

Reproduction, distribution and abundance of *Bothus constellatus* (Pisces: Bothidae), in the Gulf of Tehuantepec, Mexico

M. Tapia-García, M. C. García-Abad and G. Cerdaneres Ladrón de Guevara

Departamento de Hidrobiología, D. C. B. S. Universidad Autónoma Metropolitana-Iztapalapa Apartado Postal 55-535, México 09340, D. F. Fax 57244738; mtg@xanum.uam.mx

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Abstract: A total of 3 593 individuals of *Bothus constellatus* was captured during five oceanographic cruises carried out in the Gulf of Tehuantepec, Mexico. Its distribution, abundance, and reproduction patterns were stated by means of the analysis of the population parameters (*i.e.* density, biomass, weight and size average, visceral and gonadosomatic index, and maturity stages). *B. constellatus* is a typical demersal marine species, because it does not occur in estuaries, but occurs near to them on the continental shelf. It is distributed in the Gulf of Tehuantepec in depths lesser than 60 m, with high abundance around the 40 m isobath, and in front of Mar Muerto Lagoon. During January and May the biomass and density were high. The size at first maturity of females is 101 mm total length, and maturation occurs first in zones influenced by estuarine processes. Reproduction and recruitment were detected in all the collections.

Key words: *Bothus constellatus*, Chiapas, Oaxaca, demersal, fish ecology, fish reproduction, Gulf of Tehuantepec, Mexico.

At present, the understanding of the ecology of demersal tropical communities and the evaluation of their fishing potential is based upon the biological and ecological knowledge of the dominant species, in relation to their biology and ecology (Pauly 1982, Yáñez-Arancibia and Sánchez-Gil 1988). This is because the ecological strategies are closely adapted to the system dynamics. Then, the ecological success of dominant species is reflected in their great abundance and broad distribution, which determine the important ecological role that the dominant species have in the flow of matter and energy. In the Gulf of Tehuantepec, more than 170 fish species have been recorded (Tapia-García *et al.* 1994, Tapia-García 1998). Twenty of these are dominant, because they have broad

distribution, great abundance and high frequency in the catches, and *B. constellatus* is one of these species (Tapia-García 1998). Therefore, its study and analysis are of great importance in the ecological understanding of the system dynamics.

B. constellatus is a demersal species distributed in the tropical and subtropical Eastern Pacific (Hensley 1995), and does not exist information about its biology and ecology. The studies more related to this species have been about new species of *Bothus* genus (Hensley 1997), and larvae (Yevseyenko 1976, Evseenko 1978). One study exists about reproductive behavior of *B. ocellatus*, *B. lunatus* and *B. ellipticus* (Konstantinou and Shen 1995).

The main objectives of this study were: to determinate the distribution and abundance of *B. constellatus* to define probable patterns of

variation in space and time, and to characterize the reproduction, spawning and recruitment.

MATERIAL AND METHODS

The continental shelf of the Gulf of Tehuantepec is located in the southern Mexican Pacific, between the Huatulco Bays, Oaxaca, and the Suchiate River, Chiapas (Fig. 1). The collections were made during five oceanographic cruises in January, May and November of 1989, and March and August of 1990. The collections of January, May, November and August, were made with the "El Puma" vessel, and the collection of March with the "Don Nachito" boat. A total of 86

collections were made from 15 to 80 m of depth (Fig. 1), with commercial shrimp trawl nets (12 and 9 m mouth footrope, mesh size 4.45 cm) at an average of 3 knots during 30 minutes. The trawled area, fish catches and data were processed according to criteria discussed by Stevenson (1982), and Sánchez-Gil and Yáñez-Arancibia (1985).

