GROWTH AND REPRODUCTION OF THE TROPICAL BEACH CLAM *DONAX DENTICULATUS* (TELLINIDAE) IN EASTERN VENEZUELA

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ABSTRACT

Growth and production of a population of the tropical clam *Donax denticulatus,* and important Venezuelan fishery resource, were studied for 24 months. Growth rates were 4,22 mm per month during the first 2-3 months post recruitment, 1 mm during the next 4 months and negligible thereafter. Mean maximal total length was 19 mm. Daily production ranged from 31-466 mg per m^2 with standing dry weight biomasses of 4 to 40 g per m^2. P/B ratios ranged from 0.005 to 0.016 per day. Daily production rates were used to calculate annual production of 37.6 g (181 kcal) and 77.4 g (372 kcal) m^{-2}, respectively, for 1974-75 and 1975-76.

INTRODUCTION

Velez (1985) reported on the annual reproductive cycle, pattern of gematogenesis and sex ratio in a commercially important population of the tropical beach clam *Donax denticulatus* in Venezuela. Here we present the results of a growth and production study of the population. Despite the value of *D. denticulatus* as a fisheries resource and its apparent importance to infauna ecology throughout the Caribbean, the published information on its population biology is limited to Jamaican populations (Wade 1967, 1968; Trueman 1971; Ansell and Trueman 1973). To make management decisions for *D. denticulatus* it is essential to have comparative data on the relations among population structure, reproductive cycles and production from throughout its range.

Our objective in the present study was to provide a more complete picture of the population biology of *D. denticulatus* in different parts of its distribution in the Caribbean. Specifically, we designed the study to describe individual growth, population density, age structure and biomass production of a Venezuelan population.

MATERIALS AND METHODS

Thirty samples were collected every 2-4 weeks from June 1974 to June 1976 from a beach on the Araya Peninsula in the state of Sucre in eastern Venezuela. The beach habitat was nearly homogeneous and sampled along four 2 m transects with a dredge 10 cm deep and 5 cm wide. Based on reported

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dispersion patterns for *D. denticulatus (Rodriguez 1959;* Wade 1967), the transects were located perpendicular to the beach line from the breakwaters to the upper limit of the humid zone at 100 m intervals.

Material from each sample was passed through a series of four screens of 5.0, 2.0, 1.0 and 0.5 mm mesh size. Individuals retained by the first two screens were counted directly. Those retained by the two finer screens were counted by aliquot subsamples. Identification and enumeration of small juveniles was aided by subsample treatment with Rhodamine B and observation under a dissecting microscope. Growth, density, standing biomass and production at the site were estimated by pooling data from the four transects on a given date. Length-frequency histograms were used to estimated growth. Cohorts were distinguished in the histograms with the method of Cassie (1954).

Increases in cohort mean length were used to construct a Walford (1946) growth curve, from which coefficients were estimated for the von Bertalanffy (1938) equation

$$L_t = L_\infty \, [1 - e^{-K(t-t_o)}] \quad (1)$$

where L_t = length at time t

L_∞ = theoretical maximum length form Walford curve

K = growth constant from the Walford curve

$$t_o = t + \frac{1}{k} \ln \frac{(L_\infty - L_t)}{(L_\infty)}$$

The length-weight relation was described by

$$W = aL^b$$

where W = dry weight in grams

L = total length in mm

Because individual cohorts were not always identifiable, biomass and production were estimated using the method described by Winberg (1971) for daily estimates of biomass and production in populations with continuous reproduction.

RESULTS

There was a similar reproductive pattern in both years, suggesting that the reproductive cycle was stable in the population. Recruits, juveniles less than 4 mm total length, appeared continuously, but were most abundant between July and December (Fig. 1 in Velez, in press). Length-frequency histograms for juveniles and adults (≧ 4 mm total length) are presented in Fig. 1. A distinct juvenile cohort (modal length = 8-9 mm) can be identified in June 1974 and clearly followed to adulthood in the subsequent histograms for that year (Fig. 1). August-September recruits first became noticeable in the juvenile size classes of the October-December 1974 histograms. By January 1975, September 1974 recruits had become the dominant cohort in the population. Its decline by November 1975-February 1976 suggest a life expectancy of 13-16 months. Individual cohorts were less distinct in 1975-76 than in 1974-75. In general, histograms from both years demonstrated a dominance of juveniles from January through July and a dominance of adults from August through December.

Population densities were similar in all four transects and were therefore combined to estimate total population density (Fig. 2). Density ranged over approximately one order of magnitude during the 2 years, from 212 to 2435 individuals per m^2. Populations density of individuals ≧ 4 mm increased markedly from March to July principally from growth of recruits during November to December (Fig. 1). Mortality resulted in density decrease of individuals ≧ 4 mm from August to November.

