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A Study on the Growth of Juveniles of Tiger Prawn, *Penaeus monodon* (Fabricius) Under Different Photoperiods

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Abstract

The growth of the juveniles of *Penaeus monodon* (Fabricius) was studied for a period of 77 days under light and dark conditions in the laboratory. Length and weight relation showed that the weight of the juveniles increased more rapidly under the dark condition as compared to the light condition. The exponent values (b) obtained for dark condition was higher (b=3.99; r=0.99) as compared to light condition (b=1.52; r=0.92). The maximum growth in weight was observed between 7th and 10th weeks under dark condition whereas, between 7th and 9th weeks under light condition. The growth pattern with respect to weight fitted well with von Bertalanffy's growth equation and showed observed values closed to calculated values.

Keywords: Photoperiod; Growth; *Penaeus monodon*

Introduction

Light is one of the most important environmental factors that regulate the burrowing and reproductive behavior of the penaeid prawns [1-8]. Rhythmic behaviour including biological activity of the shrimp affected significantly by the unfavourable conditions of the environment such as continuous bright light [5]. Aaron and Wisby [9] found that the juveniles (50-105 mm TL) of *Penaeus duorarum* showed a positive attraction towards dim light during full and new moon phases.

The effect of continuous dark and light conditions on the biological behaviour of the juveniles of penaeid shrimp has not been studies in detail. Hence an attempt was made in the present experiment to demonstrate the effect of light and dark conditions on the growth of juveniles of *Penaeus monodon* (Fabricius).

Materials and Methods

In the present investigation, the juveniles of *Penaeus monodon* (Fabricius) were collected from a commercial hatchery and brought to the laboratory for further studies. The juveniles were acclimated to the laboratory conditions for a period of one week. All experiments were conducted in glass aquarium tanks of 20 liter capacity under total dark condition (0.0lx : day and light) and total light condition (384 lx : day and night). In each tank, 10 juveniles of *P. monodon* of uniform weight (0.1-0.15 g) and length (14.5-15.5 mm) were maintained at a constant salinity of 30 ppt, 8.2 pH and 30+2°C temperature. The juveniles were fed twice a day with a commercial pelleted feed at the rate of 10% of their biomass. Length and weight of each juvenile were recorded at weekly intervals. Before recording the length and weight, the juveniles were kept on a plotting paper to remove the excess water. Seawater in the experimental tanks was changed twice with fresh filtered seawater of the same salinity, pH and temperature. The unconsumed food was siphoned out every day to avoid contamination of the water and the experiment was completed within 77 days.

The relationship between total length and weight of the juveniles under total light and dark conditions was calculated by the regression equation (Least square method). Weight of each juvenile at each length interval was calculated by the allometric equation $W=aL^b$ (where W is the weight of the juveniles, L; the length and 'a' and 'b' are additive and multiplying constants, respectively). Length and weight curves were plotted separately for total light and total dark conditions. Mean weekly weight attained by the juveniles was estimated from the difference in the initial and final weights whereas; specific growth rate was calculated by the method as described by Chatterji et al. [10]

Asymptotic weight (Wα) attained by the juveniles was determined graphically by plotting weight at W_t against W_{t+1}. The computed values of growth parameters for light and dark conditions were fitted with the following von Bertalanffy's growth equation:

$$W_t = W\alpha\, [1-e^{-K\,(t-to)}]$$

Where W_t is the weight at time t, Wα = the asymptotic weight, 'e' = the base of the natural logarithm, K = the coefficient of catabolism,'t' = the time of observation and 't_o'.

= the time at which the juveniles belong to zero gram weight. The calculation of 't_o' was based on the following formula of Ricker [11]:

$$t_o = [\log_e W\alpha + Kt_o] - \log_e W / K$$

The value of $\log_e W\alpha + Kt_o$ is the y-axis intercept where $\log_e (W\alpha - W_t)$ is plotted against the mean weights

Results

A parabolic relationship was obtained when the values of length and weight of the juveniles were plotted separately during each week under light and dark conditions. The smooth curves in Figures 1a and 2a showed the calculated weights at each length intervals whereas the straight lines in Figures 1b and 2b showed the calculated regression lines. The differences in increase in length were not well marked up to 30 mm length under light and dark conditions (Figures 1a and 2a).

