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Effect of salinity and drought on the survival of *Biomphalaria arabica*, the intermediate host of *Schistosoma mansoni* in Saudi Arabia

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ABSTRACT

The effect of salinity and drought as two important abiotic factors on the survival of *Biomphalaria arabica*, the intermediate host of *Schistosoma mansoni* in Saudi Arabia was studied in the laboratory. Saudi *B. arabica* snails were collected from freshwater bodies in Abha, Asser district, Saudi Arabia. Snails were exposed to ten concentrations of Sodium Chloride as follow: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10‰. In addition, snails were exposed to a series of Sodium Chloride concentrations lie between the concentration that produced 100% mortality and the concentration lies previous to it. In drought experiments, the snails were exposed to complete dryness for 12, 24, 36 and 48 hours and the snails in moist soil were examined daily for fifteen days. The results revealed that *B. arabica* snails remain alive to 5‰ NaCl concentration and 100% mortality occurred at 7.2‰ of NaCl concentration. On the other hand, the ability of the snails to resist the complete dryness appeared to be limited, since 100% mortality was achieved after 36 hours in absence of lettuce leaves and after 48 hours in the presence of lettuce leaves. The snails in moist soil provided with fresh lettuce leaves remain survive to 15 days without any death. In the case of snails in the moist soil without fresh lettuce leaves, the survival was unaffected until 10^{th} day post-exposure, while further increases in exposure period resulted in reductions in survival up to 50% for snails exposed for 15 days. The present investigation declared that *B. arabica* has a great resistance to salinity increase and this may be explain why *B. arabica* has a great abundance in KSA. However, the ability of *B. arabica* snail to resist the dryness appeared to be limited.

Key words: salinity, drought, survival, *Biomphalaria arabica*, *Schistosoma mansoni*, Saudi Arabia.

INTRODUCTION

Approximately 200 million people in 74 countries are infected with schistosomes; 120 million are symptomatic, and 20 million suffer severe illness (Chitsulo *et al*., 2000& Ross *et al*., 2002). Schistosomiasis is the most important human helminth infection in terms of morbidity and mortality; a recent meta-analysis assigned 2 to 15% disability weight to the disease (King *et al*., 2005). The prevalence rate of schistosomiasis in Kingdom of Saudi Arabia (KSA) was 2.2/ 100,000; the percentage of urinary schistosomiasis caused by *Schistosoma haematobium* was 33.4% while that of the intestinal schistosomiasis caused by *S. mansoni* was 66.6% (Health Statistical Year Book of the Ministry of Health in KSA, 2006). In KSA, it has been found that snail of species *Biomphalaria arabica* acts as the intermediate host for *S. mansoni* (Arfaa, 1976).

Abiotic components are non-living chemical and physical factors in the environment, some authors studied the effects of these factors on the biology of

medically important snails. Yasuraoka (1961) reported on the effect of hydrogen ion concentration and salinity of water on extruding response and survival of *Oncomelania nosophora* the vector snail of *S. japonicum* in Japan. Gretillat and Gaston (1975) studied the effect of salinity on some aquatic vector snails in the Dallols' region, Niger, Africa. Leveque *et al*. (1978) tested the effects of some medium factors on the fecundity of *Biomphalaria glabrata* under laboratory conditions. Donnelly *et al*. (1983) evaluated the influence of salinity on certain biological aspects of the of *Bulinus (Physopsis) africanus*. Diaw *et al.* (1988& 1989) studied the resistance of *B. umbilicatus* and *B. senegalensis*, vectors of human and animal trematode infections in Senegal, to drought under laboratory and natural conditions. Kefford and Nugegoda (2005) measured the growth and reproduction of the freshwater snail *Physa acuta* at various salinity levels.

Sometimes the resistance of the snail to abiotic factors is affected by parasitism, Badie and Rondelaud (1982) studied the effect parasitism on the resistance of *Cionella lubrica* the intermediate host of *Dicrocoelium lanceolatum* to temperature and desiccation. Moreover, Lwambo *et al.* (1987) found that the infectivity of miracidia of *S. mansoni* in *B. arabica* was influenced by some factors such as water temperature and salinity.

In addition, the variations in abiotic factors have a strong influence on the distribution and the density of the snails and as a result on the prevalence and distribution of helminth parasites. Rogowski and Stockwell (2006) explained the relationship between salinity, snails, parasites and White Sands pupfish (*Cyprinodon tularosa*) in New Mexico State. Ibrahim (2007) determined the infection prevalence and intensity of *Angiostrongylus cantonensis* in freshwater snails in relation to some ecological and biological factors at Al-Salam irrigation Canal and Al-Abtal village, North Sinai, Egypt. The influence of climatic conditions on the prevalence and transmission of helminth parasites in a terrestrial molluscan population was studied in a grassland site in southern England by Morley and Lewis (2008).

