Can the freshwater crayfish eradicate schistosomiasis in Egypt and Africa?

Magdy T. Khalil & Setaita H. Sleem

Zoology Dept., Faculty of Science, Ain Shams University, Egypt.
mtkhalil52@hotmail.com

Abstract: Schistosomiasis is a chronic, parasitic disease, infecting more than 207 million people, mostly from Africa, with an estimated 700 million people at risk in 74 endemic countries. One of strategies to eradicate this disease is biocontrol of its vector snail. Lab experiments and field survey have been carried out to investigate the impact and the relationship between the exotic crayfish; *Procambarus clarkii* and *Schistosoma* vector snails in Egypt. In the Lab, several species of freshwater snails, fish and aquatic plants were reported to serve as food for the freshwater crayfish. In the field, a survey for the crayfish and freshwater snails has been conducted at several irrigation channels in Qalyobiya, Ismailia and Behera governorates, which had been previously surveyed during 1990s. The results of the experimental Lab indicated that the vector snails; *Biomphalaria alexandrina*, *Bulinus truncatus* and *Limnaea natalensis* were the preys of first choice for the crayfish. The fields surveys showed high reduction and sometimes complete disappearance of vector snails in irrigation channels, which have been invaded by *Procambarus clarkii,* while in water courses which do not harbor the crayfish, such as El Manayef drain and Fayed canal (West of Suez Canal), high densities of these vector snails were recorded.The present study is providing encouraging indication of the possible overcoming schistosomiasis and fascioliasis in Egypt and whole Africa by the freshwater crayfish *Procombarus clarkii.* New estimates of the Egyptian Ministry of Health indicated that the percent of infected people decreased significantly to only 4% comparing to 45% during 1960s.
[Magdy T. Khalil & Setaita H. Sleem. **Can the freshwater crayfish eradicate schistosomiasis in Egypt and Africa?.** Journal of American Science 2011;7(7):457-462]. (ISSN: 1545-1003). http://www.americanscience.org.

Keywords: Procambarus clarkii, Biomphalaria alexandrina, Bulinus truncatus, Limnaea natalensis, crayfish, schistosomiasis, fascioliasis, Egypt, Africa.

1. Introduction

Schistosomiasis is a chronic, parasitic disease caused by blood flukes of the genus Schistosoma. More than 207 million people are infected worldwide, with more than 90% of the cases occurring in Africa, at poor communities without access to safe drinking water and adequate sanitation (**Hotez, 2008, 2009; WHO, 2011**). An estimated 700 million people worldwide may be at risk of infection in 74 endemic countries as their agricultural, domestic and recreational activities expose them to infested water (**Hotez and Kamath, 2009**). One of strategies to eradicate this disease is biocontrol of their vector snails.

On the other hand, a field survey for the exotic freshwater crayfish was carried out along the River Nile, for the first time since its accidental introduction to Egypt during early 1980's, by **Ibrahim *et al.* (1996)**. They found that the crayfish has established viable populations in the aquatic ecosystems of Giza, Cairo and some Nile Delta Governorates. The coefficients of condition values have indicated the suitability of the new environment for the exotic crayfishes with regard to feeding condition.

In the Lab, **Ibrahim *et al.* (1995)** studied the feeding behavior of the exotic crayfish *Procambaraus clarkii* and its prospect in the biocontrol of local vector snails and they found that smaller snails were easier preys to be attacked by the crayfish. Moreover, **Huner and Barr (1983)** and **Mc Clain *et al.* (1993)** studied the selectivity of this species for combating certain freshwater snails, which are vectors of parasitic diseases. Moreover, *P. clarkii* has been also known for its outstanding feeding capacity on some aquatic pest weeds (**Groves, 1985).**

On the other hand, distribution, density and population seasonal fluctuation of *Biomphalaria alexandrina* and *Bulinus truncatus* snails, the intermediate hosts of *Schistosoma mansoni* and *Schistosoma haematobium*, respectively were studied by **Yousif *et al.* (1993a, b, 1998 and 1999)** in several irrigation canals in Qalyobiya, Giza and Ismailia Governorates. The results of these studies showed considerable high densities and distribution of both snail species in most water courses of the study areas. The crayfish has been introduced into many of these channels, and some observations have showed that this animal has adversely affected the densities of the freshwater snails.

