SIZE COMPOSITION, DISTRIBUTION, LENGTH-WEIGHT RELATIONSHIP AND NATURAL FOOD OF THE BLUE CRAB, *Portunus pelagicus* (L.) IN SELECTED COASTAL WATERS IN LEYTE AND VICINITY, PHILIPPINES

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Portion of a study on the Biology and Ecology of the Blue Crab, *Portunus pelagicus* (L.), in Selected Coastal Waters in Leyte and Vicinity.

Funded by the Philippine Council for Agriculture and Resources Research and Development.

ABSTRACT

Female blue crabs were relatively smaller than males. More smaller crabs (carapace lengths <50 mm) were observed in January, April and July in consonance with reported intense spawning periods. Most crabs (males and females) were generally between 60 to 70 mm long. Spatial distribution was size-related with the larger crabs (carapace lengths >50 mm) usually caught at depths greater than 6 meters and juvenile ones (carapace lengths <30 mm) found in shallower portions or near the shore. This distribution apparently resulted from migration patterns which are probably responses to the necessities of breeding, molting and feeding and is affected by salinity and substratum. Females were slightly heavier than males.

The natural diet composition of *P. pelagicus* in descending order of percentage occurrence in its guts includes Osteichthyes, Holothuroidea, Algae, Echinoidea, Anomura, Bivalvia, Porifera, Brachyura, Penaeidea, Polychaeta, Foraminifera, Sea grass, Gastropoda, Copepoda, Amphipoda and Bryozoa. Food items particularly animals with hard parts were ingested in large recognizable pieces; few small food items were ingested in their entirety; others were ingested such that their soft tissues were almost completely separated from hard parts. Plant food was also ingested in fragments.

Ann. Trop. Res. 10:127-142

KEY WORDS: *Portunus pelagicus* (L.). Size composition. Distribution. Length-weight relationship.

INTRODUCTION

The blue crab *Portunus pelagicus* (L.) has long been an important contributor to both municipal and commercial crab fishery in the Philippines. However, its depletion rate in places with possible harvest of natural populations increases a hundredfold yearly. To preserve this species and to augment its availability as a food resource, a culture technology of the species has to be developed. Hence, this study aims to provide some benchmark information concerning the biology and ecology of *P. pelagicus* in Leyte and vicinity. Specifically, it investigates the size composition, distribution, length-weight relationship and natural food of *P. pelagicus* in the study area.

Information on size composition and distribution is significant to crab fishermen and prospective crab farmers. Quantitative data, particularly equations on length-weight relationship, are useful to determine relative condition, growth and size at sexual maturity (Pullen and Trent, 1970). Furthermore, these equations serve predictive purposes and also permit comparison of data from different localities. Knowledge on natural diet composition is generally essential for studies on the species' nutritional requirements, its interactions with other organisms and its potential for culture.

MATERIALS AND METHODS

The Study Area and the Sampling Stations

The study was conducted along the western coast of Leyte and the adjacent northeastern coast of Bohol in Eastern Visayas, Philippines. Five stations were established throughout the study area, namely: Naungan, Hilongos, Bato, Aguinin and Lapinig (Fig. 1). The Aguinin and Lapinig stations are located across the Canigao Channel on the island group of President Garcia, Bohol. The remaining stations are located in mainland Leyte--Naungan in the north and Hilongos and Bato in the south. These stations were chosen

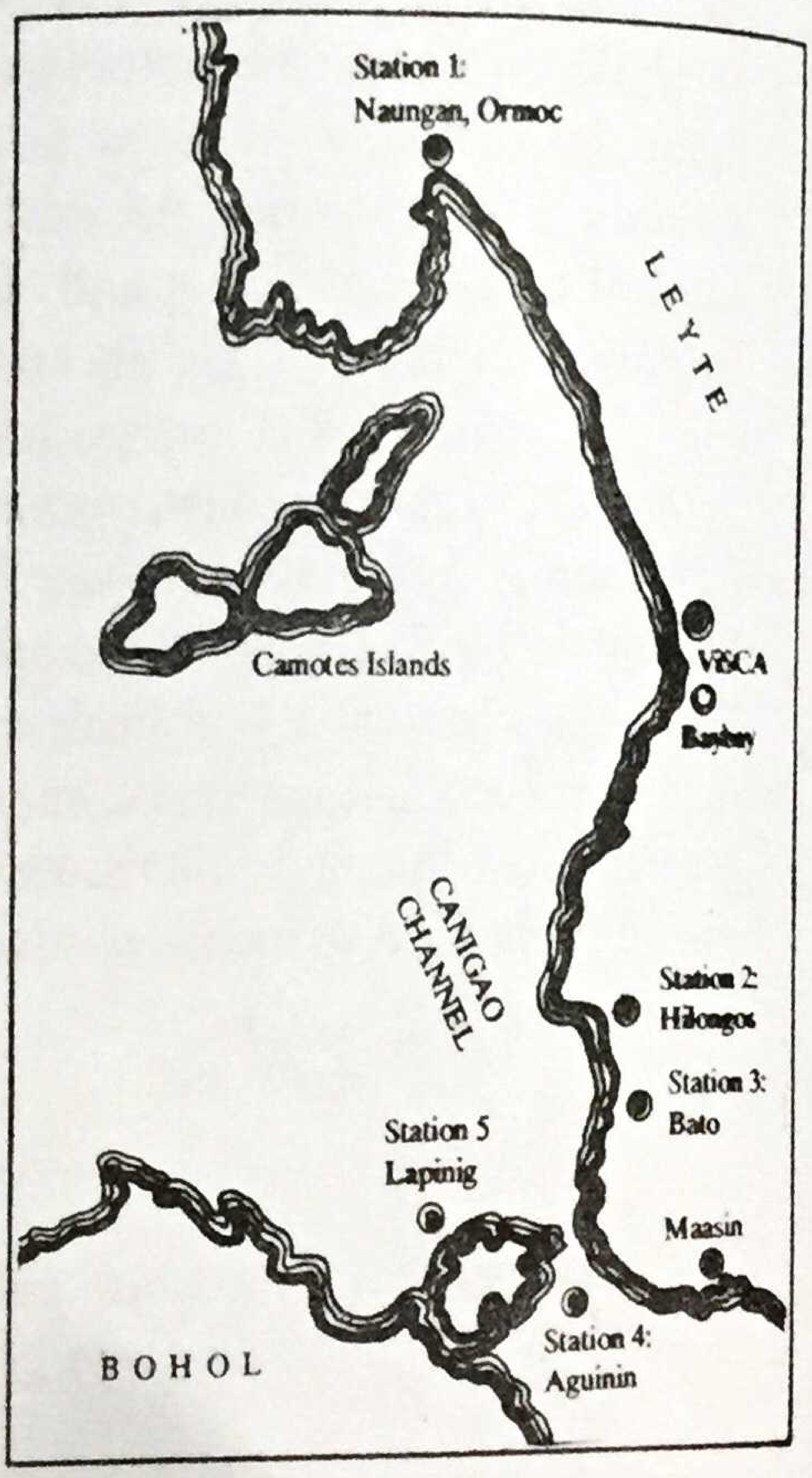


Figure 1. Map of the study area showing the sampling stations.

because they are the sources of blue crabs in the local market.