Age and growth were estimated using Cassie's (1954) method where displacement of the mean (± 1SD) length of the dominant cohort is followed through time, beginning in June 1975 (Fig. 1). The mean lengths of the cohort were replotted as a Walford (1946) growth curve in Fig. 3. The von Bertalanffy growth equation coefficients K and L_∞ were then calculated from the slope and 45° intercept of the curve. The coefficient to was calculated on the assumption that 1 month-old clams have a minimum total length of 5.0 mm. The von Bertalanffy equation

$$L_t = 18.5 [1 - e^{-0.43(t+0.058)}] \quad (3)$$

where L_t is length in mm at time t in months and t_o is the theoretical age when the mean clam had zero length (Fig. 4a). The equation, however, does not account for larval development which may require 1 month.

To determine if there were season-specific effects on the relation between length and body weight (excluding the shell), regression equations representing the four quarters of the year were compared. Because no season-specific differences were detected, a single length-weight equation

$$W = 0.016L^{2.68} \quad (4)$$

was used to convert length data to weight for estimates of biomass production. W is expressed by shell-free dry body weight in mg and total length, L, as mm. The weight curve for a typical clam is in Fig. 4b.

The rate of increase in total length was relatively high (4.2 mm per month) during the first 2-3 month post recruitment. The rate decreased to 1 mm per month during the next 4 months and appeared to be negligible after 7 months (Fig. 4a). The mean maximum length did not exceed 19 mm (Figs. 1 and 3), the length calculated for 1-year old clams (Fig. 5a).

Daily production estimates were made for each sampling date and then integrated for an estimate of annual production because cohorts were distinct only for the first year. Curves showing variation in daily biomass and production activities during the 2 years are given in Fig. 5 a, b. Daily production increased from December to August, then decreased to November with rates varying from 31 to 466 mg per m^2 (Fig. 5a). Biomass ranged from 4 to ca. 40 g per m^2 (Fig. 5b). The ratio of daily production to biomass (P/B = "specific production") increased in December-January to ca. 0.016, then decreased to 0.005 in October-November (Fig. 5c), reflecting a shift from population dominance by fast. growing juveniles to dominance by slow growing adults.

Integration of daily production over both years gives annual production estimates of 37.6 and 77.4 g per m^2 for 1974-75 and 1975-76, respectively. Using the caloric equivalent of 4.8 kcal per g determined in our laboratory, the annual production was 181 and 372 kcal per m^2, respectively.

Discussion

Since production and biomass data for other populations of *D. denticulatus* are lacking, comparison is not possible. However, population dynamics were similar to Jamaican populations (Wade 1967-1968; Trueman 1971; Ansell and Trueman 1973) and accord with reproductive patterns reported by Velez (in press).

The delay in appearance of juveniles from the December recruits until April-May during both years is similar to that reported by Wade (1968) for Jamaican *D. denticulatus*. Explanation of the delay in juvenile recruitment is difficult. The April-May peak may have resulted from an unusually high survivorship of post-larvae during January-March. Or, the juveniles appearing in February-March and those in April-May may represent fast and slow growing morphs from the same cohort. Dimorphic growth rates have been reported for other tropical species (Moore and Lopez 1970; Velez 1976).

Annual production by *D. denticulatus* is high among marine bivalves. It is exceeded only by oysters (Humphreys 1979) which occupy a three-dimensional habitat to a greater extent than does *D. denticulatus*. The P/B ratio which ranged from 0.005 to 0.018 was directly related to dominance of the population by young, rapidly growing individuals with high growth efficiencies, and was expected for an organism with the longevity and average weight of *D. denticulatus* (Zaika 1973).

Additional studies of *D. denticulatus* are necessary to provide information on geographic and among-year variation in density, growth and production, and the effect of exploitation. At this time sufficient data are not available for long-term fishery management decisions. Specifically, a stock-recruitment assessment would did aid in determining the susceptibility of the population to over-exploitation. However, based on the results of this and a preceding study (Velez, in press), we believe that population stability could be sensitive to fishery exploitation of commercial-size individuals during peak reproduction, Thus, we recommend that fishing should be limited to November-April in Venezuela.

