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9. ABSTRACT
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OBSERVATIONS ON THE BIOLOGY OF Macrobrachium americanum BATE FROM A POND ENVIRONMENT IN PANAMA¹

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ABSTRACT

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INTRODUCTION

Species of Macrobrachium have potential for aquaculture in Southeast Asia and other tropical and subtropical regions (Ling,

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1969a; Ling, 1969b; Shang, 1972). According to Hochuis (1952), 26 species of the genus are known from the Americas. All inhabit freshwater, although certain species apparently go downstream to brackish water to produce young.

During a survey of fishery resources in Panama (Smitherman and Moss, 1970), a population of prawns reaching maximum individual weights of 372 g was discovered in a 0.61-ha freshwater pond in Panama Province on the Pacific slope of Central Panama. The pond was reported to have had a sustained population for 3 years following a stocking of eight adults from a nearby man-made lake. Specimens from the pond population were subsequently identified as Macrobrachium americanum Bate, the biology of which is little known (de la Cruz, 1968).

Studies were initiated at Auburn University and in Panama to obtain basic life history data pertinent to possible aquaculture.

MATERIALS AND METHODS

Studies at Auburn University

Collection and Transportation of Specimens

Prawns were captured by wire traps from a 0.61-ha pond located on a small stream tributary to the Rio Juan Diaz, Panama Province, Republic of Panama. The pond, built in 1968 on a stream which flowed except for the months of January, February, and March, was located 5 km by air, or approximately 10 km by stream, from the mouth of the Rio Juan Diaz on the Pacific Ocean.

Traps used were of 3- to 13-mm mesh hardware cloth and had funnels tapering over 15 cm from an entrance diameter of 12.5 cm to a 7.5 cm interior terminus. Traps were rectangular or cubic, and varied from 0.57 m³ to 0.70 m³ in volume. Baits included fish, beef or chicken scraps, stale bread, and banana or pineapple peels.

On 25 June, 1970, seven adult prawns approximately 60g each were transported by air to Auburn from Panama using plastic bags, water, oxygen, and styrafoam containers. The prawns were in transit for 12 hours during which time water temperature in transport containers varied from 28.3 C at the Panama pond to 25.5 C at the Auburn University laboratory. One day after arrival, the prawns were stocked into two 0.04-ha ponds, M-9 and M-10, where the water temperature was 26.7 C. Pond M-10 received five females, one of which carried eggs, and one male. Pond M-9 received one female with eggs. Both ponds contained drainage tiles for shelter for the prawns.

On 17 November, 1970, a second shipment of prawns was received at Auburn from the pond in Panama. These animals, including six adult males, eight adult females with eggs, and 17 juveniles, were

placed in aquaria and troughs and observed for feeding behavior, fecundity, hatching, and survival of larvae. Temperature during the 17-hour transit varied from 26.7 C in the Panama pond to a low of 17.2 C and was gradually returned to 25.7 C during a 2-hour period after arrival, and maintained. To test for effects of handling, all prawns were offered flesh from the grass carp, Ctenopharyngodon idella 30 minutes after placement in aquaria and troughs.

Fecundity, Hatching and Survival of Larvae in the Laboratory

Two berried females of the November shipment were preserved in formalin and counts were made of their eggs. Prior to preservation, 10 eggs from each female were observed and measured.

Mating and egg-laying were not studied with shrimp of either shipment, but hatching, and length of larval life in the laboratory were observed in several females from the November group. Further, the effects of reconstituted sea water on survival of larvae was studied.

Growth and Survival of Adult Shrimp in Ponds

Pond M-9 received a berried female shrimp which was 156 mm in length from rostrum to telson and weighed 69 g. The pond received periodic applications of Auburn No. 2 pelleted catfish feed and triple superphosphate to maintain a phytoplankton bloom with visibility of not more than 30 cm. The pond was seined at monthly intervals with a 2-mm mesh nylon net for evidence of young, and wire traps of 13-mm mesh hardware cloth were used monthly in an attempt to capture the stocked adult shrimp. After 4 months the pond was drained and the results evaluated.