All five stations have shallow and wide shelves and the substrate grades from sandy and loamy sand in the shore and shallow areas to sandy loam and loam in the deeper areas. The location of each station, its direct distance and direction from ViSCA, its vege tation and substratum are described as follows:

Station 1: Naungan, Ormoc City, Leyte.

11°00'80"N, 124°34'36"E. 37 km northwest of ViSCA.

Substratum is loamy sand to loam without coral formation. The only visible vegetation is the well-spaced population of eel grass.

Station 2. Hilongos, Leyte.

10°20'12"N, 123°47'00"E. 45.6 km south of ViSCA.

The substrate is sandy to loamy sand. Vegetation which consists of eel grass and some brown algae (e.g. *Sargassum* sp, *Padina* sp. and *Turbinaria* sp.) is more abundant than in station 1. Mangrove trees and nipa palms border a portion of the shore.

Station 3. Bato, Leyte.

10°19'42"N, 124°47'18"E. 46.6 km south of ViSCA.

Substrate grades from sandy to loamy sand in the deeper areas. As in stations 1 and 2, the poor vegetation is dominated by eel grass with few *Halimeda* spp.

Station 4. Aguinin, President Garcia, Bohol.

10°05'42"N, 124°37'20"E. 75 km southwest of ViSCA.

Substrate varies from sandy with pebbles and coral fragments to loamy sand. Vegetation is rich with dense populations of *Sargassum* sp., *Turbinaria* sp., *Padina* sp., *Halimeda* sp., and eel grass. Corals abound in the area. Big waves from the Surigao Sea frequently sweep the shores.

Station 5. Lapinig, Pres. Garcia, Bohol.

10°07'48"N, 124°32'22"E. 73.6 km southwest of ViSCA.

Substrate varies from sandy with pebbles and coral fragments to loamy sand. Flora and fauna are richer than that in station 4 with an array of algal species and animal populations such as molluscs, crustaceans and fishes. Coral heads are also abundant but widely spaced due to earlier exploitation.

Sampling and Analytical Methods

Collection, Size Composition and Distribution. Blue crabs were collected monthly from January to November 1983 from all stations with the help of fishermen cooperators. Fishing gears used by fishermen cooperators were crab pots, gill nets and beach seines. Collection was conducted at a maximum depth of about 20 meters. Carapace length and total weight of crabs were determined sometimes by fishermen cooperators to ensure availability of monthly data because crabs were occasionally not available at sampling time. Carapace length was measured to the nearest millimeter from the tip of the frontal spine to the posterior margin using a plastic ruler. Total weight was determined to the nearest gram with a 1-kg capacity spring balance. Sampling was done at the time of the new moon since crab fishermen have observed that it is the time when crabs are most active prior to their molting at about the full moon. Subsampling was done by taking every other individual from a big catch bag without looking at the sample to minimize sampling bias. To augment the scantiness of small individuals in gill net-caught samples from stations 4 and 5, small crabs were caught by hand in shallow portions up to a depth of 1 meter.

Regardless of sex, a maximum of 25 crabs were measured per month per station. However, this number was not always attained due to poor catch in certain months in some stations. Crabs which had recently molted, gravid females, and those with missing legs, broken shells or with other organisms attached were not included as they may be a source of bias which may greatly affect the regression of weight on length (Pullen and Trent, 1970). Only freshly caught crabs were measured because "stored" crabs lose extremely great amounts of weight when kept alive in captivity.

To determine the size composition, the length data of the monthly samples were grouped into length classes of 10-mm interval and the length-frequency distribution was obtained.

Distribution was estimated based on actual observation and on information gathered from fishermen.

Length-Weight Relationship. The length data of the accumulated samples covering 11 months for each sex were subjected to the parabolic formula for length-weight relationship, $W = a \cdot L^b$, which was fitted with a linear regression by taking the logarithms (Pauly, 1983) of both length (x) and weight (y) resulting in $\log W = a + b \log L$; where W = weight, L = length, b = slope with the formula

$$b = \frac{\Sigma xy - \dfrac{(\Sigma x)(\Sigma y)}{n}}{\Sigma x^2 - \dfrac{(\Sigma x)^2}{n}}$$

and a = intercept with the formula

$$a = \left[\frac{\Sigma y}{n} - \left(b\ \frac{\Sigma x}{n}\right)\right]$$

Logarithms of length (x) and weight (y) were carried to 15 decimal places to compute the various sums and were rounded off to 4 decimal places in the final computations.

The regression coefficients obtained for the two sexes were tested for significance of difference using Steel and Torrie's (1960) formula as follows:

$$t = \frac{b_1 - b_2}{\sqrt{\left(\frac{\{\Sigma y_1^2 - [(\Sigma x_1 y_1)^2/\Sigma x_1^2]\} + \{\Sigma y_2^2 - [(\Sigma x_2 \Sigma y_2)^2/\Sigma x_2^2]\}}{n_1 - 2 + n_2 - 2}\right)\left(\frac{1}{\Sigma x_1^2} + \frac{1}{\Sigma x_2^2}\right)}}$$

where b_1, b_2 = slopes.

The standard deviation about regression ($S_{y.x}$) indicating the closeness of fit of the points to the regression line was computed for both sexes using the following formula:

$$S_{y.x} = \frac{\Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2}}{n - 2}$$

Gut Content Analysis. For this purpose, crabs were collected from stations 1 and 5 which had the poorest and the richest flora and fauna, respectively. Exclusion of the other stations should not negatively affect the results since the intention was to determine the natural diet composition of the blue crab, hence natural food had to be as rich as possible. Of the 70 crabs collected, only 37 had gastric mills which were 50-100% full and only these crabs were included to minimize bias due to residency time in the gut. The sample size of 37 gastric mills was considered adequate because Williams (1981) reported that a sample size of approximately 30 gastric mills is necessary to include most food taxa and to stabilize percentage occurrence (which is being employed here) for common food types.

The lengths of sample crabs were first measured prior to gastric mill removal. Then, a subjective estimate of the percentage fullness was made. The gastric mills were then preserved in 10% formalin in separate stoppered vials and brought to the laboratory for analysis. In the laboratory, the contents of each gastric mill were emptied into a petri dish with 70% alcohol and examined under a binocular microscope.

To analyze the gut contents, the percentage occurrence method with the following formula was used:

$$\text{Percentage occurrence for ith prey} = \frac{b_i}{n} \times 100$$

where:

b_i = number of crabs whose gastric mills contained prey type i

n = number of crabs in the sample

Percentage of occurrence measures the regularity of inclusion of a food item in the diet of a sample or population (Williams, 1981). This method is recommended when a broad description of the food types eaten by a sample of portunid crabs is required. However, the method is inaccurate only for foods with no recognizable hard parts and it may also give an inflated relative importance to small items such as foraminiferans.

Food items were identified and recorded at family or generic rank where possible. In the analysis, however, food items were grouped into taxonomic categories such as bivalves, brachyurans, echinoids, etc.

RESULTS AND DISCUSSION

Size Composition and Distribution

There were more females than males in the sample (368:315). However, the length of females ranged from 16 to 90 mm only while that of males ranged from 16 to 95 mm. This suggests that females were relatively smaller (Fig. 2) as observed by Dhawan et al. (1976).