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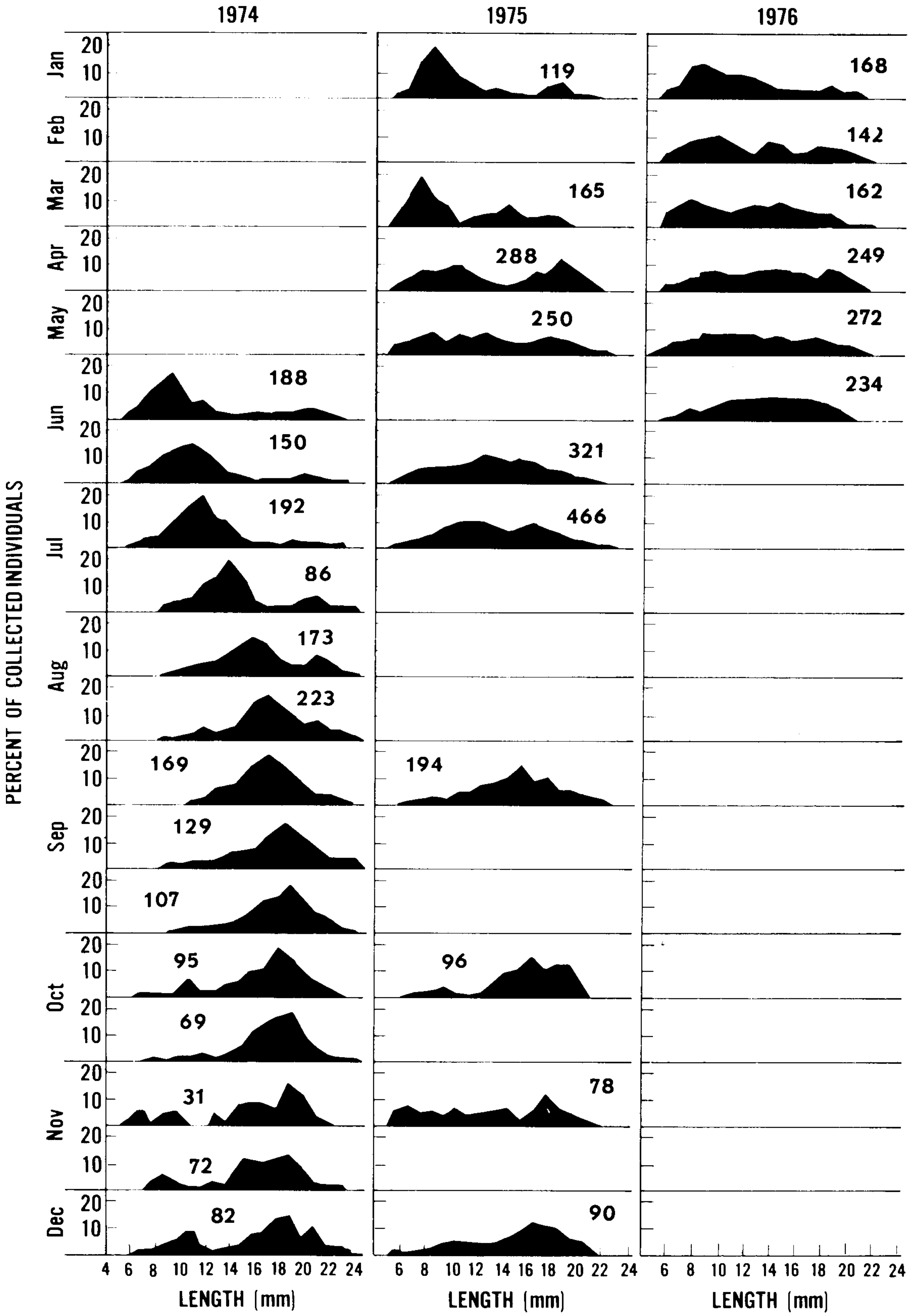

FIGURE 1. – Length-Frequency Histograms for *D. denticulatus* 1974-76 from samples taken every 2 weeks during the first year and monthly thereafter. Numbers above histograms are sample sizes. Absence of histograms indicate no data collected.