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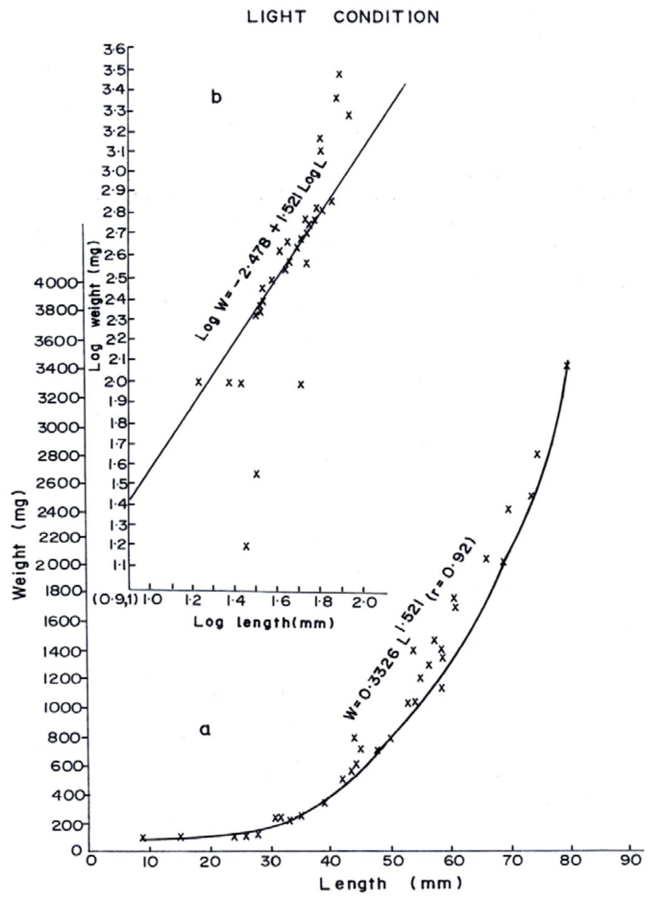


a) Smooth curve represent the calculated weight of juvenile
b) The straight line represents the calculated regression line of log weight on log length of juvenile

Figure 1: The length and weight relationship of juveniles, *P. monodon* under light and dark Conditions.

However, the increase in weight was relatively more rapid under dark conditions as compared to light conditions as evident in Figures 1a and 2a. It was observed while calculating the regressions equations that the exponent (b) value was greater under dark condition (b=3.99; r=0.99) as compared to the light condition (b=1.562; r=0.92).

The mean weekly data collected for 77 days for length and weight under light and dark conditions are presented in Figures 3 and 4 respectively. Under dark conditions, the length of the juvenile shrimp was rapid up to a period of six weeks and then it slowed down at the later phase (Figure 3). However, the pattern of increment in weight showed a higher value under dark condition as compared to the light condition between the 7th and 10th weeks (Figure 4).

The relative growth in weight showed a decreasing trend from 37.5 to 10.7% under light condition and 33.3 to 10.2% under dark condition (Table 1). Similarly the specific growth rate also showed a decreasing pattern from 46.9 to 11.0% under light condition as compared to dark condition (40.4 to 10.7%) (Table 1). The maximum increment in relative growth was noticed during the 8th week for dark condition and 9th week for the light condition (Table 1).