Smaller individuals (carapace length <50 mm) had relatively low frequency in the sample in most months for both males and females (Figs. 2 and 3). However, a higher number of smaller individuals was observed in January, April and July in consonance with intense periods of spawning reported by Batoy et al. (1987). Figures 2 and 3 also show that majority have lengths between 60 to 70 mm during most months for both males and females. This not-so-distinct progression of modal size classes is presumably due to the limited sample size.

A size-related spatial distribution was observed in all stations as supported by information gathered from fishermen. Larger crabs were caught at depths greater than 6 meters while juvenile ones, particularly those with carapace lengths less than 30 mm, were found in shallower portions or near the shore. This observation is also well supported by the fact that crab fishermen using gill nets at depths greater than 6 meters got relatively larger crabs (usually with carapace lengths exceeding 50 mm, Fig. 3) than those caught using beach seines and crab pots. Moreover, crabs caught by using crab pots varied in sizes according to the depth of placement of this fishing gear. This size-related distribution previously reported by Potter et al. (1983) apparently resulted from migration patterns which were likewise observed in other crabs. In *Callinectes sapidus,* Bainbridge (1961) reported that mating occurs in shallow water, followed by migration to deeper water for egg laying, and a return migration of young larvae inshore. Bainbridge further contended that factors governing such migrations are probably primarily physiological and in response to the necessities of breeding, molting and feeding. In this connection, it appears that as with age, *P. pelagicus* has lesser tolerance to low salinities characteristic of river runoff-affected shallow waters. Moreover, low salinity is also unfavorable for breeding (Pillay and Nair, 1971). In a rearing experiment in crab pots in the sea, large crabs died whenever a nearby river overflowed due to heavy rainfall. The type of substratum seems to be another factor affecting distribution. With depth, the substrate becomes finer as in the stations in this study

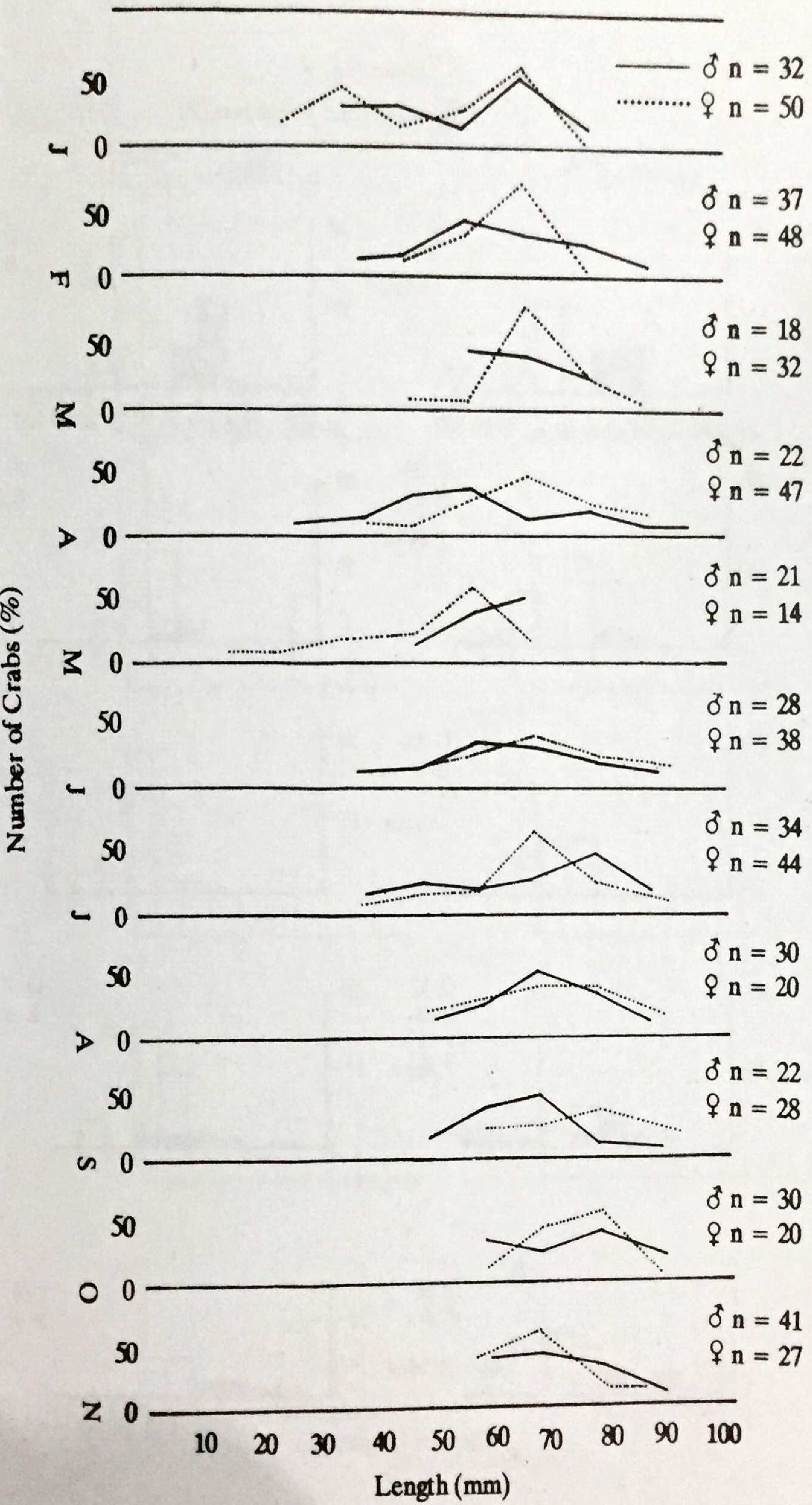


Figure 2. Length-frequency distribution of male and female *Portunus pelagicus* from Leyte and Bohol.