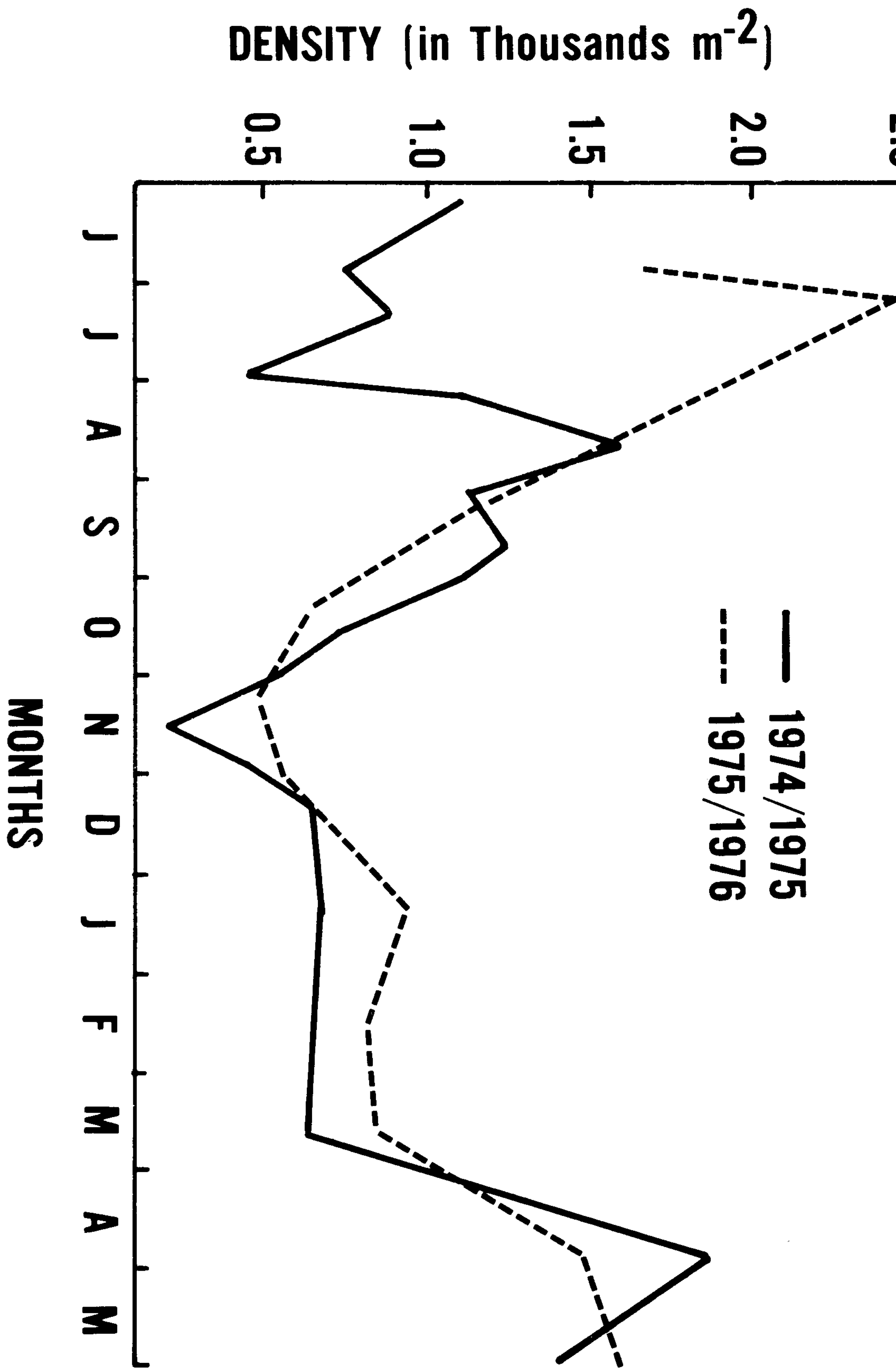

FIGURE 2.—Seasonal population density of *D. denticulatus* 1974-76.