So, the objective of the present study was to evaluate the impact of the freshwater crayfish on the above vector snails at certain water courses in Ismailia, Qalyobiya and Behera Governorates. Moreover, the feeding capacity and behavior of this crayfish - in the Lab - to different plant and animal species living in the River Nile were also examined.

2. Materials and Methods

A. Laboratory experiments:

Large numbers of adult crayfish *P. clarkii* of different sizes were collected from several Nile water courses at Giza Governorate. They were transferred to the laboratory and maintained in glass aquaria (50 x30 x20 cm) filled with continuously aerated dechlorinated tap water.

Eight species of freshwater snails including *Biomphalaria alexandrina, Bulinus truncatus, Limnaea natalensis, Physa acuta, Bellamya unicolor, Cleopatra bulimoides, Melanoides tuberculata* and *Lanistes carinatus*; in addition to a fish species *Oreochromis niloticus* and three aquatic plants namely, *Lemna perpusilla, Ceratophyllum demersum* and *Elodea canadensis* were introduced to the crayfish aquaria in combination. These organisms were collected from the same water courses from where the crayfish was obtained.

Four fully mature crayfish (4.5 – 6.5 cm in carapace length) with only one small specimen (3.0-3.5 cm carapace length) were placed in groups in the aquaria. Four replicates were set up; each aquarium was filled to 1/6 of its capacity with dechlorinated water and was used for the eight snail species (10 individuals for each species) and one individual of the fish species and 3 different plant species.

Water of the aquaria was changed every other day. The feeding activity and the reaction of the crayfish towards each of the examined species were watched for seven weeks and the devoured specimens were reported daily and photographed.

B. Field survey:

Ten irrigation water courses (tertiary channels) reaching 5.5 Km long , 4 of them, namely El-Wehda, El-Galaa (East of El-Morra Lake in Sinai; 15 Km from Ismailia City), El-Manayef drain, Fayed canal (West of Suez canal, 6 Km to the South of Ismailia City) in Ismailia Governorate, 2 canals, namely Sanafeer and Sendebis in Qalyobiya Governorate, 4 canals, namely 7-El Hamamee, 7-7-El Hamamee (Abou Homoss District), El-Hadad El-Baharee canal and Drain No. 22 (Housh Esa District) in Behera Governorate were surveyed during this study, using the standard dip net (33 x 33 Cm), which was described by **Yousif *et al.* (1992)**. The distance between each two following sampling sites was 25 meters (4 sites / 100 m.). At each sampling site 3 adjacent dip nets were taken, covering a length of about one meter.

At each channel, the collected snail samples were put in plastic containers, preserved in 5% neutral formalin and transferred to the laboratory for identification and counting.

C. Statistical Analysis:

The obtained results were subjected to analysis of variance (ANOVA) using Microsoft Office Excel, Program 2003 Ver. 7.

3. Results and Discussion

The data obtained from laboratory experiments and field observations indicated that *P. clarkii* is a polytrophic animal that can serve as an effective agent for controlling schistosomiasis and other snail borne parasitic diseases. It has a large feeding capacity to any freshwater biota, even dead organisms.

The results shown in Table (1) indicate that the crayfish consumes large numbers of snail species, hydrophytes and the offered fish that are commonly found in freshwater canals in Egypt. Regarding the snails, the crayfish tends to be selective according to shell hardness and the size of the snail. Therefore, the snails*, B. alexandrina, P. acuta, L. natalensis* and *B. truncatus* were preferred preys to be attacked by *P. clarkii* (Fig. 1). This is primarily because the shell is thin and easy to break, before getting to the soft parts. They usually crush the shell between their large claws and eat the soft body of the snail; though **Ibrahim *et al.* (1995)** reported that *P. clarkii* has been observed to devour the whole animal with its shell. It was also noticed from the present study that the crayfish could devour ten large-sized snails from each of the first four snail species (Table 1) during the first day only. The operculated snails *Cleopatra bulimoides, Bellamya unicolor* and *Melanoides tuberculata* came next to the former group in food preference of the crayfish, but after fullness the crayfish never attacks the latter snail group. *Lanistes carinatus* was more resistant to the crayfish attack due to its shell hardness and the bigger size. However, after a period of starvation for 6 weeks, the crayfish through the help of its chelipeds could orientate the snail in a suitable position so as to gain access to its retracted soft parts, leaving the empty shell and operculum.

