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Environmental Factors and Their Influence on Reproduction and Growth of Freshwater Snails in Saudi Arabia

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Comparative studies on *Lymnaea auricularia, Biomphalaria arabica* and *Physa acuta* snails, as intermediate hosts for Fasciola and Schistosomes, were accomplished. The specimens were collected from the Eastern, Central and Southern regions of the Kingdom. They were maintained in our laboratory. Presence of soil-substrate stimulates hatching of snails. Egg-laying activities by snails exposed to strong and continuous light intensity, was inhibited. *L. auricularia* snails reached maturity after 105 days, *B. arabica* after 84 days and *P. acuta* after 56 days. At maturity, the shell length of *L. auricularia* was 7.5mm and its weight 43mg; the shell length of *B. arabica* was 6mm and its weight 49mg; the length of *P. acuta* shell was 5.1mm and its weight 20mg. *L. auricularia* snails, living in crowd, showed tremendous reduction in their rate of growth and reproduction.

Freshwater in Saudi Arabia is only confined to certain places. It originates from natural springs and deep wells. It is of limited sources. The mineral constituents of such water vary from one region to another. That is why the study of freshwater fauna in this country is becoming attractive for biologists who are interested in following species variations and adaptability. It has been stated by Thomas *et al.* (1974) that the chemical composition of water has a direct effect on the growth of freshwater pulmonate snails.

This communication reports the results of field collections, identifications and laboratory maintenance of some species of freshwater snails from three regions: Eastern, Central and Southern. Snails, as mentioned by Malek (1950), usually originate (either directly or indirectly) in river water and then they are distributed through the same water

to different areas; the best example he quoted, was the River Nile which forms the main source of all the snails found in Egypt, Sudan, Ethiopia and Uganda. In this country the existence of snails in freshwater habitats, which have no access to any river source, is peculiar.

The importance of the snails, studied in this report, is not only because their presence is rather uncommon in this valuable freshwater enviroment, but also because they play very important roles in the transmission of some important human and animal diseases such as schistosomiasis and fascioliasis.

Materials and Methods

Adult snails collected from their natural habitats were maintained in our laboratory in glass tanks (measured 45 by 30cm with a depth of 10 or 15cm). The open tops of these tanks were covered with a 2–3mm glass sheets to reduce evaporation, prevent egress of snails and exclude dust, insects etc... from the tank. The tanks were filled with unfiltered tap water previously stored for 7 days to remove chlorine. Faecal debris of the snails and food debris were cleaned twice weekly employing a siphon tube. Once a week, half the water was removed and replaced. The tanks were aerated continuously and the snails were fed on fresh lettuce. The egg capsules, produced by these snails, were mainly deposited on small pieces of cellophane material which were placed in each of the tanks.

These containers have been subjected for 6hr daily to artificial light of the room. Six tanks of this type have been prepared; tanks (1) and (2), both contained 15 *Lymnaea auricularia* snails, (3) and (4), (5) and (6) contained the same numbers of *Biomphalaria arabica* and *Physa acuta* snails, respectively. Soil substrate, consisting mainly of gravel, was provided in tanks (1), (3) and (5). After about 6 days of observation, the water, with or without soil substrate, in each tank, was analysed to determine its chemical composition using flame spectrophotometer. Using the results of the above experiments, soil substrated water was then used in a different set of experiments to determine the rate of devolopment and hatching of these snails under different range of temperatures and light intensity. Small tanks, of 300ml capacity, were used for these experiments; to these tanks egg capsules of *L. auricularia, B. arabica,* and *P. acuta* snails were transferred. Development and growth of the individual snails were followed by examining the different stages under stereoscopic microscope; the average size and weight as main criteria for growth were determined.

In a final set of experiments, the rate of growth of isolated *L. auricularia* snail, using similar glass containers, was studied. Capsules containing eggs and newly hatched embryoes were examined, at intervals, under low magnification of the microscope, drawn under camera lucida, and their sizes were determined according to scale. The growth of older snails (beyond hatching stage) was studied by measuring, at weekly intervals, the

shell dimensions according to the group of the snail concerned. The shells of *L. auricularia* and *P. acuta* were measured for greater length from the apex to the end of the aperture. The diameters of *B. arabica* snail shells were measured along an axis running through the centre of the spire and the junction between the aperture and the body wall. The fresh weight of the snails was determined by, first, drying the specimens on filter paper, and then weighing them by using a chemical balance. This process of measurements was done after the end of the first day (from hatching), the 7*th* day and at maturity stage according to the procedure of Thomas *et al.* (1974).

Results

Preliminary observation on the growth of snails recently collected from the field in presence and absence of soil substrate

These experiments began towards the end of winter at a temperature of 17°C. In tanks (1), (3) and (5) containing each 15 adult snails in a soil substrated water, we noticed an increasing number of newly hatched snails; while in tanks (2), (4) and (6) containing the same number of snails but without soil substrate, only very few unhealthy hatching snails, which died at intervals, were seen.

Chemical analysis of water

The result of analysis, done on the two types of water (with and without soil substrate), using flame spectrophotometer showed differences in the concentration of the elements present in the water. For example, the concentration of calcium in soil substrated water was found to be more than one half greater than its amount in non-substrated water; sodium was found to be more than one third greater, etc... (Table 1)

Table 1. Showing concentration of important elements present in the water used for snail breeding.