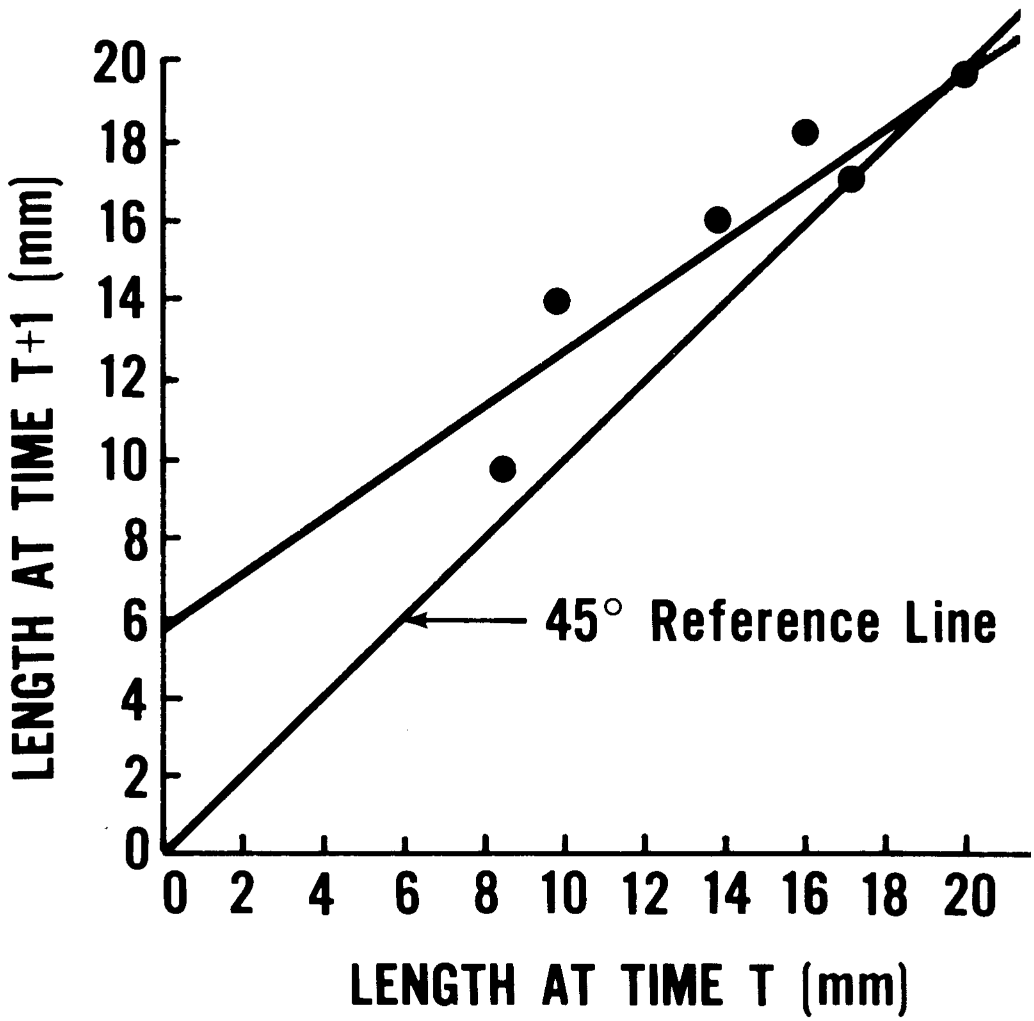

FIGURE 3. – Walford growth plot for *D. denticulatus*.

