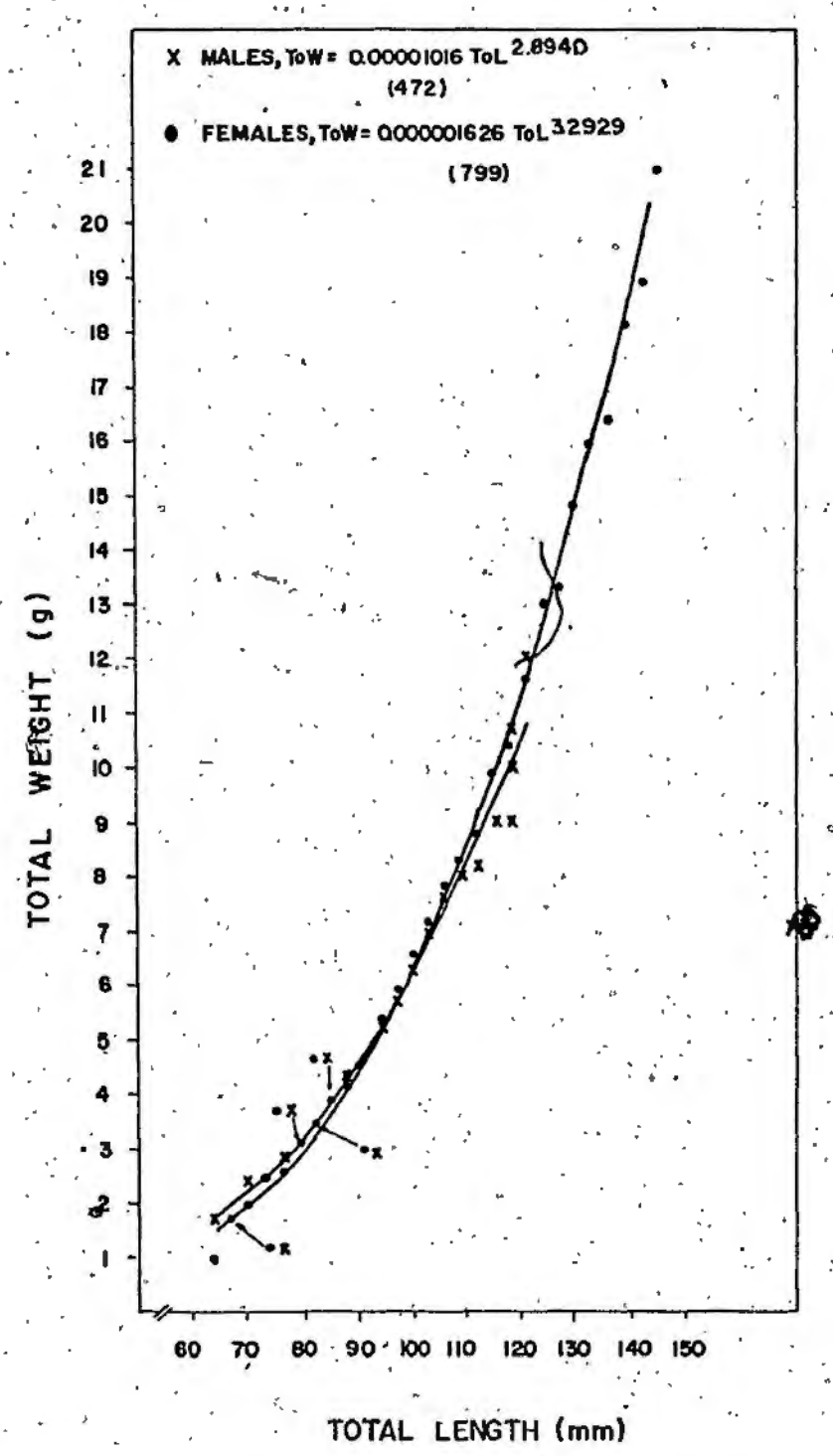

Fig. 9. Total weight-total length relationships in male and female Xiphopenaeus riveti.

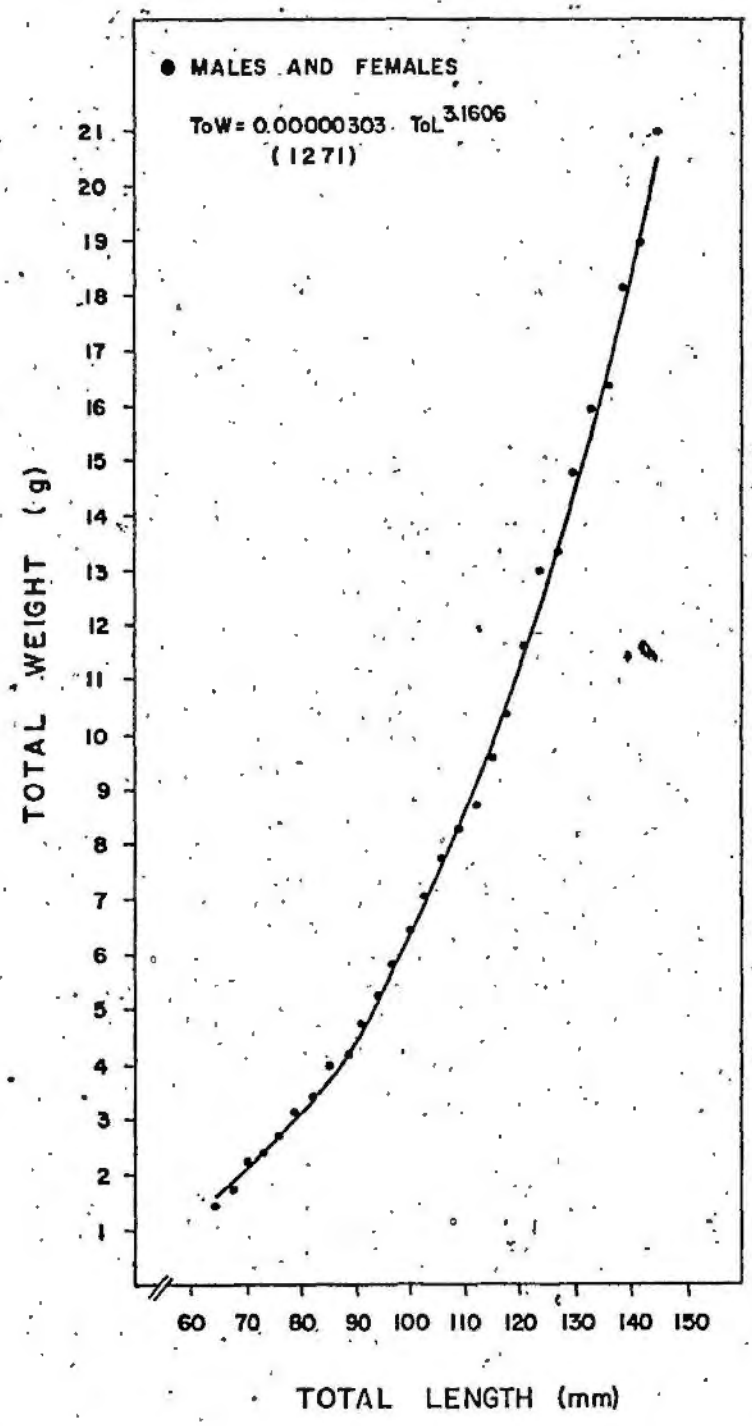

Fig. 10. Total weight-total length relationships in males and females combined of Xiphopenaeus riveti.

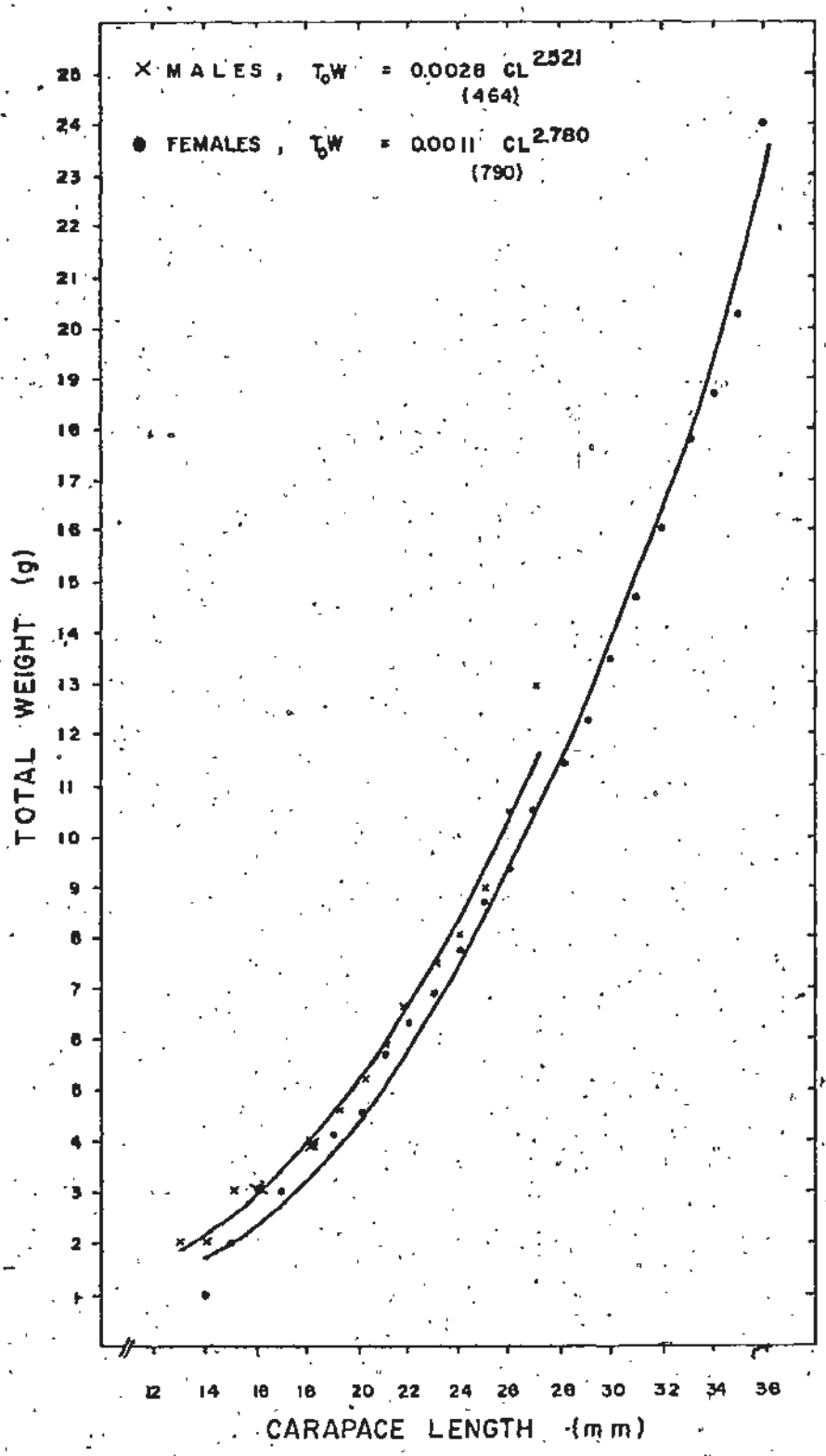

Fig. 11. Total weight-carapace length relationships in male and female Xiphopenaeus riveti.

