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EFFECT OF WATER TEMPERATURES ON SOME BIOLOGICAL ASPECTS OF THE MALACOPHAGOUS INSECT, *LIMNOGETON FIEBERI* MAYR. (BELOSTOMATIDAE: HEMIPTERA)

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Abstract

The biology of this malacophagous belostomatid *Limnogeton fieberi* was studied under four different degrees of water temperature; 20,25,30 and 35°C, in association with feeding upon *Biomphalaria alexandrina* snails, the intermediate host of *Schistosoma mansoni* Sambon, in Egypt. At the aforementioned thermal conditions, the total nymphal periods lasted, 102.09±6.33, 62.35±3.63, 36±1.8 and 26±1.76 days, respectively, showing significant differences. Consequently, respective nymphal mortalities of 45, 7.5, 37.5 and 70% were recorded and showed highly significant differences. Under these conditions 183.95±17.79, 166.81±10.5, 142.22±18.28 and 162.75±9.98 individuals of *B.alexandrina* were consumed with daily rates of 1.81±0.20, 2.7±0.22, 3.95±0.39 and 6.27±0.20 indviduals, respectively. On the other hand, respective sex ratioes (female: male) of 1.75:1,1.18:1,1.1:1 and 1:2 were recorded.

The number of egg rafts laid per female were 2.57±0.53, 7.41± 1.12, 5.83±1.59 and 3.67±0.58, giving total of 90.43±17.21, 509.94±58.51, 387.25±66.38 and 289.67±10.21, eggs / female, respectively. The consumption by adults increased with the increase of temperature from 20 to 35°C.

The longevity of females and males in association with the aforementioned thermal conditions were 443.50±73.88 and 403.5±32.19 days; 400.9±56.19 and 419.9±68.55 days; 161.3±30.76 and 256.25±74.23 days; 92.25±24.17 and 195.0±14.48 days, respectively. Thus, males lived significantly longer life span than females.

Incubation periods of eggs were 21.25±2.06; 17.74±0.63; 10.97±0.83 and 9.5±0.5 days, respectively. Consequently, hatchability per cent reached 62.5±8.52; 91.84±7.63; 83.1±7.91 and 61.78±7.52%, respectively.

Key words: Biology, Malacophagous. *Limnogeton fieberi* snails; *Biomphalaria alexandrina*, water temperature.

INTRODUCTION

Aquatic and amphibious snails are important in medical and veterinary practice because of their role as intermediate hosts for some parasitic diseases of human and domestic animals . Since such snails frequently inhabit cultivated land and there cause considerable damage to young plants and roots; for example *Pomacea* spp. in rice plantations of south and central America (Efferson, 1968) the lymnaeid in cress cultivations of France and Belgium (Ricou and Picard, 1972; Van Den Bruel and Moens, 1957and 58). In these countries as also in west Germany, Holland and England, many species of snails which are found in fields and pastures act as intermediate hosts for the liver fluke *Fasciola hepatica* L. of cattle and sheep (van Den Bruel , 1968). *Biomphalaria glabrata* (Say) one of the vectors of *Schistosoma mansoni* Sambon, has ever been found in the green houses of the botanical gardens in Berlin Dahlem in 1950 (Jaeckel and Plate, 1967). In Egypt, aquatic snails infest rice plant (Hassan and Kalliny, 1967;Lutfallah,1974) and some of them serve as intermediate hosts of some parasitic diseases such as *Schistosoma mansoni* Sambon, *S. haematobium* Bilharz, *Fasciala hepatica* L.and *Angiostrongylus cantonensis* Chen. (Azzam 1987).These make the control of these pests very important for the agriculture and health of human and domestic animals. It has been almost universally agreed that the best possible method for controlling molluscs is the utilization of biological control agents.

The present work was initiated with the aim of contributing some of the needed information on one of the most efficient malacophagous insects, *Limnogeton fieberi*, which was found in rice fields and irrigation channels. Adults and nymphs of this predaceous bug feed only on snails and are able to attack all the aquatic and amphibious snails .

MATERIALS AND METHODS

Rearing of the belostomatid *Limnogeton fieberi*, was carried out by the technique described by Awadallah *et al*., (1991).