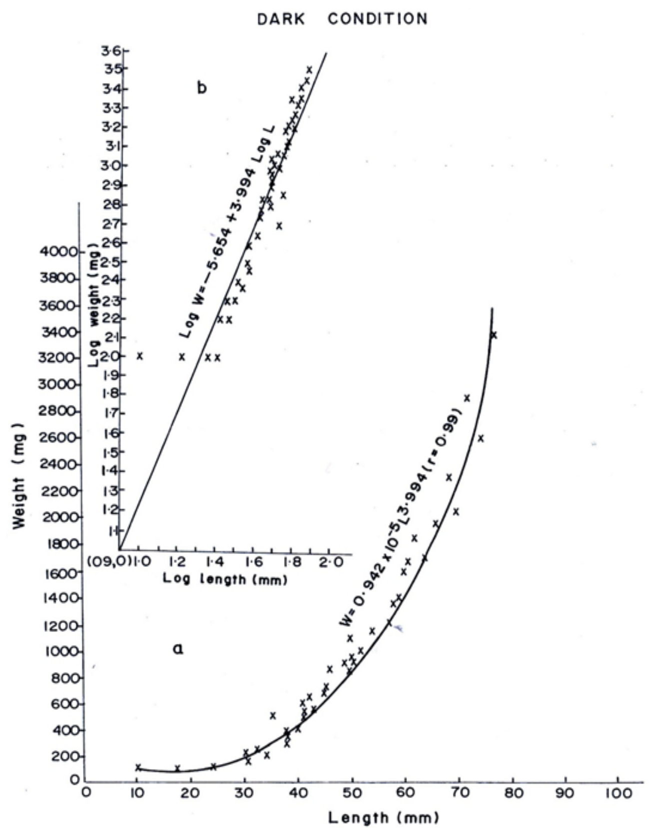
The asymptotic weight (Wα), calculated after applying Ford-Walford equation is presented in Figure 5a and 5b for light condition and Figure 6a and 6b for the dark condition. It is evident that under dark condition, the growth in weight was more rapid (Wα = 200 g) as compared to light condition (Wα = 190 g).

In the present study the calculated values obtained after applying von Bertalanffy's growth equation for the juvenile shrimps, showed a close agreement with the average observed weight under total light and dark conditions (Table 2). This showed that von Bertalanffy's growth equation fitted well in expressing the growth pattern of the juveniles of *P. monodon* under light and dark conditions.

Discussion

Environmental factors including light and dark conditions have been reported to play a significant role on the secretion of the melanophores, hormone and maintenance of water equilibrium, formation of secondary sexual feature, thyroid activity and growth of the animals [12-17]. It has also been observed that many aquatic animals experience change in their metabolic functions due to internal de-synchronization of some of the physiological processes under dark and light conditions [18].

Although light and dark conditions play a significant role in controlling various physiological processes of aquatic animals in an ecosystem no comprehensive study has so far, been done to show the effect of light and dark conditions effecting directly on the growth of juveniles shrimp. However, the juveniles of *M. rosenbergii* reared under continuous darkness (12 hr light: 12 hr darkness; 16 hr light:



a) Smooth curve represent the calculated weight of juvenile
b) The straight line represents the calculated regression line of log weight on log length of juvenile.

Figure 2: The length and weight relationship of juvenile of *P. monodon* under dark Conditions.

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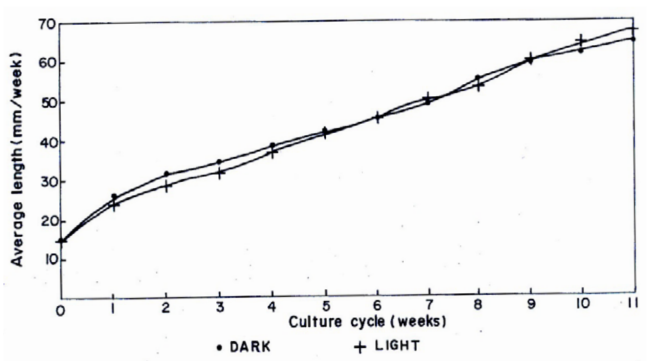

Figure 3: Mean weekly lengths (mm) attained by juveniles of *P. monodon* under light and dark conditions.