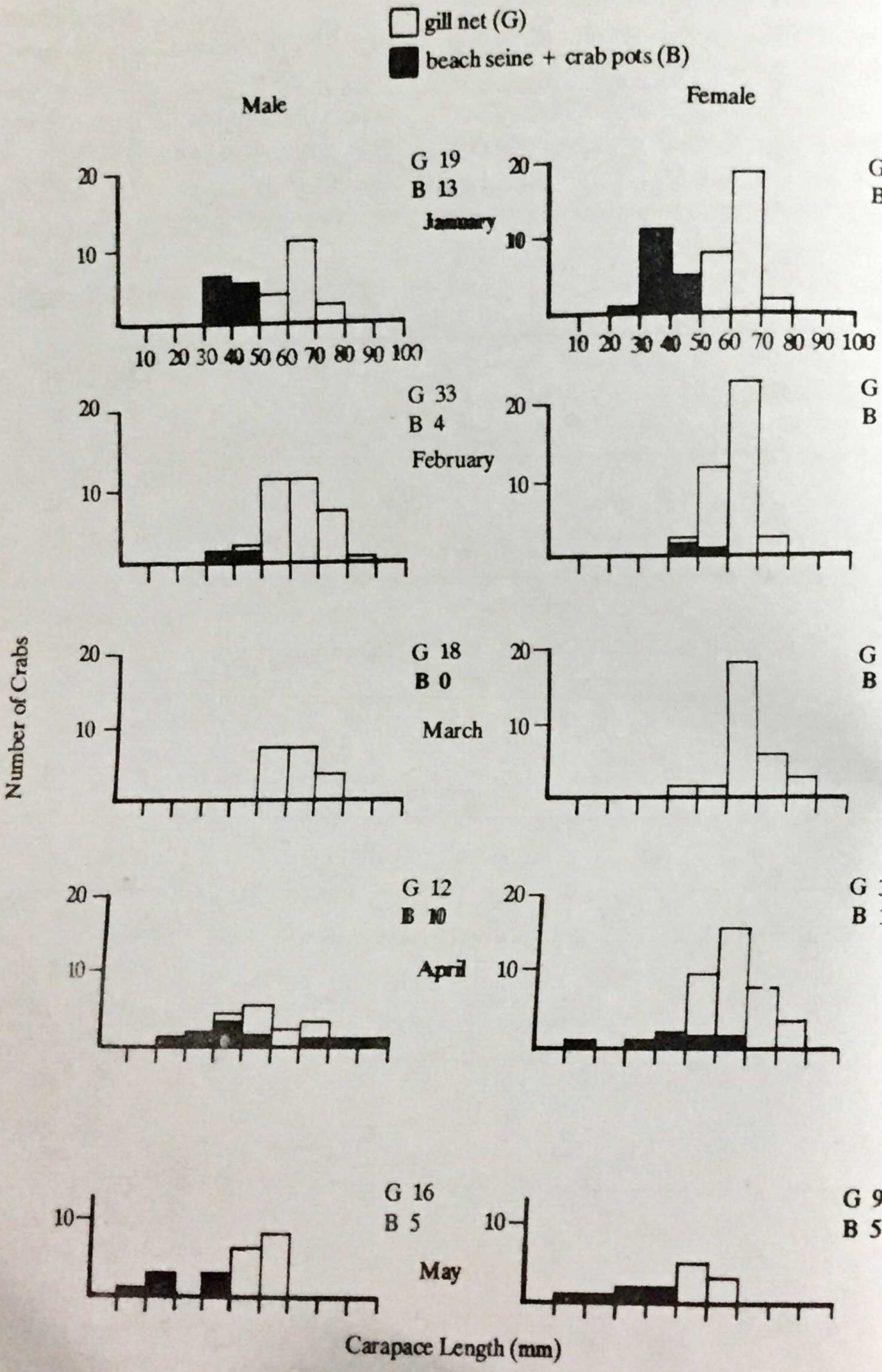
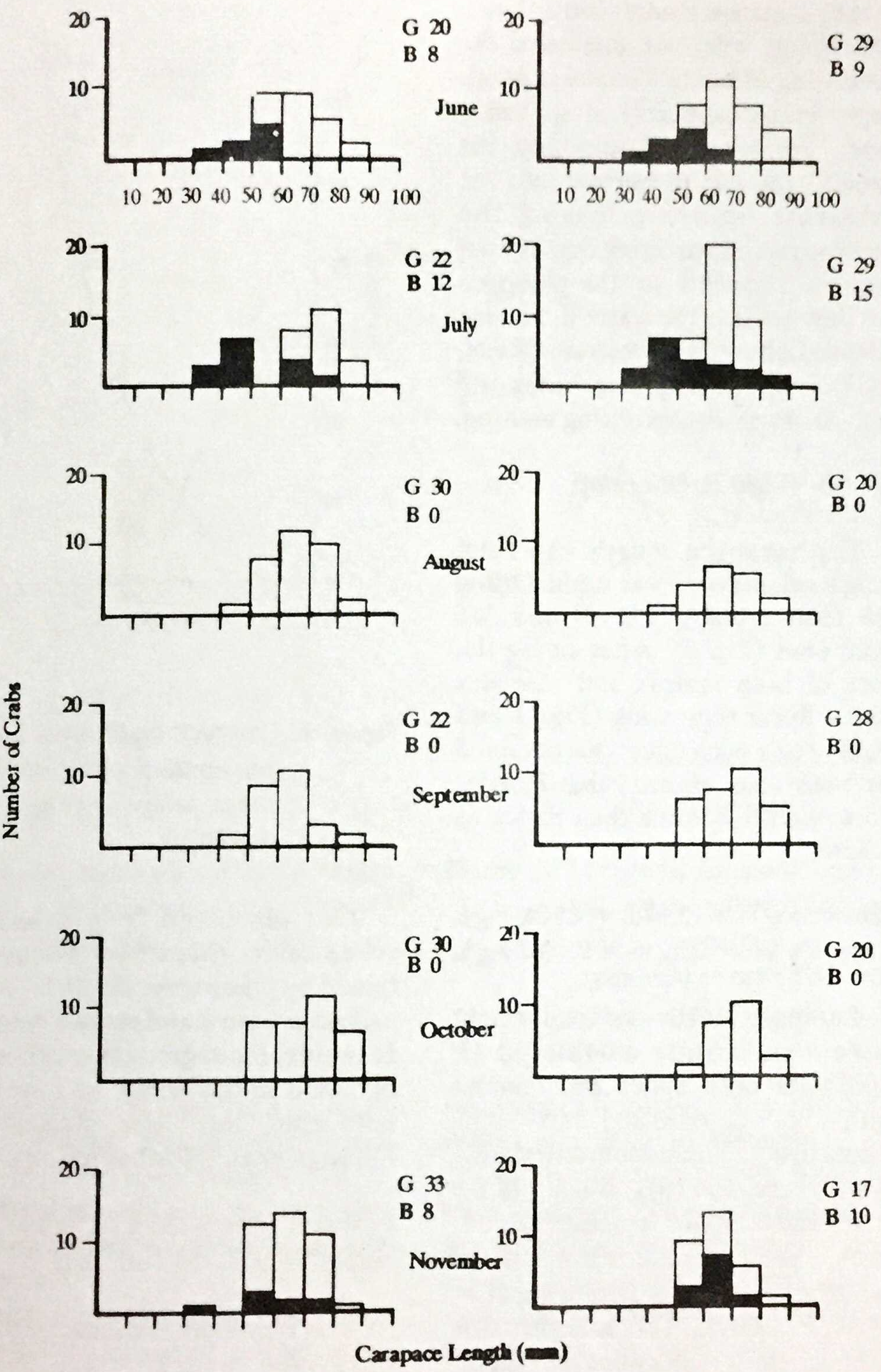


Figure 3. Sequential histograms of length-frequency data of *Portunus pelagicus* from seine + crab pots.



January to November 1983 showing numbers caught by gill net and beach wherein the shore is sandy and deeper areas are loamy sand or loam. This loamy substrate facilitates the burrowing of sexually mature, hence larger crabs especially at spawning time. For successful spawning, the female crab has to burrow into the substrate before releasing the eggs/berries since most eggs do not become attached to the pleopods but flow out into the water if they are released above the substrate (Ryan, 1967). Burrowing also hides the crabs from predators during molting.