The sharp increase of one gram in the total weight between 14 and 15 mm carapace length in females could be explained by the observation that at these lengths the first impregnation in females occurs.

For males and females it was observed that the minimum carapace length recorded was, on the average, 13 mm with 1.8 g of weight. The geometric increment in weight of one specimen was, on the average, 2.444 times each millimeter of increment in the carapace length (Fig. 12).

Tail Weight - Carapace Length Relationship

In males the range of carapace length was between 13 and 27 mm and in females from 15 to 36 mm carapace length. In males the increment in tail weight was greater than in females, thus, for males the geometric increment was 2.688 times for units of increment in carapace length. In females this increment was 2.563 times (Fig. 13).

For males and females the growth in tail weight was more or less uniform. The weight increase factor (2.436) was obtained from data on 1,254 specimens. The equation is valid for specimens between 13 and 36 mm carapace length (Fig. 14).

Growth

In females it was possible to see much better the length increments throughout the time of sampling than in male carapace length frequency distributions.

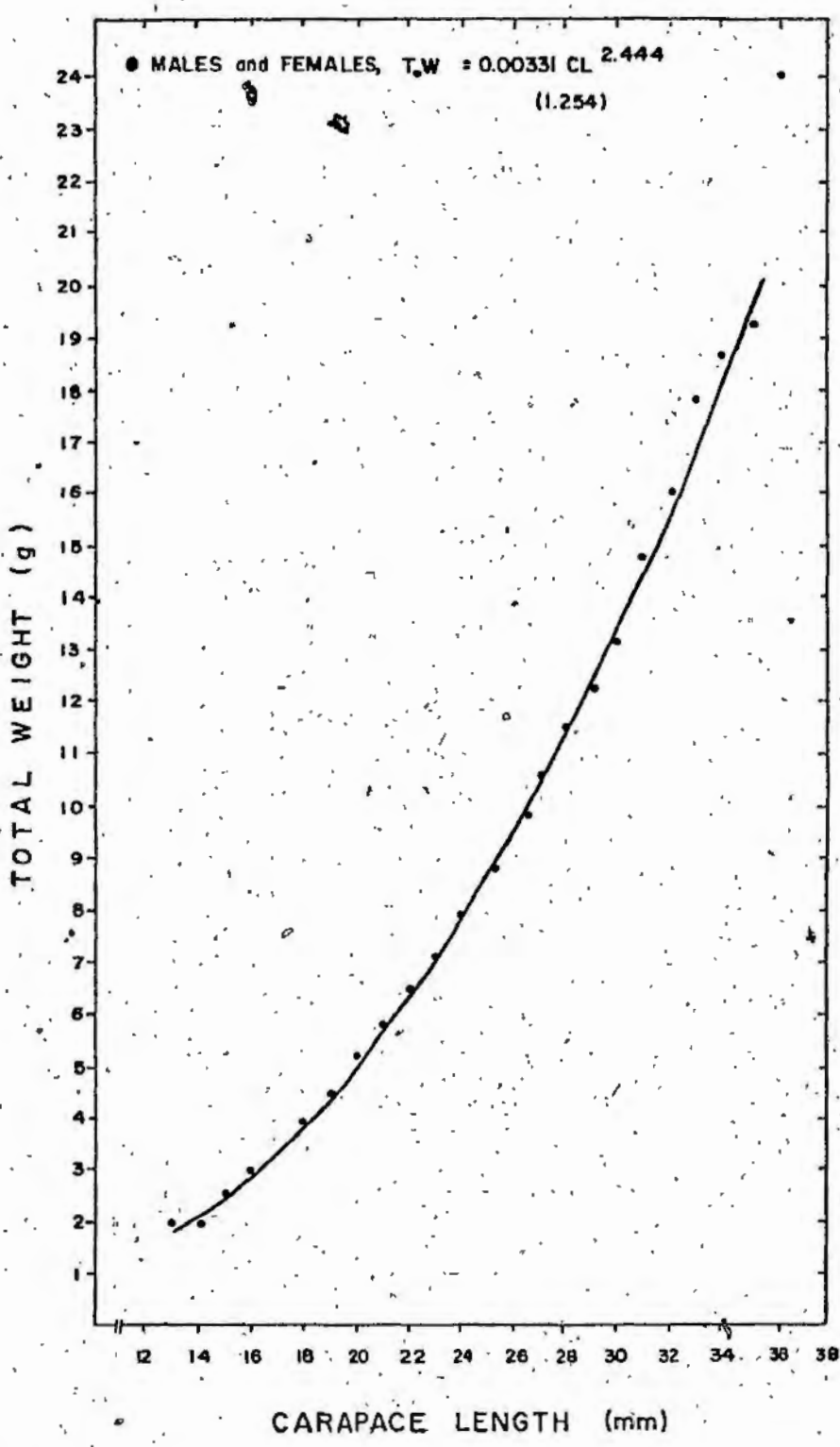

Fig. 12. Total weight-carapace length relationships in males and females combined of Xiphopenaeus riveti.

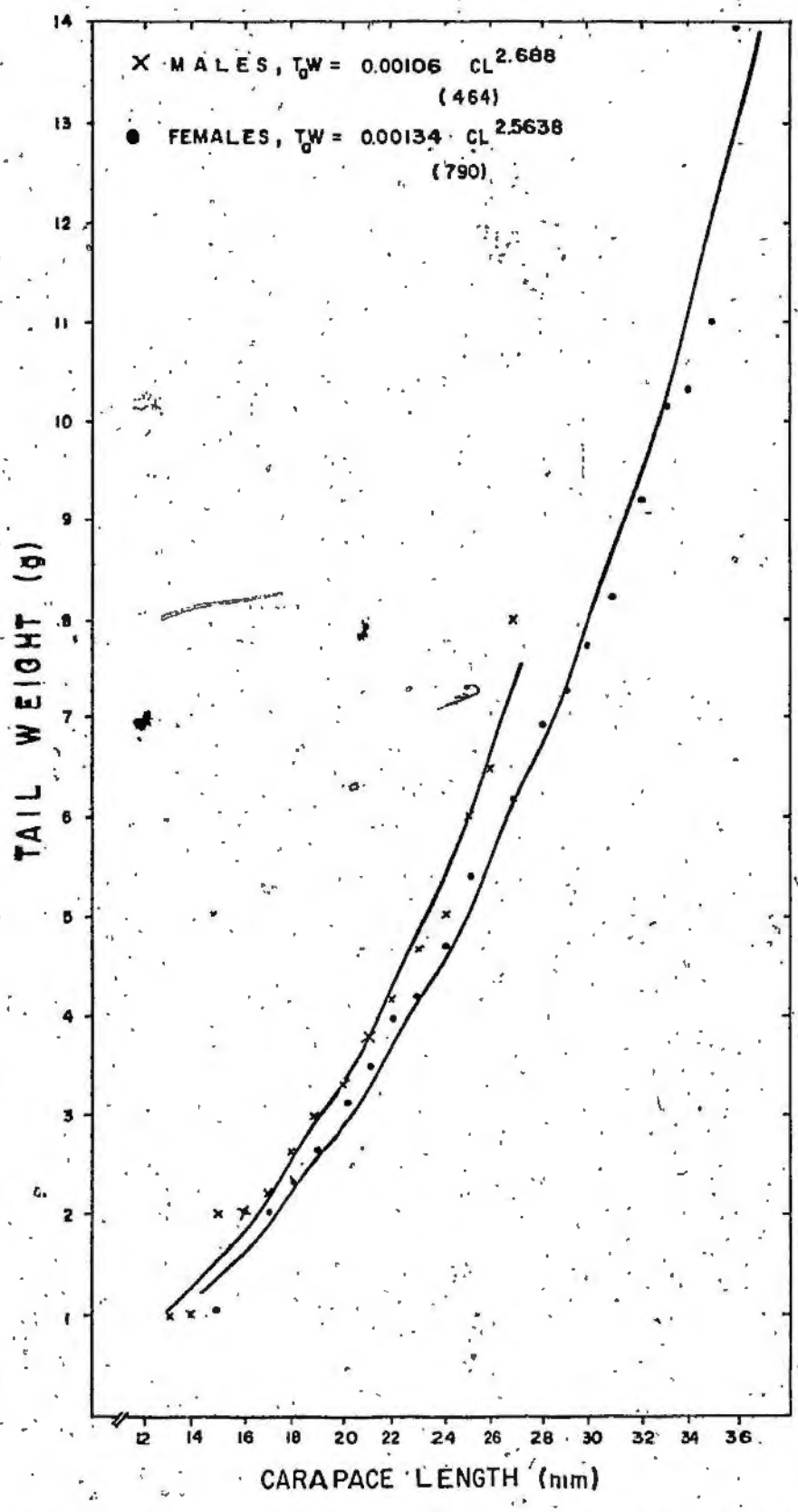

Fig. 13. Tail weight-carapace length relationships in male and female Xiphopenaeus riveti.

