Thermal effects on a medically important snail species *Lymnaea (Radix) acuminata* Lamarck (Gastropoda : Lymnaeidae)

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ABSTRACT. The snails *Lymnaea (Radix) acuminata* are registered intermediate hosts of a number of helminth parasites causing worm-diseases in man and domestic animals in Indian sub-continent. Newly hatched (zero-day old) snails reared at 15°, 20° , 25° , 30° and 35° C (± 1°C), and room temperature (22.3-33.3°C) exhibited marked differences in their biological activities. At lower temperatures snails survived for a longer period (169-518 days) and produced maximum 80-93 eggs during a reproductive period of 223-246 days. At 25° and 30°C snails had shorter life spans of 128-145 days, and produced on average 37-56 eggs per individual. Individuals exposed to 35° C had an average life span of 17 days. None of them reproduced. Growth rate was higher at high temperatures. The average total body weight gained per week by an individual was 15.13, 8.97, 35.55, 34.02 and 17.29 mg at 15, 20, 25, 30 and 35°C respectively. At room temperature the snails survived on average for 110 days, gained 35.28 mg in body weight per week, started egg laying at the age of 62 days and produced 73 eggs per individual.

INTRODUCTION

Lymnaeids are very common in tropical and temperate countries (GODAN, 1983). They have drawn special attention of the malacologists because of their role in transmitting worm-diseases in man and animals (LISTON & SOPARKAR, 1918; RAO, 1933; CHATTERJEE, 1952; MALEK & CHENG, 1974; GHOSH & CHAUHAN, 1983; BURCH, 1985; RAUT, 1986). Since snail-borne diseases are a serious socio-economical threat in many countries, eradication of host-snails is urgently needed. As the parasitic worm passes its life cycle in two hosts, and the snails act as intermediate hosts it is assumed that the management of host-snail population would prove effective to control the snail-borne diseases. Accordingly, adequate attention has been paid by the workers to note the titbits of the snail-hosts under different ecological conditions (GODAN, 1983; JONG-BRINK, 1990; MOENS, 1991, 1992; POINTIER *et al.*, 1991; BRUCE & LIANG, 1992; RAUT *et al.*, 1992; LOKER *et al.*, 1993; SLOOTWEG *et al.*, 1993). The snails *Lymnaea (Radix) luteola* Lamarck and *L.(R.) acuminata* Lamarck are very important in respect to spread of worm-diseases in India and adjacent regions (GHOSH & CHAUHAN, 1975; RAUT, 1986; RAO, 1989). Much efforts are given to collect data on various aspects of biology of these snails in order to develop more efficient control measures. In the mean time, information on the influence of certain factors on the biology of *L.(R.) luteola* has been supplied by RAUT & NANDI (1985), RAUT & MISRA (1991, 1993), MISRA and RAUT (1993) and ROY & RAUT (1994). The present communication deals with the effects of temperature on the biology of *L. (R.) acuminata* occurring in and around Calcutta, India.

MATERIALS AND METHODS

Sixty-six healthy, sexually mature *L. (R.) acuminata* were collected from a pond located at Baghajatin, Calcutta on March 18, 1992. They were released into a plastic container 30 cm in diameter and 11 cm in depth, containing pond water, 8 cm in depth. Few specimens of *Chara, Vallisneria* and *Ipomea* were also released into the water of the container to provide resting and egg-laying sites for the snails. The snails were regularly supplied with mustard leaves as food. The snails started egg laying on the very next day. The egg capsules were collected on daily basis and kept in a glass beaker (500 ml capacity) containing pond water. The water in the containers was changed regularly with fresh pond water. Through regular observation newly hatched (zero-day old) snails were taken daily from the beakers. Depending upon the availability of the required number of snails the experiments were initiated. Newly hatched snails were placed in plastic containers (2 l capacity) containing pond water. The containers were kept in BOD (Biological Oxygen Demand) chambers and room conditions. The knobs of the BOD chambers were adjusted accordingly with a view to maintain the temperature of water of the containers as desired. Thus, the snails were exposed to 15°, 20°, 25°, 30° and 35°C (±1°C) temperatures throughout. The room temperature was ranged from 22.3° - 33.3°C. For each temperature two containers, each with 30 newly hatched snail individuals were used. They were fed with mustard leaves throughout. A few specimens of *Chara, Vallisneria* and *Ipomea* were kept in water of the container to provide resting as well as egg laying support to the snails. Dead snails, faecal pellets and unconsumed food materials were removed every 24 hr., at the time of removal of water from each container.