The individuals were measured total length (mm), weighed (g) (wet weight) with and without viscera, and sexed. The population parameters of density (individuals/m²) and biomass (g/m²) were determined per station and cruise; average length and average weight were determined per cruise; visceral and gonadosomatic index were determined per sex and cruise. Although the data correspond to

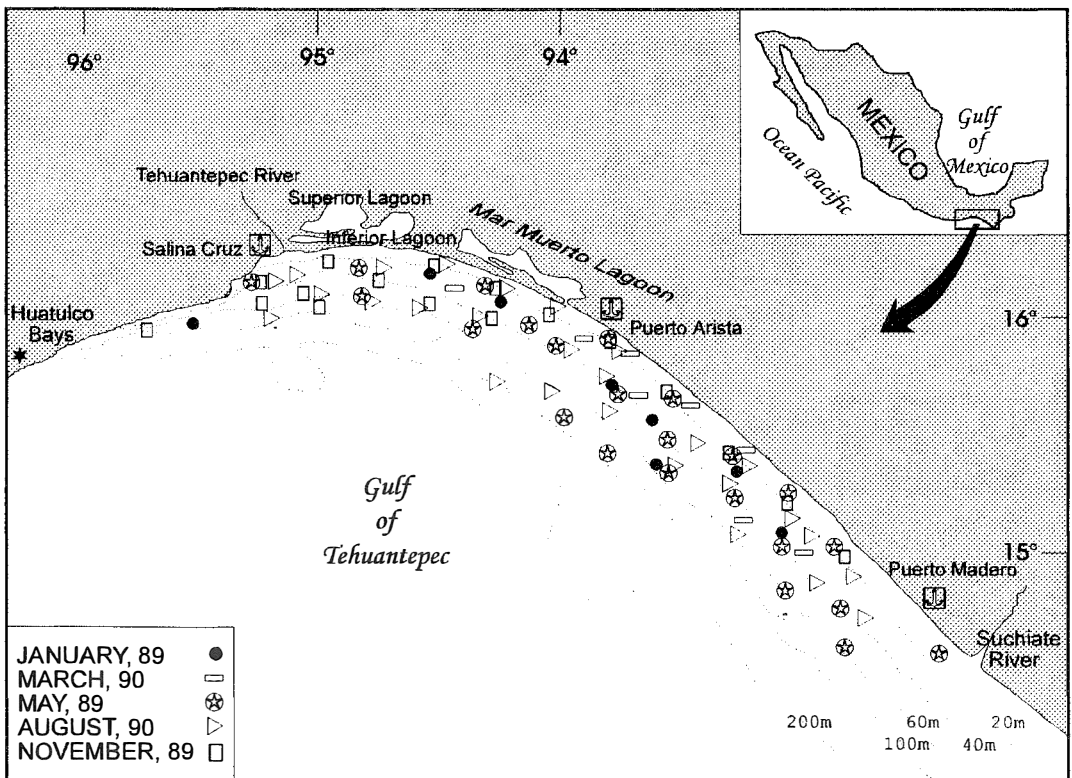


Fig. 1. Study area. The collect stations are showed in relation to the oceanographic cruises.

different years, they were ordered in an annual period to assume the variations during a year.

Gonad maturity: It was determined according to the key presented by Laevastu (1971). Stage I = immature, sexually indeterminate individuals; II = immature, sexually determinate individuals; III = in maturing; IV = mature; V = reproduction; VI = spent; VII = resting.

Size at first maturity: It was determined as the midpoint between the length of the largest immature individual (II) and the length of the smallest maturing individual (III) (Tapia-García *et al.* 1995).

Gonadosomatic index (GSI): It was evaluated according to Cailliet *et al.* (1986):

$$GSI = B/W$$

where W is the wet weight of the fish, and B is the wet weight of both gonads.

Visceral index (VI): It was evaluated with the next equation:

$$VI = V/W$$

where W is the weight of the fish, and V is the weight of the viscera.