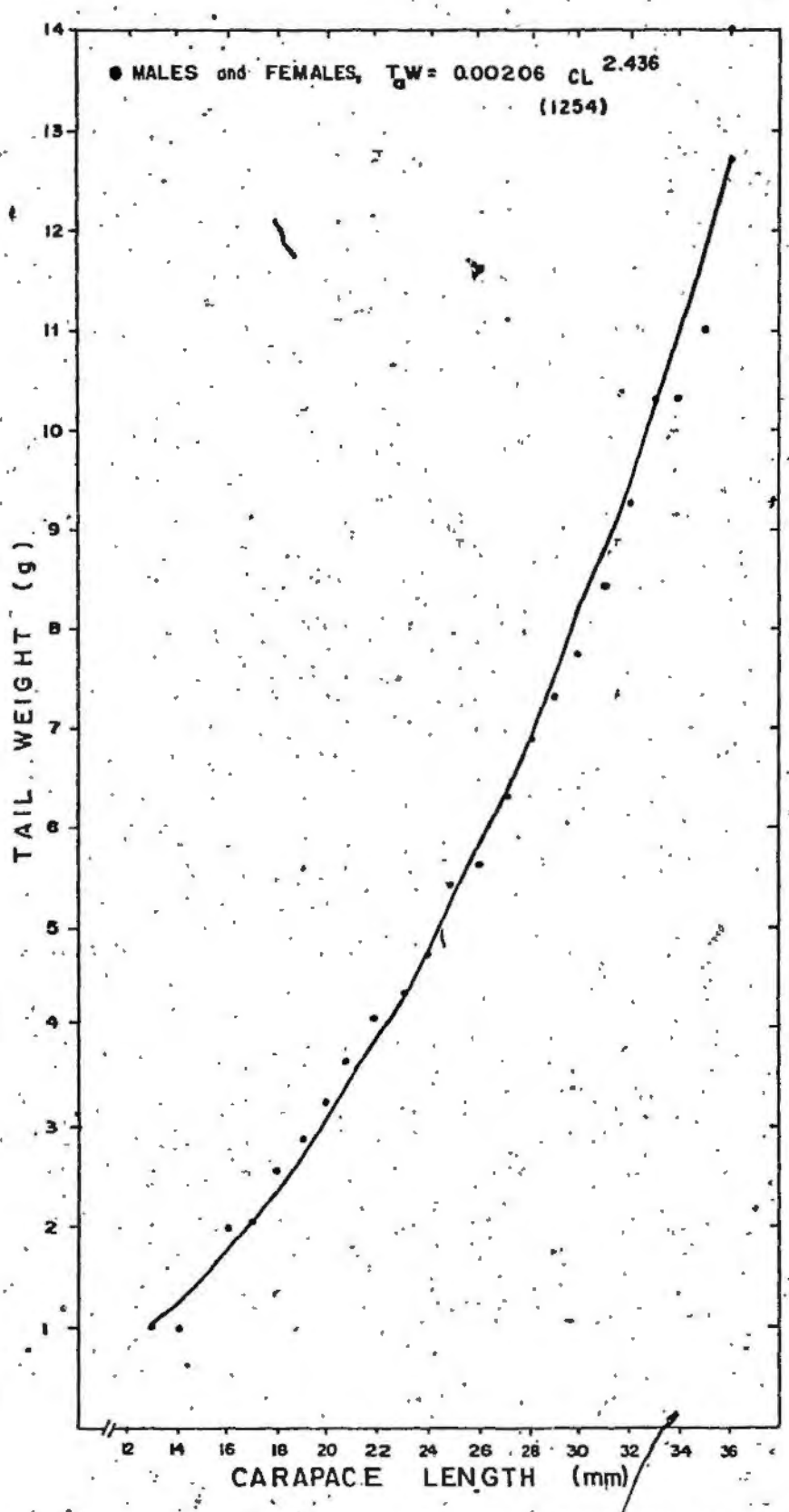

Fig. 14. Tail weight-carapace length relationships in males and females combined of Xiphopenaeus riveti.

The final equation was:

$$Lt = 41.6 \left(1-e^{-0.168\ (t + 2.3396)}\right)$$

The asymptotic length (L_∞) obtained was in agreement with samples taken in the field: in January 1969 a female 40 mm in carapace length was caught.

The curve of growth in carapace length for X. riveti is shown in Fig. 17 where age is given in months. According to this graph, female "titi" shrimps seem to grow 2.9 mm, on the average, in carapace length per month.

The curve of growth was extrapolated at its extremes and it could be estimated that the "titi" shrimp delayed two months before reaching a size vulnerable to the fisheries (about 12 mm in carapace length). On the other hand, to reach their maximum size of growth (41.6 mm in carapace length or 149 mm in total length) there could be a delay under favorable environmental conditions to 27 months.

Estimation of Conversion Factor from Tail to Total Weight

The conversion factor from tail to total weight was estimated from 44 samples. The figure was, on the average, 1.62. To convert total to tail weight the 0.61 figure was used.

No. of samples	Total weight (g)	Tail weight (g)	Total length range (mm)	Tail length range (mm)	Conversion factor
44	125.570	77.305	65-179	32-86	0.61

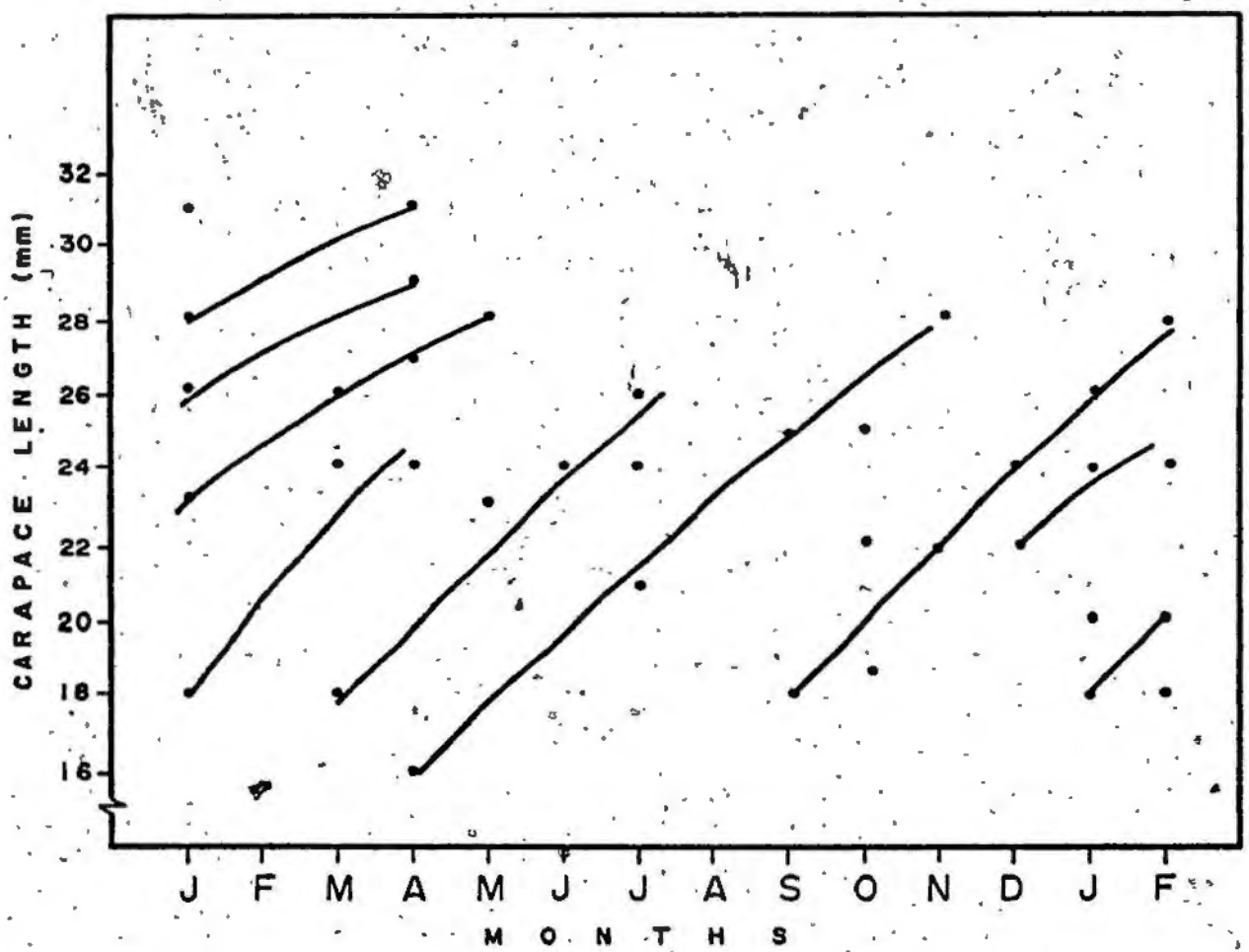

FIGURE 15. Monthly modes of females X. riveti, 1969

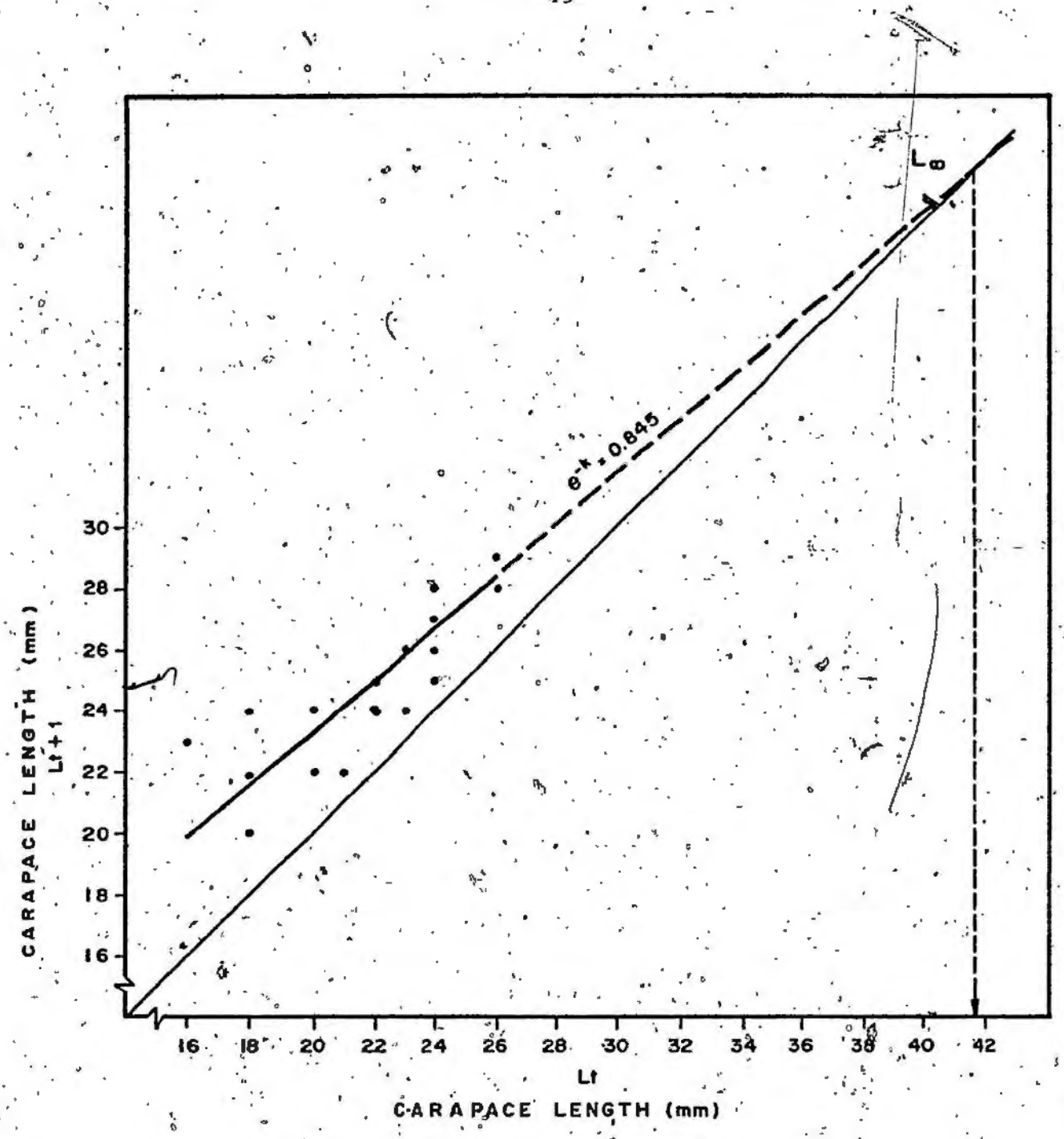

FIGURE 16. Relation between the monthly modes of one month against the modes of next month

