

Secondary Production of the Cladoceran *Simocephalus vetulus* in a Temporary Pool at Basrah, Iraq

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Abstract

Zooplankton samples were collected at three-day intervals from 15 December 1996 to 6 March 1997 from a pool at the University campus in Garmat-Ali, Basrah, using a 0.090 mm mesh net. There was a close relationship between daily population biomass, daily population production and temperature. Daily biomass of the population ranged from 4.8 mg/d/m³ to 75.8 mg/d/m³. Daily population production ranged from 0 – 16.6 mg dw/d/m³. Secondary productivity of *S. vetulus* ranged between 38.6 and 231.2 mg/m³/month during March and February, respectively. Biomass ranged between 54.3 mg/m³ during December and 150.9 mg/m³ during February. The daily growth rates of *S. vetulus* ranged from 0.0017 mg/d for generation F to 0.0025 mg/d for generation A.

Key words: Secondary production, Cladocera, *Simocephalus vetulus*, Basrah, Iraq.

Introduction

ZOOPLANKTON ARE AN IMPORTANT COMPONENT of food webs in aquatic ecosystems throughout the world, channeling energy and nutrients from algae and bacteria to fish. Because they are highly productive and important in fish diets, an improved understanding of zooplankton production and growth can be applied to increase fish production in aquacultural facilities and in the wild.

Secondary production may be defined as rate of energy storage at consumer trophic levels (Odum, 1971), or rate of production or rate of elaboration of living matter through the interaction between the organism and the space where it lives (Wheaton, 1979), or the amount of living matter elaborated per unit area per unit time (Downing, 1984). Therefore, the organism's success in an environment might be a function of its ability to fix and retain energy (Lindeman, 1942). Moreover, secondary production is not a distinct entity by itself; rather it is part of a larger scheme of the movement of material through the ecosystem, and this is based on the activities of individuals and populations of animals (Edmondson, 1974).

Furthermore, it is one of the most important components of the energy budget. There has been an increasing interest in estimating secondary production for certain macroinvertebrates in Basrah, particularly crustaceans and molluscs (e.g. Luka, 1982; Rabie, 1986; Ali & Salman, 1987; Sultan, 1987; Abdul-Sahib *et al.*, 1995; Abdullah, 1996; Soud, 1997; Hamzah, 1997; Abdul-Sahib, 1997 and Ali & Salman, 1998). However, the production of many smaller zooplanktonic species have not been considered, although they have an important ecological role in their habitats, and are very abundant and diversified (Salman *et al.* 1990; Ajeel, 1998).

Cladocera are of a special interest in this region, in that they are an important component of aquatic systems of the region and are reportedly one of the most productive groups among the zooplankton (Salman, *et al.*, 1986; Wetzel, 1983).

The present article is one of a series of articles on the energetics of *Simocephalus vetulus*, the first of which was concerned with the population dynamics of the present species (Ajeel *et al.*, 2000) and the rest are in the process of publication. It was found that *S. vetulus* is highly abundant in temporary pool systems at Basrah (Ajeel *et al.*, 2000) ranging in density from 2700 ind./m³ in 5 January 1997 to 26,700 ind./m³ in 16 February of the same year. Six generations were identified in the period 15 December 1996 – 6 March 1997. The life span of one of the generations was about 72 days.

The aim of the present article is therefore to calculate the secondary production of *S. vetulus* in a temporary pool at Basrah, a work that has not been done here before. The data on secondary production together with data on the rest of the components of the energy budget are essential to understanding the role of the species in this region, and such information is the basis for interpreting predator-prey relations in these temporary pools.