Type of water	Concentration in mg / l					
	Na	K	Mg	Cu	Fe	Ca
Soil-substrated water	345	35	44	Nil	Nil	40 75
non-substrated water	220	26	34	Nil	Nil	15

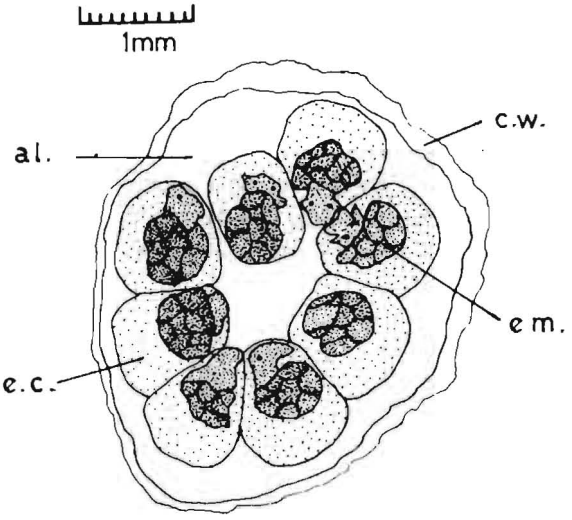

Fig. 19a. Egg capsule of *Biomphalaria arabica* in aerated tap water plus soil-substrate, after 7 days from deposition. al., albumen; c.w., capsule wall; e.c., egg cell; em. embryo.

Requirements for development and hatching

(a) *The importance of soil constituents*

Two capsules containing *Biomphalaria arabica* eggs were removed from tank (3) of the previous experiments. One capsule with 8 eggs, was placed in a small glass tank (350ml capacity) "19A" containing 300 ml of aerated tap water (previously stored for 7 days) plus soil substrate; after 7 days, the egg capsule was carefully removed, examined by the microscope, drawn under camera lucida (Fig. 19a) measured and quickly returned back to the tank. The second capsule, with 6 eggs, was placed in a similar container "19B" having 300 ml of aerated tap water (previously stored for 7 days) but without a soil substrate. These tanks were placed in an incubator at 23°C. The egg capsule was drawn in a similar manner (Fig. 19b) and its dimensions were measured after 7 days from the beginning of development.

The same experiments were repeated for *L. auricularia* and *P. acuta* snails.

The results obtained from these experiments showed that the embryoes in tank "19A" (soil substrate present) developed very fast inside the eggs and hatching for *B. arabica* and *L. auricularia* took place after 14 days and for *P. acuta* after 8 days from the beginning of development. The embryoes in tank "19B" (soil substrate absent showed very slow rate of development inside the eggs and no hatching was observed.

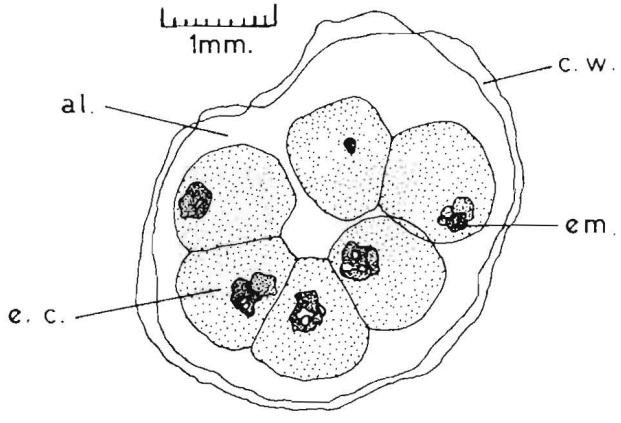

Fig. 19b. Egg capsule of *B. arabica* in aerated tap water without soil-substrate, after 7 days from deposition.

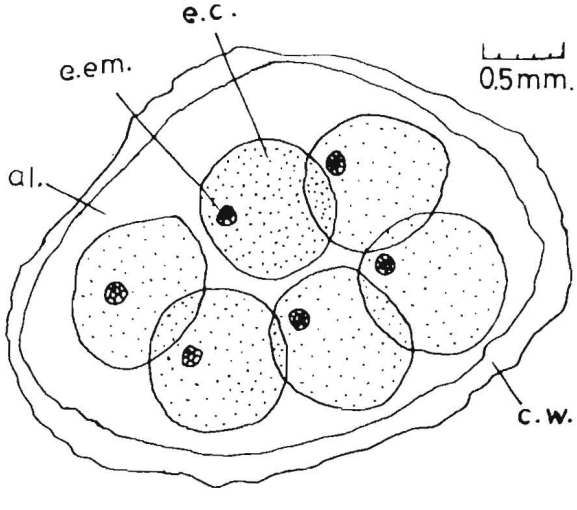

Fig. 20a. Egg capsule of *B. arabica* after one day from the start of development at 23°C. e.em., early embryo.

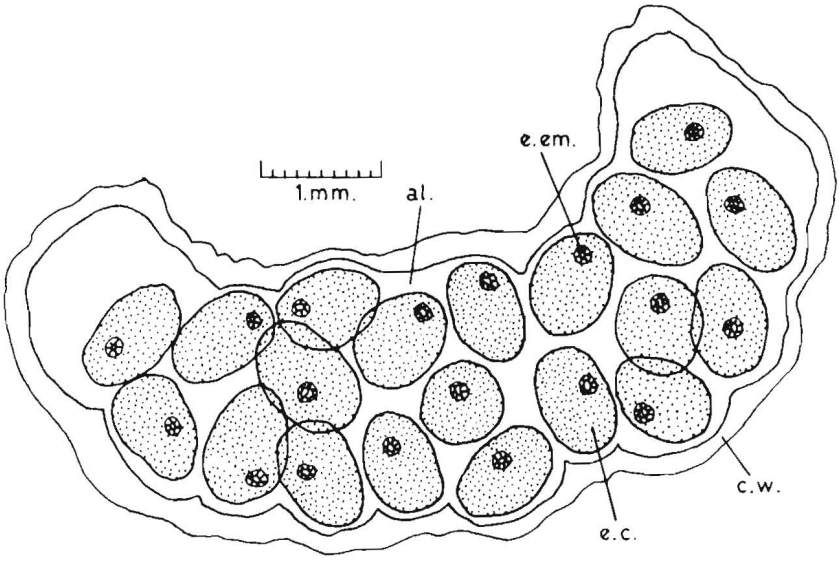

Fig. 21a. Egg capsule of *Lymnaea auticularia* after one day from the start of development at 23°C.

