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EFFECT OF SOME ALGAL SPECIES ON THE SNAIL INTERMEDIATE HOSTS OF SCHISTOSOMIASIS IN EGYPT
II. GROWTH, INFECTION AND MORTALITY RATES

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Abstract

This investigation was carried out using isolates of four algal species. Three cyanobacteria (*Lyngbya perelegans, Oscillatoria accuminata* and *Phormidium valderianum*) and one green alga (*Spirogyra* sp.) collected from Kafr Hakem (+ snails) and Sadek canals (- snails) in Giza Governorate, in addition to *Nostoc muscorum* obtained from Theodor Bilharz Research Institute (TBRI).

Snails were fed separately on fresh algal species, on a combination of two species and on a mixture of the five algal species, during twenty weeks (5 months) and lettuce was used as control.

Growth rate of snails (shell diameter and height), infection rate and mortality percentage were recorded weekly during the experimental time.

Biomphalaria alexandrina and *Bulinus truncatus* snails fed on separate algal species, sublethal concentration of *Phormidium valderianum* (LC_0) and lettuce demonstrated the highest growth rates, while the lowest rate was recorded in *Spirogyra* sp. Using mixed food of two algal species, the maximum rate of snail growth was observed in snails fed on the LC_0 of *Phormidium valderianum* + *Spirogyra* sp, followed by those fed on *Oscillatoria accuminata* + *Spirogyra* sp. Snails fed on a mixture of all algal species exhibited the maximum growth rate.

The highest rate of infection and lowest percentage of mortality were recorded in both snail species fed on lettuce (59% & 19% for *B. alexandrina* and 77.3% & 10.7% for *B. truncatus*, respectively). The minimum rate of infection and maximum percentage of mortality were observed in snails fed on *Spirogyra* sp.

The nutritional value of the algal species and lettuce, using Carbon to Nitrogen ratio (C/N ratio), were analyzed and discussed on the light of the obtained results.

Key words: *Biomphalaria, Bulinus*, algae, growth, infection, mortality, schistosomiasis.

Introduction

Freshwater snails are generally considered to be herbivores (Bronmark, 1990). The different groups of phytoplankton (green algae, cyanobacteria and diatoms) are considered to be their main food.

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Algae support good growth and reproduction of the herbivores (Rothhaupt, 1995). Those that support good growth and reproduction of the herbivory are taken as evidence for high food quality (Rothaupt, 1995), while algae of poor food quality can cause decreased herbivore growth rate, body size and reproduction rate or prevent growth and development all together (Weers and Gulati, 1997).

The intermediate hosts of schistosomiasis in Egypt, *Bulinus truncatus* and *Biomphalaria alexandrina,* are freshwater snails and the food is considered to be the main limiting factor conditioning their habitat. The food of these snails is mainly vegetables consisting of microflora (Malek, 1980 and Bronmark, 1990) and plankton makes up a large portion of their diet (Bronmark, 1989). The different groups of phytoplankton (Cyanophyceae, Chlorophyceae and Bacillariophyceae) and zooplankton are the main sources of food for these snail vectors in Egypt (El-Gindy, 1960; Jordan and Webbe, 1982 and Mahmoud, 1994). El-Gindy (1960) and Mahmoud (1994) reported that, the filamentous and unicellular green algae, cyanobacteria and diatoms were the main stomach contents of *B. truncatus* and *B. alexandrina* snails.

On the other hand, the growth of snails depends on food in any life period (Parashar *et al*, 1986) and many investigators studied the relationship between the food and the growth of fresh water snails (Skoog, 1978; Itagaki, 1987; Lee *et al*., 1994; Mahmoud, 1994).

Various cyanobacterial species produce different types of toxins. These toxins reduce herbivore abundance by causing reduction in growth rate and reduction in survival and fecundity (Lampert, 1987, Gilbert, 1990, Gliwicz and Lampert, 1990).

Algal species vary in their content of mineral nutrients and essential organic compounds such as vitamins or fatty acids and some match the nutrient requirements of herbivores much better than do others (Sterner *et al.,* 1992).

Ferreira *et al.* (2000) postulated that the rearing of snail intermediate hosts of *Schistosoma haematobium, S. intercalatum, S. bovis* and *Fasciola hepatica* is the first step to maintain the life cycle of these parasites in the laboratory. According to the traditional method, the cyanobacterium *Oscillatoria formosa* is a principle food source for these snails. Feeding on this cyanobacterium, snails reached a size three times larger than others of the same age, and they reached sexual maturity earlier, having more egg masses per snail. In addition, the rate of survival as well as the number of generations per year, under laboratory conditions, increased. Also, Lee *et al*. (1994) reported rapid growth of *Lymnaea virides*, the intermediate host of *Fasciola hepatica,* in the laboratory, when fed on cyanobacteria. Moreover, Thompson (1984) demonstrated that the growth of *B. glabrata* snails fed on the *Spirulina* sp (cyanobacterium) was consistently better than the snail fed on *Chlorella* sp (green alga). He observed that only snails maintained on a *Spirulina* medium became reproductively active and laid egg during the experimental period.

On the other hand, Mahmoud (1994) demonstrated that green algae induced poor growth rate of *B. truncatus* and *B. alexandrina* snails during both juvenile and adult stages. Besides, Skoog (1978) found that pure *Cladophora* sp (green alga) produced poor growth in *Lymnaea pergera* juveniles and adults.

The nutritional value of food is important in the growth of snails. It was expressed by McMahon *et al*. (1974) as the ratio of carbon to nitrogen (C/N). The lower ratios correspond to the higher nutritive values and were available in cyanobacteria, while the higher C/N ratios were correlated to green algae. Kornijow *et al*. (1995) used fresh and decomposed *Mougeotia* sp (filamentous green alga) and *Elodea nuttalii* (a vascular plant) as food for three species of aquatic macro-invertebrates (*Lymnaea pergra*, *Asellus neridians* and *Endochironomus albipennis*) and determined their C/N ratios. They found that the macrophyte in both states was of a high nutritional value comparing to the green alga *Mougeotia* sp. due to the fact that the C/N ratio of *Elodea nuttali* was lower than that of the filamentous alga. Besides, Elger and Lemoine (2005) reported that the palatability of macrophytes to *Lymnaea stagnalis* pond snails was positively related to their protein and low phenolic contents.