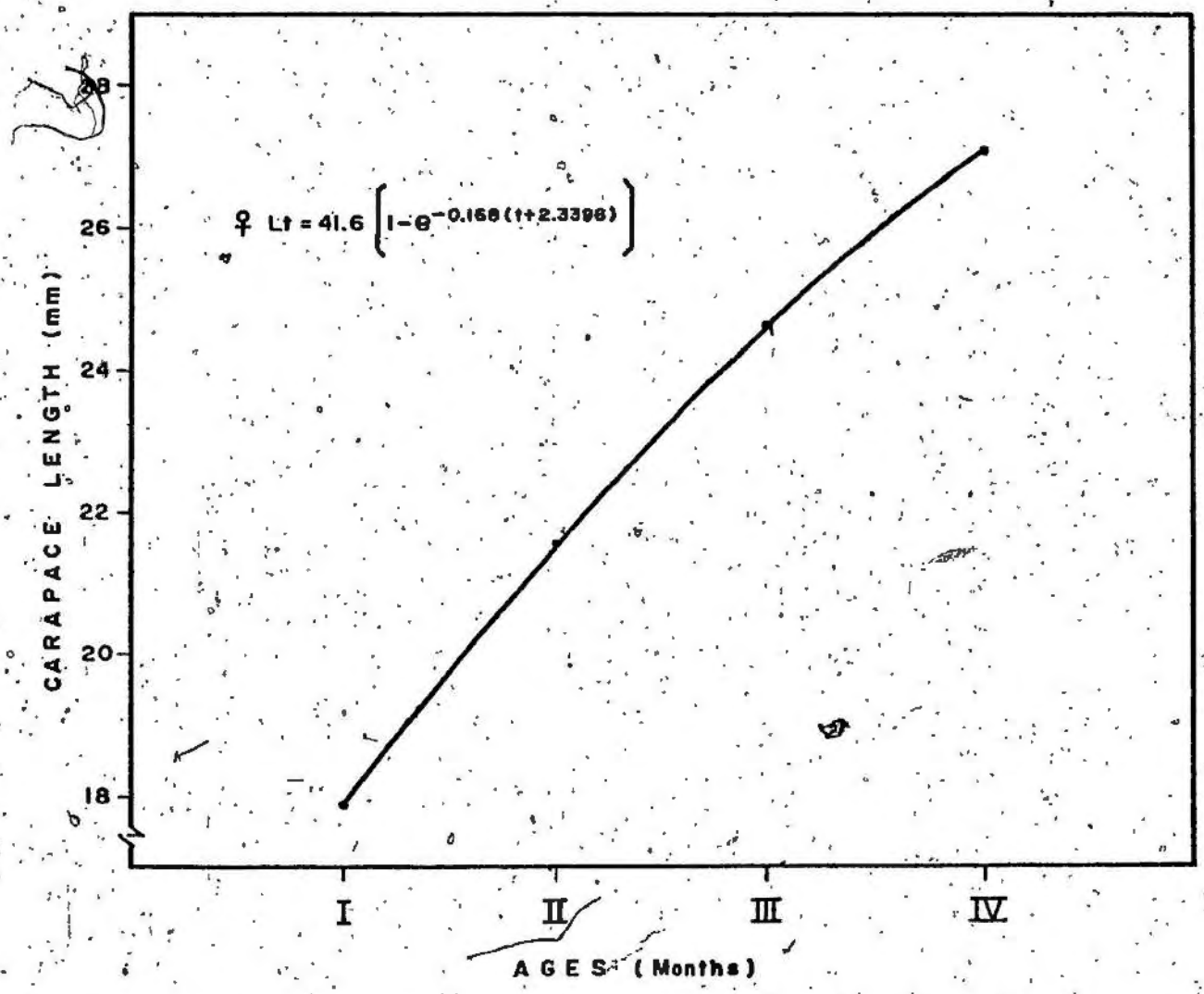

FIGURE 17. Growth curve of females X. riveti

The relationship between tail weight and cephalothorax weight was 61.2 to 38.8%. Through the process of peeling and deveining, the 30% of the 61.2% is lost, therefore only the 30% from the total weight is used as food.

Reproduction

The "titi" shrimp is heterosexual. The sexes can be easily distinguished by the presence of a thelycum in females and a petasma in males.

Male Reproductive System

In males the reproductive system is composed of two testis, two vasa deferentia, two terminal ampullae, two genital pores, one petasma and two appendices masculinae. The testis occupy the dorsal part of the cephalothoracic cavity near the cardiac region; each testis is continued by a vasa deferens; each vasa deferens descends laterally and then joins each one of the terminal ampullae which open into the genital pores located on the coxa of the fifth pair of pereiopods.

The petasma or copulative organ is between the first pair of pleopods. Between the second pair of pleopods there is a modification of the endopodites known as appendices masculinae. The function of this structure is to help in the transference of the spermatophores (King, 1948, p. 257). Possibly, its function is to expand the petasma from its base, or perform also as a support

organ of the petasma. King (1948, p. 257) and Cardenas (1952, p. 42), in studying Penaeus stylirostris and P. setiferus mention that the function of the terminal ampullae is the formation of the spermatophores. In X. riveti, as well as in X. kroyeri (Borges, 1947) the case is different, since the spermatophores are present in the vasa deferentia, that is, anterior to the terminal ampullae. Therefore, in this case, the terminal ampullae function as collectors of spermatophores, and at the same time as the producers of the cementing substance in which the spermatophores are aglutinated to impregnate the females.

In specimens preserved in formaldehyde, it is possible to press the terminal ampullae between the forefinger and the thumb to obtain a great quantity of spermatophores which are ejected through the anterior part of the ampullae.

Female Reproductive System

The female reproductive system is composed of ovaries, oviducts with respective openings and the thelycum. Ovaries are paired structures dorsally located in an anteroposterior axis. Each ovary has six lobules: the smallest found anteriorly runs over the anterodorsal part of the stomach; the mid section composed of four larger lobules and bigger than the first but smaller than the posterior one which is located over the intestine. The lateral

lobules surround the stomach. The ovary is surrounded in the cephalothoracic cavity to a degree by the hepatopancreas which may provide protection.

The thelycum is of the open type and has in its interior two spermathecae (seminal receptacles or sperm sacs). Inside of these, it is possible to see the spermatophores clearly. Most of the time the spermathecae were full of spermatophores, almost in equal quantities in both the left and right sides; some shrimps having more in one side than in the other. Empty spermathecae were recorded also, but it is not known if females can be impregnated more than once in their life cycle.

The size at first impregnation appears to be at approximately 13 mm carapace length (67 mm total length). In X. kroyeri the minimum length was reported tohave been at 20 mm carapace length (Borges, 1947).

Sexual Maturity

Males: In males, sexual maturity was found at approximately 15 mm carapace length, and it was possible to distinguish well developed spermatophores. Furthermore, it is possible that the males do not impregnatethe females until a larger size is reached.

The spermatophores in X. riveti have an ovoidal form with a diameter which varies between 0.1 and 0.2 mm. The size was

unequal. This was also found in those which were in the spermathecae of the impregnated females; the spermatophores were visible to the naked eye and had a whitish coloration in fresh specimens, as well as in preserved specimens.

Females: Since female gonads have maturation cycles, only these were analyzed. The examination of the ovaries was done with preserved specimens from the monthly samples. In the analysis with a stereoscopic microscope, three stages of ovarian maturity were distinguished:

Immatures: Flaccid ovary without well developed lobules: ova up to 0.15 mm in diameter.

Maturing: Ovary, more developed than the latter; translucid ova and between 0.15 and 0.25 in diameter.

Mature: Ovary well developed; it occupied a great part of the cephalothoracic cavity and it surrounded the stomach with its lobules. Most of the ova up to 0.25 mm in diameter.

Size at First Sexual Maturity

In order to know the size at first sexual maturity, all the data of the three recognized stages for the entire study were

graphed but showed no results. The Cummings (1961) method using a regression line was employed, but did not give good results. Then, an analysis was made with graphs for each monthly sample showing that the first sexual maturity was reached at 17 mm carapace length (81 mm total length). Borges (1947) while studying the sexual maturity of X. kroyeri said that the specimens with a carapace length less than 20 mm were juveniles.

Number of Spawnings per Year

Pereira, et al., (1968) during his studies of the population dynamics of X. kroyeri, concluded the existence of two yearly spawnings, or at least that there must be two times in which the spawnings were more intense.

In Table II the monthly percentages of sexual maturity in X. riveti are shown.

In order to estimate the number of spawnings per year, the method proposed by Squires (1972, in press) was applied which consists in summing the monthly percentages of mature females and dividing by 100%, which would give the number of months required for 100% to spawn. Another method is to take the monthly average percentage and divide it into 100% to give the number of months that 100% of the population spawns. This figure can be divided into 12 months and this would give the number of times the population would spawn during a 12-month period.

TABLE II. Monthly percentage of sexual maturity in females X. riveti .

MONTH	MATURE C.L. Range mm	%	MATURING C.L. Range mm	%	INMATURE C.L. Range mm	%	TOTAL No. examined
January	19-29	33.33	22-31	27.08	12-30	39.58	48
March	24-30	45.71	20-29	20.00	18-33	34.28	35
April	18-29	32.14	22-31	28.57	18-31	39.28	56
May	18-32	37.98	20-30	25.58	18-33	36.43	129
June	21-31	40.00	21-28	34.28	23-26	25.71	35
July	18-31	39.02	21-34	36.58	17-29	24.39	41
September	20-32	56.75	21-37	32.43	19-27	10.81	37
October	18-29	35.41	19-32	31.25	17-31	33.33	115
November	19-32	35.61	22-34	27.39	20-32	36.98	73
December	18-28	59.09	22-27	15.90	19-26	25.00	49
January	18-29	30.76	18-29	23.07	17-30	46.15	52
February	15-31	50.00	19-27	8.33	12-25	41.66	42

According to the method mentioned above, X. riveti spawns each 2.4 months, or five times a year.

Parasitism

The examination of the incidence and number of parasites was done for males and females in the cephalothoracic region. Most of the parasites were located in the hepatopancreas, in the ovary and on the external wall of the stomach, respectively.

The investigation showed that the "titi" shrimp was parasitized mostly by procercoids of cestodes (as many as 36 in one shrimp was found). Larvae of nematodes, cysts of protozoa and capsules of sporozoa were found as well. In Table III the data per cruise of the total number found in each monthly sample with percentages is given. It seems that males are most susceptible to infection than females (Table III). This appears to be the result of some substance which would help to control the level of parasites in the ovaries and/or in the hepatopancreas.

For males as well as females the minimum size of incidence is between 14 and [redacted] mm carapace length (71-75 mm total length) (Fig. 18). In females, the rate of infestation has a direct relationship to size, but in males, although not entirely clear, the relationship seems to be the inverse.

TABLE III. Monthly percentage of parasites found in male and female shrimps, North and South of Buenaventura.