Materials and Methods

Monthly samples were collected from a pool (90×70×0.5m) located at the Basrah University campus in Garmat-Ali for the period December 1995 to December 1996 to survey the zooplankton in the region. *S. vetulus* was present in the samples of December 1995 – February 1996, disappeared from March through November of the same year and appeared again in December 1996. Samples were then collected from the same site every 3 days for the period 15 December 1996 – 6 March 1997. A total of 4185 specimens were collected during the entire study. A plankton net of 0.09 mm mesh and 40 cm mouth diameter was used. A sample of one hundred liters of water was collected each time. Samples were preserved in 4% formalin. In the laboratory, samples were placed in a graduated flask and concentrated into a volume of 500 ml. Then the sample was thoroughly homogenized and three 10-ml subsamples were drawn off. Counting was carried out using a Bogorov chamber with the aid of a dissecting microscope. The mean value of the 3 sub-samples was calculated. Total lengths of all *S. vetulus* individuals were measured to the nearest 0.01 mm using an ocular micrometer fitted in the eye-piece of the microscope. The dry weights (dw) of a subsample of 71 animals collected on 20 January 1997 were measured with the aid of an electromicrobalance (Cahn) to the nearest 0.1 µg. Each individual of the subsample was put in pre-weighed foil and oven dried at 60°C for 24h. To derive a calibration curve to estimate the weights of all *S. vetulus* in the entire study, a linear regression in the form of $\log W = a + b \log L$ was established between the length (L) and the dry weight (W) of the animals (Fig. 1).

Different generations of *S. vetulus* were separated by the probability paper method (Harding, 1949; Cassie, 1954). Individuals in each sample were grouped into different size classes that were plotted on the Y-axis of a probability paper versus the cumulative frequency (percent) plotted on the X-axis. If the points of the graph occurred on a straight line, this indicated a single generation (or cohort), whereas if a curve was obtained with a single inflection point, then the sample was made up of two cohorts. If two or more inflection points were obtained, then the sample contained

two or three or more cohorts depending on numbers of the inflection points. A straight line through the regression equation can be obtained from the points before and between the inflection point(s). The vertical line drawn from the 5% cumulative frequency (X-axis) will cross the straight line(s) of each cohort and the horizontal line drawn from the cross point to the length groups (Y-axis) will mark the mean length (size) of each cohort. With the aid of the normal distribution equation, a normal distribution curve for each cohort can be drawn on the length frequency histogram. Further details of the method can be obtained from Harding (1949) and Cassie (1954). Moreover, a computer program was designed at the Marine Science Centre to ease the laborious method (see Ali *et al.* 1994) and is available on a CD. Growth rates were determined by following the mean length and numbers (N) of each cohort over time. Expected numbers of each cohort at the beginning and the end of its life were estimated from the plot of log N against time (Crisp, 1984). Mean lengths of the animals were converted to mean weight (W) by using the length-weight relationship. The mean biomass (B) of each cohort was calculated from $N \times W$ of the cohort and the production (P) of each cohort in mg dw/m^3 was calculated by the growth increment-summation method (Crisp, 1984):

$$P (\text{mg dw/m}^3) = \sum \frac{N_t + N_{t+1}}{2} (W_{t+1} - W_t)$$

where N_t and W_t = number and mean weight of individuals in the cohort at time t. To calculate the mean daily production for each sampling interval, the production estimate for that interval was divided by the days in that interval to obtain a true flow $\text{mg /m}^3/\text{d}$. Total production is the sum of the cohorts' production. In other words, each sample was separated into cohorts, following those cohorts over their survivorship period, and calculate interval production of each of those cohorts for each sampling interval during that survivorship period, then sum up the interval production for each cohort over their survivorship period and add the cohort production estimated together to get total production for the 11 week period. The absolute growth rate (AGR) of each cohort was estimated according to Warren (1971):

$$\text{AGR (mg/d)} = \frac{W_2 - W_1}{T_2 - T_1}$$

where W_1 and W_2 are, the weight at the age 1 day (T_1) and the age at the end of the period (T_2), respectively.

Results

Growth. The value of the regression coefficient (b) from the plot of length-weight relationship is slightly more than 3.0, indicating a rapid exponential increase of the species weight over time (Fig. 1). During the period 15 December 1996 – 6 March 1997, six cohorts were identified, and these were designated A, B, C, D, E and F respectively (Fig. 2). Cohort A showed exponential growth, whereas cohorts B and C exhibited a sigmoid growth pattern. The other three cohorts did not complete their lives within the period of sampling. Therefore, their growth-rate patterns could not be

determined. The lowest growth rate (0.0017 mg/d) was recorded in cohort F, whereas the highest growth rate (0.0025 mg/d) was exhibited by cohort A.