Length-Weight Relationship

The carapace length and total weight relationship was studied using 368 female crabs (Fig. 4) and 315 male ones (Fig. 5). After fitting the data of both males and females with a linear regression (Figs. 6 and 7), the regression equations obtained for both sexes showed that females were slightly heavier than males as follows:

Females $\log W = -2.3416 + 2.5146 \log L$
Males $\log W = -2.1216 + 2.4062 \log L$

Carapace length and total weight were significantly correlated (P 0.001) for both males and females with r values of 0.883 and 0.859, respectively. The standard deviation about regression ($S_{y.x}$) was 0.178 for males and 0.193 for females. The difference in the regression slopes of the two sexes was highly significant (t = 13.62, P 0.001). This indicates that although the females were only slightly heavier than males, the difference was significant and persisted throughout the length range observed.

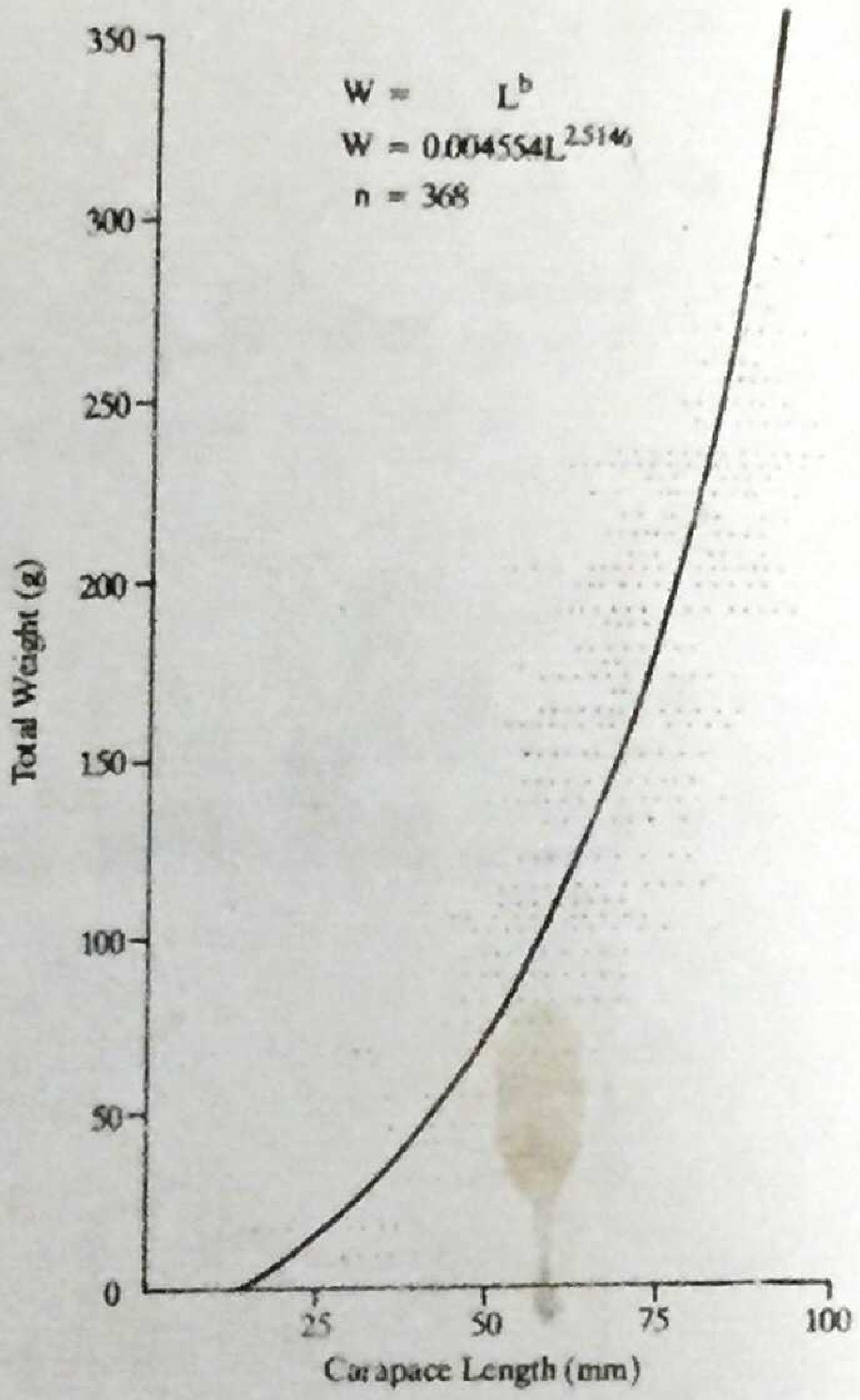


Figure 4. Carapace length-total weight relationship of female *Portunus pelagicus* from Leyte and Bohol.

The observed length-weight relationship concurs with that obtained by Dhawan et al. (1976) on *P. pelagicus* from Zuari estuary in India. However, the regression coefficients obtained in this study are lower for both sexes than those obtained by Dhawan et al. (1976) as follows:

Females $W = 4.233 \times 10^{-9} \times L^{4.969}$
Males $W = 2.750 \times 10^{-6} \times L^{3.636}$

This is probably because they used carapace width which is approximately twice the carapace length (Motoh, 1980) to derive the regression equations instead of using length. The relative proportions of