(b) *The effect of light on the production of eggs*

Six small tanks (350ml capacity) each contained 300ml of aerated tap water (as in the above experiments) plus soil substrate were prepared. To each of the first two tanks "19C1" and "19C2", 5 mature individuals of *B. arabica* snails were added; to the third and forth tanks "19D1" & "19D2", 5 *L. auricularia* snails were added; the 5*th* and 6*th* tanks, "19E1" and "19E2", each contained 5 *P. acuta* mature snails. Three tanks, "19C1", "19D1" and "19E1" were subjected to a continuous strong artificial light directed from a bulb (110 volts). Tanks "19C2", "19D2" and "19E2" were set away from any artificial source of light. The temprature in both was adjusted (using thermostate) at 25°C. In the latter tanks (kept away from light), *B. arabica* snails produced during 10 days, 38 eggs, *L. auricularia* produced during 10 days 156 eggs, *P. acuta*, during the same time, produced 50 eggs. In the former tanks (exposed to light), after 10 days of observation, no eggs were produced by the snails.

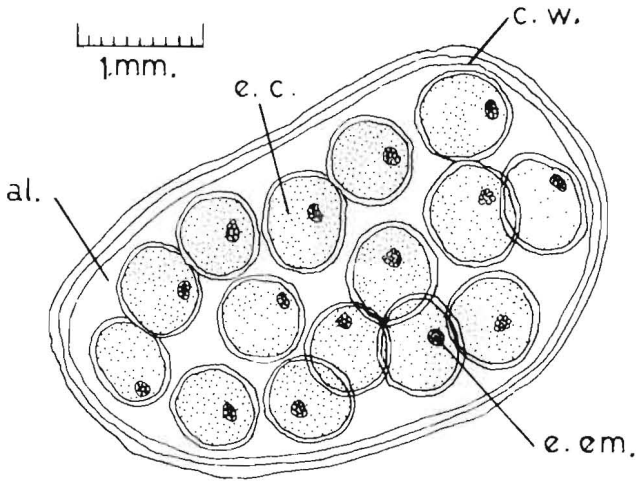

Fig. 22a. Egg capsule of *Physa acuta* after one day from the start of development at 23°C.

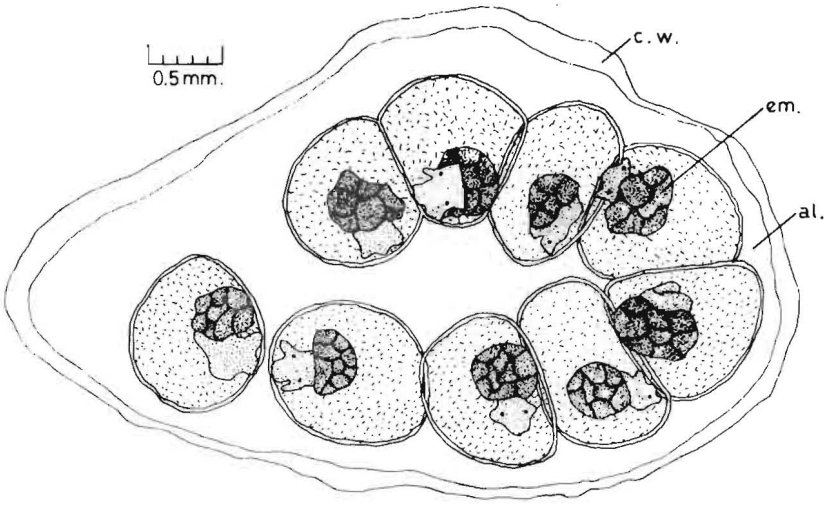

Fig. 20b. Egg capsule of *B. arabica* after 7 days from the start of development at 23°C.

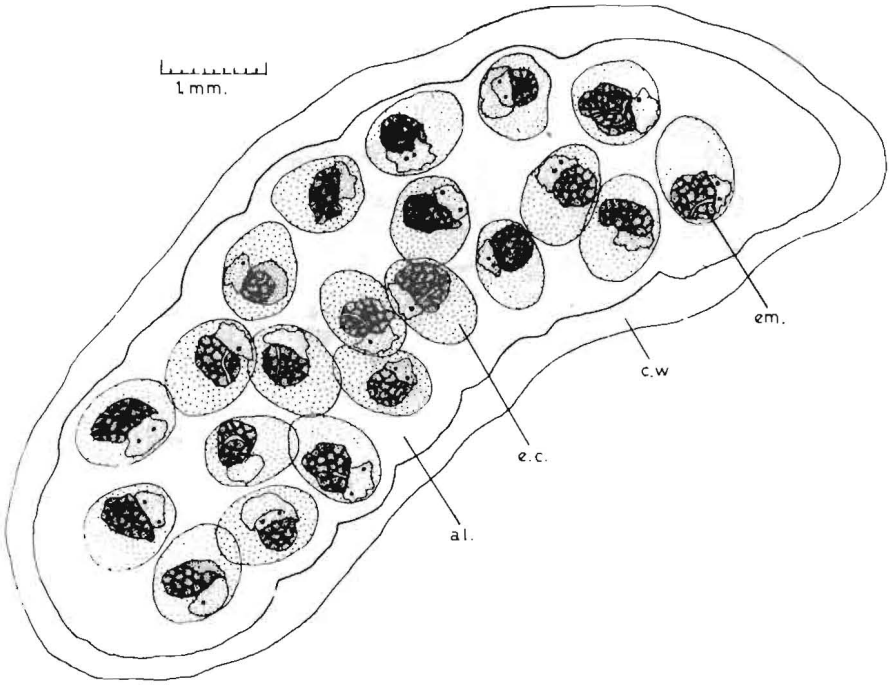

Fig. 21b. Egg capsule of *L. auricularia* after 7 days from the start of development at 23°C.