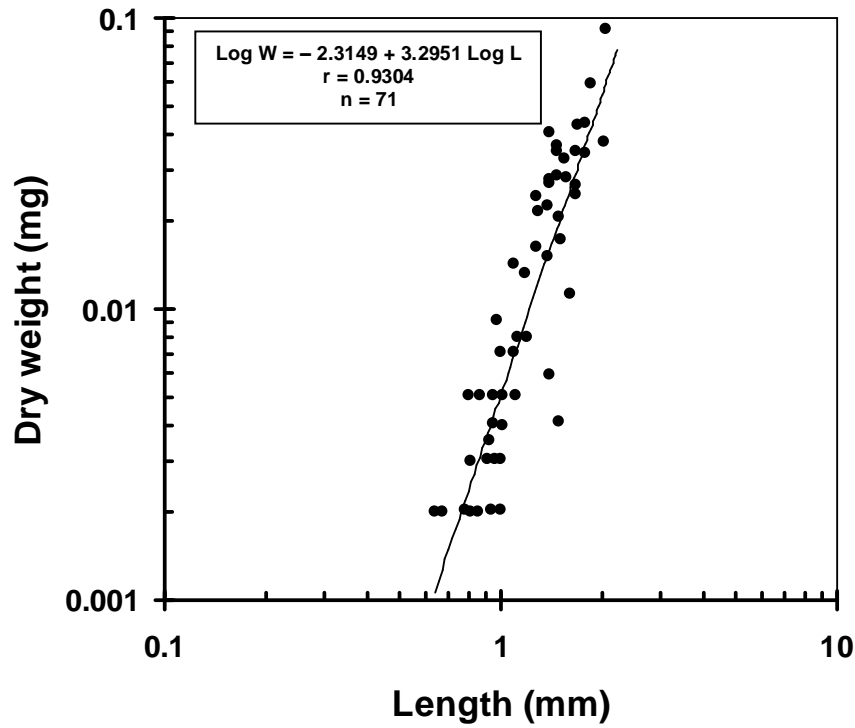


Figure 1. Length-weight relationship of *S. vetulus*. Each point represents the length and weight of a single individual in a subsample of 71 individual *S. vetulus* collected on 20 January 1997.