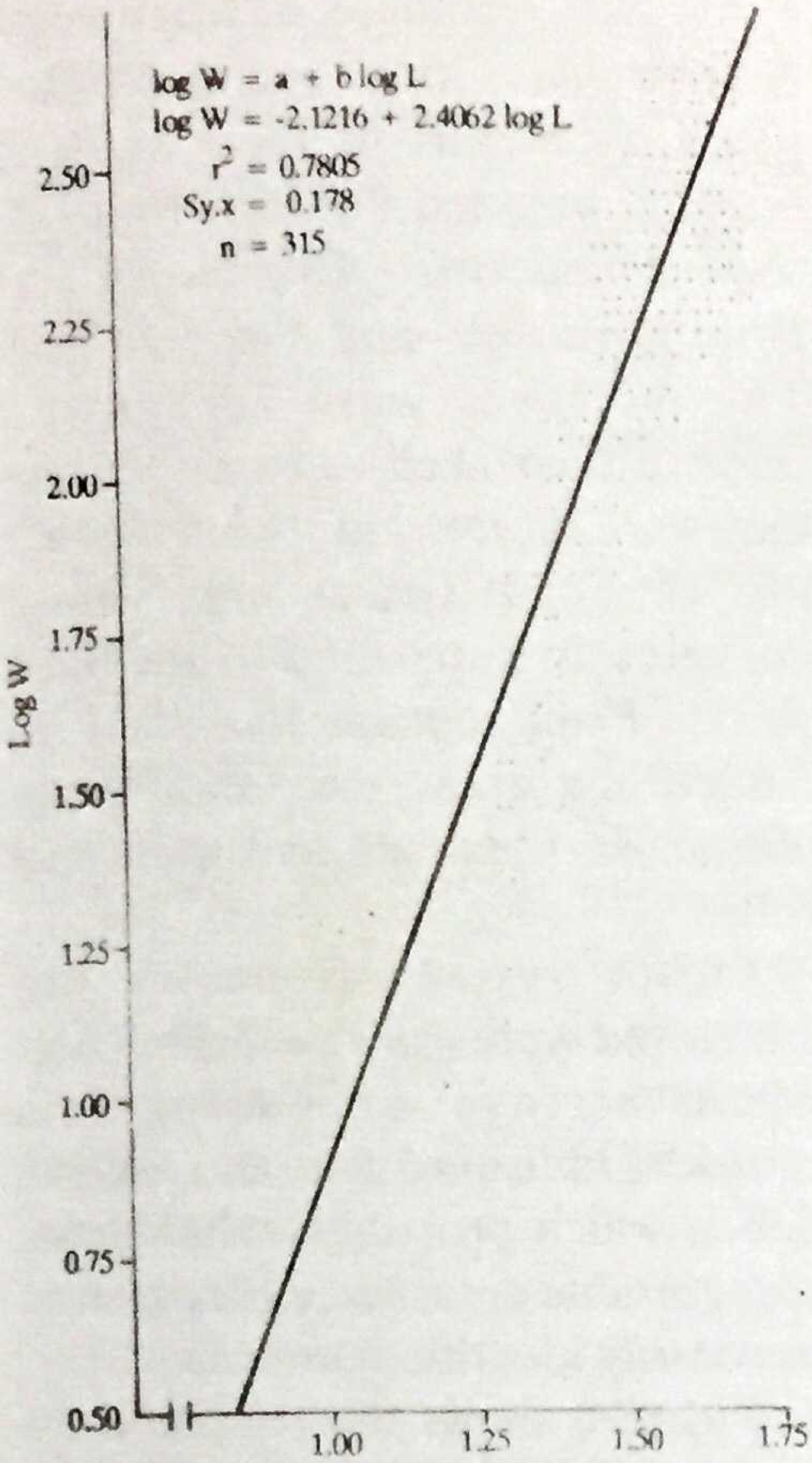


Figure 5. Carapace length-total weight relationship of male *Portunus pelagicus* from Leyte and Bohol.

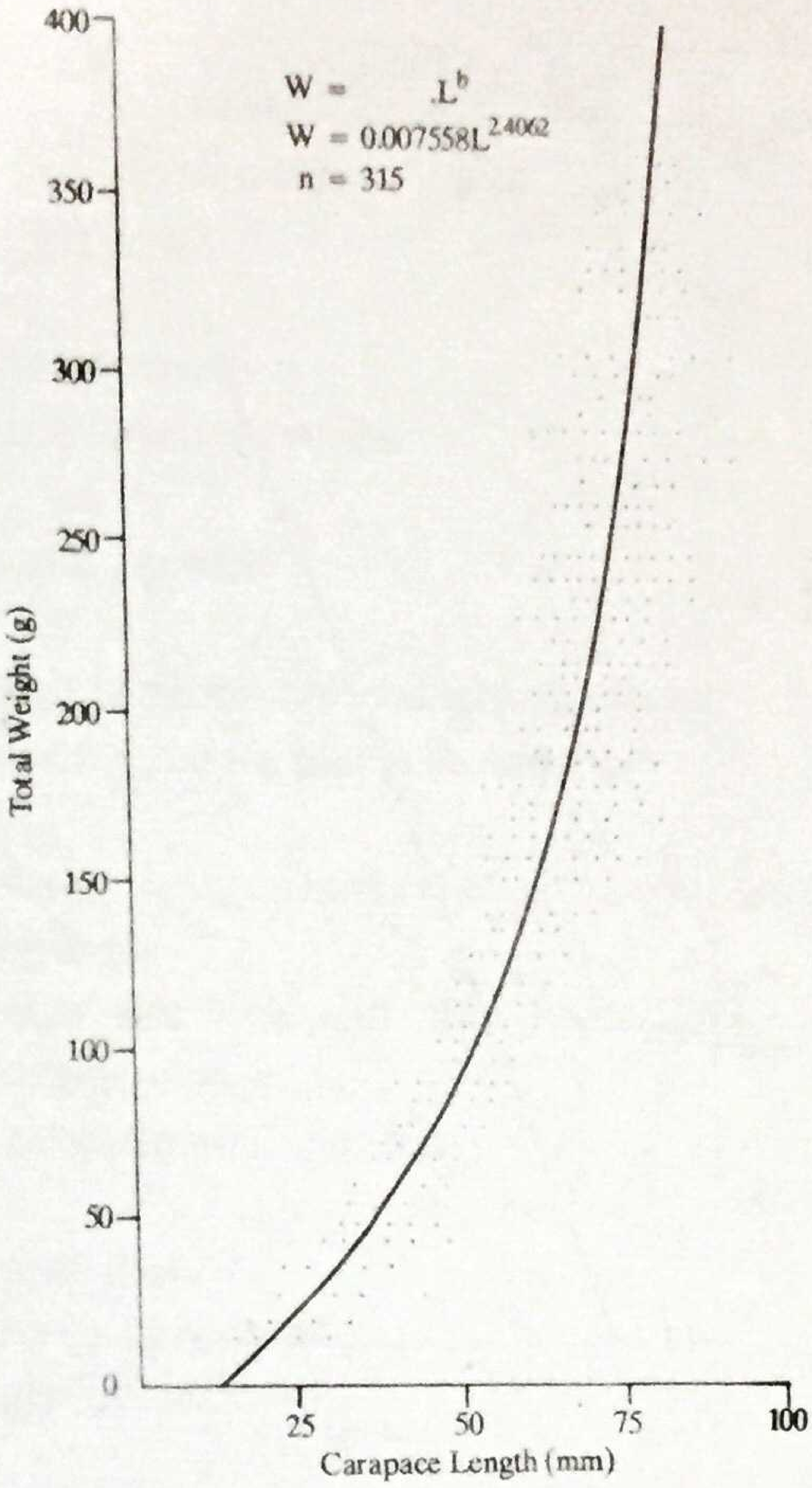


Figure 6. Linearized carapace length-total weight relationship (raw data transformed to logarithms) of male *Portunus pelagicus* from Leyte and Bohol.

the constants between the two sexes in their study should nevertheless hold here because Warner (1977) described growth between carapace length and width in crabs to be usually isometric.

Potter et al. (1983), and Pullen and Trent (1970) reported males to be significantly heavier than females in *P. pelagicus* from western Australia and in the blue crab *C. sapidus* from Texas, respectively. These findings are contradictory to the present results and those of Dhawan et al. (1976) because the former findings were observed in temperate regions as opposed to the tropical conditions in the latter. Differences in environmental conditions could be one of the reasons for the different findings. However, the effect of this difference in environmental conditions on the two sexes could not be ascertained yet.