(c) *The effect of temperature on the periods of hatching*

Nine small tanks were prepared, each containing 300ml of aerated tap water plus soil substrate. Three tanks ("19F1" having *B. arabica* egg capsule, "19F2" having *L. auricularia* egg capsule and "19F3" having *P. acuta* egg capsule) were placed in an incubator at 17°C; 3 tanks ("19G1" with *B. arabica*, "19G2" with *L. auricularia*; "19G3" with *P. acuta* egg capsules) were put in an incubator at 23°C; 3 tanks ("19H1" containing an egg capsule of *B. arabica*, "19H2" containing an egg capsule of *L. auricularia*, "19H3" containing an egg capsule of *P. acuta* snails) were put in an incubator at 28°C.

Development and hatching were observed in each set of experiments. The results showed the following:

At 17°C, in the case of *B. arabica* and *L. auricularia*, hatching of embryoes took place after 15–17 days. In case of *Physa acuta*, embryoes hatched after 12–14 days.

At 23°C, *B. arabica* and *L. auricularia* embryoes hatched after 13–15 days; *P. acuta* embryoes hatched after 8–10 days.

At 28°C, hatching of the embryoes of *B. arabica* and *L. auricularia* resulted after 8–9 days; embryoes of *P. acuta* hatched after 7 days.

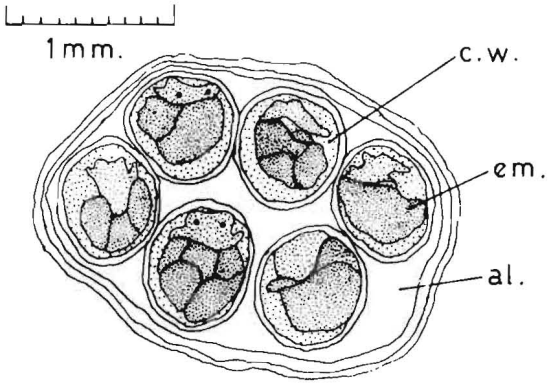

Fig. 22b. Egg capsule of *P. acuta* after 7 days from the start of development at 23°C.

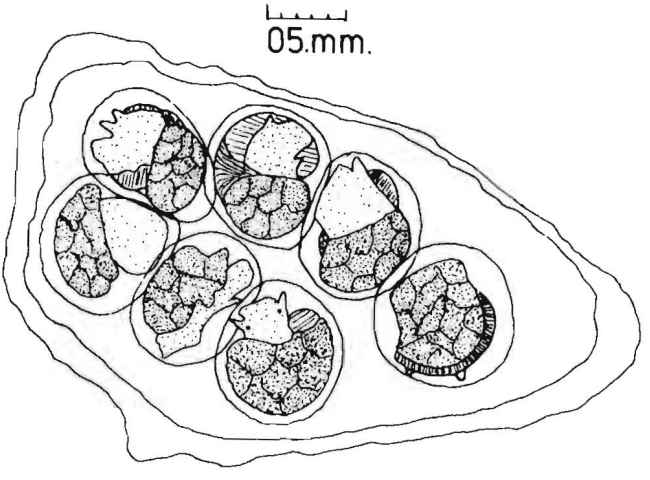

Fig. 20c. Egg capsule of *B. arabica* after 12 days from the start of development at 23°C.

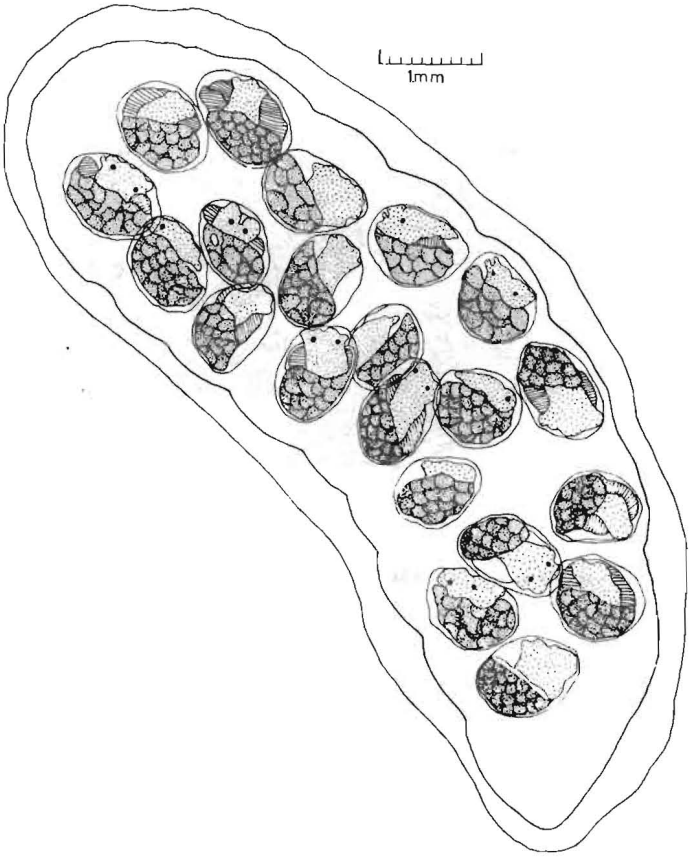

Fig. 21c. Egg capsule of *L. auricularia* after 12 days from the start of development at 23°C.