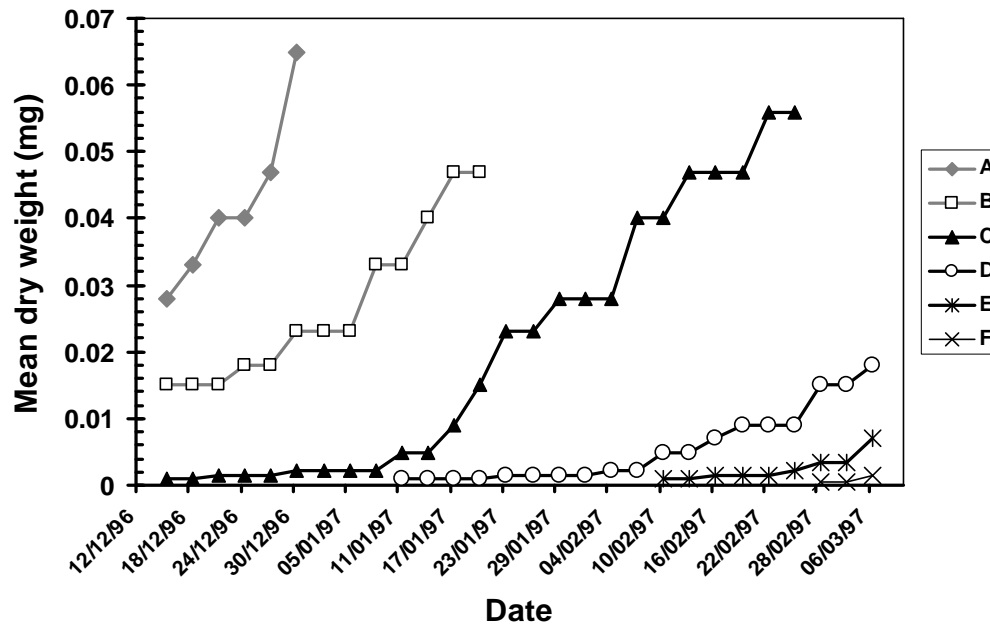


Figure 2. Growth rates of different cohorts (A - F) of *S. vetulus* in the Basrah region for the period 15 December 1996 to 6 March 1997, expressed as mean dry weight (mg) against time.

Survivorship curves. Survivorship curves of the different cohorts were estimated from the density values (log number against time) and given as number/m³. In general, the patterns of survivorship curves indicate a more or less gradual decrease in numbers of individuals of each cohort throughout their life spans (Fig. 3).

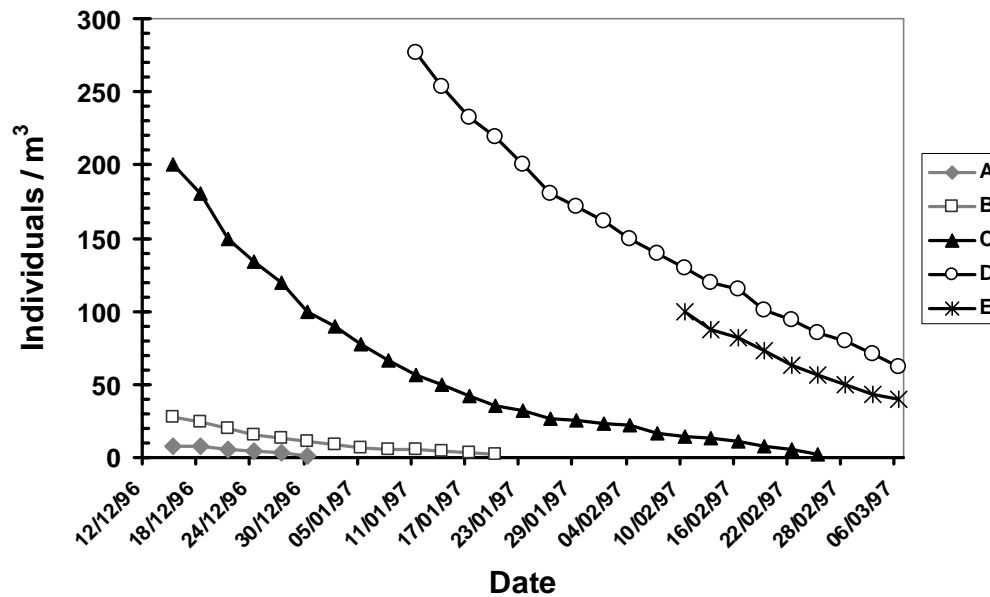


Figure 3. Survivorship curves of the different cohorts (A – E) of *S. vetulus* from the Basrah region for the period 15 December 1996 to 6 March 1997.

Biomass and Production. The lowest value of biomass was 4.8 mg/m³ and was attained on 5 January 1997 (Fig. 4), which coincided with the lowest temperature ever recorded (13.5°C). A pronounced rise (61.3 mg/m³) was recorded on 17 January