Moreover, Thompson (1984) made a comparison between the macro-nutrient composition of three food sources (*Spirulina, Chlorella* and lettuce) and showed that *Spirulina* (cyanobacterium) had a higher protein level than *Chlorella* (green alga) or lettuce which may partially explain the better growth of *B. glabrata*. He, also, found that while fresh lettuce leaves were very satisfactory food source for maintaining stock colonies, they induced poor nutrition when dehydrated. In addition, Skoog (1978) reared *Lymnaea pergra* on three types of food (diatoms, cyanobacteria and green algae) and demonstrated that pure *Cladophora* sp (green alga) gave the poorest growth rate, while the best growth occurred on mixing it with cyanobacteria.

Therefore, the present study aims to investigate the possible influence of three cyanobacteria species (*L. perelegans, O. accuminata* & *P. valderianum* and one green alga species (*Spirogyra* sp.) on the growth, infection and mortality rates of *B. alexandrina* and *B. truncatus*, the snail vectors of schistosomiasis in Egypt.

Material and Methods

1. Growth rate

300-laboratory bred *B. alexandrina* juveniles (2-3 mm) and 180 laboratory bred *B. truncatus* juveniles of the same size were used in these experiments. Ten snails of each species were transferred to a plastic aquarium (10 x 9.5 x 7 Cm), aquaria were then divided into four groups; in group (I), juveniles were fed on the non-toxic green alga and cyanobacterial species ad libitum, each species alone and lettuce was used as control; in group (II), juveniles were treated with the sublethal concentration (LC_0) of *Phormidium valderianum* and *Nostoc muscorum* was used as control; in group (III) aquaria were divided into 4 categories, in the first, juveniles were fed on mixed species of non-toxic cyanobacteria (*Lyngbya perelegans + Oscillatoria accuminata*); in the second, juveniles were fed on *Spirogyra* sp.+ *Lynbgya perelegans*; in the third, juveniles were fed on *Spirogyra* sp.+ *Oscillatoria accuminata*; in the fourth, juveniles were fed on *Spirogyra* sp. + LC_0 of *Phormidium valderianum*; in group IV, juveniles were fed on mixed species of all cyanobacteria (*Lynbgya perelegans+ Oscillatoria accuminata* + LC_0 of *Phormidium valderianum + Nostoc muscorum*) and the green *Spirogyra* species. In all experiments algae were added in their fresh form (0.5 g/L).

The growth rate was calculated according to the method applied by Sharaf El-Din (1990) and El-Sayed (1996) as follows:

$$\textbf{Growth rate} = \frac{\textbf{Size of snail at the end of the period - initial size}}{\textbf{Initial size}} \times 100$$

For all experiments, five replicates were made and the growth rate was measured, weekly, for each snail and expressed as the increase in shell diameter of *B. alexandrina* and shell height of *B. truncatus*. During the course of the experiment (20 weeks), snails were fed ad libitum and water was changed weekly to remove fecal excreta and food debris and water temperature was adjusted to 25°C ± 2.

2. Infection rate

Six hundred-laboratory bred *B. alexandrina* snails (7-9 mm diameter) and 450 lab bred *B. truncatus* snails (7-9 mm height) were used in this experiment. Snails were fed on one species only of cyanobacterium or on green alga alone before infection three weeks later.

B. alexandrina and *B. truncatus* snails were exposed individually to 7-10 freshly hatched *S. mansoni* or *S. haematobium* miracidia, obtained from eggs from the livers of infected hamsters. Snails were left over night under light and then each 25 snails were transferred to a plastic aquarium (25 x 12 x 10 Cm) filled with 2.5 liters of dechlorinated tap water. Water temperature was adjusted to 25^{o}C-27^{o}C throughout the infection process and the whole period of the experiment (8 weeks). Snails were fed ad libitum on non-toxic cyanobacteria or green alga and on the sublethal concentration (LC_0) of *Phormidium valderianum* plus lettuce which was used as control. Four replicates were made.

Four weeks later, snails were tested for infection by placing snails, individually, in test tubes containing 2 ml of dechlorinated tap water, and left under light of desk lamp, for about 2 hours. Snails which did not shed cercariae were re-examined individually, twice a week for a period of four weeks. Those that began to shed cercariae, between four and eight weeks after exposure to miracidia, were counted as infected. After 8 weeks, snails which did not shed cercariae were crushed and examined under a light microscope (400 X) for larval stages. If the snail contained any larval stages, they were considered positive according to Haroun (1996).

3. Statistical Analysis

Analysis of data was carried out using a statistical computer program (Schaefer and Anderson, 1989). Student's t-test and chi-square test (Petrie and Sabin, 2000) were used in comparing the means and infection rates of experimental and control groups.

Results

1. Effect of food types on the snail growth:

The growth of both *B. alexandrina* and *B. truncatus* snails was estimated during 20 weeks and snails were fed on different types of foods [lettuce, cyanobacteria (*Lyngbya perelegans, Oscillatoria accuminata*, *Nostoc muscorum* and sublethal concentration, LC_0 of *Phormidium valderianum*) and green alga (*Spirogyra* sp.)]. Snail growth was affected by two main factors, the type of food and the progressive rearing time (age of snails in weeks).

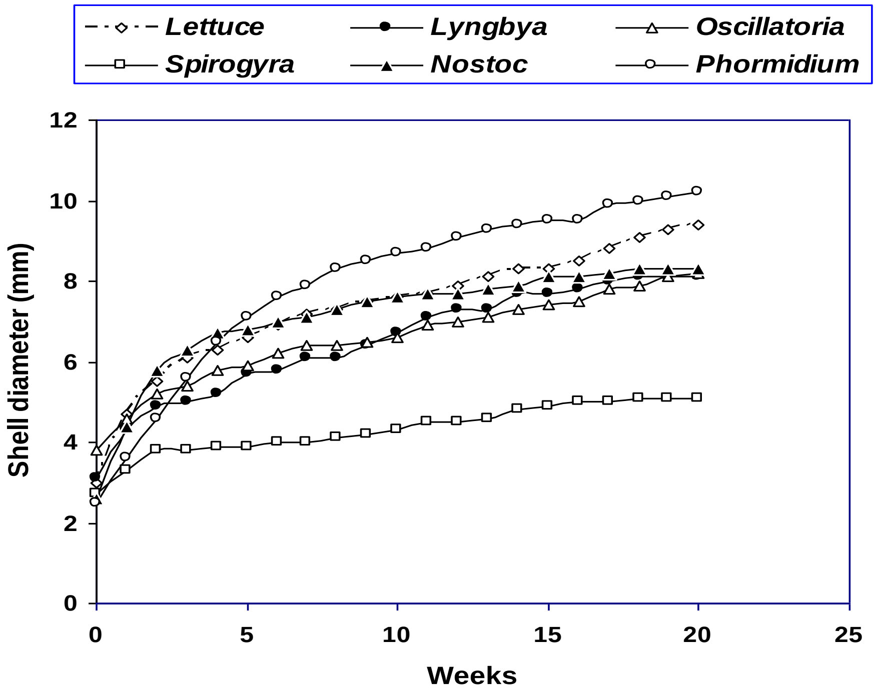
2. Growth of *Biomphalaria alexandrina* and *Bulinus truncatus* snails

Growth of *B. alexandrina* was determined by shell diameter (mm) while that of the *B. truncatus* was estimated by shell height (mm). Snails were fed during five months on separate algal species (4 cyanobacteria and 1 green alga), a mixture of two algal species or a mixed food of the five algal species.