(d) *Study of the stages of development of embryoes inside egg capsules at 23°C*

Three small tanks (20, 21, 22), each containing aerated tap water (with soil substrate) at 23°C were prepared. To tank 20, three fresh egg capsules of *B. arabica* snails were transferred; to tank 21, two capsules of *L. auricularia* were added; to tank 22, two capsules of *P. acuta* were added.

After elapse of one day, 7 days and 12 days, the capsules were drawn and measured. After one day from the beginning of experiment, no differeces in development between the various groups of snails were noticed (Fig. 20a, 21a, 22a). After 7 days, no differences in development were noticed between the embryoes of *B. arabica* and *L. auricularia* snails; but the embryoes of *P. acuta* showed complete development and some of them were very close to hatching (Fig. 20b, 21b, 22b). After 12days from the start of

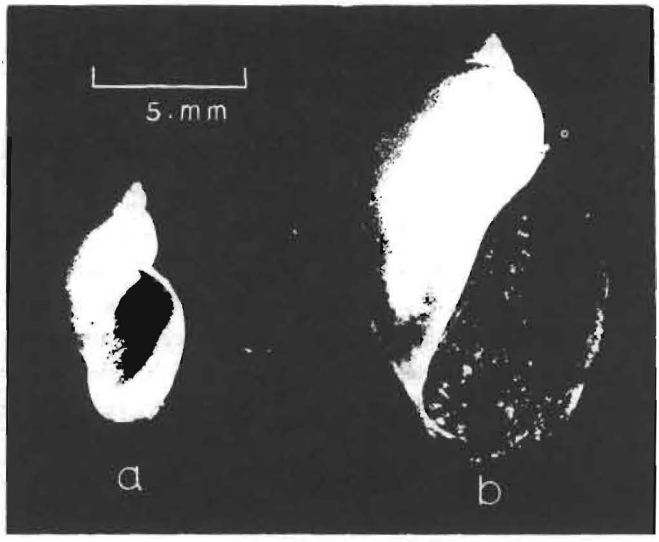

Fig. 23. *(L. auricularia)* **a- reared in crowd, b- reared in isolation.**

Table 2. Showing egg-laying activities of the snails during a week.

pin number	number of adult *L. auricularia* snails	date of egg laying	number of eggs per egg capsule	egg output per day	total
23 a	9	29 April	25 + 22	47	
		1 May	13 + 18	31	
		3 May	18	18	
		5 May	7	7	
		6 May	9	9	112
23 b	1	29 April	50 + 46 + 64	160	
		6 May	30 27 6	63	223
	number of adult *B. arabica* snails				
24	3	2 May	5 + 7 + 9 + 7	28	
		6 May	7	7	35
	number of adult *P. acuta* snails				
26	10	2 May	8 + 5 + 8	21	
		6 May	8	8	29

the experiment, the embryoes of *B. arabica* and *L. auricularia* snails completed their development and were very close to hatching (Fig. 20c, 21c). *P. acuta* embryoes hatched after 9 days only from the start of the experiment.

(e) *The effect of crowding on growth and egg production of L. auricularia snails at 23°C*

Two small tanks, each containing 300ml of aerated tap water plus soil substrate were set at 23°C. To the first tank "23 A" we transferred 20 newly hatched *L. auricularia* and to the second tank "23 B" we have added only one newly hatched *L. auricularia* snail. Shell lengths of the snails in both tanks were measured at weekly intervals until the mature stages of the snails were reached. Relations, between shell lengths of the snails and the time required by each animal to become mature in tank "23 A" at 23°C, were established (Table 3 and Fig. 24).

Nine of the 20 snails placed in tank "23 A" became mature and the remainder died before maturation. The snail isolated in tank "23 B" laid eggs at the same time (112 days) as those kept in tank "23 A"; in this tank "23 A" the average length of the shell of the

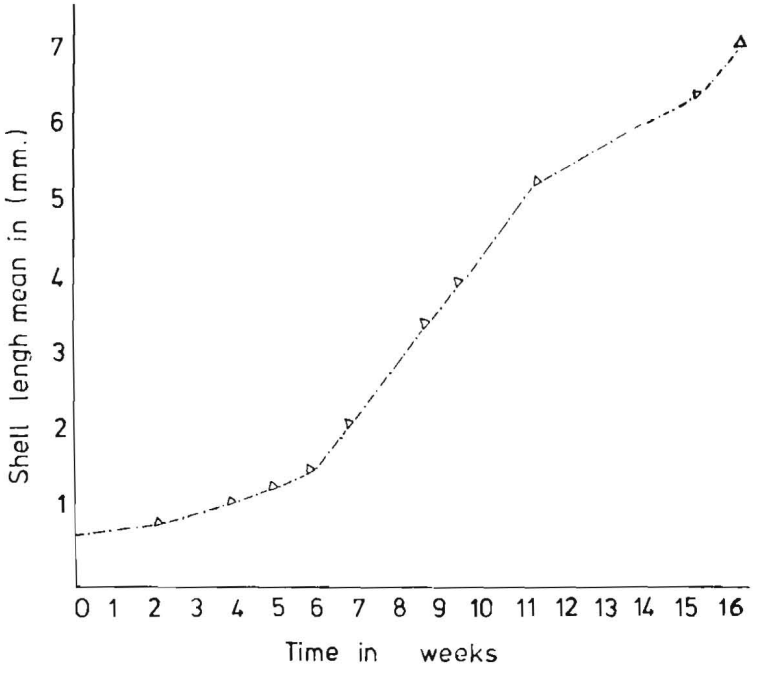

Fig. 24. Showing the relation between time and shell length (mean) for *L. auricularia* maintained at 23°C.

snails at maturity was 7.4mm and average weight was 39mg, whereas the shell length of the isolated snail in tank "23B" at the same stage of maturation was 14mm and its average weight was 270mg (Fig. 23).