The shrimp stocked into Pond M-10 were not weighed initially, but females were practically identical in size to the one stocked into M-9. Pond M-10 was treated in the same manner as M-9.

Feeding Studies

During the study period 25 June, 1970 to 20 January, 1971, numerous observations were made on foodstuffs shrimp would eat in the laboratory. Items offered included fish muscle, boiled ham, earthworms, and pelleted fish feed.

Studies in Panama

Collection of Specimens

Wire traps were used during April 1972 through June 1973 in the same 0.61-ha pond in Panama in order to establish spawning seasons for the local population of Macrobrachium americanum. Traps and baits are as described above. Trap catches were noted weekly, and seine (2 mm mesh) hauls were made approximately monthly

in an attempt to determine the presence of postlarval or juvenile shrimp. Certain weather factors including temperature and rainfall were noted for potential effect on catch.

Length-Weight

The length (mm) from tip of rostrum to tip of telson, carapace length, and extended length--tip of extended chelae to tip of telson--was recorded for each specimen by sex. Weight was taken for each in grams. Shrimp were returned to the pond after measurement.

Sex and Reproduction

Sex was determined on the smallest specimens encountered (9 g, 88 mm rostrum-telson) by the presence of paired sperm duct openings covered by flexible chitinous flaps on the coxal joints of the fifth pair of pereopods or walking legs (McCormick, 1933). The setae-covered genital pores of the females, located in corresponding position on the bases of the third pair of pereopods, were more difficult to distinguish. However, females could be distinguished up to 2 months prior to spawning by the cream to gold color of the ventral margin of the abdominal segments. The abdominal segments of the female during this pre-spawning period became noticeably lengthened and the second abdominal segment became greatly broadened as well. These modifications effectively formed a protective chamber for the eggs were noted during the 15-month period.

Males, especially those considered to be in their second year, generally were larger and possessed strong, heavy chelae. This size dimorphism has been generally used to separate the sexes (Holthius, 1952; de la Cruz, 1968).

Food Habits

Observations on types of food taken by the shrimp were made on trap baits, on regurgitated materials, and on feed offered the animals in experimental aquaria.

RESULTS

Auburn University

Transportation

All shrimp in the two shipments to Auburn survived and several adult specimens aggressively sought and fed upon cubes of flesh from the grass carp within 30 minutes after shrimp were placed in aquaria and troughs.

Fecundity and Egg Size

Egg count and egg size for two berried females were as follows:

	Length (mm)	Wt (g)	Wt eggs (g)	No eggs	Eggs per g of	Egg size (mm)
1	149	54.43	7.73	86,024	1,580	0.63 x 0.46
2	156	56.85	7.95	87,071	1,531	0.63 x 0.46

Egg size is an average value for 20 measurements for each of two axes through the ovoid, "egg-shaped eggs." The range and mean for the longer axis was 0.58 - 0.71 (0.63) mm and that for the shorter axis was 0.33 - 0.50 (0.46) mm. These data on egg size agree closely with those of de la Cruz (1968) from Mexico (0.67 x 0.44 mm), but estimates of 200,000 to 500,000 eggs per female by de la Cruz appear too high. Based on figures in the present study, and on estimates of recently hatched larvae by Diaz³, extremely large females of 187 mm and 145 g might produce up to 228,000 eggs. Most healthy females in the Panama population, which received some supplemental feed, probably produced 50,000 to 150,000 eggs.

Hatching and Survival of Larvae in the Laboratory

Five berried females not used in the fecundity study hatched their young at 25.5 - 27.8 C within 4-7 days after arrival at Auburn on 17 November 1970. One other female died when water temperature accidentally rose to 37.2 C. On arrival, eggs on berried females were yellowish to gray, and were eyed. In the conditioned freshwater of the aquaria, larvae were offered egg yolk, minced fish flesh and plankton as recommended by Ling (1968b) for M. rosenbergii. Since it was strongly believed by Panamanian personnel that the local population of M. Americanum was an isolated group sustained in freshwater, the aquarium environment was not initially altered with salt. The initially vigorous, phototropic larvae gradually became less active, and usually died within 24 hours after hatching without evidence of having taken any of the foods offered.