Data on the life cycle parameters viz. the rates of growth in shell length, shell breadth and body weights; the age of sexual maturity, the length of reproduction period, post-reproduction period; the egg laying capacity, the hatching success of the eggs, the death rate and the longevity of the snails, were collected rgularly. Growth rates were studied by selecting 10 snails at random, 5 from each of the two containers exposed to a particular temperature. For other parameters, the mean was calculated on the basis of the data obtained. On way of calculations attention was given to testify the dependency of snail populations on temperature. SOKAL & ROHLF (1973) were followed to calculate Product-moment correlation coefficients. One-way ANOVA (Analysis of Variance) was applied for statistical interpretation of the data. Detailed comparisons of the data by way of ANOVA studies were made following CAMPBELL (1989).

RESULTS

At 15° , 20° , 25° , 30°C and room temperatures (22.3 - 33.3°C) the snails, *L. (R.) acuminata* thrived and reproduced though the rate of growth, age of sexual maturity, egg laying capacity, hatching success and the length of life of the snails varied with temperatures (Figures 1-5). At 35° C, 80% individuals died within 11 days, while the surviving specimens (one survived up to 164 days) were unhealthy and abnormal (as judged by seeing deshaped shell and sluggishness) throughout. These specimens did not reproduce in their life span. The ANOVA clearly indicates (Table 1) the significant effects of temperature on the life span ($P < 0.001$), rate of average gain in shell length ($P < 0.001$), shell breadth ($P < 0.001$) and body weight ($P < 0.001$), as well as on the time required for hatching of the eggs ($P < 0.001$) of *L. (R.) acuminata*. The results of correlation tests (Table 2) revealed that the rate of gain in shell length, shell breadth and body weight, the duration of post-reproduction period and the hatching success (%) of eggs have positive correlation with temperatures while the age of sexual maturity, the length of the reproduction period, the survival rate up to the age of sexual maturity, the number of egg capsules produced per individual, the length of life and the time required for hatching of eggs are negatively correlated with temperature. Also, in some cases such correlations are strongly influenced by certain biological parameters of the snail species under consideration (Table 2).

Temperature (° C)	Parameters				
	Longevity	**Shell length**	**Shell breadth**	**Body weight**	**Hatching**
Overall	229.12*	37.64*	18.49*	7.58*	2694.82*
A *vs* B	3.03[a]	0.05[a]	0.01[a]	1.67[a]	1246.19*
A *vs* C	66.41*	58.65*	35.85*	12.34*	5402.26*
A *vs* D	54.33*	92.46*	39.05*	8.30***	6677.25*
A *vs* E	559.21*	81.32*	33.38*	0.14[a]	7770.79*
A *vs* F	124.11*	23.65*	17.05*	8.45***	9429.75*
B *vs* C	99.80*	55.24*	36.86*	22.75*	1761.18*
B *vs* D	87.34*	88.64*	39.98*	15.99*	2393.66*
B *vs* E	790.29*	77.31*	34.36*	2.67[a]	2957.12*
B *vs* F	185.94*	21.85*	17.63*	15.69*	3818.79*
C *vs* D	1.47[a]	7.54***	0.82[a]	0.06[a]	17.18*
C *vs* E	94.59*	1.76[a]	0.04[a]	9.33***	52.14*
C *vs* F	1.52[a]	2.35[a]	0.77[a]	0.00[a]	115.66*
D *vs* E	154.60*	2.43[a]	1.18[a]	6.21**	9.57***
D *vs* F	7.55***	6.67**	2.54[a]	0.03[a]	43.87*
E *vs* F	119.02*	7.04**	0.50[a]	6.46**	12.26*

Significant at 0.1% (*), 0.5% (**) and 1% (***) level ; [a] : not significant. **A** : 15° C, **B** : 20° C, **C** : 25° C, **D** : 30° C, **E** : 35° C, **F** : room temperatures (22.3° - 33.3° C), ***vs*** means *versus*.