Rearing of aquatic snails were made by the same technique described by Azzam and Tawfik (1997).

To estimate the consumption rates of the two sexes, 5 females and 5 males, which had been reared on the same prey *B.alexandrina* and temperatures, were isolated individually and provided daily with a supply of sufficient food of known number of snails until death. Consequently , the numbers of consumed snails were recorded daily.

RESULTS AND DISCUSSION

Nymph stage

Durations and mortality: The experiment involved rearing of newly-hatched nymphs of *L.fieberi* at water temperatures of 20,25,30and 35°C,(40 nymphs for each degree). Nymphal development and rate of mortality under the four degrees of temperature are recorded in Table 1.

Table 1. Durations (/day) and mortalities % of the various nymphal instars of *L.fieberi* feeding upon *B.alexandrina* snail under different thermal conditions.

Degree of temperature	Duration (/day) of various nymphal instars					Total nymphal period (/day)
	1st	2nd	3rd	4th	5th	
20°C	14.44±1.36 (12-16) *36 **10	13.33±1.99 (10-17) 30 16.67	17.4±1.77 (15-21) 30 0	20.27±1.76 (16-22) 30 0	38.23±4.02 (33-40) 22 26.67	102.09±6.33 (87-118) 22 45
25°C	9.20±0.56 (8-10) 40 0	8.31±1.08 (7-11) 39 2.5	8.72±0.92 (8-12) 39 0	12.42±1.64 (9-15) 38 2.56	23.41±1.42 (21-26) 37 2.63	62.35±3.63 (57-68) 37 7.5
30°C	5.17±0.45 (4-6) 35 12.5	5.06±0.67 (4-6) 32 8.57	5.28±0.85 (4-7) 32 0	7.66±0.94 (6-10) 29 9.38	12.8±1.41 (9-16) 25 13.79	36.00±1.80 (34-43) 25 37.5
35°C	3.16±0.37 (3-4) 31 2.5	3.76±0.44 (3-4) 25 19.35	4.41±0.56 (3-5) 22 12	5.53±0.51 (5-6) 17 22.73	9.92±1.08 (9-12) 12 19.41	26.00±1.76 (24-29) 12 70

* No. of replicates ** Mortality % ( ) Range

As seen in Table 1. durations of nymphal instars were decreased with the increase of temperature . The longest periods were recorded at 20 °C, while the shortest occurred at 35°C.It appears from the above data that the fifth nymphal duration lasted the longest period (38.23±4.02days) at 35 °C, while the shortest (3.16±0.37 days) was reported for the first instar under 20 °C. By feeding upon *Biomphalaria alexandrina* (Ehrenberg), the total nymphal period (102.09±6.33 days) was recorded at 20°C, while the shortest (26±1.76 days) was detected at 35°C.

Awadallah *et al.* (1991) reported nymphal periods of 56.0±0.52 and 76.5±1.05 for *L.fieberi* at 18-28°C by feeding on *H.duryi* and *B.alexandrina*, respectively.

It appears that the nymphal duration of this predator increases as temperature decreases from (3 5 to 20°C). However, mortality got higher as temperature decreases or increases from 25°C .

Statistical analysis of data given above for the various nymphal stadia and total nymphal periods showed high significant differences (P>0.01) in the first instar between 30 and 35°C and very high significant differences (P>0.001) between other thermal conditions. Insignificant difference appeared between 30 and 35°C in both the second and third instars, while a very high significant differences (P>0.001) were reported for both stadia in association with other thermal conditions. In the fourth and fifth nymphal stadia there were very high significant differences (P>0.001) between data recorded under all thermal conditions and a similar result was seen in the total nymphal period . Concerning nymphal mortality, a very high significant differences (P>0.001) occurred under various temperatures.

Consumption : As seen in Table 2, the highest daily consumption (7.57±1.06 snails nymph) was recorded for the third nymphal instar reared at 35°C, while the lowest (1.45±6.31 snail) was recorded for first instar under 20°C .It appeared that the daily consumption rate increases as temperature increases from 20°C to 35°C . A similar conclusion was reported for the adult by Tawfik *et al.* (1991).