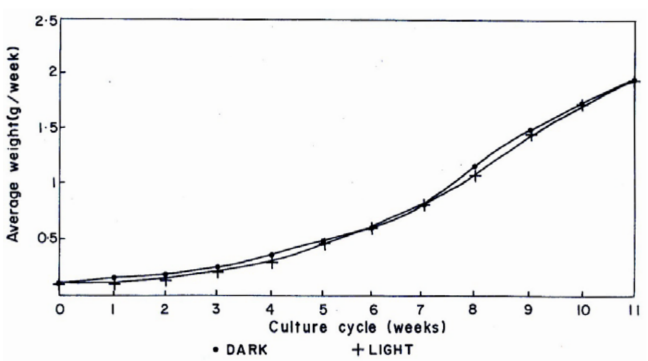

Figure 4: Mean weekly weights (g) attained by juveniles of *P. monodon* under light and dark conditions.

Weeks	Relative growth (%)		Specific growth (%)		Growth increment (%)	
	Light period	Dark period	Light period	Dark period	Light period	Dark period
1	-	33.3	-	22.9	-	0.05
2	37.5	16.6	46.9	15.3	0.06	0.03
3	23.8	28.0	27.1	10.7	0.05	0.07
4	34.3	32.4	42.1	40.4	0.11	0.12
5	30.4	26.0	36.2	18.2	0.14	0.30
6	26.9	19.3	31.4	32.8	0.17	0.12
7	25.0	20.5	28.7	39.2	0.21	0.16
8	21.4	35.0	24.1	30.1	0.23	0.42
9	26.7	20.5	31.0	21.5	0.39	0.31
10	16.0	14.2	17.5	22.9	0.28	0.25
11	10.7	10.2	11.0	10.7	0.21	0.20

Table 1: Relative growth, specific growth and growth increment of the weight under total light and dark conditions.

8 hr darkness and 20 hr light: 4 hr darkness) for 110 days showed a higher growth and survival rate under dark condition than any other photoperiod conditions [19]. Similarly, Tay-Hc [20] reported that the starved larvae of *P. esculatus* kept under different photoperiod conditions (24 hr dark, 24 hr light and 12:12 hr dark/light) showed rapid growth in the 12:12 dark/light conditions. Continuous light conditions showed a slower growth in the larvae of *P. esculatus* [20]. The present study corroborates the earlier findings where higher growth rate in penaeid shrimps was recorded under dark conditions.

The light intensity affected the growth of the shrimp (*Fenneropenaeus chinensis*) by influencing mainly the food conversion efficiency (FCE) [21]. The specific growth rate (SGR) in juvenile of the same shrimp was measured over a period of 35 days under different light intensities i.e. 0, 50, 300, 1300 and 5500 lx by Fang et al. [21]. The shrimps were reported to grow faster under lesser light condition. Additionally these workers have found that the SGR of the shrimp under 5500 lx was only 29.4%, 27.1%, 21.1% and 19.7% of those under 0, 1300, 50 and 300 lx, respectively (P<0.05). The shrimp under 5500 lx showed a lower feed intake (FI) and FCE resulting in a lower SGR values [21]. However Fang et al. [22] in another experiment found that when the shrimps (wet weight: 0.945±0.005 g) were kept in glass aquaria under four photoperiod conditions (0 light/24 dark, 24 light/0 dark, 10 light/14 dark, and 14 light/10 dark) for 35 days, no significant difference in specific growth rate, food intake, and food conversion efficiency among the shrimps under the four photoperiods was recorded. But the moulting frequency of the shrimps under 14 light/10 dark and 10 light/14 dark were significantly higher than those under 0 light/24 dark, 24 light/0 dark [22]. The difference in growth of the shrimps among four photoperiod treatments was not significant.