Regarding the fish as a source of food to the crayfish, it was noticed that it can devour only the dead fish (Table 1) after consuming the non operculate snail species.

Table (1): Food consumption of *Procambarus clarkii* to different aquatic species in the laboratory

Food types	Quantity	Food consumption / day							Total food consumption (during one week)
		1	2	3	4	5	6	7	
1-*Biomphalaria alexandrina*	10	10	--	--	--	-	--	--	10
2- *Bulinus truncatus*	10	10	--	--	--	-	--	--	10
3- *Limnaea natalensis*	10	10	--	--	--	-	--	--	10
4- *Physa acuta*	10	10	--	--		-	--	--	10
5-*Cleopatra bulimoides*	10	--	--	--	5	3	2	--	10
6- *Bellamya unicolor*	10	--	--	--	3	3	2	2	10
7- *Melanoides tuberculata*	10	--	--	--	4	3	2	1	10
8- *Lanistes carinatus*	10	--	--	--	--	-	--	--	--
9- *Oreochromis niloticus*	1	--	--	1	--	-	--	--	1
10- *Lemna perpusilla*	High density	--	all	--	--	-	--	--	all
11- *Ceratophyllum demersum*	3 branches	2	1	--	--	-	--	--	3
12- *Elodea canadensis*	3 branches	1	1	1	--	-	--	--	3

On the other hand, the crayfish is known to consume most species of aquatic plants that can be considered an essential part of its diet (**Groves, 1985; Bishop, 1992**). During the present study, *P. clarkii* consumed all species of aquatic plants that were added in their aquaria. Moreover, **Ibrahim *et al.* (1995)** reported that *P. clarkii* fed actively on *Elodea canadensis*.

Cannibalism phenomenon is very common among crayfish individuals (**Groves, 1985**). Results of the Lab experiment showed that when 5 crayfish (4 large-sized and one small-sized) were left without supply of favorite food (easy preys) for about 10 days, the smaller one were devoured by the others (Fig.2). **Ibrahim *et al.* (1995)** reported that cannibalization happens primarily during molting and aggressiveness of parent against the offspring when they are hungry.

The analyses of variance (ANOVA) for the experimental results showed a high significant reversible correlation between the presence of the crayfish and disappearance of vector snails in all replicates at $p < 0.05$.

On the other hand, field surveys during the present study showed that the crayfish populations were successfully established in many water courses along the River Nile, and in some of the newly habitats in Sinai through the irrigation system.

The results in Table (2) indicate that *P. clarkii* appeared in 6 canals, with densities of 10, 4, 20, 2, 8 and 2 in El-Wehda, El-Galaa, Sanafeer, Sendebis, El-Hadad and Drain Nº.22, respectively in three governorates. In El-Wehda canal, in the east of El Morra Lakes in Sinai, there were no *B. truncatus* or *L. natalensis* snails, while two *B. alexandrina* were found with 10 crayfish. In El- Galaa canal there were 3 *B. truncatus* only against 4 crayfish. In El-Manayef drain, the crayfish was missing completely, while there were 10, 4 and 5 of *B. alexandrina, B. truncatus* and *L. natalensis*, respectively. Also, there were no crayfish in Fayed canal in presence of 5, 3 and 4 of *B. alexandrina, B. truncatus* and *L. natalensis*, respectively.