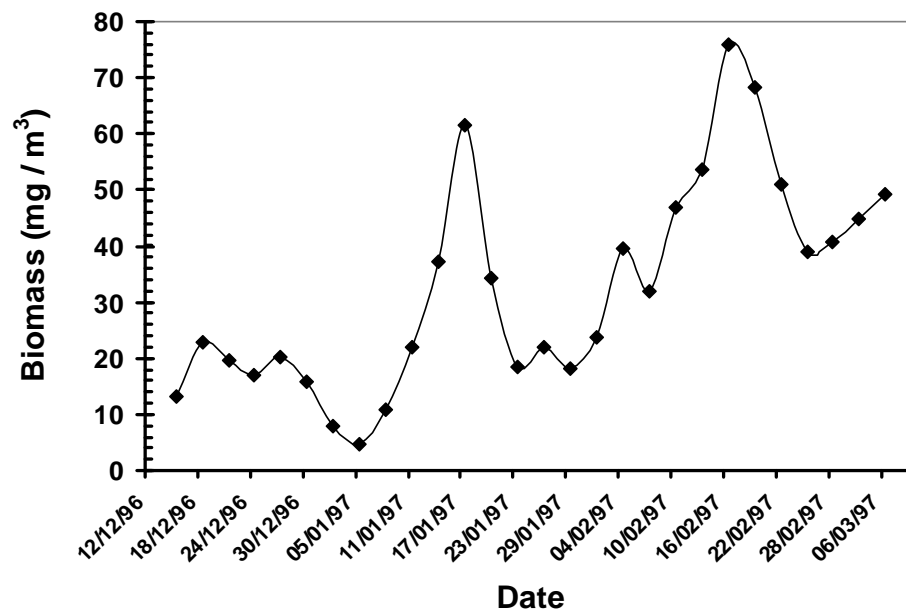


Figure 4. Daily average biomass (mg/m³) of *S. vetulus* for the period 15 December 1996 to 6 March 1997.

(temperature, 17.5°C), then followed by a sharp decline and a gradual rise until the highest peak (75.8 mg/d) was reached on 16 February (temperature, 18°C).

Maximum production was attained by cohort D (192.9 mg dw/m³) during a period of 54 days (Table 1). Cohort C, which was followed for a longer time (72 days), gave a production of 176.6 mg dw/m³ (Table 1). Furthermore, these two cohorts also had the maximum mean biomass (56.39 and 40.94 mg dw/m³, respectively).

Table 1: Biomass and production of different cohorts of *S. vetulus* from a pool at Garimat-Ali.

Cohort	Mean biomass (mg dw/m ³)	Production (mg dw/m ³)	Period
A	14.63	13.05	15 Dec. 96 - 30 Dec. 96
B	32.54	41.20	15 Dec. 96 - 20 Jan. 97
C	40.94	176.60	15 Dec. 96 - 25 Feb. 97
D	56.39	192.90	11 Jan. 97 - 6 Mar. 97
E	13.82	32.80	10 Feb. 97 - 6 Mar. 97
F	1.97	2.25	28 Feb. 97 - 6 Mar. 97

On a daily basis, however, the production (Fig. 5) showed a great fluctuation with relatively lower values until the middle of the third week of January when a peak was reached (14.08 mg dw/d/m³; temperature, 17.5°C), followed by a gradual decrease towards the beginning of February when a value of zero was recorded (temperature, 18.5°C)

Other major rises were observed on the second week of February (14.23 mg dw/d/m³; temperature 19.0°C) and on the third week of the same month (14.26 mg dw/d/m³; temperature 18.0°C). Maximum daily production was recorded during the last week of February (16.6 mg dw/d/m³; temperature 21°C). The general trend of the production curve corresponds with water temperature for most of the time (Fig. 5).