Statistical analysis of the data given for nymphal consumption under the different thermal conditions showed non significant differences in predation between all degrees of temperature in the fourth instar, between 30 and 35°C in the second instar, between 20 and 25°C in the third instar and between 25, 30°C in the fifth instar and very highly significant differences (P>0.001) between other data . Concerning the daily consumption rates, there were no significant differences between 25 and 30°C in the first and third instars, between 30 and 35°C in the fifth instar, highly significant differences (P>0.01) between 25and 30°C in second instar and very highly significant differences (P>0.001) between other data.

Audit stage

Sex ratio: For *L.fieberi* sex ratio was in favour of females, being 1.75:1 (14: 8) at 20°C,1.18:1(20: 17) at 30°C . However, this ratio became in favour of males at 35°C, being 1:2.(4 :8). Awadallah *et al.* (1991) reported the sex ratio 1.5:1 in favour of females by feeding on *B.alexandrina* and 1:1 by feeding on *H.duryi.* Tawfik *et al.* (1978) reported the sex ratio 1.2:1 in favour to females for the first generation and 1:1.2 in favour to males for the second generation .

From data demonstrated in Table 3, the longest preoviposition and post oviposition periods (351.43±34.77 and 62±17.62 days, respectively) occurred at 20°C, while the longest ovipostition period (288.1±48.79 days) was recorded at 25°C .On the other hand, the shortest preoviposition period (20.33±3.06 days) was detected at 35°C and the shortest postoviposition period (15.20±8.71days) occurred at 25°C, while that for the oviposition period (61.02 days) occurred at 35°C .

Statistically, concerning the preoviposition period, there was a very highly significant differences (P>0.001) between data recorded at 20°C and each of 30 and 35°C; high significant differences (P>0.01) between data reported at 20 and 25°C and insignificant difference existed between other data.While in the case of oviposition period there was significant differences (P>0.05) between data reported at 25°C and each of 20,30 and 35°C. Insignificant differences existed between other data. For the postoviposition period, there was a significant differences (P>0.05) between data reported at 20 and 25°C and insignificant differences between other data .

Egg-Productivity : It was found that the female reared at 25°C gave the highest egg-production, (7.41±1.12 rafts containing 509.94±58.51 eggs / female) . The lowest numbers of eggs (90.43±17.2 eggs in 2.57±0.53 rafts/ female) were recorded at 20°C .

Awadallah *et al*, (1991) estimated the egg-productivity of *L.fieberi* by feeding on *B.alexandrina* and *H.duryi*; being 5±0.35 rafts with 486.92±36.2 eggs / female and 3.29±0.42 rafts with 305.29±27.62 eggs / female for the first and second preys, respectively .

Statistical analysis of the data given for the egg-productivity of females ,showed

Table 2. Predation of the various nymphal instars of *L.fieberi* as reported for individual nymph fed on *B.alexandrina* under different thermal conditions.

Degree of temperature	No. of prey/ nymph instar					Total and daily Average
	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	
20°C	*★21.06±4.97 (12-30) **1.45±0.31 (0.83-2.45) ***36	★20.5±4.81 (12-27) *1.48±0.12 (1.20-1.73) 30	★25.73±3.45 (18-31) *1.55±0.36 (0.92-2.10) 30	★★37.67±6.61 (31-45) **1.86±0.26 (1.44-2.36) 30	★★★79.86±15.53 (33-107) ***2.15±0.38 (1.35-2.89) 22	183.95±17.79 (140-204) 1.81±0.20 (1.39-2.10) 22
25°C	15.00±3.41 (10-26) 1.62±0.36 (0.83-2.60) 40	26.08±5.90 (17-40) 3.04±0.61 (1.58-4.75) 39	26.33±5.28 (18-39) 3.11±0.46 (2.38-4.00) 39	34.76±4.40 (26-43) 2.88±0.42 (2.14-4.33) 38	65.38±6.82 (58-86) 2.81±0.34 (2.12-3.82) 37	166.81±10.50 (146-197) 2.70±0.22 (2.34-3.39) 37
30°C	8.83±1.92 (6-14) 1.71±0.35 (1.17-2.4) 35	13.56±3.00 (9.21) 2.68±0.51 (1.8-4.0) 32	16.3±2.96 (10-22) 3.13±0.57 (1.86-4.40) 32	38.69±6.49 (23-52) 5.05±0.62 (3.83-6.14) 29	64.24±13.55 (31-103) 4.98±0.67 (3.44-6.44) 25	142.22±18.28 (103-200) 3.95±0.39 (2.86-4.65) 25
35°C	15.09±2.49 (10-19) 4.79±0.69 (3.33-6.33) 31	27.96±4.53 (18-36) 7.52±1.41 (5.00-10.33) 25	32.59±5.57 (24-42) 7.57±1.06 (4.80-12.67) 22	34.18±2.53 (29-38) 6.21±0.45 (5.33-7.00) 17	51.50±3.53 (46-58) 5.52±0.37 (4.55-5.89) 12	162.75±9.98 (144-175) 6.27±0.20 (5.97-6.48) 12