Data indicate that there was a highly significant increase in the snail size ($F1, 19 = 140.43$, $P<0.001$, $r = 0.939$) in relation to rearing time in *B. alexandrina* and a very highly significant and positive linear relationship ($F1, 19 = 96.96$, $P< 0.001$, $r = 0.91$) between size and rearing time, in *B. truncatus* snails fed on lettuce (Fig. 1).

B. alexandrina snails fed on the sublethal concentration of *Phormidium valderianum* demonstrated the highest growth rate, followed by lettuce, *Nostoc*, *Lyngbya*, *Oscillatoria* and *Spirogyra* in a descending order. While in *B. truncatus* snails, lettuce gave the highest growth rate followed in a decreasing order by *Oscillatoria*, *Lyngbya*, *Phormidium, Nostoc* and *Spirogyra.*

Spirogyra sp showed the minimum growth rate in juvenile and adult *B. alexandrina*, snails, allover the time of the experiment; while in *B. truncatus* snails the adult stages were not represented throughout the course of feeding on the green alga and all snails were still immature with a maximum shell height of 4.7 mm and minimum growth rate (Fig. 1). Thus, the relationship between snail height and rearing time after feeding on *Spirogyra* sp was highly significant ($F1, 19= 125.7$, $p < 0.001$, $r= 0.932$).



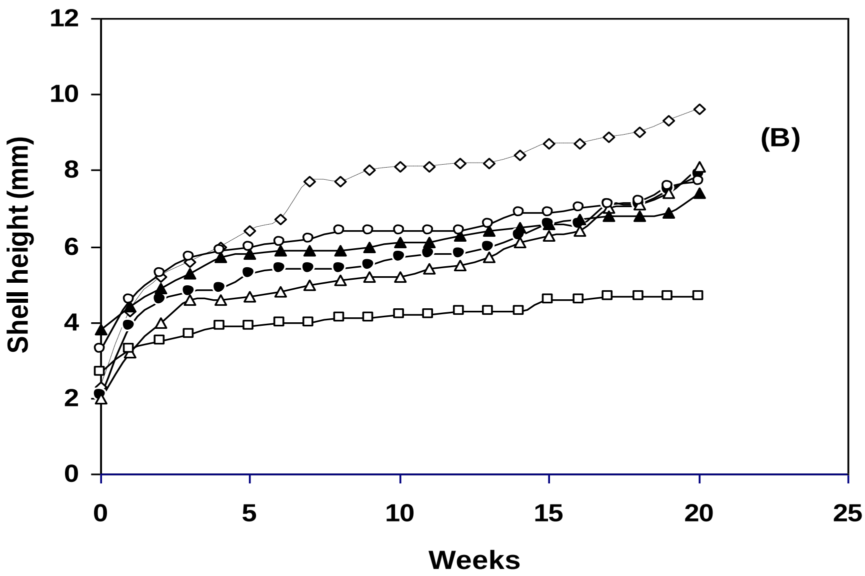


Figure (1): Growth curve of *Biomphalaria alexandrina* [A] and *Bulinus truncatus* [B]fed on separate algal species for 20 weeks.

Using a mixture of two algal species, the maximum growth rate of snails was recorded in *B. alexandrina* fed on *Spirogyra* sp. + LC_0 of *Phormidium valderianum* followed by those fed on a mixture of *Spirogyra* sp + *Oscillatoria accuminata*, then those fed on *Spirogyra* sp + *Lyngbya perelegans*; while the mixture of *Oscillatoria accuminata* + *Lyngbya perelegans* induced the minimum growth rate value. In case of *B. truncatus*, the mixture of *Lyngbya perelegans* + *Oscillatoria accuminata* demonstrated the highest growth rate and shell height, followed by that of *Spirogyra* sp+ *Lyngbya perelegans*, then by *Spirogyra* sp+ *Phormidium valderianum*, *Spirogyra* sp + *Oscillatoria accuminata* (Fig. 2).

Studying the effect of a mixture of all algal species on *B. alexandrina* and *B. truncatus* growth, the obtained results illustrated in Fig. 3 indicate that the growth of snails were significantly higher than the control group. Maximum size of *B. alexandrina* snails (13 mm) and maximum shell height of *B. truncatus* snails (10 mm) were recorded when snails were fed on a mixed food of all algal species.

3. Infection and mortality rates

The infection and mortality rates of *B. alexandrina* and *B. truncatus* snails are expressed in Fig. 4. Data reveal that the highest percentage of infection was observed in *B. alexandrina* snails fed on lettuce (59%) with a mortality rate of 19%, followed by those fed on the sublethal concentration of *Phormidium valderianum* (52%), with a lower mortality rate (15%). Snails fed on *Oscillatoria accuminata* showed a 50% infection rate and a higher mortality (25%), then follows snails fed on *Lyngbya perelegans* (46%), with a higher mortality rate (29%). On the other hand, the lowest value of infection was observed in snails fed on the green alga *Spirogyra* sp. (31%) with the highest mortality rate (46%) among all experimental groups followed by snails fed on *Nostoc muscorum* (41%) which showed 39% mortality.

The percentages of infection and mortality of *B. truncatus* snails (Fig. 4B) indicate that snails fed on lettuce had the maximum infection rate (77.3%) with the minimum mortality (10.7%) followed by snails fed on LC_0 of *Phormidium valderianum* with (69.3%), which, showed a higher mortality (22.7%). The infection rate of snails fed on *Oscillatoria accuminata* came next (64.0%) with the same mortality rate (22.7%). On the other hand, snails fed on *Lyngbya perelegans* showed the lowest infection rate (58.7%) among all groups fed on cyanobacteria, but with the same mortality rate (22.7%). Moreover, the minimum value of infection was noticed in snails fed on the green alga *Spirogyra* (44%), with the maximum value of mortality (52%), among all experimental groups.

The nutritional value (inverse of C/N ratio) and percentage of total protein of cyanobacteria, green alga and lettuce were determined and tabulated in Table 1. *Spirogyra* sp showed the highest C/N ratio and the lowest nutritional value, while *Nostoc muscorum* have the minimum ratio and the highest nutritional value.