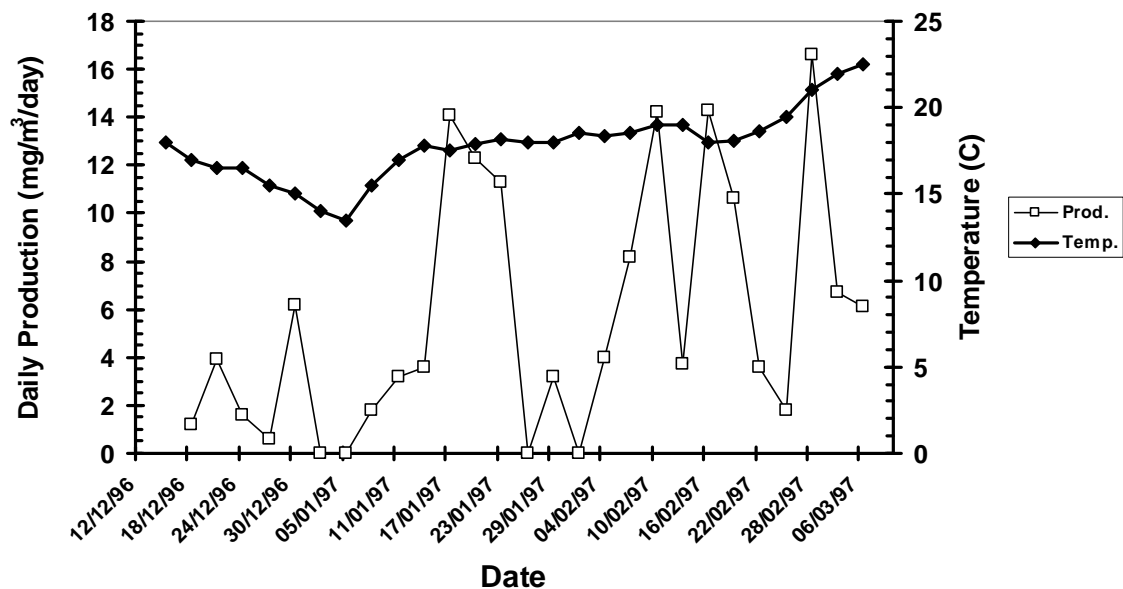


Figure 5. The relationship between daily production of *S. vetulus*, time, and temperature in the Basrah region for the period 15 December 1996 to 6 March 1997.

On a monthly basis, however, the lowest population production occurred during March 1997 (38.55 mg dw/m³), although the mean biomass was relatively high (143.6 mg dw/m³). During February 1997 the population showed the maximum values of both biomass and production (150.9 mg dw/m³ and 231.2 mg dw/m³/month, respectively; Table 2). The total population production of *S. vetulus* over the entire period was 458.8 mg dw/m³/81days. The production to biomass (P/B) ratio for this period was 4.22 (Table 2).

Table 2: Monthly biomass, production and P/B ratio for the population of *S. vetulus* at Garmat-Ali during the period December 1996-March 1997.

Month	Mean biomass (mg dw/m ³)	Production (mg dw/m ³ /month)	P/B
December 1996	54.3	40.40	0.74
January 1997	86.2	148.65	1.72
February 1997	150.9	231.20	1.53
March 1997	143.6	38.55	0.26
Total	108.7	458.8	4.22

Discussion

It has long been known that temperature affects biochemical processes from the molecular level to the organismal level. Therefore it is not surprising that the daily population biomass (mg/m³) of *Simocephalus vetulus* was closely related to temperature, as there was a significant relationship between temperature and daily population biomass ($P < 0.05$, $r = 0.586$). Although daily population production was less regular than biomass, there was still a significant relationship between daily production and temperature ($P < 0.05$, $r = 0.3614$). Therefore, temperature is one of the potential ecological factors determining these variations in both biomass and production of *S. vetulus*. However, there were extreme variations across cohort and season in biomass and production (Table 1). Only cohort C was followed throughout its entire life, whereas the rest of the cohorts were followed in the field during only part of their lives. Cohort C was present for 72 days and had attained a production of 176.60 mg dw/m³. Cohort D had the highest production (192.90 mg dw/m³) ever recorded in the population, but it was sampled for the major part of its life (54 days), as sampling was ended on 6 March 1997. Thus we missed an important period of the life of this cohort, which certainly affects the production estimate and ultimately the drawing of a solid conclusion. Nevertheless, it is generally concluded that the longer-lived animals have lower rates of production (see Downing, 1984, for references). Cohorts B and E were only present for 36 days and 24 days, respectively, and had even lower biomass and production (Table 1). Therefore the sampling regime needs to be extended for a longer period to cover the lives of these cohorts, in order to give comparable results of the biomass and production of the different cohorts.