★ Diameter 3.6±0.69 (3-5.1) mm ★★ Diameter 10.3±1.56 (9-12) mm ★★★ Diameter 14.52±1.27 (13.1-16.1) mm

* No of individuals consumed during the nymphal stadium.

** Average daily consumption.

*** No of replicates.

high significant differences (P>0.01) between data reported at 20 and 30°C, very high significant differences (P>0.001) between 25°C and each of 20, 30 and 35°C and non significant differences existed between 35°C and each of 20 and 30°C concerning numbers of egg-rafts and a very highly significant differences (P>0.001)between data reported at 20°C and each of 25 and 30°C, a highly significant differences (P>0.01) between 25°C and each of 30 and 35°C, significant differences (P>0.05) between 20 and 35°C and no significant differences existed between 30 and 35°C, in the case of total number of eggs/female.

Table 3. Oviposition records of *L.fieberi* females reared on *B.alexandrina* under different thermal conditions.

Degree of temperature	Period (/day)			No. of rafts /female	No. of Eggs /female
	Preoviposition	Oviposition	Postoviposition		
20°C	351.43±34.77 (320-400) 7	87.29±21.91 (60-110) 7	65.00±17.62 (47-94) 7	2.57±0.53 (2-3) 7	90.43±17.21 (75-116) 7
25°C	95.10±15.89 (56-119) 20	288.10±48.79 (251-415) 20	15.20±8.71 (3-28) 20	7.41±1.12 (6-10) 17 *12.33±0.58 (12-13) 3	509.94±58.51 (461-665) 17 *846±57.00 *(798-909) 3
30°C	27.33±7.73 (17-43) 12	104.17±29.24 (62-150) 12	31.83±11.72 (21-63) 12	5.83±1.59 (4-8) 12	387.25±66.38 (332-573) 12
35°C	20.33±3.06 (17-23) 3	61.00±2.00 (59-63) 3	19.33±4.16 (16-24) 3	3.67±0.58 (3-4) 3	289.67±10.21 (278-297) 3

*Three females put abnormal number of egg rafts and eggs.

*Three females which reared at 25°C laid abnormal number of egg rafts 12.33±0.58 (12-13) including 846±57 (798-909) eggs/ female.

Longevity : As seen in Table 4 at 20°C, adult longevity became the longest (443.5±73.88 days) in females and males (403.5±32.19 days, respectively) but, it became the shortest (92.25±24.17 and 195.0±14.48 days, respectively) at 35°C. Thus, longevity decreased as temperature increased and longevity is longer in male than in female except at 20°C. These results are in complete accordance with those previously reported by Awadalla *et al.*, (1991).

Very highly significant differences (P>0.001) existed between records reported for the longevity of either of the two sexes under 25°C and each of 30 and 35°C, between 20°C and each of 30 and 35°C, and insignificant differences existed between 20 and 25°C . On the other hand, insignificant differences existed between 30 and 35°C in the case of females and significant differences (P>0.05) appeared between 30 and 35°C in the case of male . Very high significant differences (P>0.001) became evident between females and males at all the thermal conditions.