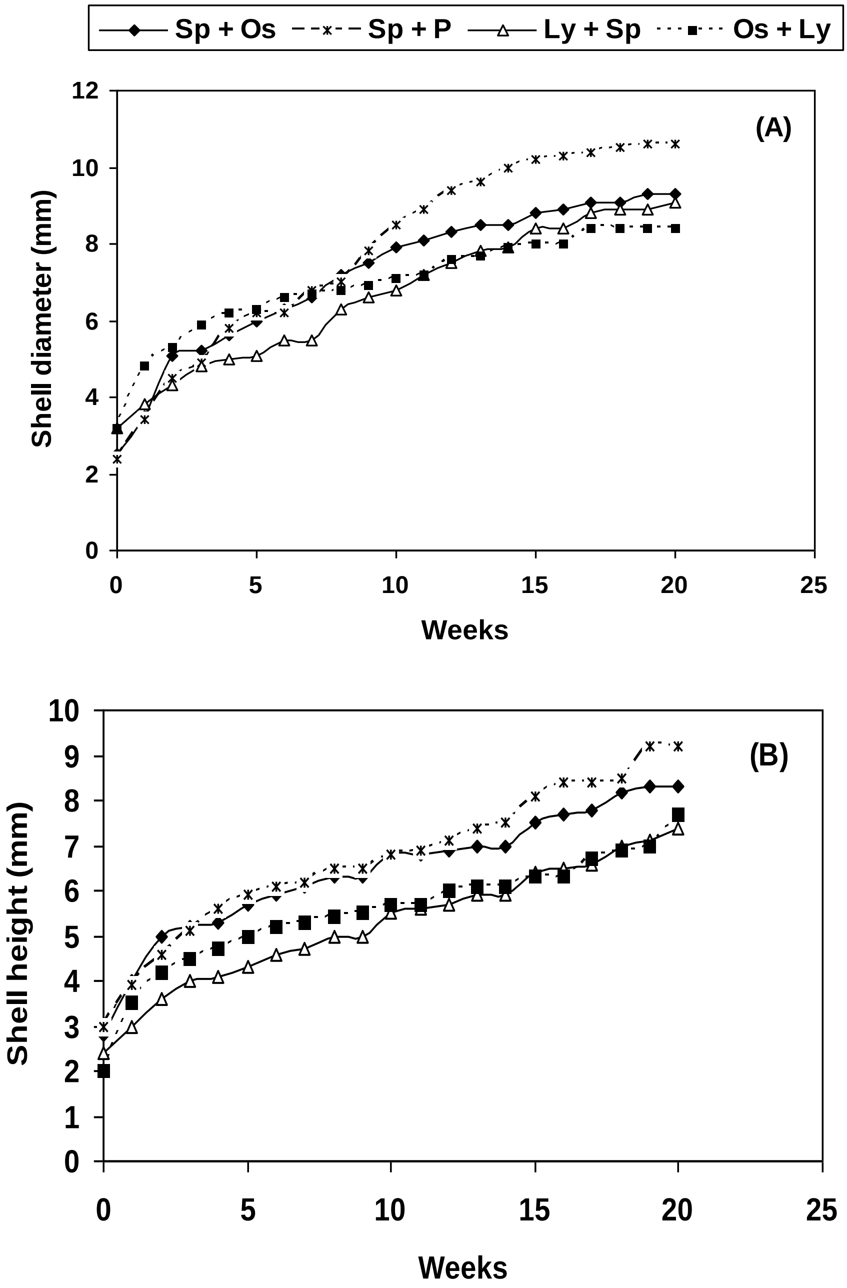


Figure (2): Growth curve of *Biomphalaria alexandrina* [A] and *Bulinus truncatus* [B] fed on a mixture of two algal species for 20 weeks. Sp = *Spirogyra*, Os = *Oscillatoria*, P = *Phormidium*, Ly = *Lyngbya*.

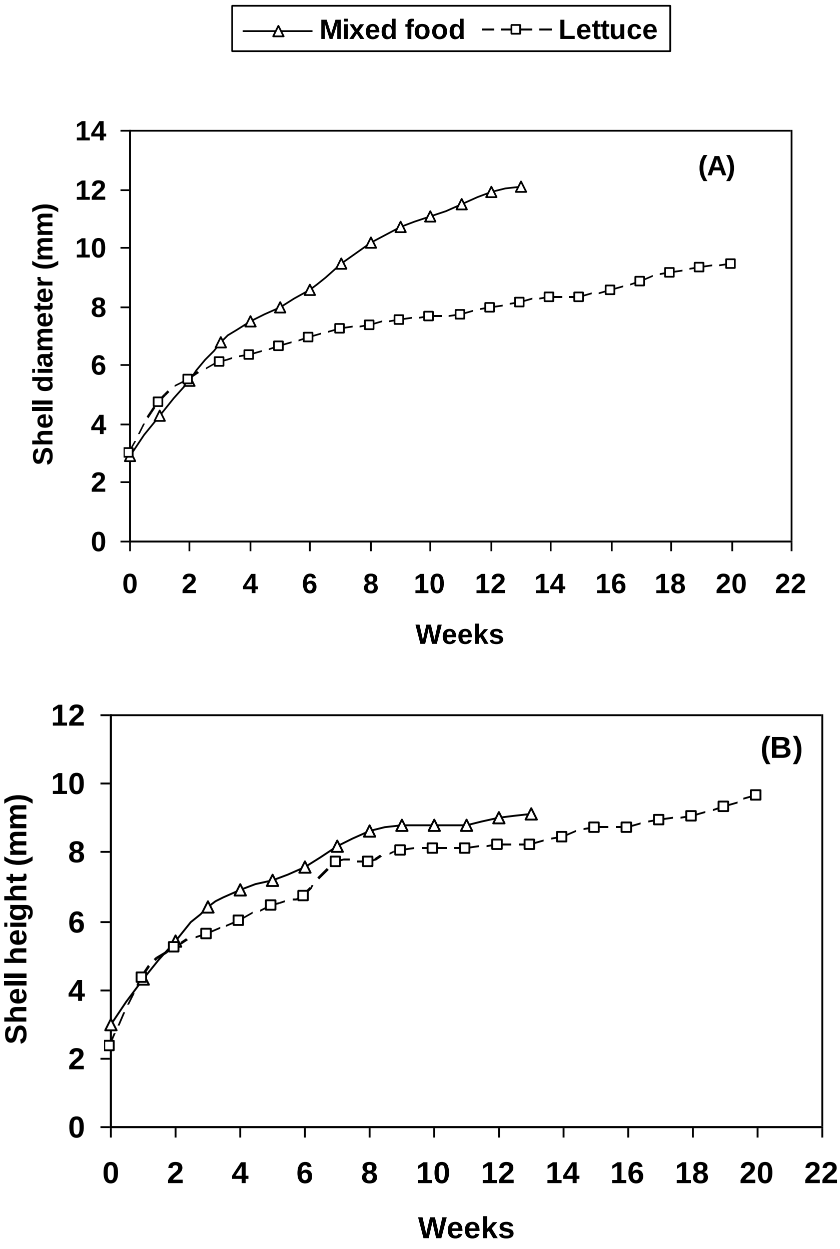


Figure (3): Growth curve of *Biomophilaria alexandrina* [A] and *Bulinus truncatus* [B] fed on a mixture of all algal species for 20 weeks.