The juveniles of *Jasus edwardsii* (1–10 g weight) were subjected to five photoperiod conditions [0L(light):24D(dark); 6L:18D; 12L:12D; 18L:6D; 24L:0D] during a 112-day of experimental period where growth, survival, colour and food consumption were examined by Crear et al. [23]. The specimens of *J. edwardsii* showed lower mean weight and specific growth rate under 6L:18D and 24L:0D photoperiods (P < 0.05) than any other treatments. Crear et al. [23] have not found any photoperiod effect on the survival or colour of lobsters. Major

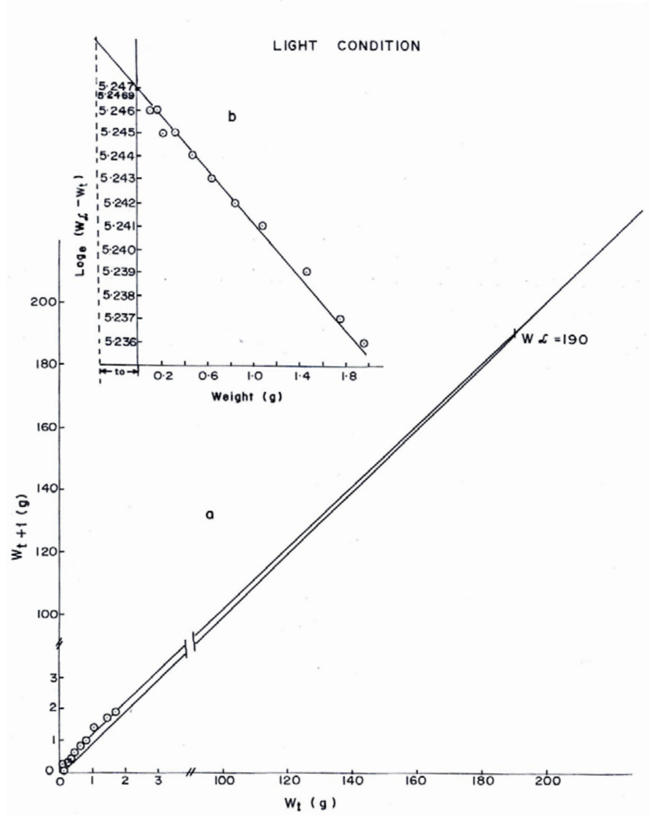

Figure 5a: Ford-Walford plot of growth of *P. monodon* with reference to weight under light conditions. **5b :** $\log_e (W\alpha - W_t)$ plotted against weight for estimation of 't_o' for *P. monodon* under light condition

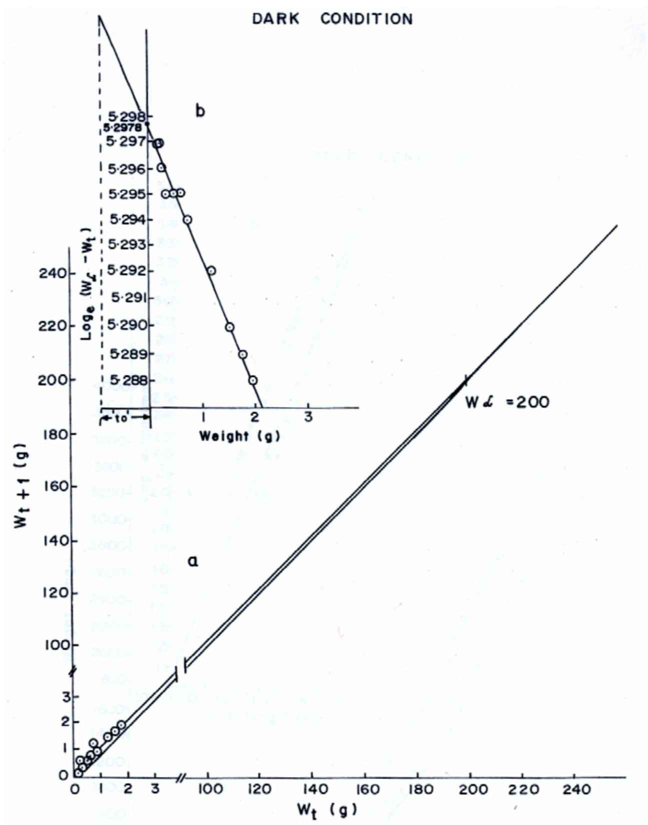

Figure 6a: Ford-Walford plot of growth of *P. monodon* with reference to weight under dark conditions. **6b :** $\log_e$ (Wα - W_t) plotted against weight for estimation of 't_o' for *P. monodon* under dark condition