Cruise	C.L. range mm	No.of shrimps examined		No.of shrimps infected		Total number of parasites found	Infection %	
		M	F	M	F		M	F
6901 - South	18-31	5	15	2	6	31	40	40
6902 - North	19-31	4	16	4	11	72	100	69
6903 - South	20-31	4	19	4	5	29	100	26
6904 - North	17-31	13	22	8	8	61	62	36
6905 - South	17-31	5	25	1	13	45	20	52
6906 - North	18-29	8	12	5	5	30	63	42
6907 - South	16-31	5	25	3	9	27	60	36
6908 - North	16-29	13	17	3	9	31	23	53
6909 - South	18-31	6	27	3	4	17	50	15
6910 - North	18-29	5	10	1	4	9	20	40
6911 - South	17-30	10	22	4	4	14	40	18
7001 - South	17-30	5	17	3	5	86	60	29
7001 - North	14-27	13	17	7	5	50	54	29

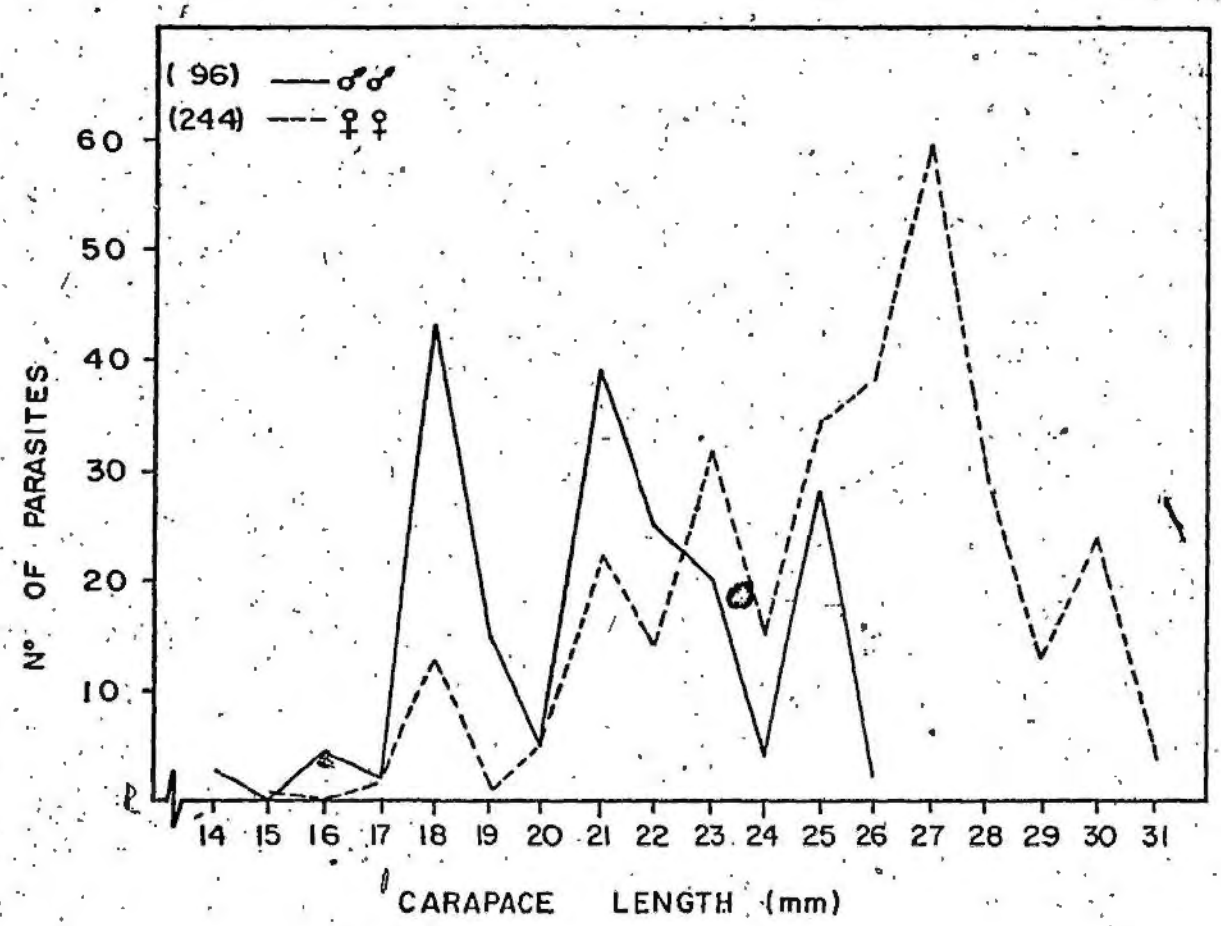

Fig. 18. Number of parasites found in Xiphopenaeus riveti males and females at each carapace length.

If it is supposed that when a spawning is completed the number of parasites in the cephalothoracic region decreases, then it could be said that a female which has reached 30 mm in carapace length (127 mm total length) had made four spawnings per year. If the above supposition is valid, then the life span of this species could be one year.

In male as well as female "titi" shrimps it appears that the periods in which the incidence of infestation is minimal are at 15, 17, 21, 24 and 26 mm carapace length (75, 82, 96, 107 and 114 mm total length). If it is further assumed that this shrimp can rid itself of parasites on moulting, then the males could moult five times a year and females six or seven times.

Food and Feeding

The stomach contents of 1,309 shrimp were analyzed. The "titi" shrimp is carnivorous (Table IV). The greatest percentage (26.2%) was crustacean residue, next tubes of polychaeta (23.3%), then pelecypod fragments (21.1%), and 6.5% was classified as "unidentified material". In all the stomach contents there was a percentage of this material present. Fine sand (Table IV) is not to be confused with the aforementioned "unidentified material". A total of 4.9% of the stomachs were empty. These could not be directly related to the texture of the carapace (soft), a condition which would indicate that the shrimp had just moulted. Nematodes

TABLE IV. Per cent of different elements in stomach contents of X. riveti

Contents Found	No. of Stomachs	%
Crustacean residues	530	26.2
Polychaetes	472	23.3
Pelecypod fragments	427	21.1
Fine sand	139	6.9
Gastropods	84	4.1
Amphipods	36	1.8
Wood and vegetable fibers	27	1.3
Ostracods	22	1.1
Foraminiferans	18	0.9
Scales	17	0.8
Eggs (unidentified)	10	0.5
Scaphopods	7	0.3
Coelenterates	3	0.1
Nematodes	3	0.1
Unidentified material	132	6.5
Empty stomachs	99	4.9

were found in the stomachs, but these are not considered to be normal diet components because it is believed they were parasitic.

Ecology

The adult "titi" shrimp is sympatric with several other shrimps. Some of these are commercial and others, due to their small size and low abundance, are not taken into account in the fisheries. The commercial species are the following: the "white" shrimp or "langostino" Pénaeus (L) occidentalis, and three "tiger" shrimp Trachypenaeus byrdi, T. faoae, and T. similis pacificus. The non-commercial species are the "pomada" shrimp Protrachypene precipua, and a caridean, Palaemon (Nematopalaemon) colombiensis. Besides the shrimps mentioned above, there are commercial portunids known locally as "jaibas". These are Callinectes toxotes and Callinectes arcuatus. There is also the non-commercial "jaiba mora", Euphylax dovi. The latter, at certain times of the year, causes difficulties to the fishermen because of their great abundance. Their migration from the estuaries to the sea seasonally is shown by their great numbers taken in trawl nets which makes separation of the shrimp from the total catch quite difficult.

The two species of Callinectes seem to differ in feeding habits. Callinectes arcuatus almost exclusively feeds on shrimp while C. toxotes feeds primarily on bivalves of the genus Mytilus. The principal food of the white shrimp Penaeus occidentalis is also

a bivalve (Barona, MS 1973), while that of the "titi" shrimp are crustaceans. From the above information it could be inferred that there is little interspecific competition for food between these populations. Also, it is difficult to determine if cannibalism or predation occurs between them because of the difficulty of identifying contents in the stomachs. A great variety of fishes are captured together with the "titi" shrimp. The more representative in order of relative importance are the following:

Vernacular name (Spanish)	Scientific Name
Barbeta blanca	Polynemus approximans
Barbeta amarilla	Polynemus opercularis
Nato	Sciades troschelli
Pelada	Cynoscion sp
Botellona	Menticirrhus panamensis
Cajero	Larimus sp
Sierra	Scomberomorus sierra
Bocon	Nebris occidentalis
Pargo lunarejo	Lutjanus guttatus

Despite the scarcity of data on stomach contents of these fish species (except the "sierra" Scomberomorus sierra, which is known not to be a shrimp predator; Artunduaga, personal communication), it is assumed that some are predators because they are carnivorous and

are sympatric with the commercial shrimps. However, if they are predators, the effect on mortality could not be as much as fishing.

Other points related to ecology are discussed under other sections.

Population

Structure

Sexual Ratio

In X. riveti the sexual ratio varied monthly. The lowest value (13% males) was obtained in October, south of Buenaventura, and one value of 52% males was recorded in the same zone in January, 1970. The mean value was 36% males (Table V).

Sexual ratio is biased by two causes: first, in the earliest samples aboard the M/V "Cacique" the samples were not random for small sizes; second, due to females being bigger than males the net selects more females.

Distribution

Local Geographic Distribution

The distribution range of the "titi" shrimp in the Pacific coast of Colombia is between Bahia Humboldt and Cabo Manglares. An annual resume of the catches per area with some hydrographic data is shown in the tables.

North of Buenaventura

The following was the order of catch per hour of the "titi" shrimp in the areas north of Buenaventura (except the Catripe area):

TABLE V. Sex ratio of *X. riveti* north and south of Buenaventura

Cruise	No. of Males	No. of Females	Total	Sex ratio (% males of total)
6901 - South	106	235	341	32
6902 - North	247	416	663	37
6903 - South	271	411	682	40
6904 - North	286	417	703	41
6905 - South	215	499	714	30
6906 - North	308	334	642	48
6907 - South	210	751	961	22
6908 - North	610	630	1,240	49
6909 - South	98	630	728	13
6910 - North	205	519	724	28
6911 - South	243	414	657	37
7001 - South	361	334	695	52
7001 - North	200	309	509	39

TABLE VI . Average catch of *X. riveti* by the M/V "Cacique" and enviromental conditions in areas North of Buenaventura.*

Area	Depth range fm	Average Surface temp. °C	Water transp range m	Total Catch kg	No. of hours fished	Average caught kg/h
Bahía Humboldt	5.0 - 20.0	28.0	0.5 - 12.0	25.5	8	3.2
Cupica	5.0 - 10.0	26.9	3.0 - 10.0	4.6	5	0.9
Nuquí	5.0 - 10.0	27.8	1.5 - 7.5	269.2	9	29.9
Catripe	5.0	27.6	2.0	38.7	1	38.7
Pizarro	5.0 - 30.0	27.6	0.5 - 4.0	298.8	12	24.9
Togoromá	4.0 - 10.0	27.6	1.5 - 3.0	104.5	7	15.0
Juanchaco	4.0 - 10.0	26.7	0.3 - 1.7	86.5	5	17.3
7	4.0 - 30.0	27.5	0.3 - 12.0	827.8	47	17.6

*Squires, et al., 1970 and 1971

Nuqui (29.9 kg/h), Pizarro (24.9 kg/h), Juanchaco (17.3 kg/h). Togoroma (15.0 kg/h), Bahia Humboldt (3.2 kg/h) and Cupica (0.9 kg/h). The average catch per unit of effort was 17.6 kg/h and the average temperature of the surface water was 27.5°C (Table VI) (Squires, et al., 1970 and 1971).