Table 1. Results (F-values) of ANOVA tests and detailed comparisons of the data by way of one-way ANOVA indicating the effects of temperature on certain life cycle parameters of *Lymnaea (Radix) acuminata*.

It is evident that the duration of reproduction period is shorter at higher temperatures (Figure 3) but snails exposed to such conditions become sexually mature at an earlier date (Figure 2). Likewise, lower temperatures allow snails to reproduce for a longer period. Accordingly, the interacting effects of these parameters could be visualised from Figures 1-5. The average length of post-reproduction period in snails was 14.5, 23.0, 52.0, 25.5 and 21.0 days at 15, 20, 25 and 30° C and room temperatures respectively.

The snails *L. (R.) acuminata* had the probability of production of eggs in both ways, through self-and cross-fertilization. It raises a question whether the data obtained on the size and frequency of egg clutches are statistically significant. To verify the same ANOVA tests were made and the results presented in Table 3. The snails exposed to room temperature (22.3 - 33.3°C) though were free from the effects of 20° C and 35°C temperatures had to face the influence of around 2°C temperature below 25° C and above 30° C.

Under such a situation whether the effect of room temperature was close to the mean effect of four constant temperatures viz. 20, 25, 30 and 35° C was testified through χ^2 studies. As the snails failed to rerproduce at 35° C, χ^2 was applied separately for the first (A to F) and last (G to L) six parameters (see Table 2). The results were significant at 1% level (for the first six parameters χ^2 = 30.28, for the last six parameters χ^2 = 12.88) in both the cases.

	T	A	B	C	D	E	F	G	H	I	J	K
A	-0.89 **											
B	-0.85 *	0.93 ***										
C	0.35	-0.38	-0.74									
D	-0.20	0.30	-0.53	-0.57								
E	-0.18	0.32	0.55	-0.63	0.99 ****							
F	-0.74	0.72	0.79	-0.42	0.78	0.74						
G	-0.90 **	0.94 ***	0.91 **	-0.50	0.17	0.18	0.65					
H	0.23	-0.05	0.05	0.12	0.70	0.62	0.64	-0.24				
I	-0.92 ***	0.99 ****	0.92 ***	-0.49	0.29	0.31	0.65	0.84	-0.37			
J	0.89 **	-0.87 *	-0.92 ***	0.50	-0.58	-0.56	-0.94 ***	-0.88 **	-0.15	-0.81 *		
K	0.86 *	-0.94 ***	-0.96 ***	0.55	-0.52	-0.52	-0.89 **	-0.93 ***	-0.07	-0.81 *	0.98 ****	
L	0.41	-0.98 ****	-0.93 ***	0.51	-0.45	-0.47	-0.79	-0.70	-0.18	-0.44	0.68	0.79

T : temperature. **A** : age of attainment of sexual maturity. **B** : length of reproduction period. **C** : length of post-reproduction period. **D** : individuals survived (%) up to the age of attainment of sexual maturity. **E** : number of egg capsules produced per individual. **F** : number of eggs produced per individual. **G** : time required for hatching of eggs. **H** : hatching success (%) of eggs. **I** : longevity. **J** : weekly gain in shell length. **K** : weekly gain in shell breadth. **L** : weekly gain in body weight.

Table 2. Results of correlation tests (r-values) between temperature and biological parameters of *Lymnaea (Radix) acuminata*. [* $P < 0.05$, ** $P < 0.02$, *** $P < 0.01$, **** $P < 0.001$].

Source of Variation	SS	df	MS	F	Remarks
Between Levels	23772.55	3	7924.18	11.09	Significant at 0.1% level
Residual	199388.58	279	714.65		
Total	223161.13	282			

Table 3. Results of ANOVA tests to justify the validity of the data obtained on the frequency and size of egg clutches of *L. (R.) acuminata* cultured at 15°, 20°, 25°, 30° and 35° C temperatures.