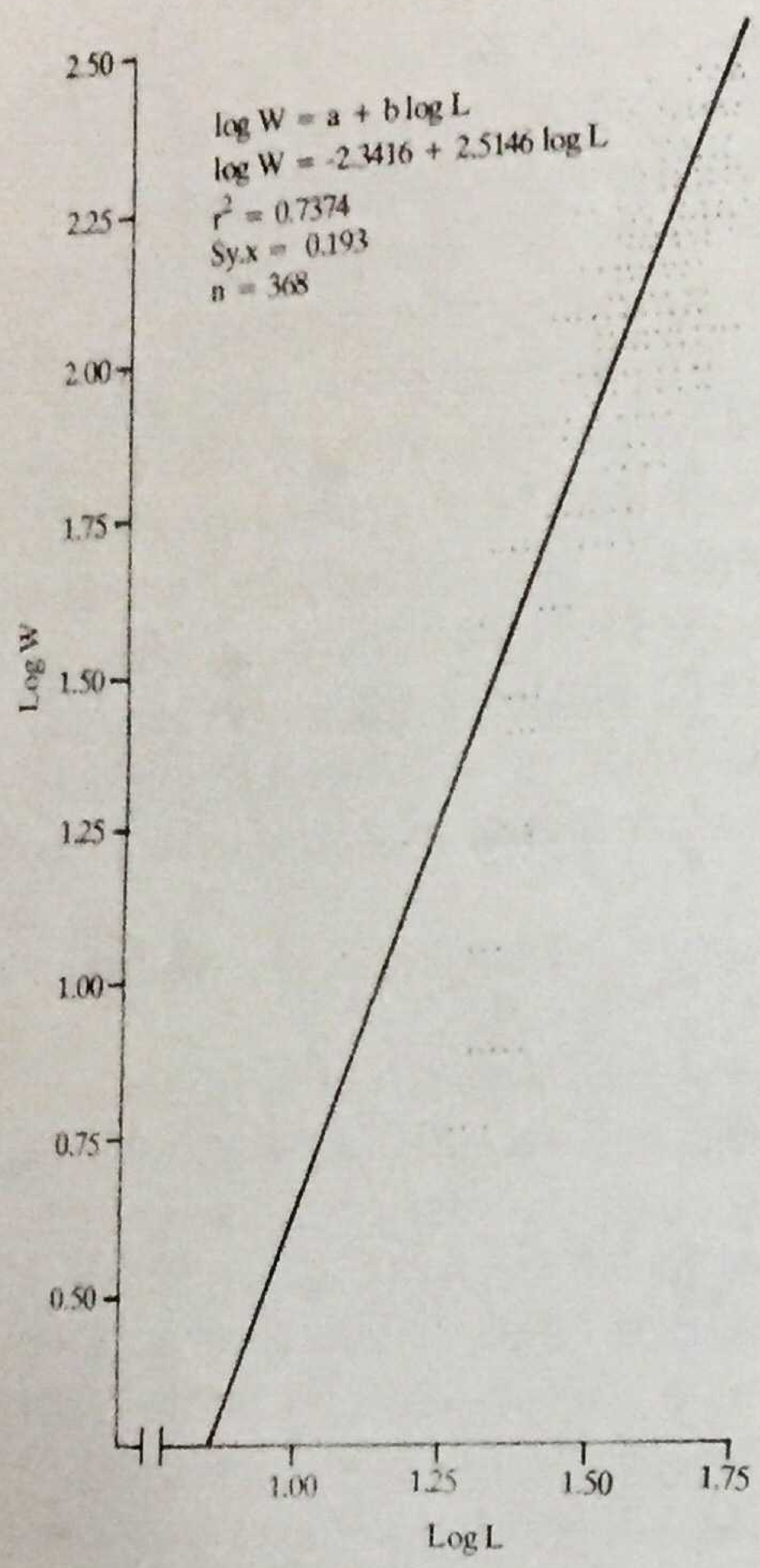


Figure 7. Linearized carapace length-total weight relationship (raw data transformed to logarithms) of female *Portunus pelagicus* from Leyte and Bohol.

Natural Food and Feeding Habit

Table 1 presents a summary of the food categories and the corresponding types of fragments found in the gastric mills of *P. pelagicus*. Several food items particularly animals with hard parts were ingested in large recognizable pieces or in their entirety, hence their remains were identified with certainty. These included Foraminifera, Polychaeta and the following crustacean taxa - Copepoda, Penaeidea, Anomura, Brachyura and Amphipoda. Other food items identified by means of their skeletal remains included Porifera, Bryozoa, the echinoderms - Echinoidea and Holothuroidea, and Osteichthyes. The molluscs were recognized through their shell remains because they were ingested in such a manner that their soft tissues were almost completely separated from hard parts. Plant remains identified included sea grass, and algal blade fragments, filaments and groups of cells.

Other types of matter encountered were sand particles, short nylon strings probably from dilapidated fishing nets, and organic debris which probably included unrecognizable detached material from previously identified animals.

Figure 8 shows the relative composition of food found in gastric mills of *P. pelagicus* in terms of percentage occurrence. The relative importance of the different food categories in the natural diet of blue crabs varies as shown by the differences in their values. Unidentifiable organic debris showed the highest percentage occurrence value. This was expected because of the detached organic material from previously identified animal food. Moreover, soft-bodied organisms with no hard parts such as some difficult-to-identify coelenterates could have possibly been included. Thus, it is difficult to ascertain the importance of such food items in the crab's natural diet. Likewise, sand particles had a high percentage occurrence despite its lack of gustatory and nutritive value.

Table 1. Summary of food categories found in gastric mills of *Portunus pelagicus.*[1]

Food Type	Types of Fragments Found in Gastric Mills
Foraminifera	Whole tests (1-2 in a gastric mill)
Porifera	Spicules and spongin fibers
Mollusca	
Gastropoda	Shell fragments and opercula
Bivalvia	Shell fragments and attached tissues
Annelida	
Polychaeta	Setae and pieces of body wall
Crustacea	
Copepoda	Harpacticoid body fragments, appendages and setae
Penaeidea	Rostrum, carapace fragments, pleopods and other appendages
Anomura	Hermit crab cephalothorax, uropod setae, pleopods and various appendages
Brachyura	Carapace fragments, gills, setae and other appendages
Amphipoda	Gammarid appendages and setae
Bryozoa	Gymnolaemate exoskeleton fragments
Echinodermata	
Echinoidea	Test fragments and spines
Holothuroidea	Ossicles and portions of body wall
Osteichthyes	Bones, scales, eggs and vertebrae
Plants	
Algae	Blade fragments, filaments and cell groups
Sea grass	Leaf fragments

[1]Based on 37 gastric mills which were 50-100% full.

This is probably due to the scavenging behavior of these decapods by which sand grains may incidentally get ingested. As Tressler and Lemon (1951) pointed out, blue crabs are basically scavengers and cannibals although they occasionally feed upon aquatic vegetation. This scavenging habit in search of food was also reported by Hill (1979) in another portunid, *Scylla serrata*. Osteichythyes and Holothuroidea also showed relatively high percentage occurrence. The relative importance of Osteichythyes might have been overestimated since the crab fishermen in station 1 employed fish baits. Meanwhile, a previous survey of the same area indicated the abundance of holothurians. Thus, the relative importance of food items in the diet is influenced by their local abundance, and that food preference is a function of food availability. Moreover, where food is readily available, preference for particular food types may tend to