South of Buenaventura

The average catch per unit of effort was less than in the northern zone (12.4 kg/f). This figure is reduced to 9.2 kg/h if a one-hour trawl of 220 kg made in the San Juan area is not taken into account.

To explain the areas with greater productivity, the data for the Timbiqui area was also not included.

In the zone south of Buenaventura, the rate of production per area found during the time of sampling was: Tumaco (12.0 kg/h), Naya (10.6 kg/f), Tortugas (8.4 kg/h), San Juan (8.0 kg/h), Punta Coco (7.9 kg/h) and Cabo Manglares (0.8 kg/h) (Table VII).

Bathymetnic Distribution of Juveniles and Adults

Taking into consideration that individuals with a carapace length up to 18 mm are juveniles, the bathymetric distribution of juveniles and adults has been compared based on measurements from the subsamples.

TABLE VII. Average catch of X.riveti by the M/V "Cacique" and enviromental conditions in areas South of Buenaventura.*

Area	Depth range fm	Average Surface temp °C	Water transp. range m	Total Catch Kg	No. of hours fished	Average caught kg/h.
Tortugas	3.0 - 10.0	28.3	2.0 - 4.0	75.5	9	8.4
Naya	3.5 - 10.0	28.2	1.5 - 4.0	105.9	10	10.6
Pta. Coco	3.0 - 10.0	27.7	0.8 - 2.5	70.7	9	7.9
Timbiquí	3.8	28.8	---	17.7	1	17.7
San Juan	4.0 - 20.0	27.5	0.9 - 6.0	340.3	16	21.3
Tumaco	3.0 - 20.0	28.0	1.0 - 5.0	227.5	19	12.0
Cabo Manglares	5.0 - 10.0	28.2	3.0 - 3.5	3.1	4	0.8
7	3.0 - 20.0	28.1	0.8 - 6.0	840.7	68	12.4

*(see also Squires, et al., 1970 and 1971)

The population seems to have its larger concentration at the depth range from three to five fathoms. At the following depths the percentages were: 69.2 % for juvenile females and 66.0% of adult females; 74.1% of juvenile males and 64.4% of adult males. In general at this depth a total of 67% of the "titi" population was present (Table VIII).

The distribution is more or less similar up to ten fathoms. In two cases where they were caught at 20 and 30 fathoms the samples were exclusively adult. During 1969 the occurrence of the greatest catches was at 5 fathoms in depth.

General Bathymetric Distribution

In the tables which follow (Tables IX and X) the catch per unit of effort according to depth is shown.

In the northern zone of Buenaventura there were no data from zero to three fathoms, first because the major portion of this zone does not have a sufficiently wide platform and, second because of the possible danger to the ship's hull in some areas.

One difference between north and south of Buenaventura was that at one station 7.5 kg was captured at 30 fathoms (55 m) in the northern part, while no specimens were found at this depth in the south.

TABLE VIII. Depth distribution of male and female juveniles and adults from both North and South of Buenaventura.

Depth range fm	FEMALES				MALES				TOTAL	
	No. of Juveniles	%	No. of Adults	%	No. of Juveniles	%	No. of Adults	%		%
0 - 3.0	41	9.6	632	11.9	80	7.0	298	11.7	1.051	11.2
3.5 - 5.0	295	69.2	3.484	66.0	838	74.1	1.643	64.4	6.260	66.7
5.5 -10.0	87	20.4	967	18.3	205	18.1	523	20.5	1.782	19.0
20.0	3	0.7	137	2.6	7	0.6	58	2.2	205	2.1
30.0	0	0	58	1.1	0	0.0	27	1.0	85	0.9
0 - 30	426	99.9	5.278	99.9	1.130	99.8	2.549	99.8	9.383	99.9

TABLE IX. Total catch and catch per unit of effort according to depth range in the northern zone of Buenaventura, 1.969.

Depth range fm	Average surface Temperature °C	Total catch kg	Effective hours of fishing h	Catch/h kg/h
0 - 3.0				
3.5 - 5.0	27.5	605.5	30	20.2
5.5 -10.0	27.5	174.5	15	11.6
20	26.8	39.9	2	20.0
30	30.7	7.5	1	7.5

TABLE X. Total catch and catch per unit of effort according to depth range in the Southern zone of Buenaventura, 1.969.

Depth range fm	Average surface temperature °C	Total catch kg	Effective hours of fishing h	Catch/h kg/h
0 - 3.0	28.0	61.8	8	7.7
3.5 - 5.0	28.1	341.4	26	13.1
5.5 -10.0	28.0	344.0	20	17.2
20	28.3	20.4	4	5.1
30				

In general, the largest average catch per hour was obtained in the northern part between 3.5 and 5.0 fathoms (6.4 and 9 m), and between 5.5 and 10.0 fathoms in the southern part. The 20.0 kg/h figure from 20 fathoms (36 m) in the north was not taken into account for this analysis because it was not representative.

FISHING

History of the Pacific Shrimp Industry

The shrimp fishery in Colombia began as a minor industry in 1937. At that time the fishing was by canoe and with beach-seines around the Bahia de Buenaventura. The product was sold "heads-on" and frozen in ice blocks, and was only for local consumption. In 1949 a bigger industry began, but it was not until 1957 that it was organized as a fishery in Buenaventura. In 1963 refrigeration was installed in Tumaco, and in 1965 one shrimp fishing company was established there. In 1970 a processing plant was begun in Guapi, and at present a modern plant is being built in Buenaventura. Along the entire coast there are nine packing and processing plants: six in Buenaventura, two in Tumaco and one in Guapi. Some of their characteristics are shown in Table XI.

Boats and Fishing Gear

The shrimp boats which operate in Colombia have been made in the United States, Panama, Mexico, Ecuador, Spain and Colombia. Iron hulls comprise 55% of the fleet and the remaining 45% are wooden. Of the total vessels, 37% have echosounders and 66% have radiotelephones. The number of boats according to vessel length are shown in Table XII.

TABLE XI. Some characteristics of shrimp processing plants located on the Pacific Coast of Colombia, 1.971.

Name of Company	Location	Date founded	Capacity (lb) Store and/or freeze	Personal Administrators	Personal Workers
Acopesca	Buenaventura	1968	128.000	7	393
Arlibia	"	.	77.000	.	.
Impesca	"	1960	.	3	5
Pesquería del Pac.	"	1958	120.000	.	.
Pesqueros Unidos	"	1958	100.000	6	47
La Polar	"	1966	150.000	.	.
Pesmaco	Tumaco	1963	90.000	.	100
Redmar	Guapi	1970	.	.	60

TABLE XII. Some characteristics of the shrimp fleet of the Pacific Coast of Colombia, 1972.

Length ft.	Buenaventura		Tumaco		Guapi		Total	
	No.	%	No.	%	No.	%	No.	%
30 - 40	.	.	2	15	13	93	15	11
41 - 50	16	14	2	15	1	7	19	14
51 - 60	18	16	9	69	.	.	27	19
61 - 70	55	49	.	.	.	.	55	39
71 - 80	24	21	.	.	.	.	24	17
Total :	113		13		14		140	

The crews (some are foreigners), consist of a captain, an engineer, a cook and two or three fishermen. Frequently, the engineer and the cook join in the handling of the catch when the shrimps are abundant.

The doublt rigged otter trawl has been used from 1957 to the present time. Besides these trawls, a try net known locally as "changa" is used; the try net is put into the water for about 15 minutes in an area which is believed to have shrimp. If the try is positive in capturing shrimps, a haul with the complete gear for a period of 2 hours or more is made. The fishing is usually done during the day time, but in some zones, such as the Tortugas area, diurnal and nocturnal operations are copducted.

Physical Characteristics of the Coast

The Colombian Pacific coast is 1,300 km in length from the Panamanian to the Ecuadorean border. The Pacific watershed has an area of 77.446 km^2 and is formed by many rivers of short length (Acevedo, 1967).

The Pacific waters near the shoreline support climatic conditions of the equatorial type: temperatures over 26°C, and abundant rains throughout the entire year. Over these waters, during a 9 month period, the winds are predominately south and southwest. The surface salinity is low due to local precipitation as well as river drainage (Acevedo, 1967).

A mountainous zone exists between Cabo Corrientes and the Panamanian border, but from Cabo Corrientes southward to the Ecuadorean border a long stretch of lowlands is found along the coast.

Approximately 85% could be described as "the more extreme tropical rain forest" and the remaining 15% as simply "tropical rain forest"; the latter in the southern portion.

Coastal Features and Fishing Areas

North of Cabo Corrientes the shoreline is composed of stepped rocky cliffs found along a narrow platform. South of Cabo Corrientes the shoreline is composed of sandy or mud and sand beaches with numerous estuarine areas which are bordered by mangroves where the intertidal zone is easily distinguishable. The mangrove zonation of these estuaries is composed of the following fringes: a first outer fringe of small mangroves, Avicenia nitida; a second, more abundant fringe, of red mangroves, Rhizophorae mangle, which is the main tree utilized by the mangrove industry; and a third, inner fringe, of yellow mangroves, Laguncularia racimosa.

The following description of the coastal shelf and the shrimp fishing areas was taken from Squires, et al., 1970: "The coastal shelf is narrow, with its greatest width of about twenty five miles in a rectilinear indentation which includes Buenaventura Bay in its northeast corner and extends from the Golfo Tortugas to

south of Isla Gorgona or to a length of about 90 miles. Another shelf area north of Buenaventura is about 70 miles long and 10 miles wide and extends between Cabo Corrientes and Punta Charambira. Both shelf areas and the Ensenada de Tumaco to the south constitute the shrimp fishing grounds of the coast. On these shrimp fishing grounds the level bottom is of soft mud or mud and sand. In the regions near the larger land projections such as just south of Punta Charambira and just south of Punta Guascama the shelf is narrow and the bottom frequently uneven. North of Cabo Corrientes the coast is high and hilly with occasional cliffs and the coastal shelf is very narrow and occasionally rocky.

Shrimp Processing

At present the shrimp companies of this coast export the "titi" shrimp as well as the "langostino" or "white" shrimp. The "titi" shrimp is exported peeled and deveined in 5-pound plastic bags. Some companies pack it in 5-pound waxed boxes using the following classification: special, regular and large.