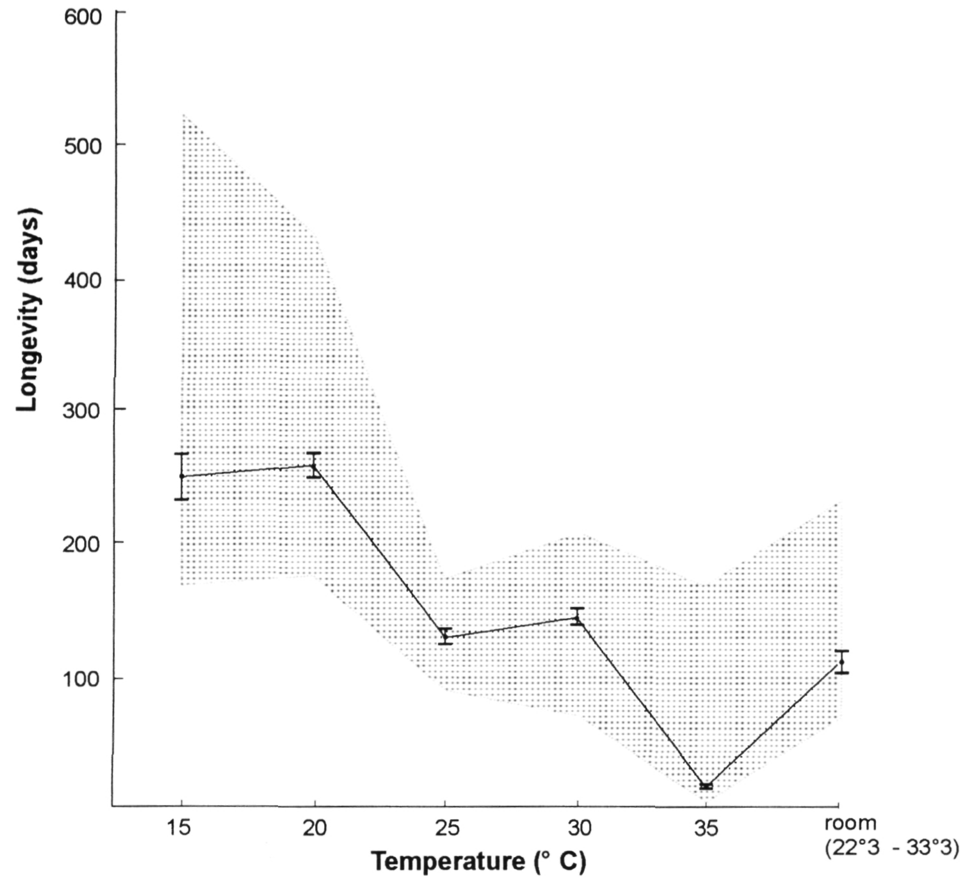

Fig. 1. Range (shadowed area) and mean (± s.e.) length of life of the snails *L. (R.) acuminata* cultured at different temperatures.