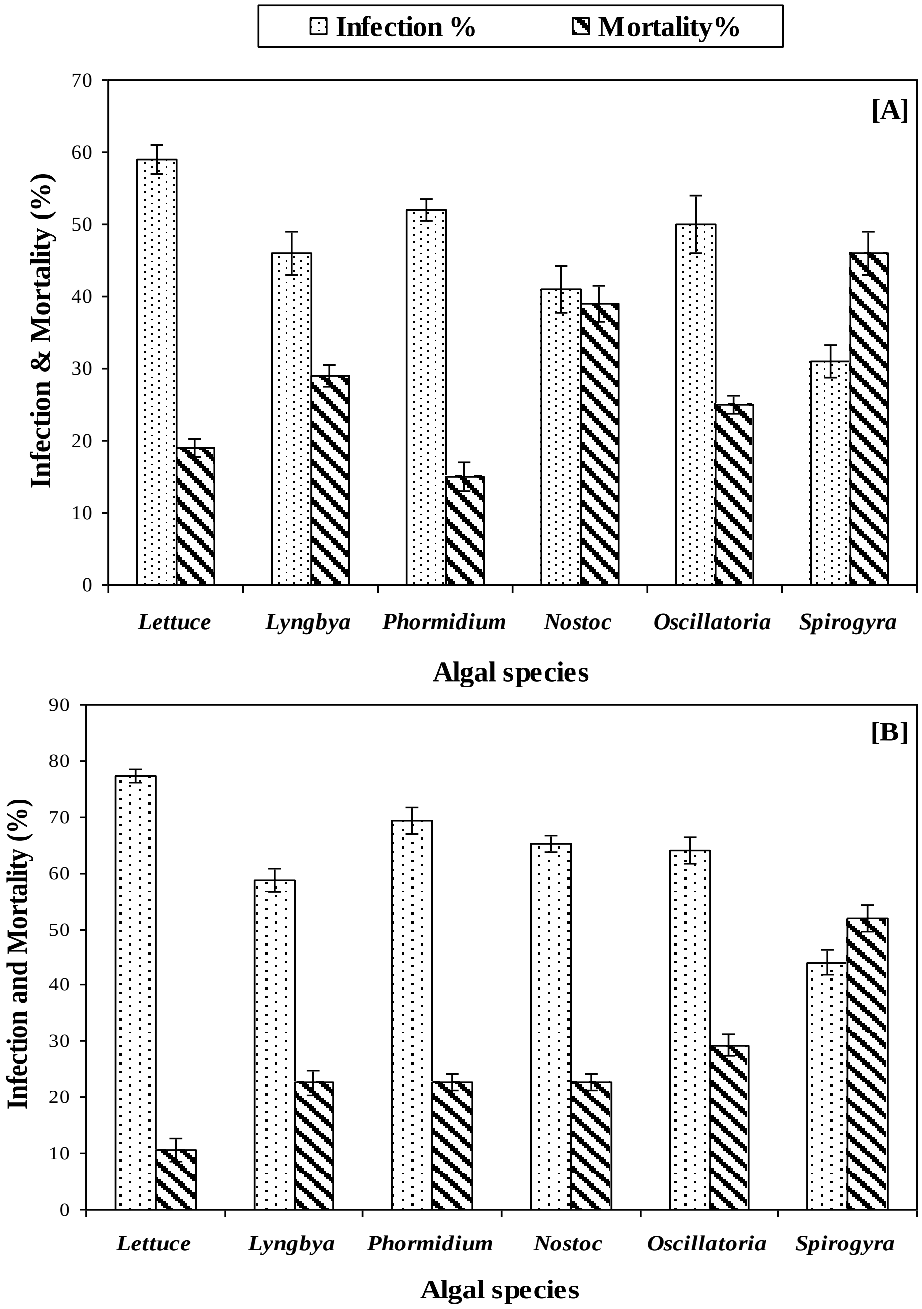


Figure (4): Infection and mortality rates of *Biomphalaria alexandrina* [A] and *Bulinus truncatus [B]* fed on separate algal species and exposed to *Schistosoma mansoni* miracidia.

Table (1): Carbon – Nitrogen ratio and total protein of lettuce, cyanobacteria and green algae

Food items	**Lettuce**	***Lyngbya perelegans***	***Oscillatoria accuminata.***	***Spirogyra Sp.***	***Nostoc* muscorum**	***Phormidium valderianum***
Carbon	**39.4**	**19.4**	**19.6**	**32.6**	**43.6**	**22.2**
Nitrogen	**3.5**	**2.3**	**2.8**	**1.8**	**8.2**	**3.9**
C/N ratio	**1:11.3**	**1:8.4**	**1:7**	**1:18.1**	**1:5.3**	**1:5.7**
%of total protein	**32.68**	**16.54**	**15.46**	**29.41**	**21.00**	**27.23**

Concerning total protein, lettuce recorded the highest percentage (32.68%) followed by *Spirogyra* sp (29.41%) then *Phormidium valderianum* (27.23), while the minimum total protein content was determined in *Nostoc muscorum* (21%).