"Titi" shrimp are peeled and deveined by hand by female laborers, using a wooden punch. The punch is inserted into the headless shrimp (the "tail") at the dorsal anterior portion, thrusting posteriorly and upward thereby slitting the shell and removing the intestine and ovary residue, if the shrimp is a female (Fig. 19). Then the shrimps are washed with fresh water in galvanized wire

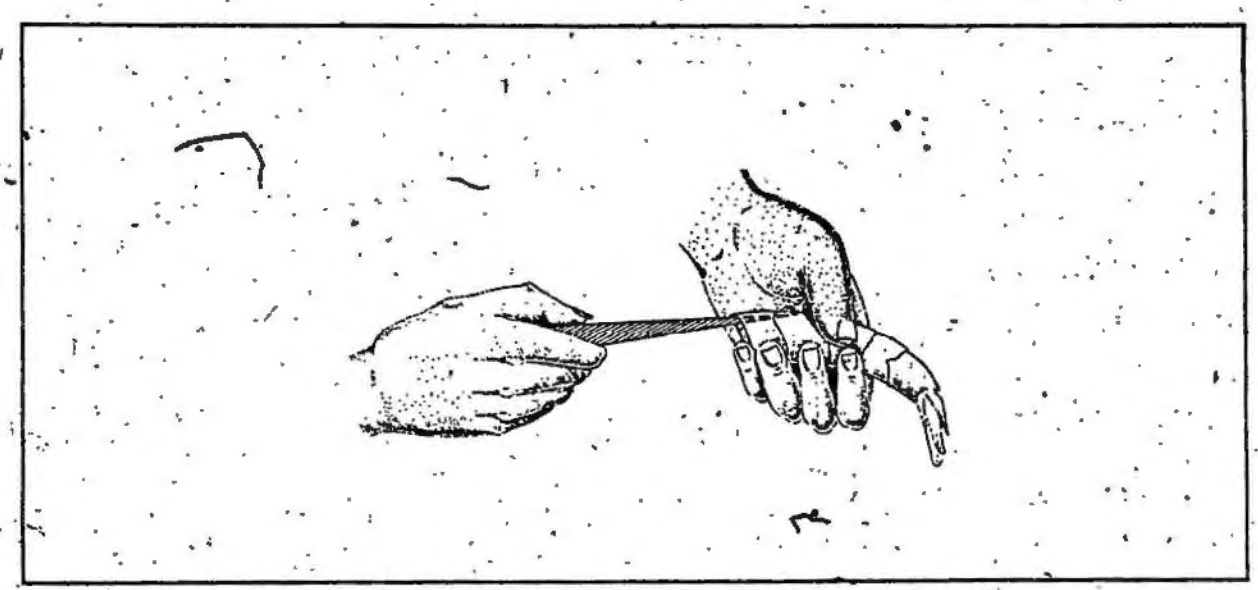

Fig. 19. Peeled and deveining "titi" shrimp at the shrimp processing plants of the Pacific Coast of Colombia.

sieves and classified by size mechanically or manually. By these procedures the shrimp lose up to 30 or 35% of their total tail weight (Table XIII). Shrimp with an inferior quality (i.e., broken) are processed in a different manner and sold for national consumption. These are known as "precooked" shrimp. The "tails" are cooked in aluminium pails with two pounds of salt (NaCl) to 40 pounds of "titi" (0.05 g/lb). It is boiled for 10 to 15 minutes, then deveined and peeled. The final product is packed in one-pound plastic bags and frozen. Sometimes the precooked shrimp are sun dried and packed in plastic bags.

Monthly Landings and Recruitment

With a four year average, from the monthly commercial landings, a graph was made in order to know the abundance of the "titi" shrimp through the calendar year. The shrimp showed two periods of maximum abundance between November and December, and between February and July (Fig. 20). The months with minimum landings were January, August and October.

In the same graph the percentage of recruits, that is, specimens up to 18 mm carapace length obtained from the measurements of the samples taken abroad the M/V "Cacique" in 1969, was included. Although the picture is not very clear, there seems to be four periods of recruitment, being the most significant in October (Fig. 20). In the graph it is also observed that there is a negative correlation between the average monthly landings and the periods of recruitment.

TABLE XIII. Loss of weight in "titi" shrimp X. riveti through the process of peeling and deveining.

Tails No.	Weight of tails g	Pealed and deveined weight of tails g	Weight loss %
85	500	375	25
82	500	375	25
85	500	375	25
79	500	375	25
90	500	375	25
80	500	400	20
100	500	375	25
97	500	350	30
100	500	350	30
107	500	350	30

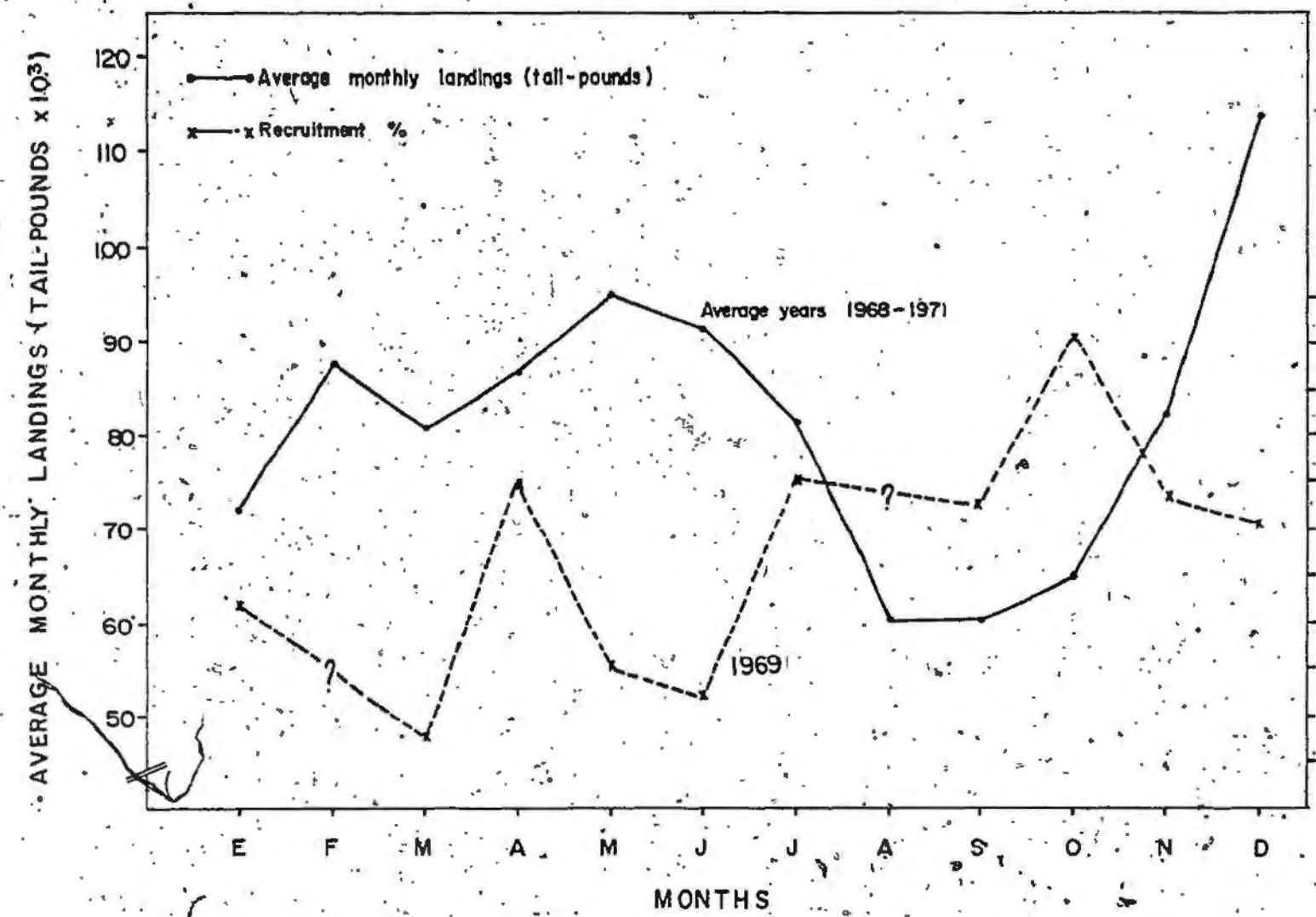

Fig. 20. Average monthly catch (tail weight lb) and percentage of recuitment of "titi" shrimp Xiphopenaeus riveti from the Pacific Coast of Colombia.

Annual Landings

The annual landings of the "titi" shrimp have increased considerably from 1958, a year in which were reported about 8,000 tail-pounds up to 2,727,000 in 1971 at Buenaventura (Table XIV).

In Tumaco, during the last three years the landings were little above half a million pounds and the same occurred in Guapi during 1971 (Table XIV).

For the whole Pacific Coast 3,834,000 tail-pounds were landed in 1971. The great increase in landings for the most part was due to the companies not processing this shrimp before 1969 because of low prices in the international market. However, from 1969 the companies obliged captains to land all the captures. Before 1966 some of these shrimp had been landed at the companies and others were discarded at sea.

Total Effort

The vessels which landed the shrimps in Buenaventura fished along the whole coast and made, on a three year average, 1.7 trips per month, and spent 13.5 days per trip.

The vessle which operated from Tumaco or Guapi made daily trips wiht a duration of ten effective hours of fishing and 13 to 15 trips a month, on the average, for Guapi and Tumaco, respectively.

TABLE XIV. Annual landings of "titi" shrimp X. riveti, of the Pacific Coast of Colombia, 1958 - 1971.

Source : Pérez, A., and Companies
Unit : 1000 tail - lb.

Year	Buenaventura	Tumaco	Guapi	Total
1958	7.7	.	.	7.7
1959	14.4	.	.	14.4
1960	167.9	.	.	167.9
1961	130.4	.	.	130.4
1962	459.1	.	.	459.1
1963	398.5	.	.	398.5
1964	.	.	.	.
1965	.	.	.	.
1966	.	.	.	.
1967	190.7	.	.	190.7
1968	601.9	98.2*	.	700.1
1969	1218.3	509.4	.	1727.7
1970	2019.6	517.9	310.0**	2847.5
1971	2726.7	540.7	562.2	3833.6

* August - December
** March - December

Since the data of effort were combined there was a necessity to convert or to standardize these data to that of Buenaventura. This was done because 81% of the fleet worked from this port. Also, the data of total catch were combined.

In spite of some variations in total effort since 1968, the catches per unit of effort indicated a progressive increase. This occurred with the catch per vessel-month, the catch per trip, and the catch per hour which in 1971 was four times higher than in 1968. This was an indication that the population of "titi" shrimp was not being affected by the fishing effort, as is shown in Fig. 21 and Table XV.

TABLE XV. Total landings, total effort and catch per unit of effort of "titi" shrimp of the Pacific coast of Colombia.

Unit: 1000 lb.