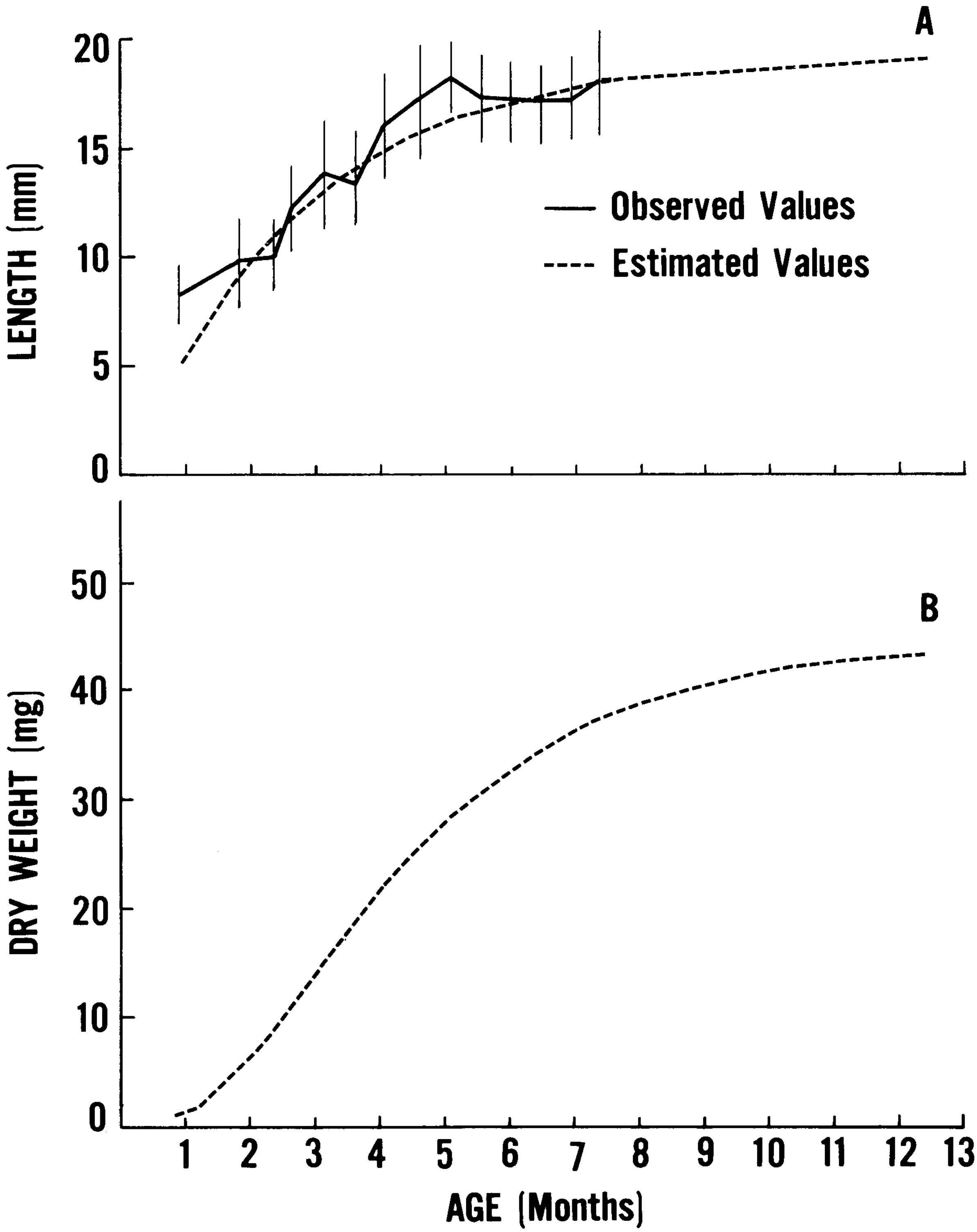

FIGURE 4. – Growth curves for *D. denticulatus*. A. Estimated values based on the von Bertalanffy equation. Observed values (+ 2 S.D.) based on size-frequency histograms presented in Fig. 2 B. Dry weight growth curve obtained by applying a length-weight equation to lengths predicted by the von Bertalanffy equation.