Discussion

The quality of food influences the growth of the different species of snails (Itagaki, 1987). Rothaupt (1995) confirmed that algae support good growth of herbivores including snails. As observed in the present work, the type of food affected the growth rate of *B. truncatus* and *B. alexandrina* snails. Snails of *B. truncatus* and *B. alexandrina* reared on lettuce showed a marked increase in growth in all life stages (juveniles and adults). These results are parallel with the findings of Leveque and Pointier (1976). They reported that *B. glabrata* fed on lettuce grow slightly faster in the laboratory than in nature. On the contrary, Belfaiza *et al.* (2004) reported that the intensity of cercarial shedding in *Galba truncatula* infected with *Fasciola hepatica* was significantly higher when snails were fed on mixed food of tetraphyll (fish food) and lettuce rather than on lettuce only or mixed with microalgae (or Boray's diet). Also, Berrie (1970) stated that snails fed exclusively on leaves of higher plants grow much more slowly than those fed on algae. The toxic cyanobacterium *Phormidium valderianum*, used in the present work, induced an increase of growth rate in the early juvenile and adult stages of *B. alexandrina*, but showed bad growth of *B. truncatus* snails. This agrees with the findings of El-Assal *et al*. (1992) who reported that food requirements are different for *B. alexandrina* and *B. truncatus* snails. On the other hand, *Oscillatoria accuminata* showed good growth of *B. truncatus* and *B. alexandrina* following that of lettuce. This coincides with the findings of Ferrira *et al.* (2000) who have shown that *B. truncatus* snails fed on *Oscillatoria formosa* had better growth and reached three times the size of snails of the same age fed on other types of food. Similar observations were reported by Itagaki (1987) who mentioned that *Lymnaea allula* snails supplied with *Oscillatoria* sp grew faster than those fed on other food items. The juvenile stages of both *B. alexandrina* and *B. truncatus* snails fed on *Nostoc muscorum* induced good growth in the present investigation. This consents with the finding of Skoog (1978) who reported that the cyanobacteria gave a good growth of juveniles of *Theodoxus fluviatilis.* Furthermore, Weers and Gulati (1997) concluded that algae may be a poor food, causing a decreased herbivore growth and reproductive rates or prevent growth and reproduction altogether. This agrees with the present results in case of the green alga *Spirogyra* which induced a poor growth of *B. truncatus* and *B. alexandrina* snails, during both juvenile and adult stages or prevented maturation. The above mentioned data disagree with the WHO's report (1999) which indicated that green algae are acknowledged to be the best food for young snails of pulmonate genera, including the intermediate hosts of schistosomiasis. Also, it contradicts the finding of Ahlgren *et al*. (1990) who reported that the nutritional value of the cyanobacteria is relatively poor compared to that of the green algae. On the contrary, the present study shows that the nutritional value of cyanobacteria is greater than that of green algae, by determining, analytically, the carbon and nitrogen content of each type. The C/N ratio indicated that the green alga *Spirogyra* sp had a higher C/N ratio (18:1) than the cyanobacterium *Nostoc* (5.3:1), followed by *Phormidium valderianum* (5.7:1) then *Oscillatoria* (7:1). Similar observations were made by Kornijow *et al*. (1995) who reported that the C/N ratio of the freshwater plant *Elodea nuttalli* was lower than that of the filamentous green alga *Mougeotia* sp (11.6:1 and 15.7:1, respectively) and thus, the nutritional value of *Elodea* was much greater than that of *Mougeotia* sp.

The experiments of snail feeding using a mixture of two species of cyanobacteria or a mixed food of one species of cyanobacteria and one species of green alga showed a linear and logarithmic increase in the growth of *B. alexandrina* and *B. truncatus* snails, indicating that mixing one species of cyanobacteria with one species of green alga or two species of cyanobacteria gives a good growth rate than the use of one species of cyanobacterium or green alga alone. This is due to the higher nutritional value of the mixed food, according to the determination of the total protein of each type of food. Moreover, the mixed food consisting of *Lyngbya + Oscillatoria + Nostoc + Phormidium + Spirogyra* gave an excellent and unexpected result, indicating that the mixture of all species of cyanobacteria and green alga increased the nutritional value of diet presented to the snails and the mixed food becomes better than green alga or any species of cyanobacteria separately. This agrees with the findings of El-Emam and Madsen (1982) who stated that the combination of two or more food types appears to induce better growth and better egg laying of *B. alexandrina* and *B. truncatus* snails.

On the other hand, some investigators reported that some algae exhibit potent molluscicidal activity against the snail vectors of schistosomiasis. In freshwater, the primary algal toxin-producing species are the cyanobacteria (Graham and Wilcox, 2000) and some other algal species, releasing repellants, antifeedants or toxicants (Carmichael, 1980 and Graham and Thomas, 1990). Renno (1972) demonstrated that the freshwater *Chara vulgaris* was associated with high mortality of *Lymnaea* snails in aquaria. Similarly, the results of the present investigation revealed that crude extract of *Phormidium valderianum* caused the mortality of both snail species. While, concentrations of 500 and 1000 ppm caused 3.33 and 6.66% mortality of *B. truncatus* snails, respectively, no mortality in *B. alexandrina* was recorded using these concentrations, confirming the sensitivity of *B. truncatus* snails to the toxins. The concentration of 3000 mg/L caused 26.6% and 11.5% mortality in *B. truncatus* and *B. alexandrina* snails, respectively. This agrees with the findings of Falch *et al.* (1995) who found that crude extract of *Phormidium* sp caused the mortality of *B. glabrata* snails at the concentration of 50 mg/mL. It, also, coincides with the findings of Mohamed *et al*. (1992) who stated that the cyanobacterium *Oscillatoria agardhii* showed a high molluscicidal effect on *Melanoides* snails. A crude bloom extract (LC_{50} 500 mg/L) and pure cell free extract had a much higher molluscicidal activity under laboratory conditions (LC_{50} 10 mg/L).

Besides, it is well known that there is a direct relationship between the state of nutrition of the snail and the development of the parasite. The rate of development of the parasite, as indicated by the number of cercariae which attain full maturity in a given times, was influenced partly by the number of rediae present in each snail and markedly by the amount of food that the snail received (Kendall, 1949; Fried *et al*., 2002). This agrees with the present result, *B. alexandrina* and *B. truncatus* snails fed ad libitum during infection showed the highest percentage of infection, when fed on lettuce. Coles (1973) stated that addition of a high protein tropical fish food and normally dried lettuce to *B. glabrata* snails increased the numbers of *Schistosoma mansoni* cercariae shed. Similar observation was reported by Ismail and Haroun (2001) who stated that both *B. alexandrina* and *B. truncatus* snails maintained on a mixture of fish food + mice food + algae + lettuce showed the highest infection rate as compared to other food types. The present result indicates that the lowest infection value was in snails fed on the cyanobacterium *Nostoc muscorum*. This is in agreement with the finding of Ismail and Haroun (2001) who stated that *B. alexandrina* and *B. truncatus* snails fed on *Nostoc* alone showed the lowest infection rate. Also, similar observation was registered by Mohamed *et al*. (1998) who found that *B. alexandrina* snails fed on a mixture of common aquatic plants showed a high susceptibility to infection with *Schistosoma mansoni*, while the infection was low in snails maintained on rabbit food.