Most of our estimates of *Simocephalus vetulus* production, such as the examples mentioned below, were for different fractions of the year. It was thought that the most meaningful comparison could be achieved by converting the data to a monthly basis. We found that the monthly production of *S. vetulus* (114.7 mg dw/m³/month) is apparently very much lower than that of *Daphnia magna* (1808.4 mg dw/m³/month), another cladoceran living in the same area (Ajeel, 1998) and much lower than that of

many other cladocera from other geographical regions (Table 3), such as *D. cucullata* from Lake Jeziorak (Zawislak, 1972), *Bosmina coregoni* from Kiev Reservoir (Zhdanova, 1969) and *Ceriodaphnia putchella* also from Kiev Reservoir (Zhdanova & Tseyer, 1970). However, production of *Diaphanosoma brachyurum* from Lake Sartlan (Pomerantseva, 1974), is about 3 times higher than that of the present species. In the meantime, production of *B. longirostris* from Kiev Reservoir (Zhdanova, 1969), is only slightly higher than that of *S. vetulus*.

On the other hand, the P/B ratio is only slightly higher than that of the native cladoceran *D. magna* and much lower than that other species discussed above. The P/B ratio of the present species is comparatively higher than that of some other crustaceans from the Shatt Al-Arab region viz, the amphipod *Parhyale basrensis* (3.06; Ali and Salman, 1987), the isopods *Annina mesopotamica* and *Sphaeroma annandalei annandalei* (2.86 and 2.30 respectively; Soud, 1997). It equals that of the crab *Sesarma boulengeri* (4.1; Sultan, 1987) and is lower than that of the crab *Elamenopsis kempi* (5.9; Ali and Salman, 1998).

Table 3. Secondary production (mg dw/m³) and P/B ratio of different species of Cladocera from various localities.

Species	P/B	Productivity (mg/m ³ /month)	Study area	References
<i>Daphnia magna</i>	3.03	1808.4	Pool in Basrah	Ajeel (1998)
<i>D. cucullata</i>	-----	3370.0	Lake Jeziorak	Zawislak (1972)
<i>Diaphanosoma brachyurum</i>	8.2	353.3	Lake Sartlan	Pomerantseva (1974)
<i>Ceriodaphnia putchella</i>	6.3	846.5	Kiev Reservoir	Zhdanova & Tseyer (1970)
<i>Bosmina longirostris</i>	12.5	191.1	Kiev Reservoir	Zhdanova (1969)
<i>B. coregoni</i>	22.0	1419.2	Kiev Reservoir	Zhdanova (1969)
<i>Simocephalus vetulus</i>	4.22	114.7	Pool in Garbat Ali	Present study

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الإنتاجية الثانوية للنوع *Simocephalus vetulus* في بركة مؤقتة في البصرة

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الخلاصة:

جمعت عينات الهائمات الحيوانية من مستنقع في جامعة البصرة (موقع كرامة علي) وبواقع عينة كل ثلاثة أيام للفترة من 15 كانون الأول 1996 لغاية 6 آذار 1997 بواسطة شبكة مخروطية الشكل قطر فتحاتها 0.090 ملم وقطر فوهتها 40 سم. تراوحت الكتلة الحية اليومية للجماعة السكانية للنوع *S. vetulus* بين 4.8 ملغم/يوم/م³ إلى 75.8 ملغم/يوم/م³. وتراوحت الإنتاجية الثانوية اليومية للجماعة السكانية بين 0 - 16.6 ملغم وزن جاف/يوم/م³. بينما تراوحت الإنتاجية الثانوية للنوع *S. vetulus* بين 38.6 - 231.2 ملغم/م³/شهر خلال آذار وشباط على التوالي، في حين تراوح معدل الكتلة الحية بين 54.3 ملغم/م³ خلال كانون الأول 1996 إلى 150.9 ملغم/م³ خلال شباط 1997. بينما تراوحت معدلات النمو اليومي بين 0.0017 ملغم للجبل F إلى 0.0025 ملغم للجبل A.