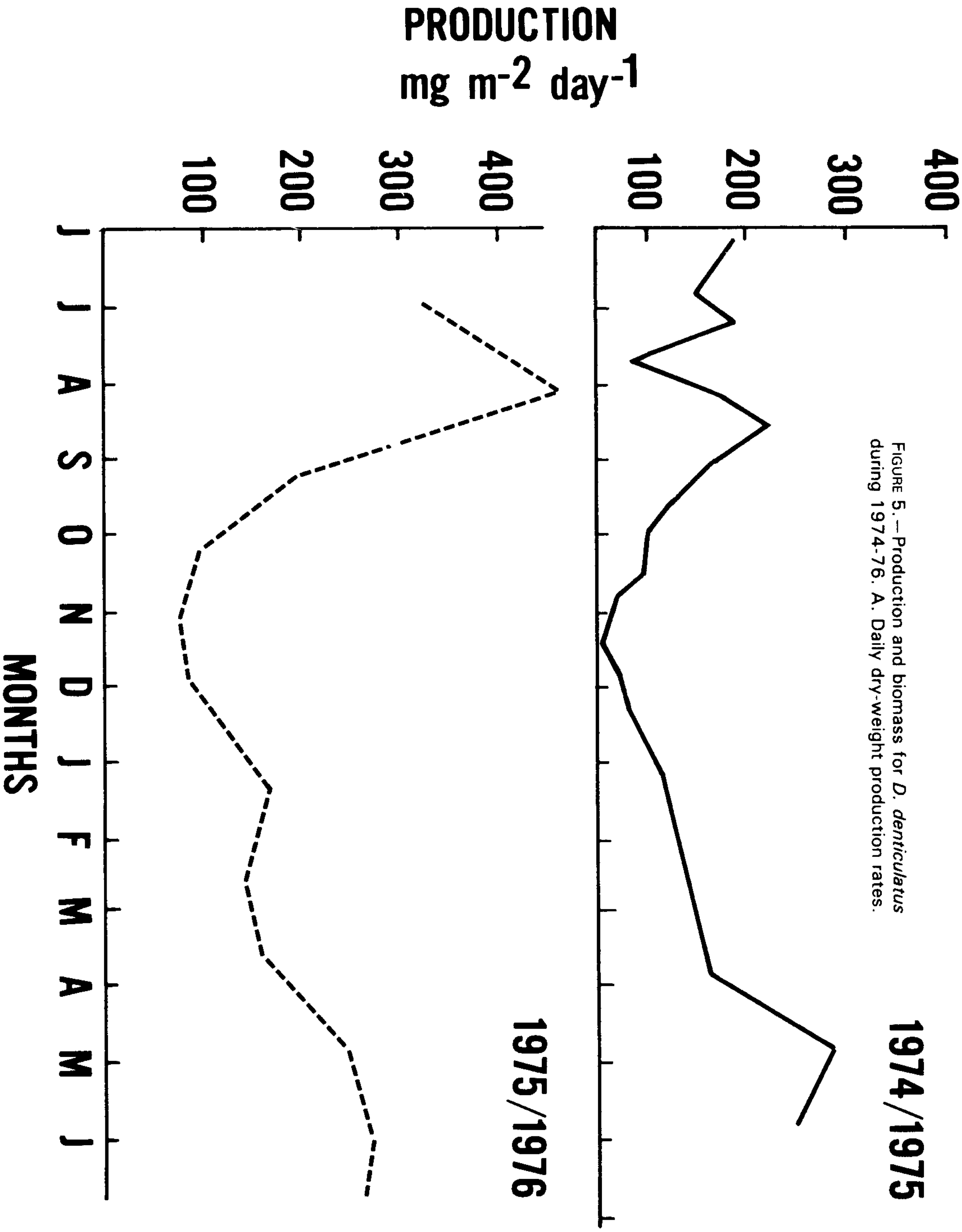

FIGURE 5.—Production and biomass for *D. denticulatus* during 1974-76. A. Daily dry-weight production rates.

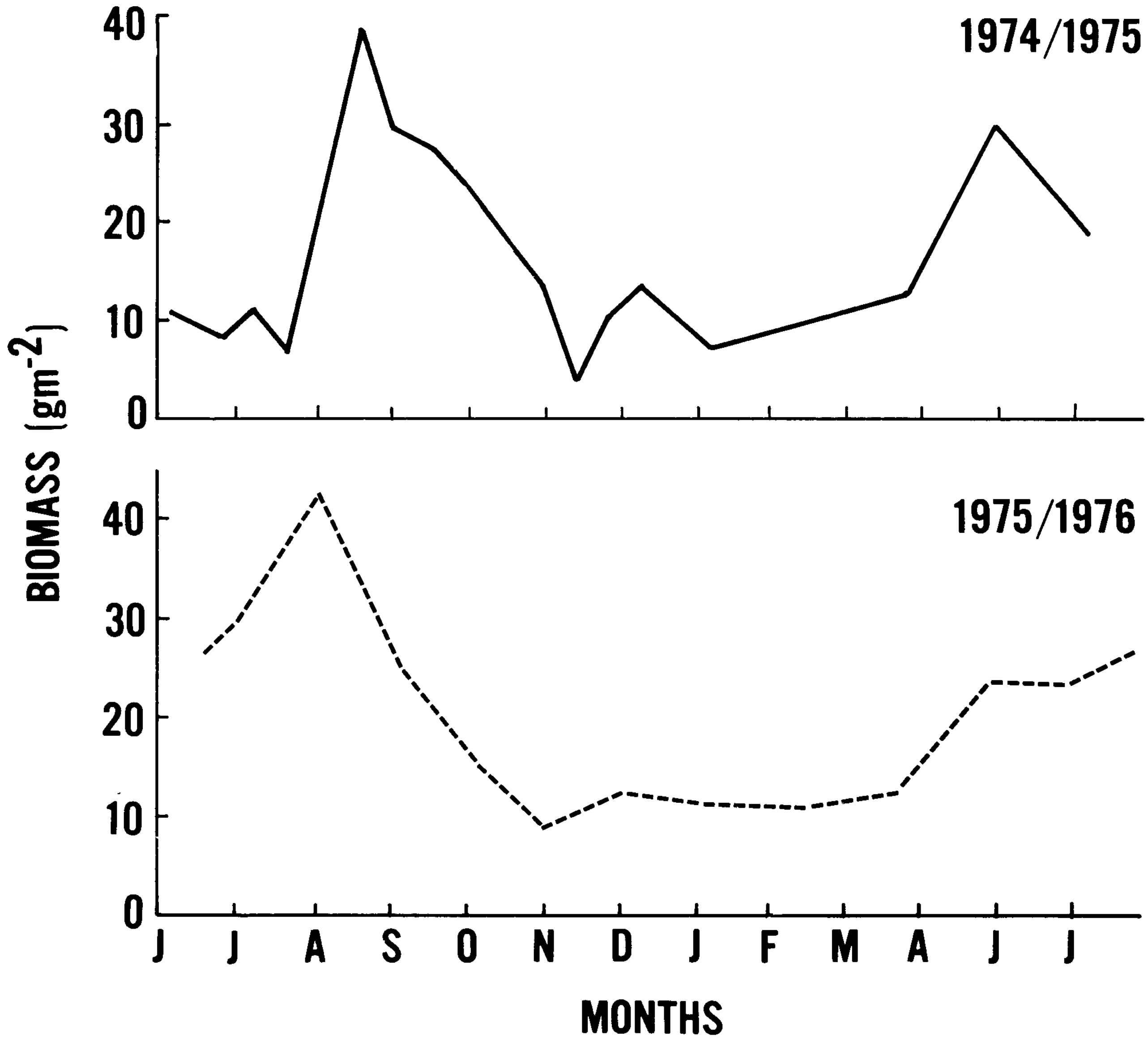

FIGURE 5. – B. Seasonal dry weight biomass densities.