In conclusion, lettuce or LC_0 of *Phormidium valderianum* or a mixture of algal species can be used in the feeding of snails, in the laboratory, to obtain the best growth rate and to induce large number of egg masses needed for any experiment. While, *Spirogyra* sp must be avoided in snail feeding as it inhibits the growth and prevents snails from reaching maturation. Also, *P. valderianum* is toxic to both snail species, especially, at higher concentrations and it may be used in the biological control of schistomiasis, in Egypt.

Vital processes of snails are affected by the algal composition of canals, which in turn are influenced by environmental and seasonal conditions, leading to the dominance of certain algal species and the disappearance of others. Moreover, the allelopathic interactions between the different organisms (phytoplankton, and/or zooplankton) inhabiting the water body play an important role. All these factors may affect the snail population either positively or negatively. More investigations are needed to answer the question, why certain canals contain snails (as kafr Hakem) while others not (as Sadek canal)?

References

Ahlgren, G. L.; Lundstldt, L.; Brett, M. T. and Forsberg, C. (1990). Lipid composition and food quality of some freshwater phytoplankton for Cladoceran zooplankters. *J. Plankton Res.*, **12: 809-818.**

Belfaiza, M.; Abrous, M.; Rondelaud, D.; Moncef, M. and Dreyfuss, G. (2004). The use of Tetraphyll as food for snails increases the intensity of cercarial shedding in *Galba truncatula* infected with *Fasciola hepatica*. Parasitology-Research., **94 (2): 86-90.**

Berrie, A. D. (1970). Snail problems in African schistosomiasis. *Adv. Parasitol.*, **8: 43-96.**

Bronmark, C. (1989). Interaction between Epiphyton, macrophytes and Freshwater snails. A review. *J. Moll. Stud.*, **55: 299-311.**

Bronmark, C. (1990). How do herbivorous fresh water snails affect macrophytes. A comment. *Ecology*, **71: 1212-1215.**

Carmichael, W. W. (1980). Freshwater blue green algae (cyanobacteria) Toxins. A review. *Inter. Conf. Water Envir. Algal toxins and Health*, **10-11.**

Coles, G. C. (1973). The effect of diet and crowding on the shedding of *Schistosoma mansoni* cercariae by *Biomphalaria glabrata*. *Ann. Trop. Med. Parasitol.*, **67: 419-423.**

El-Assal, F. M.; El-Gindy, H. I.; Roushdy, M. Z. and Fahmy, Z. H. (1992). Studies on the optimal conditions for breeding, maintenance and infection of snail vectors of *Schistosoma mansoni* and *S. haematobium.* I. Effect of crowding, water volume and diet on the egg production and survival rate of reared snails. *J. Egypt. Ger. Soc. Zool.*, **8B: 135-157.**

El-Emam, M. and Madsen, H. (1982). The effect of temperature, darkness, starvation and various food types on growth, survival and reproduction of

Helisoma duryi, Biomphalaria alexandrina and *Bulinus truncatus* (Gastropoda: Planorbidae). *Hydrobiologia*, **88: 265-275.**

Elger, A. and Lemoine, D. (2005). Determination of macrophytes palatability to the pond snail *Lymnaea stagnalis. Freshwater Biology,* **50 (1): 86-95.**

El-Gindy, H. I. 1960. The ecology of snail intermediate hosts of schistosomiasis and *Fasciola*. Ph.D. Thesis Fac. Science, Cairo University.

El-Sayed, K.A. (1996). Ecological studies on snails associated with *Biomphalaria alexandrina* and their impact on schistosome transmition in Egypt. Ph. D. Thesis, Faculty of Science, Cairo University.

Falch, B. S.; Konig, G. M.; Wright, A. D.; Sticher, O.; Angerhofer, C. K.; Pezzuto, J. M. and Bachmann, H. (1995). Biological activities of cyanobacteria: Evaluation of extracts and pure compounds. *Planta Med.*, **61: 321-328.**

Ferreira, M. F.; Delgado, M. L.; Seixas, L. A. M. and Sampaio-Silva, M. L. (2000). Optimum conditions for growth in liquid medium *Oscillatoria formosa Bory* used as the principle food in laboratory culture of intermediate hosts for schistosomiasis and fasciolosis. *Parasitol.*, **7: 227-231.**

Fried, B.; Laterra, R. and Kim, Y. (2002). Emergence of cercairae of *Echinostoma carproni* and *Schistosoma mansoni* from *Biomphalaria glabrata* under different laboratory conditions. *J. Helminthol.,* **76: 369-371.**

Gilbert, J. J. (1990). Differential effects of *Anabaena affinis* on Cladocerans and Rotifers: Mechanisms and implications. *Ecology,* **71: 1727-1740.**

Gliwicz, Z. M. and Lampert, W. (1990). Food thresholds in *Daphnia* species in the absence and presence of blue green filaments. *Ecology,* **71: 691-702.**

Graham, J. C. and Thomas, J. D. (1990). Grazing interaction between pulmonate snails and epiphytic algae and bacteria. *Freshwater Biology,* **23: 505-522.**

Graham, L. E. and Wilcox, L. W. (2000). Algae: Prentice Hall, Inc.

Haroun, N. H. (1996). Differences in susceptibility of *Biomphalaria alexandrina* to *Schistosoma mansoni* from Giza and Dakahlia governorates, Egypt. *J. Egypt. Soc. Parasitol.,* **26 (2): 327-335.**

Ismail, N. M. M. and Haroun, N. H. (2001). effect of various foods on *Biomphalaria alexandrina* and *Bulinus truncatus* and their susceptibility to *Schistosome miracidia*. *J. Egypt. Soc. Parasitol.,* **31(3): 939-952.**

Itagaki, T. (1987). Influence of food on the growth and fecundity of *Lymnaea ollula*, the intermediate host of the liver fluke. *Jap. J. Parasitol.*, **36: 30-35.**

Jordan, P. and Webbe, G. 1982. Ecology and bionomics of intermediate hosts In (Schistosomiasis, Epidemiology, Treatment and Control). William Hainemann Medical Books. LTD London.