TABLE 1

Total abundance and lengths of B. constellatus by oceanographic cruise

Cruise	Number (ind.)	Wet Weight (g)	Total Length (mm)
January, 1989	209	6 728.1	64-157
March, 1990	3 171	57 892.5	61-149
May, 1989	247	4 504.2	51-155
August, 1990	291	4 974.6	69-147
November, 1989	310	5 341.7	62-150
TOTAL CATCH	4 228	79 441.1	51-157

RESULTS

Distribution and abundance: A total of 4 228 individuals of *B. constellatus* were captured, with a total weight of 79 441.1 g, and a size range of 51 to 157 mm total length (Table 1). This species was widely distributed in depths lesser than 60 m on sand and sandy-muddy sediments. Greatest density (0.0012 to 0.0068 ind./m²), and biomass (0.0293 to 0.907 g/m²) occurred around the 40 m isobath in the northern Gulf, mainly in front of Mar Muerto Lagoon during January, March and November (Figs. 2a, 2b). The monthly density pattern

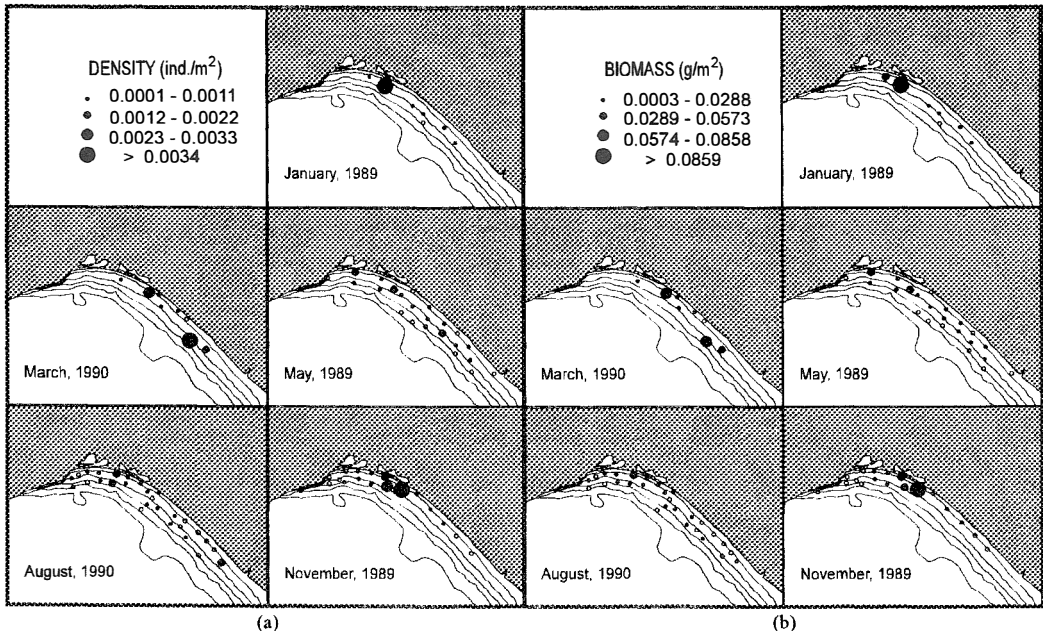


Fig. 2. a) Spatial distribution of the density. b) Spatial distribution of the biomass in the Gulf of Tehuantepec. Empty circles mean that the species was not found in these stations.