Table (2): Density of vector snails and crayfish in the study areas

Governorate	Location	Village	Canal / Drain (surveyed length)	No. of *B. alexandrina*	No. of *B. truncatus*	No. of *L. natalensis*	No. of Crayfish
Ismailia	East of El-Morra Lakes in Sinai	El-Wehda	El-Wehda canal (300 meter)	2	0	0	10
		El-Galaa	El-Galaa canal (300 meter)	0	3	0	4
	West of Suez Canal	El-Manayef	El-Manayef drain (300 meter)	10	4	5	0
		Sarapyoum	Fayed canal (300 meter)	5	3	4	0
Qalyobiya	Qalyoub District	Sanafeer	Sanafeer canal (500 meter)	0	0	0	20
	El-Kanater District	Sendebis	Sendebis canal (500 meter)	0	0	> 1000	2
Behera	Abou-Homoss District	Abou El - Khazr	7-El Hamamee canal (1Km)	48	6	60	0
			7-7-El Hamamee canal (1 Km)	650	30	48	0
	Housh Esa District	El-Hadad El Baharee	El-Hadad canal (1 Km)	0	0	0	8
			Drain No. 22 (300 meter)	20	0	16	2

On the other hand, in Sanafeer canal, the vector snails disappeared completely, in presence of a high density of crayfish; 20 individuals. In Sendebis canal, there were two crayfish only with a high number of *L. natalensis*. In 7-El Hamamee canal, there were 48, 6 and 60 of *B. alexandrina, B. truncatus and L. natalensis* snails, respectively in the absence of the crayfish. Also, the same in 7-7-El Hamamee canal, there were no crayfish, in presence of high densities of the snails; (650, 30 and 48 of *B. alexandrina, B. truncatus* and *L. natalensis*, respectively). In El Hadad canal there was no snails found against 8 crayfish. In Drain N$^{o.}$ 22, there were 20 and 16 of *B. alexandrina* and *L. natalensis*, respectively, but no *B. alexandrina* in presence of 2 crayfish.

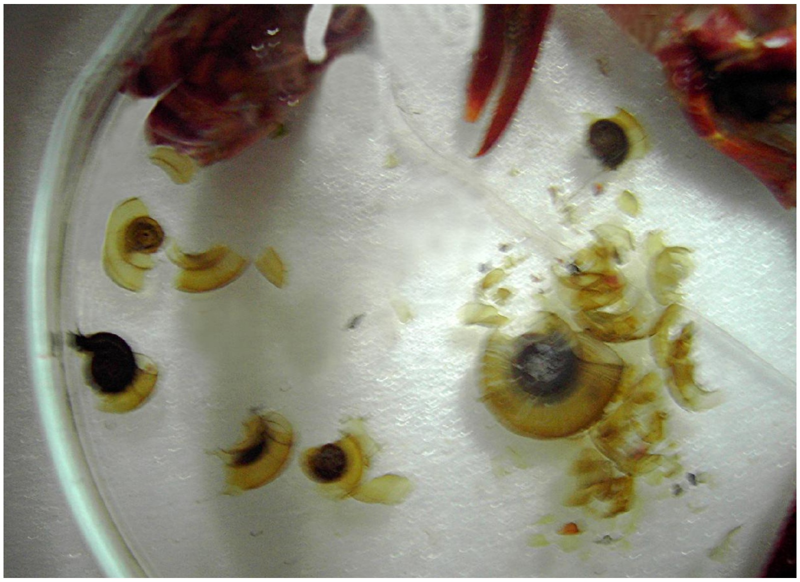

Fig. (1): *Biomphalaria alexandrina* shells after devouring by the crayfish

Fig. (2). Cannibalism phenomenon in the crayfish

The analyses of variance (ANOVA) for field survey results showed a highly significant correlation between the abundance of the crayfish and disappearance of snails at both of Ismailia and Qalyobiya Governorates (r = -0.64, -0.93 and -0.84 at $p < 0.05$ for *B. alexandrina*, *B. truncatus* and *L. natalensis,* respectively). In Behera Governorate, it showed also a highly significant correlation. (r = - 0.49,- 0.55 and – 0.88 at $p < 0.05$ for *B. alexandrina*, *B. truncatus* and *L. natalensis,* respectively).

The reduction or complete absence of freshwater snails in water courses of the present study is attributed mainly to the presence of the crayfish, which acts as a predator for snails, especially *Schistosoma* and *Fasciola* vector snails due to their slow movement and thin shells. This agrees with **Ibrahim *et al*. (1995)**, where they claimed that the snails *B. alexandrina, B. truncatus,* *L. cailiaudi* and *Physa acuta* were easier preys to be attacked by the crayfish.