Food consumption : Consumption of the males carrying eggs,was the highest daily consumption rate at all. As seen in Table 4, it appears that females recorded higher daily consumption rates at all thermal conditions than free males, or those males carrying egg-rafts that showed the lowest rate of consumption. 1.3±0.62 (1-3), 1.67±0.81 (1-3), 2.93±1.22 (1-5) and 4.27±2.28(1-7) snails at 20,25,30, and 35°C, respectively.

The highest total consumption (2915 snails) was recorded for females reared at 25°C, while the lowest (1316 snails) was reported for female reared at 35°C. The respective total consumption recorded at 20 and 30°C, were 1951 and 1718 snails . The differences in consumption rates seem to be due to differences of the longevity of the females under different thermal conditions.

Table 4. Longevity and consumption rate of adults of *L.fieberi* feeding upon *B.alexandrina* under different thermal conditions.

Degree of	Longevity in days		No. of consumed snails/adult		
temperature	Female	Male	Female	Male	Male carrying eggs
20°C	443.5±73.88 (355-573) 4	403.5±32.1 (375-481) 8	*4.40±1.55 (2-7) **1951	2.77±0.88 (1-4)	1.30±0.62 (1-3)
25°C	400.9±56.19 (340-546) 20	419.9±68.55 (386-556) 17	7.33±3.56 (2-13) 2915	4.00±2.00 (1-7)	1.67±0.81 (1-3)
30°C	161±30.76 (125-221) 12	256.25±74.23 (166-398) 12	10.67±3.2 (6-16) 1718	6.67±2.06 (4-10)	2.93±1.22 (1-5)
35°C	92.25±24.17 (57-112) 40	195±14.48 (179-222) 8	14.26±5.69 (6-20) 1316	8.27±3.83 (2-13)	4.27±2.28 (1-7)

*Daily consumption ** Total consumption

Thus, daily consumption rates of adult females, free males and males carrying eggs increase as temperature increase from 20°C to 35°C. Similar observations were reported for the same predator by Tawfik *et al*, (1991) and by Azzam and Tawfik (1997) for *Sphaerodema urinator.*

Analysis of variance showed very high significant differences (P>0.001) between records reported for the daily consumption of the female, free male and male carrying egg-raft kept at the various thermal conditions. Concerning the differences between the thermal conditions in each case, very high significant differences (P>0.001) became evident between data reported for 20 and 30°C and between 25 and 35°C . Significant differences (P>0.05) appeared between 25°C and each of 30 and 20°C and between 30 and 35°C, in the case of females. In the case of males, the differences were very highly significant (P>0.001) between 25 and 35°C, 20 and 30°C and highly significant difference (P>0.01) between 25 and 30°C, 20 and 35°C and insignificant differences between 30 and 35°C, 25 and 20°C . Non significant differences also existed between 20 and 25°C in the case of male carrying eggs, while very highly significant differences (P>0.001) appeared between 35 and each of 20 and 25°C. Highly significant differences (P>0.01) became obvious between other data.

Egg stage

Incubation period: Results showed that temperature affects the incubation period; it decreased as temperature increased from 20 to 35°C. Incubation period was longest 21.25±2.06 days with a range of (14-20 days) at 20°C, while it lasted the shortest (9.50±0.5 (9-10) days) at 35°C. The differences in those periods were statistically significant as incubation period decreases as temperature increase . A similar result was reported for the same predator by Voelker (1968) and also by Awadallah *et al.*, (1991).

Hatchability: The rate of hatchability of *L.fieberi* eggs increased as temperature increased from 20 to 25°C, but it decreased as temperature increased from 25°C to 30°C, Table 5. Thus, at 20°C, this rate was represented by 62.5±8.52 (50-74.42%), while at 25°C it was 91.84±7.63 (74.19-100%). Respective rates of 83.10±7.91 (66.21-94.21%) and 61.78±7.52 (54.87-71.32%) were recorded at 30 and 35°C.

Statistical analysis of the data showed non significant differences between records reported for 20 and 35°C and very highly significant differences (P>0.001) between other data .

Table 5. Incubation period (/day) and hatchability (%) of eggs laid by *L.fieberi* females reared on *B.alexandrina* under different thermal conditions .