Weeks	Light condition		Dark condition	
	Average observed weight (g) [± SD]	Weight determined by using von Bertalanffy's growth equation	Average observed weight (g) [± SD]	Weight determined by using von Bertalanffy's growth equation
Initial	0.10 ± 00	-	0.10 ± 00	-
1	0.10 ± 00	0.20	0.15 ± 0.05	0.23
2	0.16 ± 0.048	0.39	0.18 ± 0.06	0.43
3	0.21 ± 0.030	0.58	0.25 ± 0.05	0.63
4	0.32 ± 0.124	0.77	0.37 ± 0.14	0.83
5	0.46 ± 0.149	0.96	0.50 ± 0.20	1.03
6	0.63 ± 0.228	1.15	0.62 ± 0.22	1.23
7	0.84 ± 0.272	1.34	0.78 ± 0.35	1.43
8	1.07 ± 0.343	1.53	1.20 ± 0.51	1.63
9	1.46 ± 0.438	1.72	1.51 ± 0.59	1.83
10	1.74 ± 0.498	1.90	1.76 ± 0.75	2.02
11	1.95 ± 0.650	2.09	1.96 ± 0.80	2.22

Table 2: Average observed weight, calculated weight for total light and dark conditions.

feeding activity was found during dark periods for the lobsters exposed to photoperiods that had light and dark regimes.

Series of experiments were carried out on the larvae and juveniles of *Lates calcarifer* by Barlow et al. [24] to determine the effect of extended periods of light on the growth, survival, feeding pattern and daily feed consumption. They found that the larvae 2–10 days old grew relatively faster under conditions of 8, 16 and 24 hr light per day whereas larvae 8–20 days old grew significantly slower in 8 hr light than in 16 and 24 hr light conditions. It has been observed that when the juveniles (11–12 mm total length) exposed to an extended light condition, the growth rate increased considerably during their first 8–10 days, but thereafter it became less important. There was no significant difference in the growth or survival rates in 12, 18, or 24 hr of exposure of *Lates calcarifer*. Downing and Litvak [25] while conducting two separate experiments had cultured larvae of haddock (*Melanogrammus aeglefinus*) under different photoperiods (24L : 0D or 15L : 9D) and different combinations of tank colour (black or white) with light intensity ranging from 1.1 to 18 µmols $^{-1}m^{-2}$. They observed that the growth in terms of standard length and body weight were higher under light conditions as compared to dark condition. This shows that animals inhabiting at the bottom need dark condition for their better growth.

The feeding rates of *Mysis mixta* and *Praenus flexuousus* on a copepod (*Acartia* sp) was compared under light and dark conditions by Viherluoto abd Viitasalo [26]. The feeding rates of pelagic mysids were significantly higher in total darkness than in light condition. The feeding rates of littoral mysids did not differ under the dark conditions.

The effect of light and dark cycles on the growth and mortality of *Palaemon elegans* under laboratory conditions has been studied by Dalley [27] who reported a significant decrease in the growth rate of the juveniles in non-circadian regime when the data were compared with 12 hours light and 12 hours dark conditions. The lower growth rate in juveniles was on account of non-circadian regimes. In the present investigations, a higher growth rate was observed under dark condition as compared to light conditions. The relationship of length and weight of juvenile shrimps under light and dark conditions was carried out primarily to understand the growth pattern of the animal. The present study showed that weight in juvenile shrimps was increased more than the cube of the length under dark conditions (b=3.994). However, though the relationship was parabolic under light conditions, the weight of the shrimp increased equal to the length of juveniles (b=1.521). This indicates that the juveniles of *P. monodon* grow faster under dark condition as compared to light condition which strongly supports our results.

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