The total number of the eggs produced by 9 adult snails in tank "23A", during a week, was 112 eggs and the biggest number of eggs contained in the egg capsule laid by these snails was 25 eggs; while the isolated snail in tank "23B" produced a total of 223 eggs during the same week and the biggest number of eggs contained in the egg capsule was 64 eggs (Table 2).

Table 3. Relationship between shell length and time for *L. auricularia* maintained at 23°C.

Week	Shell length range in (mm)	Shell length mean in (mm)
0	0.8 – 0.85	0.82
2	0.85 – 0.90	0.88
4	0.90 – 1.60	1.16
5	1.0 – 2.0	1.38
6	1.2 – 2.4	1.56
7	1.3 – 3.0	2.10
9	3.0 – 4.0	3.40
10	3.5 – 4.5	4.00
12	4.5 – 5.6	5.20
15	5.3 – 6.4	6.00
16	5.8 – 7.8	7.40

(f) *Comparative study of growth of snails in relation to time at 28°C*

Three small tanks 24, 25, 26 were prepared as in the above experiment and the water was set at 28°C. To tank "24" we transferred 6 newly hatched snails of *B. arabica* and to tank "25" we added 15 snails of *L. auricularia*, to tank "26" we added 15 snails of *P. acuta*. Drawing and measurements of the snails were carried out after one day, 7 days (from the start of the experiment) and at the adult stages (Fig. 20d, 20e, 20f) of *B. arabica*, (Fig. 21d, 21e, 21f) of *L. auricularia*, and (Fig. 22c, 22d, 22e) of *P. acuta*.

Relationship between shell length and time at the adult stages of these snails was established (Table 4 and Fig. 25).

B. arabica snails in tank "24" reached adult stage after 84 days, *L. auricularia* in tank "25" after 105 days and *P. acuta* in tank "26" after 56 days. At maturity, the shell lengths of *B. arabica, L. auricularia* and *P. acuta* were 6.0mm, 7.5mm and 5.1mm and their fresh weights were 49.0mg, 43.0mg and 20.0mg, respectively. Three out of 6 in case of *B. arabica* snails and 9 out of 15 in the case of *L. auricularia* and *P. acuta* snails survived and became mature; the remainder died at intervals.

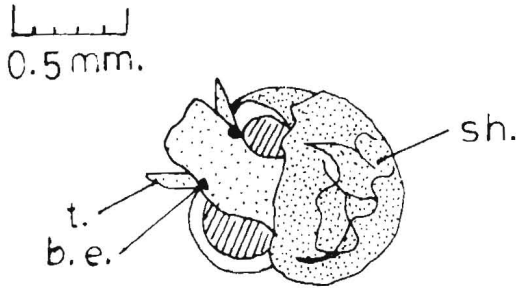

Fig. 20d. Young *B. arabica* after one day from hatching. b.e., basement eye; sh., shell; t., tentacle.

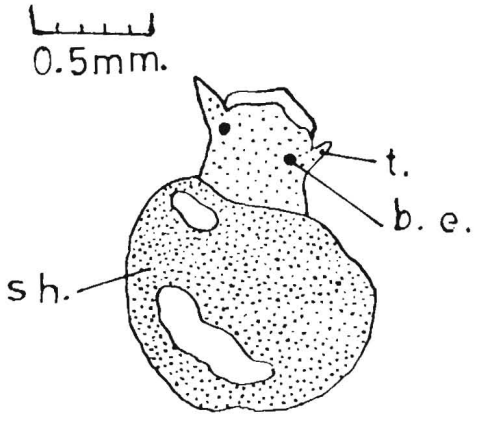

Fig. 20e. Young *B. arabica* after 7 days from hatching.

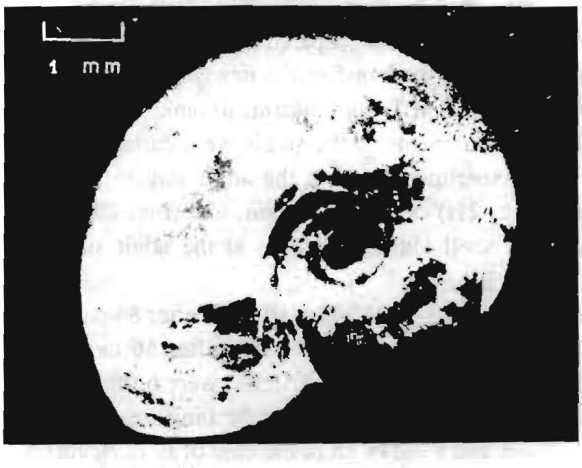

Fig. 20f. Shell of the adult stage of *B. arabica*.

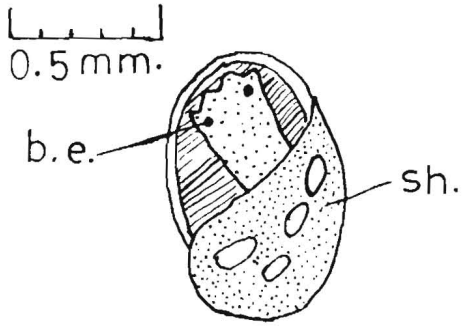

Fig. 21d. Young *L. auricularia* after one day from hatching.