When sea salt was added to the culture medium, survival of larvae was dramatically enhanced. The following results were obtained in tests initiated with vigorously swimming 20-hour-old larvae:

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Diaz, E. L. 1973. Personal communication.

Salinity ppt	Survival (%) of larvae at hours					
	0	4	16	24	41	50
0	100	76	0	0	0	0
12	100	100	100	100	27	13
18	100	100	100	100	63	17
36	100	100	100	100	60	43

These and other observations indicated that *M. americanum* found many km inland in seemingly isolated environments in Panama were dependent upon brackish water for larval development. Indeed, later studies by Mulvihill (1971) showed that *M. carcinus*, a close relative of *M. americanum*, could be reared using modified culture methods of Ling (1969b).

Growth and Survival of Adult Shrimp in Ponds

Pond M-9, stocked with a single-berried female, had no young shrimp when seined or when drained after 4 months. In October, 1970. The female grew from 156 mm to 175 mm (rostrum-telson) and gained 23 g during this period. On 16 October water temperature in M-9 dropped 12.8 C. When the female shrimp was recovered upon draining it was practically immobile. When its container water was gradually raised to 21.1 C over a 1-hour period, however, the animal rapidly regained mobility and fed on dry fish feed pellets from 17 to 20 October. On 20 October soon after the shrimp had been handled and measured, it was offered live earth worms in an aquarium where the water was 20.0 C. The shrimp immediately captured and ate the earthworms.

Ponds M-10, stocked with five female shrimp (one berried) and one male, had no young when seined or when drained after 4 months. No initial measurements were taken at stocking, but estimated weight of each female was 50 g. At draining, only two females: 164 mm, 66g; and 160mm, 64 g, were recovered. These were also exposed to 22.8 C temperature and were handled as that in M-9. Both females recovered and fed on fish feed and earthworms.

Feeding Studies

During laboratory observations shrimp ate boiled ham, fish muscle, pelleted fish feed, and earthworms. Males were generally more aggressive, and learned within 1 or 2 days to reach near the water surface of their trough or aquarium to take cubes of fish flesh from human hands. Females, especially ovigerous ones, tended to take food under cover where it was consumed. Plant materials alone were not offered the shrimp; however, specimens captured from ponds M-9 and M-10 sometimes regurgitated green substances. A juvenile specimen was observed to eat another juvenile when the latter had recently molted.

Panama

Collecting shrimp from the 0.61-ha pond with wire traps resulted in 536 specimens of M. americanum ranging from 88 to 233 mm, and 9 to 372 g. Both traps and seines took large numbers of fishes as small as 10 mm and specimens of M. digueti as small as 25 mm. Fishes present were several small species of the family Characidae, Aequidens coeruleopunctatus (Cichidae), Synbranchus marmoratus (Synbranchidae), and Rhamdia wa. eri (Pimelodidae).

It was noted that catches varied in the traps which differed in both volume and bottom surface. It was determined that both volume ($r=0.67$) and bottom surface ($r=0.95$) were positively correlated with catch. The greater correlation with bottom surface indicates that M. americanum has specific space requirements. The animals were observed fighting and pinching one another in traps and when confined with little space. This should be considered when designing harvesting and holding facilities of any potential culture operation for this species.

Seasonal pattern of catch was indicated by that in a single rectangular sided trap with volume of 0.57 m³ and bottom surface of 1.25 m². It was noted that catch generally increased during the rainy season of May to November and reached a low in January of the dry season. Catch again increased as rainy season approached and temperature decreased.

Length-Weight (Rostrum-Telson)

Length-weight relationships for 220 females, 288 males, and 536 combined observations were calculated and presented in Figures 1, 2 and 3. Twenty-eight specimens were measured before methods for determining sex were developed during the first 2 months of the experimental period. Females ranged in length from 88 to 195 mm and in weight from 9 to 145 g. Males ranged from 90 to 233 mm, and 10 to 372 g, respectively.