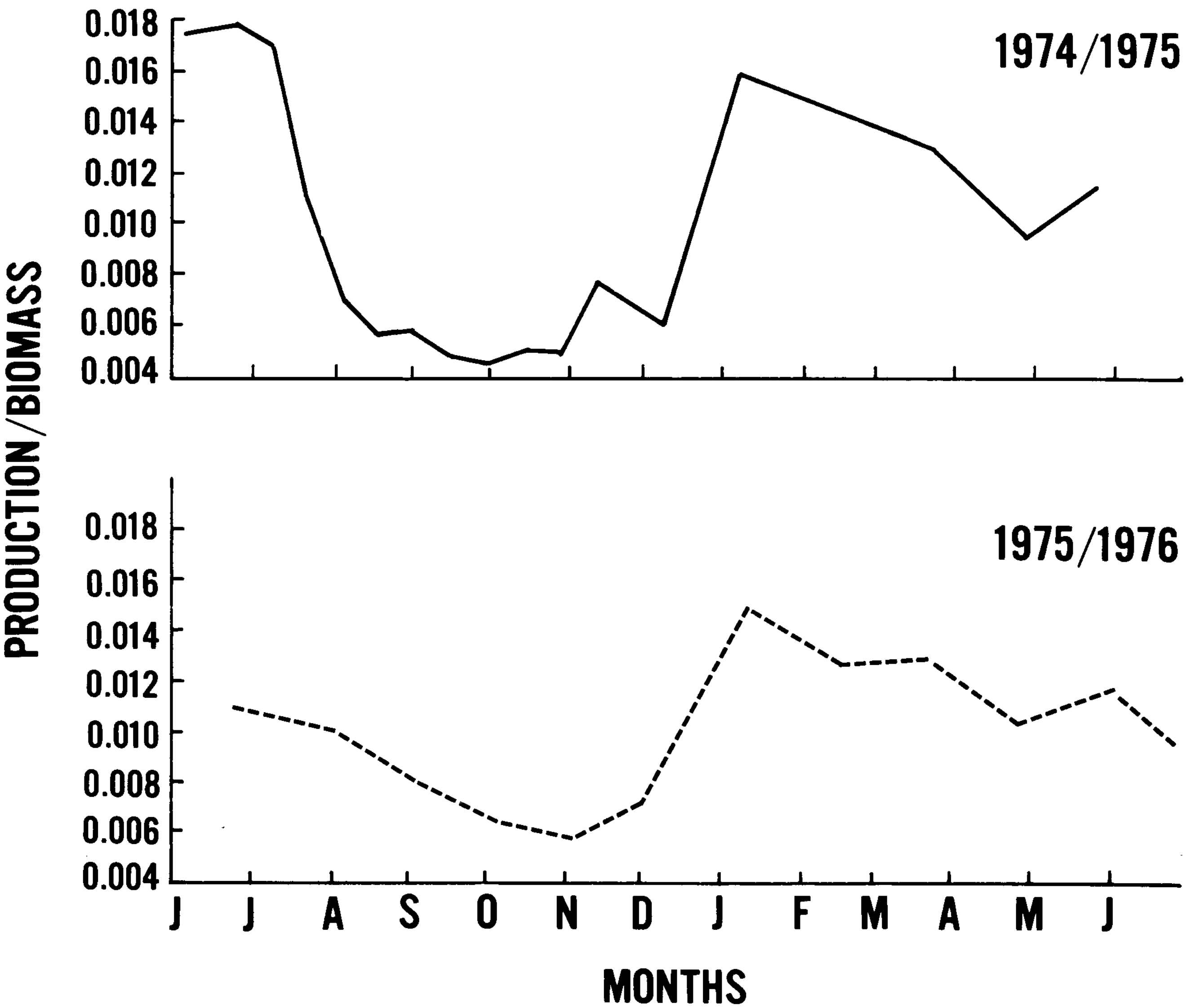

FIGURE 5. – C. Weight-specific dry-weight production.