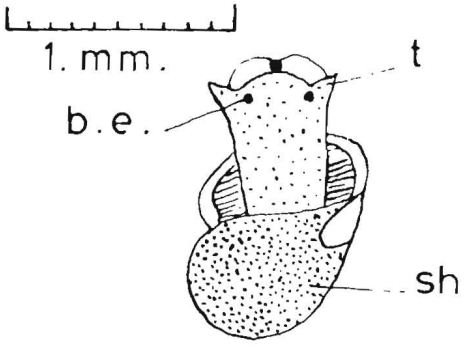

Fig. 21e. Young *L. auricularia* after 7 days from hatching.

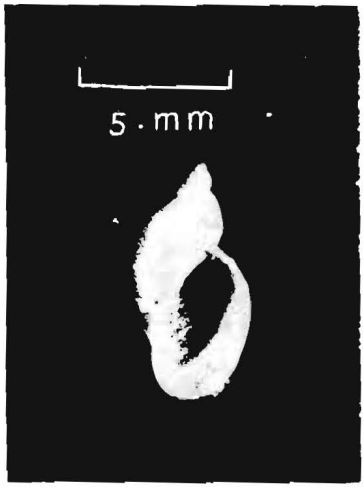

Fig. 21f. Shell of the adult stage of *L. auricularia*.

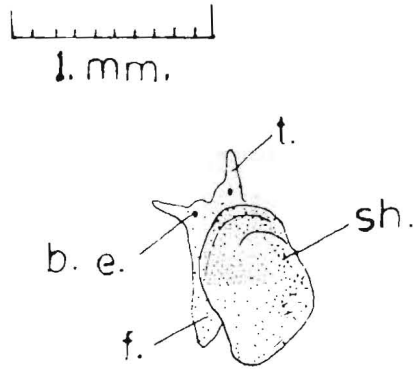

Fig. 22c. Young *P. acuta* after one day from hatching. f., foot.

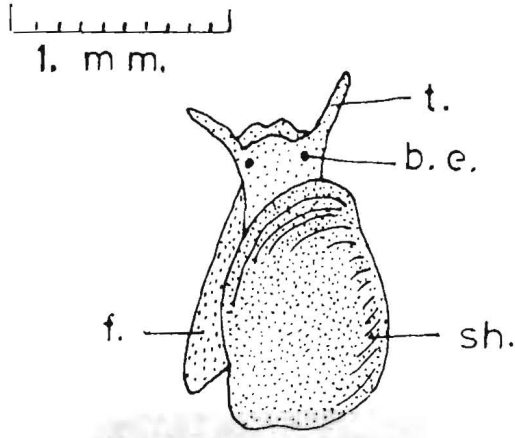

Fig. 22d. Young *P. acuta* after 7 days from hatching.

Fig. 22e. Shell of the adult stage of *P. acuta*.

Table 4. Relationship between shell lengh and time for *B. arabica, L. auricularia* and *P. acuta* maintained at 28°C.

Week	*B. arabica*		*L. auricularia*		*P. acuta*	
	shell length range in mm	shell length mean in mm	shell length range in mm	shell length mean in mm	shell length range in mm	shell length mean in mm
0	0.8 – 0.9	0.84	0.8 – 0.9	0.85	0.7 – 0.8	0.75
1	1.0 – 1.1	1.05	1.2 – 1.4	1.30	1.0 – 1.1	1.04
2	1.2 – 1.3	1.28	1.3 – 1.7	1.40	1.4 – 1.7	1.52
3	1.6 – 1.7	1.66	1.6 – 1.8	1.70	2.7 – 3.3	2.90
4	2.0 – 2.3	2.16	2.0 – 2.5	2.30	3.0 – 3.9	3.40
5	2.9 – 3.1	2.96	2.2 – 2.8	2.50	3.4 – 4.0	3.70
6	3.9 – 4.3	4.96	2.5 – 3.5	2.90	3.6 – 4.4	4.30
7	4.4 – 5.4	4.96	3.3 – 3.8	3.50	4.6 – 4.8	4.70
8	4.5 – 5.6	5.05	3.5 – 4.1	3.80	4.9 – 5.3	5.10
10	4.7 – 5.9	5.40	3.7 – 5.2	4.50		
12	5.6 – 6.6	6.00	4.8 – 6.5	5.70		
15			5.5 – 7.8	7.50		

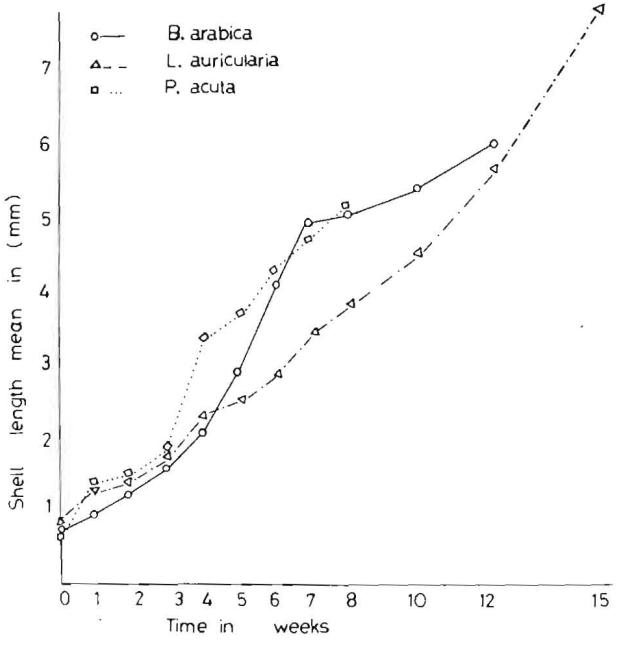

Fig. 25. Showing the relation between time and shell length (mean) for *B. arabica, L. auricularia* and *P. acuta* maintained at 28°C