Sex and Reproduction

The female shrimp population had ovigerous individuals from June to November, 1972 and again in June 1973. This egg-laying and egg-bearing season is the same as reported for 1969 to 1971 by the pond owner and corresponds quite closely with the rainy season. The egg-bearing peak was in September when 55% of females captured had eggs. Females bearing eggs ranged in length from 132 to 187 mm, and in weight from 40 to 145 g.

Eggs were yellow when first deposited on the pleopods, and gradually transformed in color to orange to red-brown to grey when eyespots appeared in approximately 2 weeks. Hatching occurred between 3 and 4 weeks after egg-laying. As indicated by recaptures of identifiable individuals, at least some of the females hatched

their eggs in the freshwater pond, although some may have migrated downstream to the Pacific. Since no small shrimp less than 23 mm were captured in the pond, it is concluded that replenishment of the stock in the pond which has yielded a harvest of approximately 2 kg (20 specimens) per week during 1968 through 1972 is mainly from migration of postlarvae or juveniles upstream into the pond during the rainy season when there is stream flow. The smallest specimens trapped in the pond were in February. It is estimated that after an incubation and larval development period of approximately 3 months (June to August), postlarvae and juveniles could have traveled from the estuary to the pond in the period September to December while there was stream flow.

Food Habits

During collecting operations in the Panama pond, bread, bananas, beef, fish, shrimp, poultry, and pineapple were used successfully as bait. In addition, shrimp collected often regurgitated green material thought to be Chara sp. which was an abundant aquatic plant. When shrimp were placed in aquaria with characins, or eichlids, they often caught and consumed these fishes. It is assumed they occasionally preyed on fish while in the pond. Shrimp in aquaria also fed on Elodea sp. and aquarium fish food pellets.

SUMMARY

1. Macrobrachium americanum, like most others of its genus, apparently requires brackish water for development of its larvae.
2. This shrimp is omnivorous, but apparently prefers food of animal origin.
3. This animal, which lives normally at approximately 26.7 C, can survive 12.8 C. When one female was exposed to 37.2 C, death occurred.
4. Fecundity of 54-57 g females was 86,000 to 87,000 eggs; and size of the ovoid egg was 0.63 mm x 0.46 mm. Projected fecundity of the largest female in the Panama population was 228,000 eggs.
5. Adult female shrimp transported from the Panama pond to Auburn ponds increased approximately 33% of body weight in 4 months from June to October. Survival was 40% to 100% in the Auburn ponds.
6. Length-weight relationships, linear and curvilinear, were calculated for males, females, and combined population for M. americanum in a pond environment in Panama.
7. Spawning season in Panama was found to include the months of June to November, which corresponds closely to the height of the rainy season. Ovigerous females ranged from 132 to 187 mm, and 40 to 145 g, respectively.

8. Eggs of M. americanum are yellow when deposited, turning orange, red-brown, and grey before hatching at about 3 weeks.

ACKNOWLEDGMENTS

Appreciation is expressed to Mr. Antonio Dominguez, Panama, owner of the pond, who provided shrimp specimens and use of his facilities for the studies. Dr. A. E. Smalley, Department of Biology, Tulane University, New Orleans, Louisiana, kindly identified the shrimp and suggested valuable references. Special thanks are extended to Mr. Richard Pretto, for assistance in collecting data at the Panama pond, and to Dr. W. D. Davies, Auburn University Department of Fisheries and Allied Aquacultures, for guidance with statistical analysis of the data.