Kendall, S. B. (1949). Nutritional factors affecting the rate of development of *Fasciola hepatica* in *Lymnaea trunculata*. *J. Helminthol.*, **23: 179-190.**

Kornijow, R.; Gulati, R. D. and Ozimek, T. (1995). Food preference of freshwater invertebrates: comparing fresh and decomposed angiosperm and a filamentous alga. *Freshwater Biology*, **33: 205-212.**

Lampert, W. (1987). Laboratory studies on zooplankton-cyanobacteria interactions. *New Zealand J. Mar. & Freshwater Res.*, **21: 483-490.**

Lee, C. G.; Kim, S. K. and Lee, C. Y. (1994). Rapid growth of *Lymnaea viridis*, the intermediate host of *Fasciola hepatica*, under laboratory conditions. *Vet. Parasitol.*, **51: 327-331.**

Leveque, C. and Pointeir, J. P. (1976). Study of the growth of *Biomphalaria glabrata* (Say) and other planorbidae in Guadeloupe (West Indies). *Ann. Trop. Med. Para.*, **70: 199-204.**

Mahmoud, K. A. (1994). The feeding ecology of snails intermediate hosts of Schistosiomiasis in Egypt. M.Sc. Thesis, Faculty of Science, Cairo University.

Malek, E. A. (1980). Ecology and habit characteristics in snail transmitted parasitic disease. Washington D.C., USA, American Health Organization.

McMahon, R. F.; Hunter, R. D. and Russel-Hunter, W. D. 1974. Variation in aufwuchs at six water habitats in terms of carbon biomass and carbon : nitrogen ratio. *Hydrobiologia*, **45: 391-404.**

Mohamed, A. M.; Jamel Al-Layl, K. S. and Jamal Al-Lail, S. S. (1992). Toxic effects of the fresh water cyanobacterium Oscillatoria agardhii (blue green algae) on the snail Melanoides tuberculata (Muller). *J. Egypt. Ger. Soc. Zool.* (Invertebrate & Parasitology), **9D: 223-235.**

Mohamed, H. M.; Rizk, E. T. and Abu-Nasr, N. F. (1998). Effect of different food items and starvation on some metabolites and susceptibility of *Biomphalaria alexandrina* to *Schistosoma mansoni* infection. *Egypt. J. Aquat. Biol. Fish.*, **2(4): 201-219.**

Parashar, B. D., Kumar, A. and Rao, K. M. (1986). Role of food in mass cultivation of the fresh water snail *Indoplanorbis exustus* vector of animal schistosomiasis. *J. Moll. Stud.*, **52: 120-124.**

Petrie, A. and Sabin, C. (2000). Medical Statistics at a Glance. Blackwell Science Ltd, Oxford.

Renno, R. (1972). Contribuico aoestudo das characeae parao cambate a squistosome. *Ann. De la Real Academi de Farmacia*, **38: 688.**

Rothaupt, K. O. (1995). Algal nutrient limitation affects rotifer growth rate but not ingestion rate. *Limnology and Oceanography*, **40: 1201-1208.**

Schaefer, R. L. and Anderson, R. B. (1989). The Student Edition of Minitab, Statistical software, copyright addition, Wesley Publishing Company Inc.

Sharaf El-Din, A. T. (1990). Testing *Helisoma duryi* as a biocontrol agent against *Biomphalaria alexandrina* under simulated field conditions in Egypt. M.Sc. Thesis, Faculty of Science, Cairo University.

Skoog, G. (1978). Influence of natural food items on growth and egg production in brackish water populations of *Lymnaea peregra* and *Theodoxus fluviatilis* (Mollusca). *Oikes*, **31: 240-248.**

Sterner, R. W.; Elser, J. J. and Hessen, D. O. (1992). Stoichiometric relationships among producers and consumers in food webs. *Biogeochemistry*, **17: 49-67.**

Thompson, S. N. (1984). Spirulina as a nutrient source in experimental media for maintaining the schistosome vector *Biomphalaria glabrata*. *Ann. Trop. Med. Parasitol.,* **78: 547-548.**

Weers, P. M. and Gulati, R. D. (1997). Growth and reproduction of *Daphnia galeata* in response to changes in fatty acids, phosphorus and nitrogen in *Chlamydomonas reinhadtii*. *Limnology & Oceanography*, **42: 1584-1589.**

WHO (1999). Report of WHO informal consultation on schistomiasis control. Geneva, 2-4 December 1988. Geneva, World Health Organization. WHO/CDS/CPC/SIP/ 99.2.

تأثير بعض أنواع الطحالب على القواقع الناقلة لمرض البلهارسيا فى مصر
اا- معدلات النمو، العدوى و الوفاة

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تم فى هذا البحث تغذية قواقع العائل الوسيط لمرض البلهارسيا فى مصر (البيومفلاريا الكسندرينا و البولينس ترنكاتس) بثلاثة أنواع من السيانوبكتيريا (اوسيلاتوريا اكيوميناتا و لنبيا بريليجنس، و الفورميديم فالدريانم) و نوع من الطحالب الخضراء (سبيروجيرا) و التى تم عزلها من قناة كفر حكيم التي يوجد بها قواقع و قناة صادق الخالية من القواقع في محافظة الجيزة، بالاضافة الى طحلب نوستوك موسكورم المأخوذ من معهد تيودور بلهارس.

تم في هذا البحث تعيين معدل نمو القواقع و معدل العدوى و نسبة الوفاة بعد التغذية لمدة خمسة أشهر بكل نوع من أنواع الطحالب على حده أو فى صورة خليط من طحلبين أو خليط من الأنواع كلها.

و لقد أظهرت النتائج أن تغذية قواقع البيومفلاريا الكسندرينا على التركيز تحت المميت(LC_0) لطحلب الفورميديم قد سجلت أعلى معدل للنمو خلال مده التجربه، بينما قواقع البولينس ترنكاتس قد أعطت أعلى نمو لها عند تغذيتها على الخس. أما باستخدام خليط من طحلبين، فقد أعطى خليط الفورميديم و السبيروجيرا أعلى معدلات للنمو فى كلا النوعين من القواقع، أما الخليط المكون من الخمسة أنواع طحلبية معا فقد أثبت فاعليه كبيرة حيث أعطى أفضل معدلات للنمو فى كلا النوعين من القواقع. أما تغذية القواقع على أوراق الخس فقد سجلت أعلى معدلات للعدوى فى قواقع البيومفلاريا الكسندرينا و البولينس ترنكاتس و أقل نسبة وفاة بينما أقل نسبة عدوى و أعلى معدل للوفاة رصد عند استخدام طحلب السبيروجيرا الأخضر كغذاء لكلا النوعين من القواقع.

كما تم حساب القيمة الغذائية لكل نوع من أنواع الطحالب المستخدمه و الخس (المجموعة الضابطة) و ذلك بتعيين نسبة الكربون/النيتروجين و كذلك نسبة البروتين الكلى للطحالب.وتم ايضا تحليل النتائج و مناقشتها على ضوء نوع الغذاء المقدم للقواقع و تأثيره على معدلات النمو و العدوى و الوفاة.