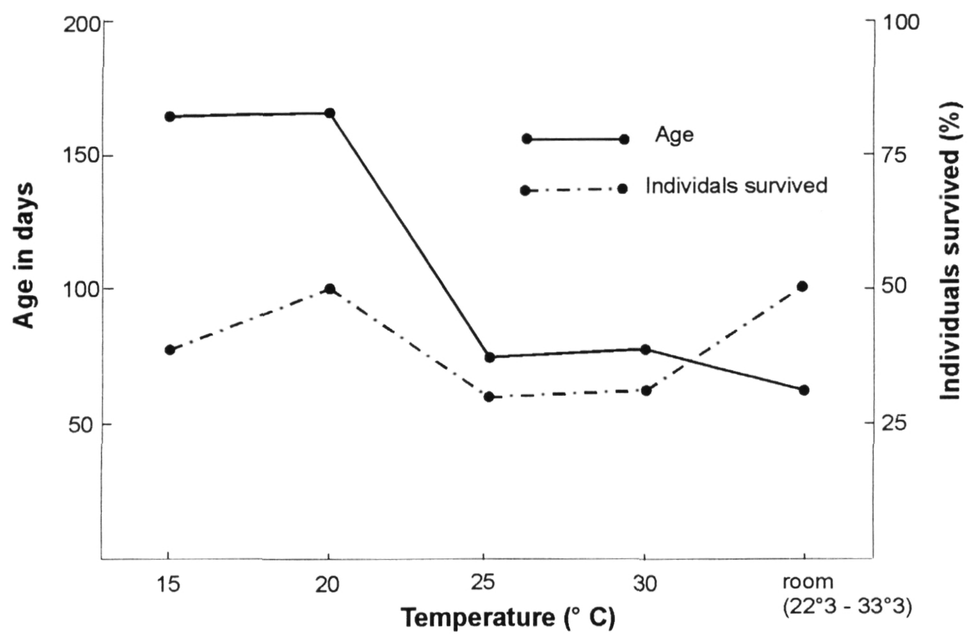

Fig. 2. The age of sexual maturity (as judged from the fact of deposition of first egg capsule by the snails of the batch concerned) and the percentage of individuals survived up to the age of attainment of sexual maturity when the snails *L. (R.) acuminata* were cultured at different temperatures.

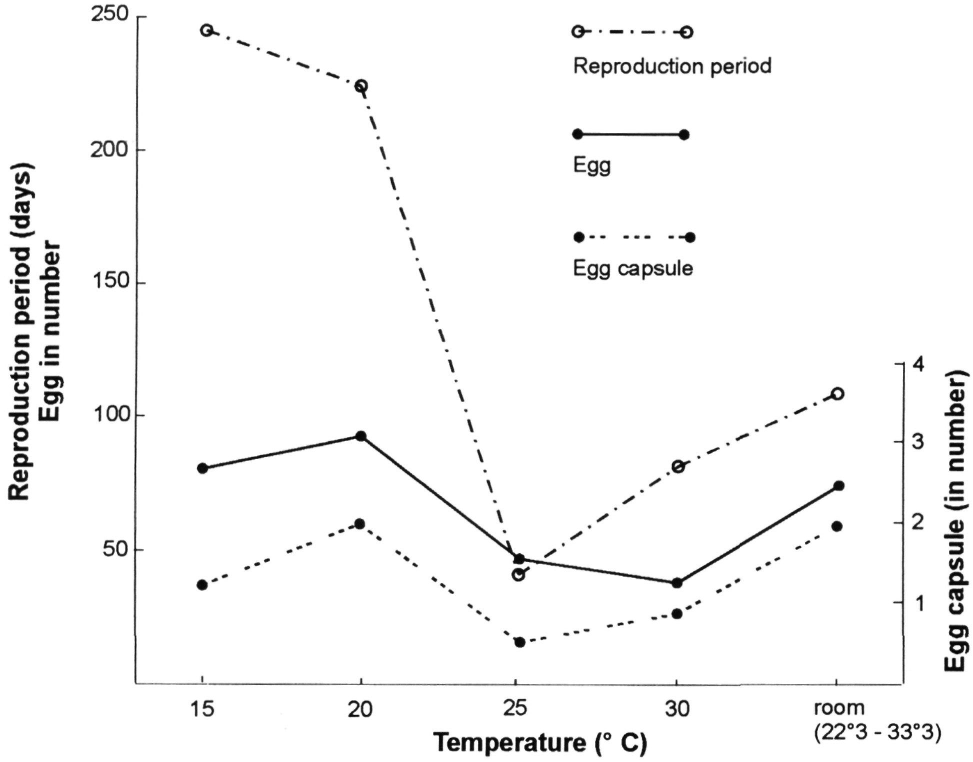

Fig. 3. The mean length of reproduction period and the number of egg capsules and eggs produced per individual when the snails *L. (R.) acuminata* were cultured at different temperatures.