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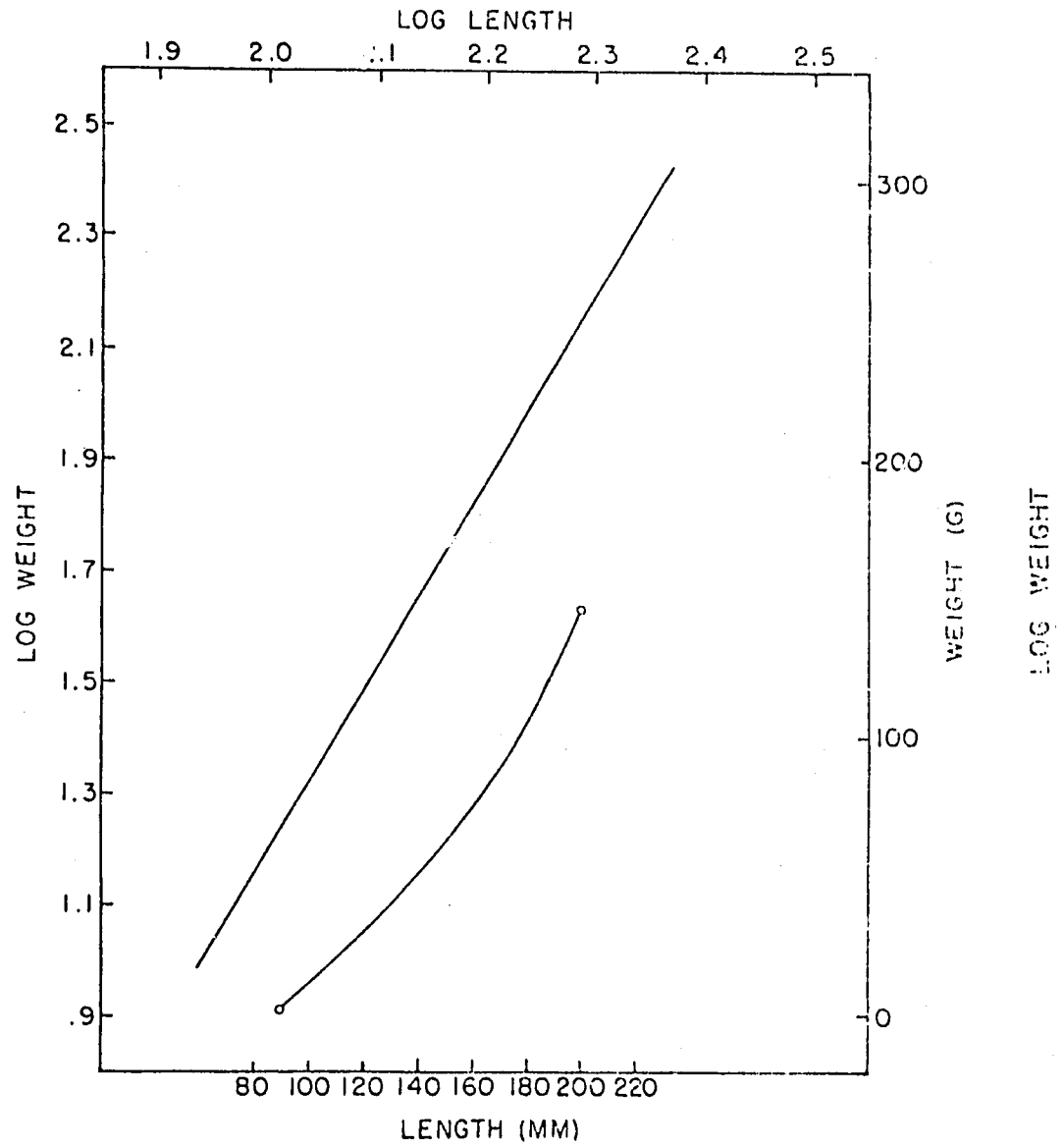


Figure 1. Length - weight relationships of 270 female *Macrobrachium americanum* Bate (range 88 - 195 mm) are presented using the following equations: $\text{Log } W = -5.5809 + 3.3836 \text{ Log } L$ (linear), and $W = -22.9077 + 0.1721 L_1 + .0050 L_1^2$ (curvilinear).