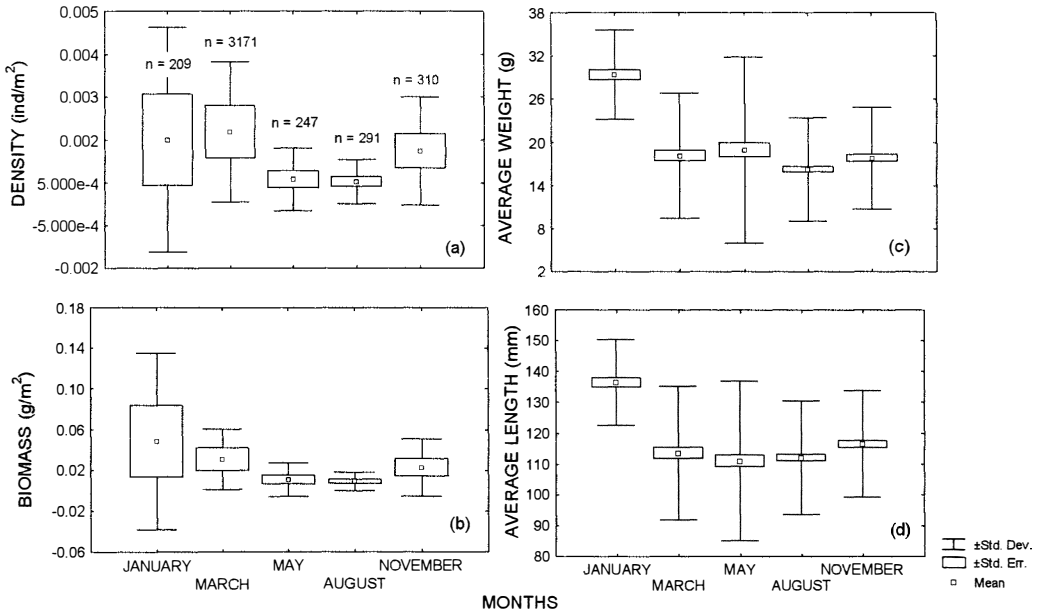


Fig. 3. Average variation of the population parameters. a) Density. b) Biomass. c) Weight. d) Length.

showed a high concentration of individuals during January and March ($\bar{x} = 0.0015$ and 0.0017 ind./m² respectively), while the minimum value was during August ($\bar{x} = 0.0005$ ind./m²) (standard deviation and "n" are showed in fig. 3). The biomass pattern was similar to the density with the highest biomass during January ($\bar{x} = 0.048$ g/m²), and the lowest during August ($\bar{x} = 0.009$ g/m²) (Fig. 3b). During January a high number of individuals with the highest weight ($\bar{x} = 29.5$ g) and length ($\bar{x} = 136$ mm) were observed, while during the other months these parameters decreased. The individuals with the lowest weight and size were in May (Figs. 3c, 3d). The analysis of the spatial length distribution indicates that the largest individuals were in front of the main estuarine systems of the zone, and the smallest individuals occurred towards the southeastern of the Gulf. The length frequencies were multimodal, except in January (Fig. 4), these were according with the great variation of the weight and length of the individuals during March, May, August and November (Figs. 3c, 3d).

Reproductive biology: In the collections the female: male ratio was near to 1:1, and only the sexually indeterminate individuals (juveniles) were a small fraction (<5%) (Fig. 5). The individuals had a spatial tendency to distribute by sexes.

The gonadosomatic index pattern was similar in both sexes. A maximum average was observed in January (0.029 and 0.004, females and males respectively), and the lowest average values were in March and August (Figs. 6a, 6b).

The visceral index pattern was also similar in both sexes, with the maximum average in May and November, and the minimum averages in January and August (Figs. 6c, 6d). For the females the maximum variations were between May and August, and the minimum variations were between January and March. For the males, the maximum variation was in May and the minimum in January.