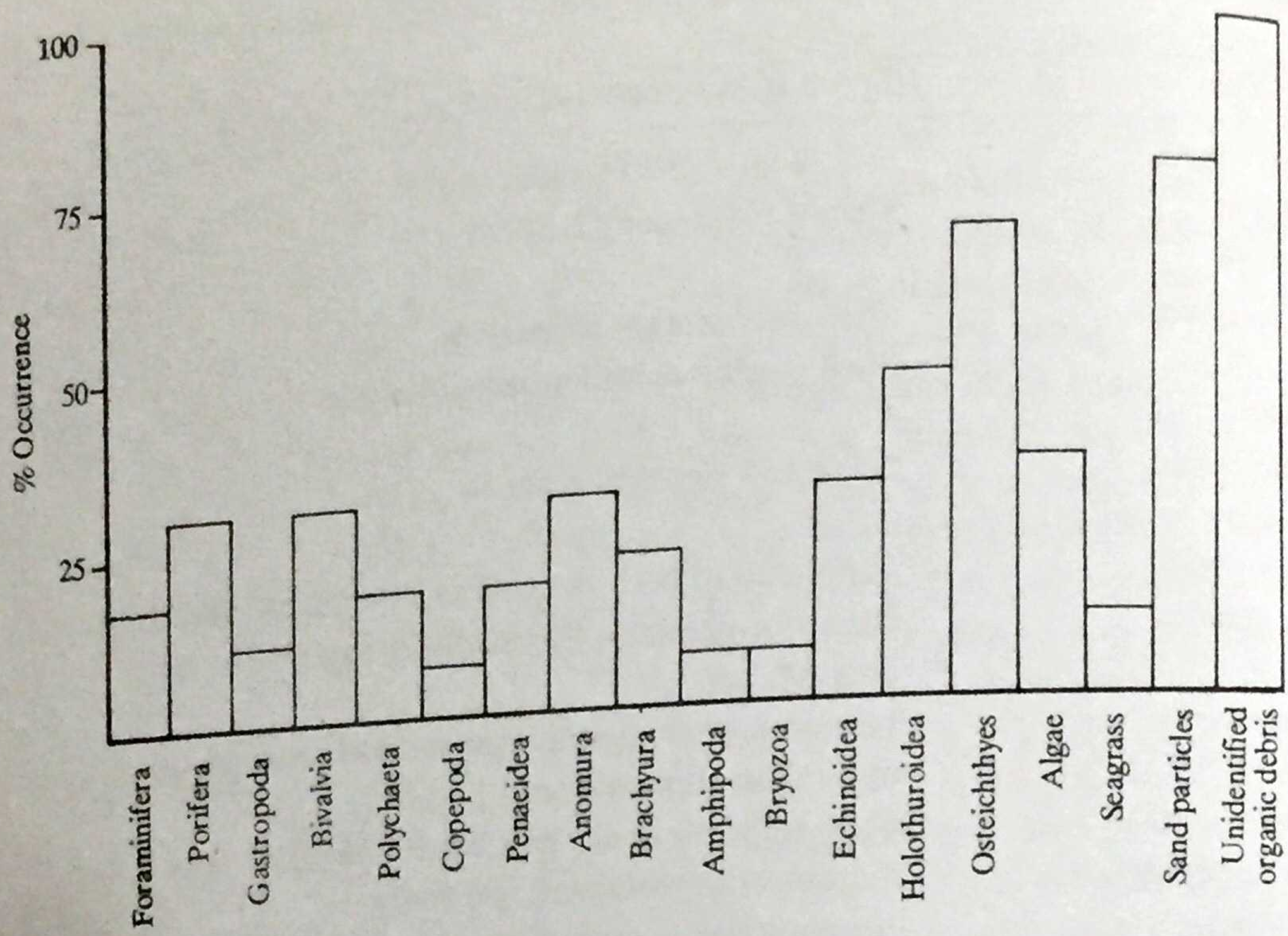


Figure 8. Relative composition of food found in gastric mills of 37 individuals of *Portunus pelagicus* (22-28 mm carapace length) as shown by occurrence values.

be influenced by other factors like the mass and energy content of the food item. Food organisms with larger mass and higher energy content may be preferred. This was demonstrated by Hill (1979) in the portunid *S. serrata* and might also be true in *P. pelagicus*. *Scylla serrata* in a South African estuary reportedly preferred small crabs (as indicated by Ivlev electivity index) to bivalves despite the higher population density of the latter. Analysis of the samples showed that the small crabs had larger mass (based on ash-free dry weight) despite their lesser density and also had higher energy content. Results of gut content analysis of the present study indicate the occurrence of more crustacean taxa compared to other groups such as molluscs and echinoderms (Table 1, Fig. 8), hence the conjecture.

Findings of this study on food types are very similar to the report of Williams (1981) on four species of sympatric portunid crabs (*Portunus pelagicus, Thalamita crenata, T. danae* and *T. sima*) collected from Moreton Bay, Australia. Fourteen of the 22 food types reported by Williams (1981) were also encountered in this study. Some of the remaining food types might have been included in the gut contents of the sample crabs but they might have been overlooked due to taxonomic limitations. Furthermore, the absence of soft parts might have rendered some taxa unidentifiable e.g. the coelenterates. However, two food types encountered in this study namely:

Penaeidea and Copepoda were not reported by Williams. Findings also substantiated previous contentions that blue crabs prefer living and moving animal food to plant food.

LITERATURE CITED

BAINBRIDGE, R. 1961. Migrations. **In:** The Physiology of Crustacea. Vol. II. T. H. Waterman (ed.). Academic Press, New York. 200 p.

BATOY, C.B., SARMAGO, J.F. and PILAPIL, B.C. 1987. Breeding, sexual maturity and fecundity of the blue crab, *Portunus pelagicus* (L.) in selected coastal waters in Leyte and vicinity, Philippines. Ann. Trop. Res. 9(3):157-177.

DHAWAN, R.M., DWIVEDI, S.N. and RAJAMANICKAM, G.V. 1976. Ecology of the blue crab ***Portunus pelagicus*** (L.) and its potential fishery in Zuari Estuary. Indian J. Fish. 23(1-2):57-64.

HILL, B.J. 1979. Aspects of the feeding strategy of the predatory crab, *Scylla serrata.* Marine Biology 55:209-214.

MOTOH, H. 1980. Field Guide of the Edible Crustacea of the Philippines. SEAFDEC Aquaculture Dept., Iloilo, Phil. pp. 72-73.

PAULY, D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Paper 234:52.

PILLAY, K.K. and NAIR, N.B. 1971. The annual reproductive cycles of *Uca annulipes, Portunus pelagicus* and *Metapenaeus affinis* (Decapoda:Crustacea) from the southwest coast of India Marine Biology 11:152-166.

POTTER, I.C., CHRYSTAL, P.J. and LONERAGAN, N.R. 1983. The biology of the blue manna crab, *Portunus pelagicus* in an Australian estuary. Marine Biology 78:75-85.

PULLEN, E.J. and TRENT, W.L. 1970. Carapace width and total weight relationship of blue crabs from Galveston Bay, Texas. Trans. Am. Fish. Soc. 4:795-798.

RYAN, E.P. 1967. Structure and function of the reproductive system of the crab, *Portunus sanguinolentus* (Herbst) (Brachyura:Portunidae) II. The female system. Proc. Symp. Crustacea. Mar. Biol. Assoc. India. January 12-15, 1965, Ernakulam. pp. 522-544.

STEEL, R.G.D. and TORRIE, J.H. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., New York. pp. 161-182.

TRESSLER, D.K. and LEMON, J.M. 1951. Marine Products of Commerce. Reinhold, New York.

WARNER, G.F. 1977. The Biology of Crabs. Unwin Bro. Ltd. The Gresha, London. pp. 119-194.

WILLIAMS, M.J. 1981. Methods for analysis of natural diet in portunid crabs (Crustacea: Decapoda: Portunidae). J. Exptl. Mar. Biol. Ecol. 52:103-113.