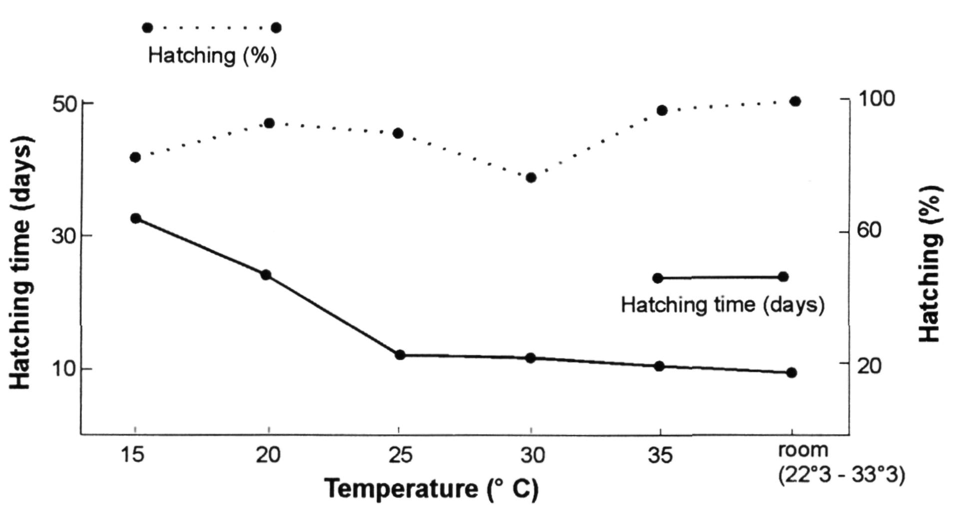

Fig. 4. The mean (error bars not shown because of very small) time required for hatching and the percentage of hatching of eggs of the snails *L. (R.) acuminata* when cultured at different temperatures.