Maturity stages analysis showed in January one evident group of adult organisms

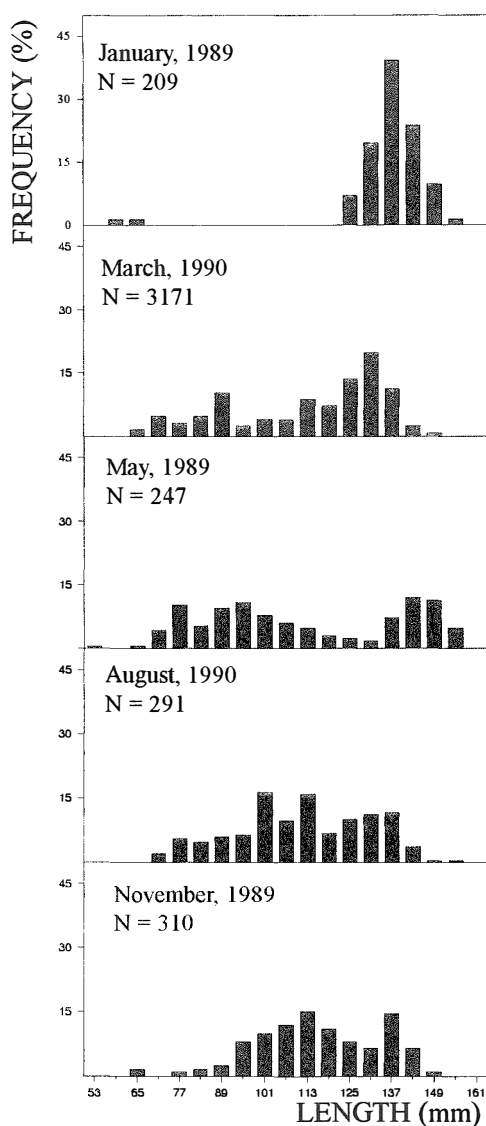


Fig. 4. Length frequencies of *B. constellatus* for each month.

in a maturing process, and some young individuals that have not yet engaged in reproduction. During the other months all maturity stages were observed (Fig. 7).

The size at first maturity of *B. constellatus* is 101 mm because the largest immature individual (II) was 122 mm of total length (November) and the smallest in maturing (III)

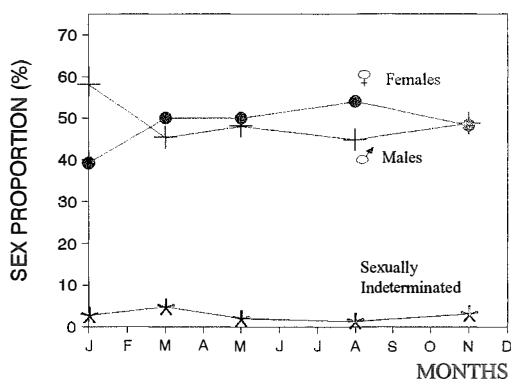


Fig. 5. Sex proportion of *B. constellatus*.

was 80 mm (May) (Fig. 7). An analysis of spatial distribution of maturity stages of individuals showed that mature individuals were mainly in front of the Mar Muerto Lagoon.

DISCUSSION

Distribution and abundance: *B. constellatus* has been considered as a dominant species in the Gulf of Tehuantepec because it had a wide distribution, high abundance (biomass and density), and high frequency of occurrence (Tapia-García *et al.* 1994). This species was one of the 20 species that represented more than 80% of relative abundance (number and weight) in each analyzed month, among a total of 170 species. The highest abundance was around the 40 m isobath and towards the northern Gulf. *B. constellatus* is a typical marine species, which has not been reported in estuarine systems.

B. constellatus occurred in depths of less than 60 m on sandy and sandy-muddy sediments, according to the report of distribution of sediments (Carranza-Edwards *et al.* 1989). This pattern is similar to the report of Amezcua-Linares (1996). *Syacium ovale* also has a similar distribution in the Mexican Central Pacific (Barba-Torres 1990). This pattern also has been observed in *S. gunteri* in the Gulf of Mexico, which is most abundant in