Year	Total Landings Tail-lb.	TOTAL EFFORT			CATCH PER FISHING EFFORT	
		No. of Vessel-months	No. of trips	No. of hours	Catch/ Vessel-month lb.	Catch/trip lb.
1968	700.1	888	1,417	307,507	788	494
1969	1,727.7	1,083	1,891	393,876	1,595	914
1980	2,847.5	1,328	1,908	382,597	2,144	1,492
1971	3,833.6	1,288	2,038	391,430	2,976	1,881

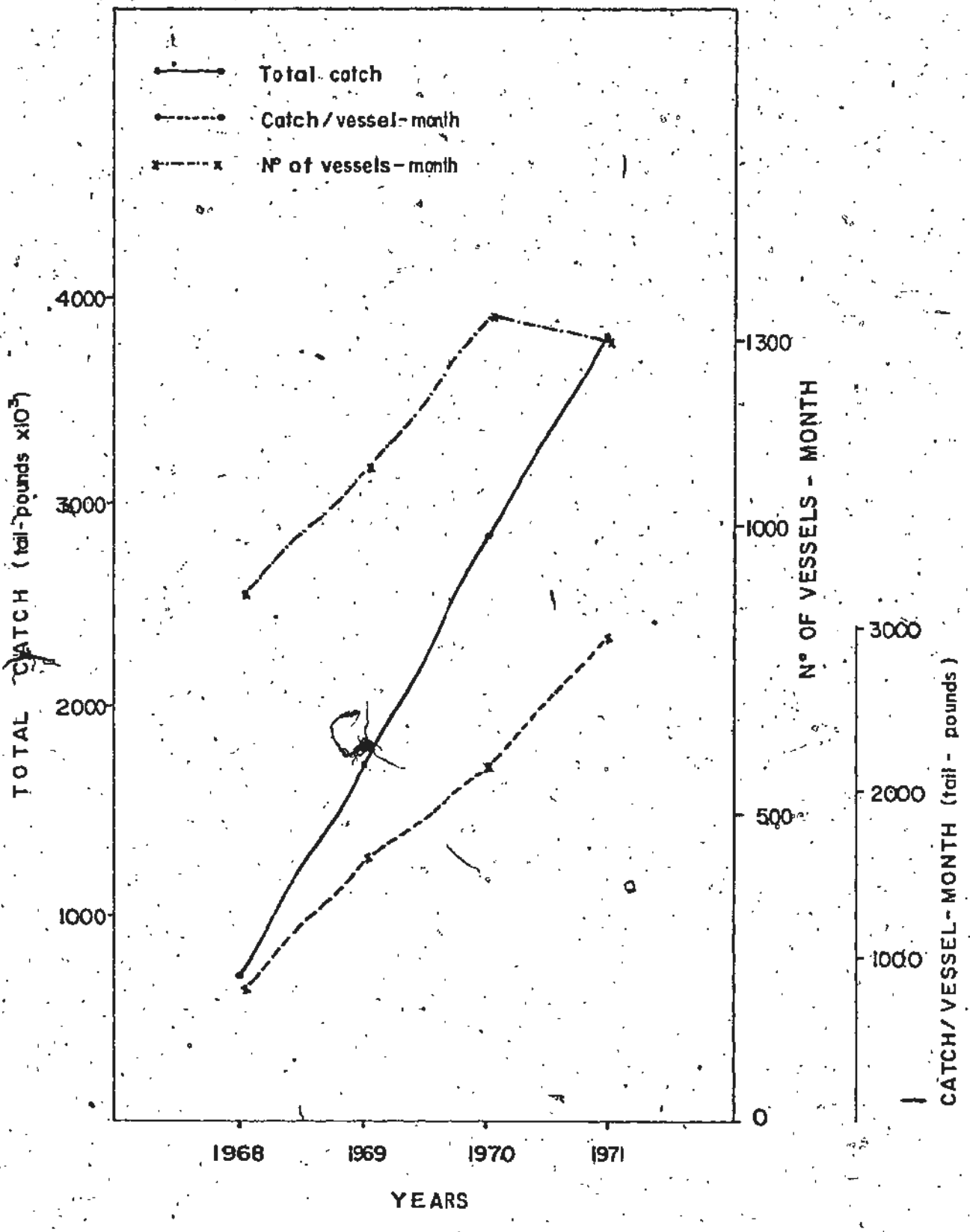

FIG. 21. Total catch per vessel-month and total fishing effort (number of vessel-months) for "titi" shrimp Xiphopenaeus riveti, 1968-1971

DISCUSSION AND CONCLUSIONS

Morphology

Burkenroad (op. cit.) in studying X. kroyeri made some morphological comparisons of some specimens from Louisiana and Brazil stocks. He also compared X. kroyeri with X. riveti from the west coast of Panama. He concluded that X. riveti is a varietal form of the single species of the genus. Rioja (op. cit.) doing studies on secondary sexual characteristics of X. rivetf considered it to be a subspecies and named it X. kroyeri riveti Bouvier.

Further work will have to be done to definitely distinguish X. riveti from X. kroyeri. For the purposes of this paper, however, X. riveti has been treated as a separate species.

Length and Weight Relationships

Males showed a greater increase in total length, total weight and tail weight in comparison with females of the same carapace length. Females instead increased more in total weight-tail weight relationship than males after 2.5 g in tail weight.

In total weight-total length relationship, males weighed more than females up to 98 mm in total length and after this length the situation was the reverse. This change could be due to increase in ovary weights. But, in all events, females grew larger than

males, so sexual dimorphism in size and weight in "titi" shrimp was quite apparent.

Growth

The estimation of growth in length of "titi" shrimp indicated, as is common in wild animals, that during the first months of life the effect of the rate of growth was more prominent than when it was older.

The estimation of 27 months to reach the maximum length does not mean that the shrimp cannot live longer. In any case there could be rare cases of this because the fishing pressure is taking the average sizes and it does not permit shrimps to grow to larger sizes. The effect of fishing pressure could be compensated for by the frequency of spawnings which are considered to be high in tropical waters.

Length Frequency Distributions

From total and carapace length frequency distributions for males and females north and south of Buenaventura, it was not possible to make a clear estimation of recruitment of juvenile shrimps to the fishing grounds. However, they permitted growth of female shrimps to be estimated.

The length frequency distributions were polymodal and it was an indication that growth is rapid, or otherwise recruitment

had almost a continuous occurrence. This statement could be true if it is considered that the food supply does not change throughout the year because there are no seasons, and also the reproductive potential of tropical crustaceans is great.

Sexual Maturity

In males there is a continuous production of spermatophores and they do not have cycles of maturation as females do. It was difficult to explain why spermatophores were unequal in size and with ovoidal or spherical shape, but in any case most of them were ovoidal and, independent of size, all had well developed spermatozoa.

In the case of female sexual maturation of crustaceans in tropical waters, oogenesis and embryogenesis occur faster than in temperate or cold waters (Berry, 1971) but with intermediary resting periods between each ovulation. Considering that maturation of the ova is cyclical, there must be periods in which the percentage of mature females is higher than during the "resting period" or synchronization of maturity could occur as is common in biological systems. For this reason, if we sampled a population every week the result would be more accurate in showing the cycle than if the sampling was done with the time more spaced, as was done in the present study. Although the sampling was done only monthly, the results permitted us to conclude that X. riveti spawned each 2.3

months, or five times a year because the average percentage of ripe shrimp in each monthly sample was relatively high.

Parasitism

As Cestoda parasites complete their life cycles by going through two or more hosts at certain periods of their lives, they have to abandon their hosts and find another one. In the case of marine Cestoda, there are two ways of doing this: first being in the prey of birds or fishes, and second the parasites get free and into the water if ecdysis or spawnings occur. In X. riveti at 15, 17, 21, 24 and 26 mm carapace lengths it was found that the numbers of parasites was minimum and the explanation for this minimal incidence at those lengths could be that spawnings or ecdysis had occurred and carried away some of the parasites.

Food and Feeding

Strong competition for food between different species which occupy the same habitat seems not to occur in this species, or in other words, the species have a different niche in the ecosystem under consideration. The niche is defined as "the nutritional role of the animal in its ecosystem, that is, its relations to all the food available to it (Weatherley, 1963). Barona (MS 1972) in studying P. occidentalis demonstrated that the usual food eaten by this shrimp was pelecypods. The "titi" and "white" shrimps were frequently

caught together but this did not mean that they were sympatric in the strict meaning of the word. It is possible that these two species go from one place to another in their searching for food in small schools which are composed only of one of the two species. Then, competition for food or space would not take place. The case seems to be that when the net is on the bottom, it takes a mixture of species from possibly different habitats.

Sexual Ratio

The monthly variation in sexual ratio observed for "titi" shrimps was possibly due to selectivity of the net, since females were bigger than males, and also due to changes in the population itself. As females are said to move to deeper waters in order to lay their eggs, this fact could influence the sex composition of the population. These movements have to be cyclical and influenced by hormonal factors or otherwise influenced by changes in water conditions such as temperature (movement of the thermocline) or salinity due to the runoff from the rivers.

Local Geographic Distribution

The differences between productivity from the different fishing areas could be due to local ecological factors such as temporary lack of food and migrations to areas with poor fishing bottoms and therefore the shrimp population was not available to the trawl.

Bathymetric Distributions

The variation in the concentration according to bathymetric distribution north and south of Buenaventura (from 3.5 to 5.0 fathoms north and from 5.5 to 10 fathoms south) could possibly be attributed to the fact that in the northern zone it was impossible to fish near the coast in some places due to irregularities in the bottom and also to the narrowness of the continental platform. South of Buenaventura, although the platform is wide, it is not all fishable and the shrimp vessel could not fish near the coast (in water shallower than three fathoms). In any case, although the population seemed to be concentrated at certain depths, it could be that occasionally it spread out uniformly, for example, over a large area from less than two to ten fathoms deep.

The fact that the population was fished once at 20 and 30 fathoms could indicate that a migration of the older individuals to spawn in deeper water, or a change in the thermocline had occurred which might have permitted the shrimps to go deeper and still in water of high temperature.

Monthly Landings

Variations in the monthly landings observed in the last four years do not seem to be correlated with fishing effort in any year but with cyclical oscillations in the population itself. Due to lack of precipitation data it was not possible to do comparisons between the two phenomena.

Annual Landings

The annual landings showed the increasing importance every year of "titi" shrimp on the Pacific coast of Colombia. Before 1968 the annual landings were lower than 500 thousand tail-pounds, but in 1971 3,834,000 tail-pounds were landed, exceeding the white shrimp landings which for all the time of exploitation of the shrimp resources on the Pacific coast had occupied the first position in weight and value.

The increase in the figures of landings for the last four years could be explained by the increase in the prices in the international market since 1968-1969 and because captains were obliged to land all the shrimps caught. Another reason that obviously influenced the total increase in landings was the introduction of small fishing boats (9-12) known locally as "titiceros" or "mosquitos" which operate from Guapi and Tumaco. These vessels are of low draught and their length range is between 30 to 40 feet. The mesh opening is the same as that of the bigger vessels (3½") but they can operate nearer to the coast than can the latter. The inclusion of these boats and also a great number of larger ones had increased the fishing effort along the entire coast.

Due to incomplete information on the data of landings and fishing effort before 1968, it was difficult to make curves of

abundance or to estimate the effect of the fishing effort on this resource. Nevertheless, it is apparent that the population is at the point of needing management by limiting the number of vessels - especially small vessels - fishing on this coast.

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