The present article was aimed to study the effect of two important abiotic factors: salinity and drought on the survival of *Biomphalaria arabica,* the intermediate host of *Schistosoma mansoni* in Saudi Arabia.

MATERIAL AND METHODS

Snails: Saudi *B. arabica* snails with diameter ranged from 5 to 8 mm (mean 6.9 mm) were collected from freshwater bodies in Abha, Asser district, Saudi Arabia. The first generation of *B. arabica* snails was used in the present investigation to be sure that the snails were clean and free from any pathogens.

Salinity experiment: ten concentrations of Sodium Chloride (Na Cl) were prepared in deionized distilled water as follow: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10‰**.** Control experiments were performed with deionized water alone. Tests were performed in 24-well plates; snails were placed individually in the wells with about two ml of tested saline concentration. To prevent the snails from crawling out of the wells, the wells were covered and the space between the solution and the cover didn't allow the snails to leave the solution. Groups of ten snails were exposed to each of saline concentration for 24 hours, and then the snails were transferred to dechlorinated water for another 24 hours for recovery. After this period, the snails were examined with the help of stereoscopic microscope to count the dead and living snails to calculate the mortality percentage. The death of the snails was confirmed by contraction of the soft parts within the shell, absence of muscle contractions in response to needle probe and

change in the shell color. In addition, snails were exposed to a series of NaCl concentrations lie between the concentration that produced 100% mortality and its previous concentration. All experiments were independently repeated three times.

Drought and starvation experiment: 38 Petri dishes of 9 cm diameter were supplied with sterilized soil, the dishes were divided into two groups: the first one consists of 8 dishes contain completely dry soil; ten snails were placed in each dish; four dishes of them were supplied with small pieces of fresh lettuce leaves and the other dishes were not supplied. The snails were exposed for 12, 24, 36 and 48 hours. The second group consists of 30 dishes contain moist soil; ten snails were placed in each dish; fifteen dishes of them were supplied with small pieces of fresh lettuce leaves and the other fifteen dishes were not supplied. The snails were examined daily for fifteen days. Control experiments were performed with dechlorinated water. After the exposure period, the snails were transferred to dechlorinated water for 24 hours for recovery, and then examined with the help of stereoscopic microscope to count the dead and living snails to calculate the mortality percentage. All experiments were independently repeated three times.

RESULTS AND DISCUSSION

Increasing of salinity in rivers and wetlands is a serious environmental problem on all inhabited continents (Williams, 1987), and is likely to affect aquatic organisms (Hart *et al.*, 1990, 1991). Recently, there has been interest in the lethal effects of high salinity on fresh water macroinvertebrates (Kefford and Nugegoda 2005). The present results (Tables 1& 2) declared that *B. arabica* has a great resistance to salinity increase, since they remain alive to 5‰ NaCl concentration and 100% mortality occurred at 7.2‰ of NaCl concentration. This result was correlated with that of Donnelly *et al*. (1983) who reported that the survival of adult *B. africanus* was unaffected in salinities < 3·5 ‰ while further increases in salinity resulted in significant reductions in survival up to a lethal salinity of 8·7 ‰, which caused 100% mortality within 24 hours. In addition, Leveque *et al*. (1978) reported that *B. glabrata* snail is not affected by very high rates of concentrations of Na, Ca, Mg, and K-salts but eggs' laying is getting down when the amount of NaCl is between 2000 and 4000 mg/1. The high resistance of *B. arabica to* salinity may be explain their great abundance in KSA (Browen and Wright, 1980). Moreover, the great tolerances of this snail to high salinity enabling them to live in temporary water bodies formed after rainfall while the increase in the salinity of this water bodies is prospected due to evaporation during the period between two rainfalls. Diaw *et al.* (1989) reported that the variations in some abiotic factors like the temperature and the pH of water do not seem to have a strong influence on the ecology while rainfall has a great importance on the distribution and the density of molluscs. The variation in the salinity of water bodies has direct effects on the prevalence of parasites transmitted by snails living in such water bodies; Rogowski and Stockwell (2006) in their study about the relationship between salinity, snails, parasites and White Sands pupfish (*Cyprinodon tularosa*) in New Mexico State, reported that at the high salinity sites, springsnails were absent and pupfish trematode abundance was much lower, and fish condition was intermediate.