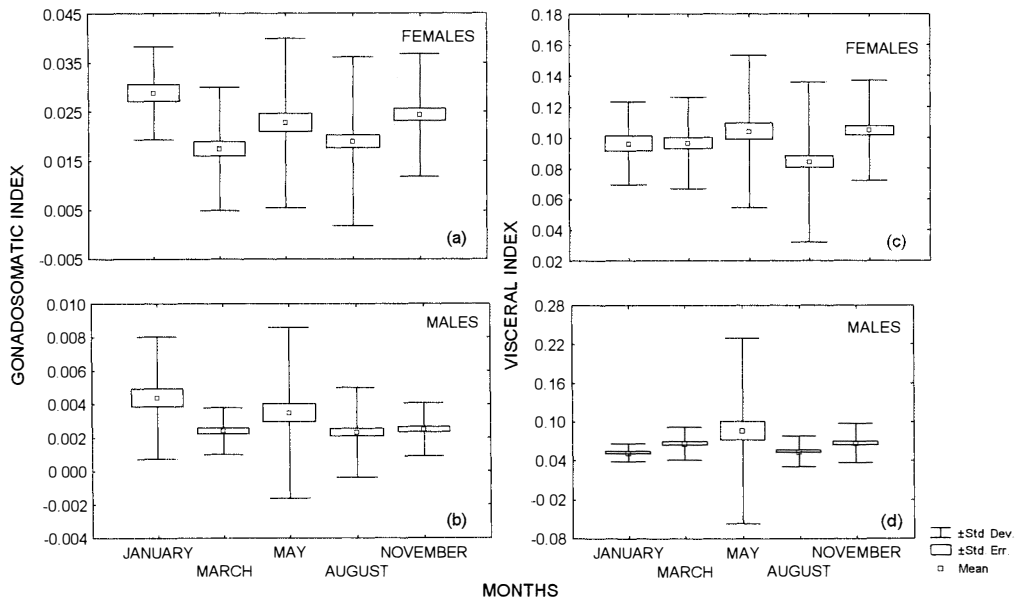


Fig. 6. Variation of the visceral and gonadosomatic index for females and males.

muddy-silty sediments, between the 18 and 36 m isobath, in areas influenced by estuarine processes (García-Abad *et al.* 1992, Sánchez-Gil *et al.* 1994).

The biomass of *B. constellatus* was high in January, which is attributed mainly to the presence of abundant adult fish (average 136 mm total length) (Figs. 3b, 3d, 4). From March to November the biomass values result mainly from the great abundance of juveniles, which is probably associated to a long recruitment period of juveniles to the adult population, although also there is recruitment during the other months, but with less intensity. The juveniles observed in these months are being recruited completely to the adult population in November, which is reflected in a lightly increase of the density and the biomass.

The size frequencies also show the modal progression as a result of growth and recruitment. The multimodal distribution shows a wide period of reproduction and recruitment. The maximum size was 157 mm, and Amezcua-Linares (1996) reported a maximum size of 145 in the Mexican Central Pacific.

Reproductive biology: The female:male ratio was practically 1:1 throughout the study period and this could indicate a synchronous maturation between both sexes. The presence of sexually indeterminate individuals (juveniles) during all the months suggests a continuous recruitment and a large reproductive period. Also, a period of less reproductive activity can be supposed from November to February. This period could be associated with oceanographic changes in the system, which are caused by the presence of the north winds during this time (Monreal Gómez and Salas de León 1998, Gallegos García and Barberán Falcón 1998).

The constant presence of sexually indeterminate fish (I), immature (II), in maturing (III), mature (IV), and in reproduction (V), suggests that the reproduction occur throughout the year. The analysis of the gonadosomatic index in females and males shows two peaks in January and May. This would indicate high spawning during these months. Although in May also there were individuals with low gonadosomatic and visceral index, the