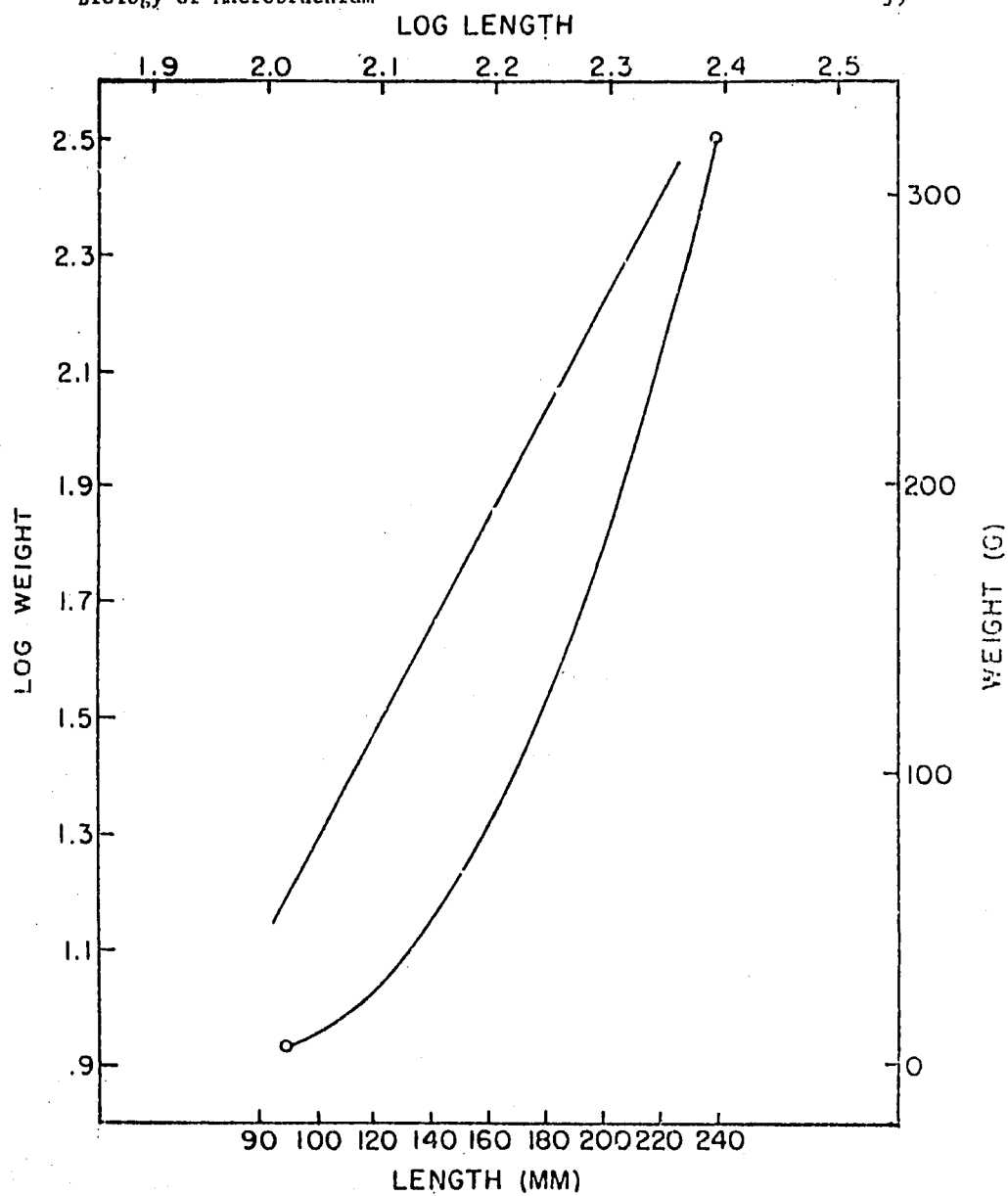


Figure 2. Length - weight relationships of 288 male *Macrobrachium americanum* Bate (range 90 - 233 mm) are presented using the following equations: $\text{Log } W = -6.1761 + 3.6655 \text{ Log } L$ (linear), and $W = 86.6416 - 2.0063 \cdot L_1 + .0124 L_1^2$ (curvilinear).