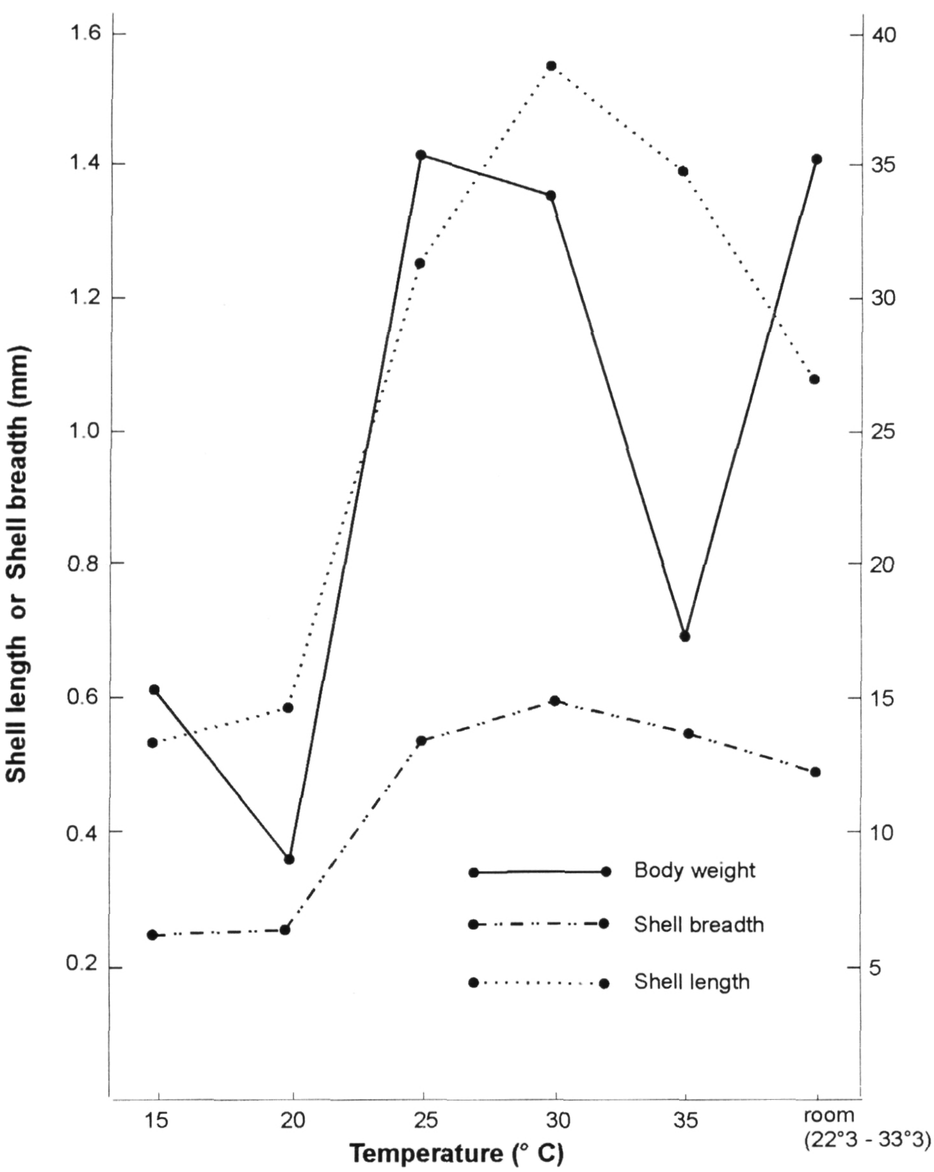

Fig. 5. Weekly average gain (error bars not shown because of very small) in shell length, shell breadth and tota body weight in *L. (R.) acuminata* cultured at different temperatures.

DISCUSSION

That temperature is a critical factor in the ecology of most organisms is well known (PRECHT *et al.*, 1973; MAGNUSON *et al.*, 1979; VIANEY-LIAUD, 1982; AHMED & RAUT, 1991; RAUT *et. al.*, 1992; AZIZ & RAUT, 1996). It is reported that the rate of growth, age of sexual maturity, length of reproduction period and egg laying capacity in snails *Lymnaea stagnalis* (VAUGHN, 1953), *Australorbis glabratus* (MICHELSON, 1961), *Bulinus (Physopsis) globosus* (SHIFF, 1964), *Biomphalaria pfeifferi* (STURROCK, 1966; APPLETON, 1977), *Biomphalaria glabrata* (CHERNIN, 1967; STURROCK & STURROCK, 1972; VIANEY-LIAUD, 1982), *Biomphalaria alexandrina* (EL-HASSAN, 1974), *Indoplanorbis exustus* (RAUT *et al.*, 1992) and *Lymnaea (Radix) luteola* (AZIZ & RAUT, 1996) fluctuate considerably within tolerable temperature ranges of the species concerned. Usually, low (15 - 20° C) temperatures delay the process of attainment of sexual maturity but enhance life span in tropical snails. Though, at such low temperatures the snails get a longer period for reproduction it is evident that the potentiality to produce eggs is reduced drastically as compared to the snails exposed to higher temperatures (RAUT *et al.*, 1992; AZIZ & RAUT, 1996). This phenomenon, as is evident from the results of present studies is also true for the snails *L. (R.) acuminata*.

The effect of temperature on the biology of *L. (R.) acuminata* is manifold because, a particular temperature acts differently on different biological parameters of an individual. Since a snail added on average 0.27, 0.39, 1.26 and 0.35 new individuals per day to the existing population of the species concerned while exposed to 15°, 20°, 25° and 30° C temperature respectively it can be said that density of *L. (R.) acuminata* is largely temperature dependent. As the recruitment rate is gradually higher with the increasing temperatures from 15° C to 25° C which is followed by a decline when the temperature was increased to 30° C, it is most likely that 25° C is ideal for maximum production. This suggests that the density of a snail population is largely temperature dependent, and thermal stimulus may act as influencing factor in regulation of population size.

Our results suggest that *L. (R.) acuminata* are highly sensitive to temperature differences as is evident from the data obtained on the rate of recruitment of new individuals at different temperatures. Though a particular temperature grade has a definite impact on the reproductive physiology of the snails under study the total mean effect of the fixed temperatures (20, 25 and 30° C) is almost equal to the effect noted for the snails exposed to room temperature. Because, the recruitment rates (0.67 at room temperature and 0.66 at fixed temperature) in these cases were almost equal. This suggests that the snails *L. (R.) acuminata* are apt to regulate the physiological process at par in respect to tolerable thermal conditions with a view to maintain the rate of reproduction at maximum level.

It appears that the snails *L. (R.) acuminata* are adapted to a wide range of temperatures and their population size would vary in different areas in respect to thermal conditions of the water bodies concerned.

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