Degree of temperature	Incubation period (/day)	Hatching %
20°C	21.25±2.06 (19-23)	62.5±8.52 (50-74.42)
25°C	17.74±0.63 (14-20)	91.84±7.63 (74.19-100)
30°C	10.97±0.83 (8-14)	83.1±7.91 (66.21-94.21)
35°C	9.5±0.5 (9-10)	61.78±7.52 (54.87-71.32)

On basis of the aforementioned information, it appears that 25°C is the most favorable degree for rearing the predator *L.fieberi* to use it in field application .

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تأثير درجة حرارة الماء على بعض المعايير البيولوجية للحشرة المفترسة للقواقع لينوجيتون فايبيري من عائلة بلوستوما تيدي – رتبة نصفية الاجنحة

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تم دراسة بيولوجي البقة المفترسة للقواقع ليمنوجيتون فايبيري تحت أربع درجات حرارة مختلفة هي ٢٠، ٢٥، ٣٠، ٣٥ درجة مئوية مع التغذية على قوقع بيومفلاريا الكسندرينا العائل الوسيط لبلهارسيا الامعاء في مصر.

استغرقت فترة العمر الحوري تحت درجات الحرارة السابقة على التوالي ١٠٢,٠٩±٦,٣٣، ٦٢,٣٥±٣,٦٣، ٣٦±١,٨، ٢٦±١,٧٦ يوما وكانت نسبة الموت للحوريات ٤٥٪ ، ٧,٥٪، ٣٧,٥٪، ٧٠٪ على التوالي.

كان متوسط استهلاك الحورية من القواقع خلال فترة العمر الحوري كله وتحت درجات الحرارة السابقة ١٨٣,٩٥±١٧,٧٩، ١٦٦,٨١±١٠,٥٠، ١٤٢,٢٢±١٨,٢٨، ١٦٢,٧٥±٩,٩٨ قوقعاً على التوالى بمعدل استهلاك يومي للحورية قدره ١,٨١±٠,٢، ٢,٧±٠,٢٢، ٣,٩٥±٠,٣٩، ٦,٢٧±٠,٢ قوقعاً على التوالي.

بعد تحول الحوريات للطور الكامل كانت النسبة الجنسية (إناث : ذكور) تحت درجات الحرارة الاربعة هي ١,٧٥ : ١ و ١,١٨ : ١ و ١,١ : ١ و ١ : ٢ على التوالي.

متوسط عدد البيض للانثى تحت درجات الحرارة الاربعة كان ٢,٥٧±٠,٥٢، كتلة احتوت على (٤٣,٩٠±١٧,٢١ بيضة)، ٧,٤١±١,١٢ كتلة بها (٩,٩٤±٥٠٥٨,٥١ بيضة) ، ٥,٨٣±١,٥٩ كتلة بها (٣٨٧,٢٥±٦٦,٣٨ بيضة)، ٣,٧٦±٠,٥٨ (٢٨٩,٦٧±١٠,٢١ بيضة) على التوالي.

بلغ متوسط طول عمر الحشرات الكاملة من الاناث والذكور ٤٤٣,٥±٧٣,٨٨، ٤٠٣,٥±٣٢,١٩ يوما، ٤٠٠,٩±٥٦,١٩، ٤١٩,٩±٦٨,٥٥ يوما ١٦١,٣±٣٠,٧٦، ٢٥٦,٢٥±٧٤,٢٣ يوما ٢٩,٢٥±٢٤,١٧، ١٩٥,٠٠±١٤,٤٨ يوما تحت درجات الحرارة المذكورة على التوالي بزيادة معنوية في عمر الذكور عن الاناث.

تراوحت فترة حماية البيض بين ٢١,٢٥±٢,٠٦، ١٧,٧٤±٠,٦٣، ١٠,٩٧±٠,٨٣، ٩,٥٠±٠,٥٠ يوما تحت درجات الحرارة الاربعة : على التوالي. ونسبة الفقس ٦٢,٥±٨,٥٢ ٪، ٩١,٨٤±٧,٦٣٪، ٨٣,١±٧,٩١ ٪، ٦١,٧٨±٧,٥٢٪.

من ذلك يتضح أن درجة حرارة ٢٥°م هي أنسب درجة لتربية المفترس لاستخدامه التطبيقي الحقلي لمكافحة القواقع.