Discussion

The freshwater snails, collected from "Kharj" (in the Central region of the Kingdom), "Hassa" (in the Eastern region) and Jizan (in the Southern region), were identified according to their anatomy, shell size and structure of each adult snail. Our identification, which was confirmed by Dr. Brown of the British Museum, resulted in three species of snails, namely; *Biomphalaria arabica*, an intermediate host for *Schistosoma mansoni*, a parasite that causes intestinal bilharziasis; *Lymnaea auricularia,* a susceptible host for *Fasciola gigantica,* a parasite that causes liver fascioliasis of domestic animals; *Physa acuta,* a probable host for *Schistosoma haematobium*, a parasite causing urinary bilharziasis.

B. arabica is of very limited distribution and it is quite possible that the presence of this snail is confined to Saudi Arabia and probably other parts of the Arabian peninsula; its ecology and distribution has not yet been studied. This snail, according to morphological and anatomical features, is closely related to *B. alexandarina* of Egypt and *B. pfefferi* of Sudan and other neighbouring African countries. That is why we think it is susceptible, like its relatives, to infection with *Schistosoma mansoni* and could be the chief transmitter of the intestinal bilharziasis present in this country.

P. acuta is of rare occurrence throughout the world. The snail, according to the main anatomical and morphological features described, is closely related to *Bulinus truncatus* which is the most popular agent for the transmission and spread of urinary bilharziasis in the world. Thus, we believe that *P. acuta* (sister snail of *Bulinus truncatus)* could play the same role in the spread of the disease occurring in this country.

This communication reports, for the first time, the relationship of *P. acuta* to the environment of Saudi Arabia; further experiments are being conducted in our laboratory to prove the susceptibility of these snails to infection with *S. mansoni* and *S. haematobium,* respectively.

Our report also confirms the presence of *L. auricularia* (a popular intermediate host for *Fasciola gigantica* throughout the world) in this country, which is responsible for the occurrence of Fascioliasis reported in a previous paper by Magzoub and Kasim (1978) to be existing in all the regions of Saudi Arabia.

Thomas *et al.*, in a recent publication in (1974), referred to the effect of chemical conditioning of the environment on growth rates of *Biomphalaria glabrata*. Whitlock *et al.* (1977), compared two methods (closed container system, consisting of glass jars, and shallow aquarium system, consisting of glass tanks) for the maintainence of *Lymnaea tomentosa* in the laboratory; both methods were found to be working. Eisenberge (1965) surveyed the density of the pond snail, *Lymnaea elodes,* in its natural habitat and observed the effect of density on the behaviour of these snails. In the present communication, we have maintained in our laboratory at the Department of Zoology of Riyad University, three species of snails (*B. arabica, L. auricularia* and *P. acuta*) collected from similar

environments in the field. Efficient reproduction and growth of these snails seemed to demand certain environmental requirements. We have observed the importance of soil substrate for hatching; we, therefore, analysed the components of the environment in absence and presence of soil substrate. Our results showed the existence of more than 50% of calcium, more than 30% of potassium and sodium, and more than 25% of magnesium in substrated water compared to the non-substrated one. It become possible from this finding to state that the elements calcium, potassium, sodium and magnesium, in concentrations of 40.75, 35.00, 345.00 and 44.00 mg/l, respectively, are important for proper and efficient hatching of these snails.

One of the other important factors studied was the effect of strong artificial light intensity. It is interesting to mention that the snails that were subjected continuously for 10 days to strong light intensity showed no signs of egg production. It, thus, looks as though light of this nature inhibits egg-laying activities of the snails. This point, we must say, could be followed further by investigating the effect of such light on the physiology of the reproductive systems of these animals.

Our experiments on crowding, however, revealed that the snails, which were reared in isolation, increased tremendously in size and weight and produced an enormous amount of eggs compared to those reared in crowd.

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العوامل البيئية وأثرها على تناسل ونمو قواقع المياه العذبة في المملكة العربية السعودية

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أجريت دراسات مقارنة على قواقع **ليمنيا اوريكيولاريا وبيومفالاريا أرابيكا وفايزا أكيوتا** كعوائل وسطى للدودة الكبدية وديدان البلهارسيا . وقد أجريت هذه الدراسات المعملية على قواقع المنطقة الشرقية والوسطى والجنوبية للمملكة .

وجد أن عناصر معينة في التربة تعمل على تنشيط افقاس القواقع كما أن عملية وضع البيض قد توقفت نتيجة لتعرض القواقع للضوء القوي المستمر .

أظهرت التجارب أن قواقع **ليمنيا** تصل إلى الطور البالغ بعد ١٠٥ يوماً وقواقع **بيومفالاريا** بعد ٨٤ يوماً وقواقع **فايزا** ٥٦ يوماً . وعند الطور البالغ ، وجد أن طول صدفة **الليمنيا** ٧,٥ مم ووزنها ٤٣ ملليجرام وطول صدفة **بيومفالاريا** ٦ مم ووزنها ٤٩ ملليجرام وطول صدفة **فايزا** ٥,١ مم ووزنها ٢٠ ملليجرام .

والجدير بالذكر أن تواجد القواقع بكميات كبيرة مع بعضها البعض له أثر عكسي على النمو والاخصاب .