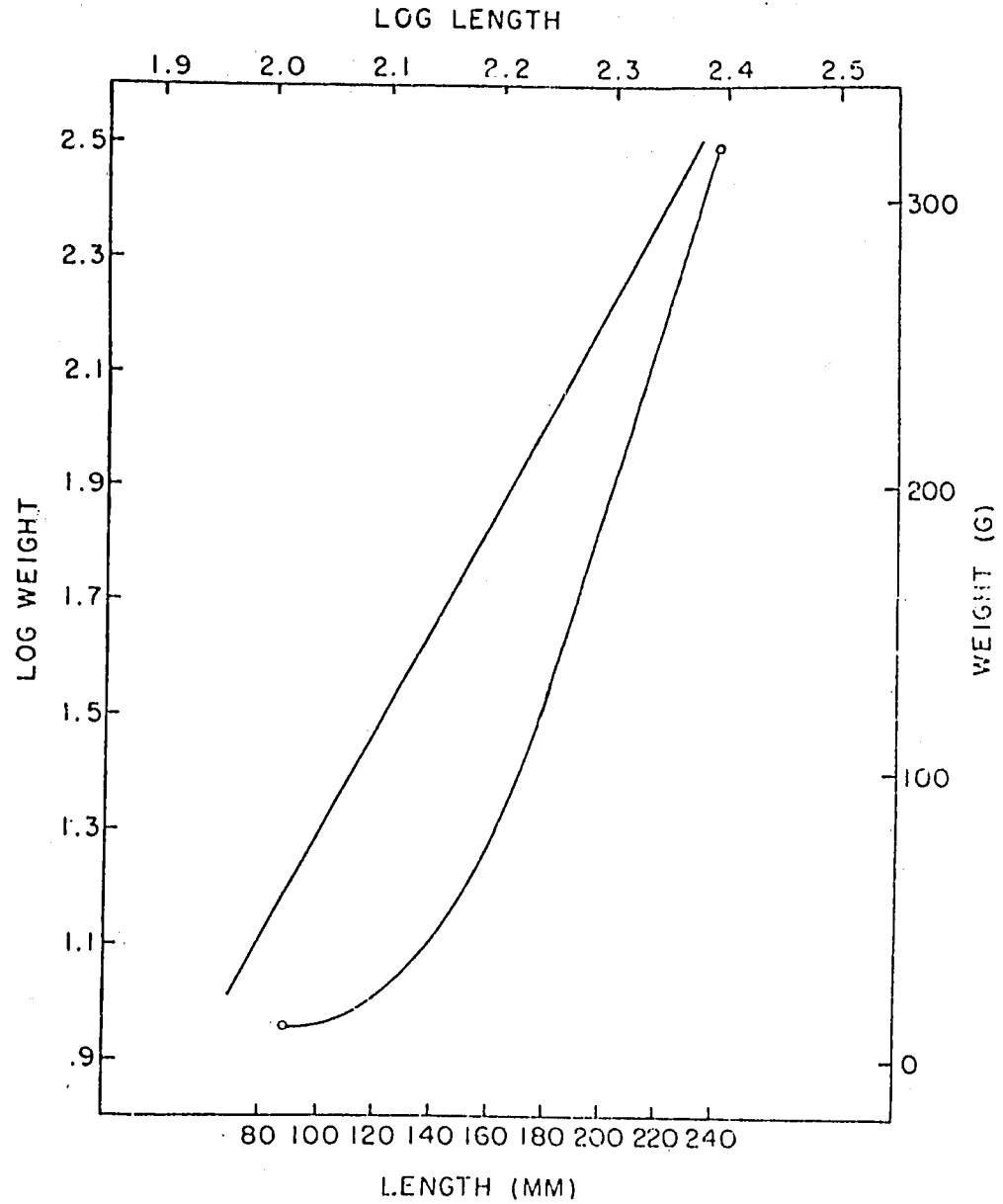


Figure 3. . Length - weight relationships of the combined population of 536 specimens of *Macrobrachium americanum* Bate (range 88 - 233 mm) are presented using the following equations: $\text{Log } W = -6.1216 + 3.6353 \text{ Log } L$ (linear), and $W = 139.5919 - 2.6688 L_1 + .0143 L_1^2$ (curvilinear).