As a fact, the quantity of water and the drying out period of the ponds depend upon rain factors which rule the existence and the survival of the malacological fauna (Diaw *et al*., 1989). The present investigation declared that the ability of *B. arabica* snail to resist the complete dryness is limited, since 100% mortality was achieved

after 36 hours in absence of lettuce leaves and after 48 hours in the presence of lettuce leaves (Table 3). The positive effects of the presence of lettuce leaves on the delaying the death of the snails may be due to the considerable humidity allowed by fresh lettuce leaves within the Petri dishes; since we observed that the snails were crawled and hidden below the lettuce leaves.

The snails in moist soil and supplied with fresh lettuce leaves, remain survive to 15 days without any death. In the case of snails in the moist soil and not supplied with fresh lettuce leaves, the survival was unaffected until 10^{th} day post-exposure, while further increases in exposure period resulted in reductions in survival up to 50% for snails exposed for 15 days (Table 4). Very interested observation was recorded -in the case of snails in moist soil- that is the snails were burrowed in the soil and buried themselves under moist soil grains. The resistance to drought has a great importance on the distribution and the density of molluscs. Diaw *et al.* (1989) studied the ecology and drought resistance of *B. umbilicatus* and *B. senegalensis* on 3 temporary ponds in the North-Sudan area (region of Tambacounda, Senegal) through two years. These ponds were dry during 6 to 8 months per year. However, the populations of molluscs regenerate regularly and reach their maximum number in the second part of the rainy season, a fact which presupposes a certain ability to resist drought.

Table (1): Percentage of mortality of *Biomphalaria arabica* exposed to various concentrations of NaCl

NaCl Conc. in ‰	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Mortality rate%	**0**	**0**	**0**	**0**	**0**	**50**	**75**	**100**	**100**	**100**

Table (2): Percentage of mortality of *Biomphalaria arabica* exposed to concentrations of NaCl between 7.1 to 7.9 **‰**

NaCl Conc. in ‰	**7.1**	**7.2**	**7.3**	**7.4**	**7.5**	**7.6**	**7.7**	**7.8**	**7.9**
Mortality rate%	**85**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table (3): Percentage of mortality of *Biomphalaria arabica* in completely dry soil

Exposure time (in hours)	12	24	36	48
In presence of lettuce leaves	0	0	20	100
In absence of lettuce leaves	0	20	100	100

Table (4): Percentage of mortality of *Biomphalaria arabica* in moist soil

Exposure time (in days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
In presence of lettuce leaves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
In absence of lettuce leaves	0	0	0	0	0	0	0	0	0	0	12	20	20	40	50

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ARABIC SUMMARY

تاثير الملوحة والجفاف على حياة قواقع بيفولاريا أربيكا العائل المتوسط لشيستوسوما مانسونى في المملكة العربية السعودية

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في هذا البحث تم دراسة تأثير أثنين من أهم العوامل غير الحيوية على قواقع بيفولاريا أربيكا- العائل المتوسط لشيستوسوما مانسونى في المملكة العربية السعودية - وهما الملوحة والجفاف. تم جمع القواقع من تجمعات المياه العذبة بأبها، منطقة عسير بالسعودية. عرضت القواقع لعشرة تركيزات من كلوريد الصوديوم وهي 1، 2، 3، 4، 5، 6، 7، 8، 9، 10 % لمدة 24ساعة، ثم تم تعريض القواقع لسلسلة من التركيزات تقع بين التركيز الذي أحدث 100% وفيات والتركيز الذى يسبقه، وقد اظهرت النتائج ان قواقع البيمفولاريا أربيكا تبقى غير متاثرة بزيادة الملوحة حتى تركيز 5‰، وتم تسجيل 100% وفيات عند تركيز 7.2% . وفى تجربة تاثير الجفاف تم تعريض القواقع للجفاف التام لمدة 12، 24، 36، 48 ساعة، كما تم فحص القواقع يوميا فى التربة الرطبة لمدة خمسة عشر يوماً. وقد اظهرت النتائج ان قدرة القواقع على تحمل الجفاف التام محدودة حيث تحقق 100% وفيات بعد 36 ساعة في غياب الطعام، وبعد 48ساعة فى وجود الطعام. أما فى التربة الرطبة فقد بقيت القواقع حتى خمسة عشر يوما بدون وفيات في وجود الطعام، أما في غياب الطعام فقد بقيت القواقع بدون وفيات حتى اليوم العاشر، وتحقق 50% وفيات في اليوم الخامس عشر من التجربة.