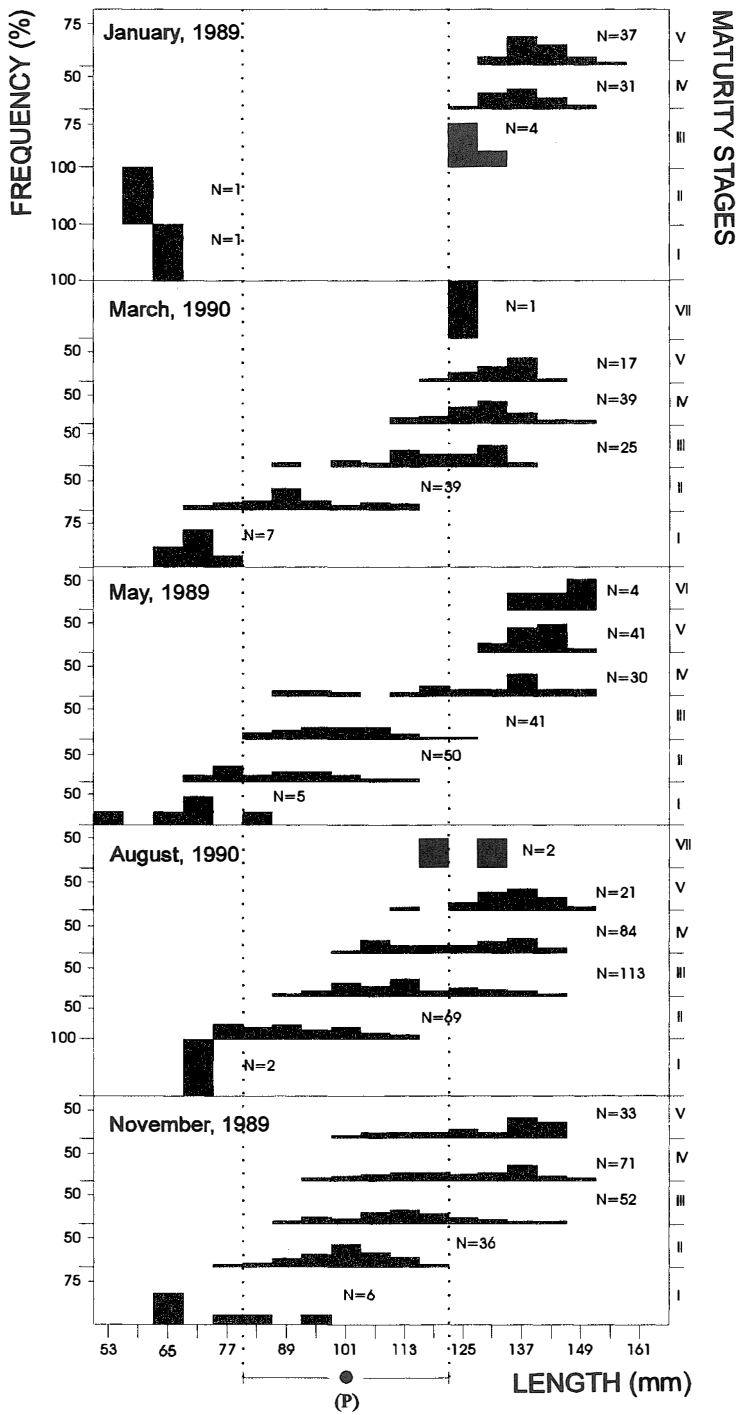


Fig. 7. Size frequencies of *B. constellatus*, and their relation to the gonad maturity for each month studied size of first maturity (P).

presence of two groups was evident. This behavior is characteristic of tropical fish, which show a constant recruitment of juveniles, short cycles of life, and reproduction during all the year. *B. constellatus* probably lives around a year, because it shows patterns of distribution and reproduction like other bothids. *S. gunteri* is reported with a cycle of life around one year (García-Abad *et al.* 1992, Sánchez-Gil *et al.* 1994) and *S. ovale* also presents fast growth (Barba-Torres 1990).

The size at first maturity was 101 mm TL. Other species of bothids have a size at first maturity similar to *B. constellatus*; as *S. papillosum* (101 mm) and *S. gunteri* (106 mm) in the Gulf of Mexico, and *S. ovale* (95 mm) in the Mexican Central Pacific (Toop y Hoof 1972, Barba-Torres 1990, García-Abad *et al.* 1992). The individuals distributed in front of Mar Muerto Lagoon, matured first. This suggests the importance of estuaries on the fish, because these zones are highly productive and therefore guarantee a food source for the fish, as a nursery habitat.

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