In conclusion, the present study indicates that the crayfish became of a wide range of distribution along the irrigation system of Egypt, reaching to Ismailia, Qalyobiya and Behera Governorates and even to Sinai. Moreover, it has a wide range of acceptable foods, such as non operculate freshwater snails, small fish and aquatic plants. So the crayfish can act as a biological control agent for these vector snails, providing promising indication of its possible use for the control of schistosomiasis and fascioliasis in Egypt.

This article was supported by a grant from RDI Programme (no. S2/A9/69), Ministry of Higher Education and Scientific Research, Egypt.

Corresponding Author:
Prof. Dr. Magdy T. Khalil
Zoology Dept., Faculty of Science, Ain Shams University, Egypt.
Email: mtkhalil52@hotmail.com

References

1. Bishop, T. ,1992. The great Yabbie farming book. Yabbie Nippers, Wy-Wurrie Yabbies, Bordertown, South Australia, Australia.
2. Groves, R. E. ,1985. The crayfish nature and nuture, Fishing New Books Ltd, England.
3. Hotez, P. J. ,2008. Forgotten people, forgotten diseases: the neglected tropical diseases and their impact on global health and development. Washington (D. C.): American Society of Microbiology, 215 pp.
4. Hotez, P. ,2009. Mass drug administration and integrated control for the world's high-prevalence neglected tropical diseases. Clin. Pharmacol. Ther., 85: 659–664.
5. Hotez, P.J. and Kamath, A. ,2009. Neglected tropical diseases in sub-Saharan Africa: review of their prevalence, distribution, and disease burden. PLoS Negl Trop Dis., 3: e412.
6. Huner, J. V. and Barr, J. E. ,1983. Red swamp crayfish. Biology and exploitation (revised ed.) (Louisiana Sea Grant Prog., center for wet land resources Louisiana St. Univ., Baton Rouge, Louisiana).
7. Mc Clain, W. R.; Ollich, P. K. and Huffman, D. C. ,1993. Relaying: A mean to increase market size of *Procambarus clarkii* and increase net returns from rice crayfish production. Freshwater Crayfish, 9: 13-17.
8. Ibrahim, A. M.; Khalil, M.T. and Mubarak, F. M. ,1995. On the feeding behavior of the exotic crayfish *Procambarus clarkii* in Egypt and its prospects in the biocontrol of local vector snails. J. Union. Arab. Biol., .4: 321 – 340.
9. Ibrahim, A. M.; Khalil, M.T. and Mubarak, F. M. ,1996. Ecological studies on the exotic crayfish *Procambarus clarkii* (Girard, 1852) and *P. zonangulus* Hobbs & Hobbs 1990, in the River Nile. J. Egypt. Ger. Soc. Zool., 20: 167 – 185.
10. WHO, 2011. Schistosomiasis: number of people treated worldwide in 2009. Weekly Epidemiological Record, 9 :73–80
11. Yousif, F., Khalil, M.T. and El-Emam, M. ,1992. Evaluation of three common tools in estimating *Biomphalaria alexandrina* snail populations in irrigation ditches. Egypt. J. Bilh., 14 : 151-158.
12. Yousif, F.; Kamel, G.; El-Emam, M. and Mohamed, S., 1993a. Ecology of *Biomphalaria alexandrina* the snail vector of *Schistosoma mansoni* in Egypt. J. Egypt. Soc. Parasitol., 23: 29-42.
13. Yousif, F.; Kamel, G.; El-Emam, M. and Mohamed, S. ,1993b. Population dynamics and schistosomal infection of *Biomphalaria alexandrina* in four irrigation canals in Egypt. J. Egypt. Soc. Parasitol., 23: 621-630.
14. Yousif, F.; El–Emam, M.; Abdel Kader, A.; Sharaf El-Din, A.; El-Hommossany, K. and Shiff, C. ,1998. Schistosomiasis in newly reclaimed areas in Egypt. 1- Distribution and population seasonal fluctuation of intermediate host snails. J. Egypt. Soc. Parasitol., 28: 915 – 928.
15. Yousif, F.; El-Emam, M.; Abdel Kader, A.; Sharaf El-Din, A.; El-Hommossany, K. and Shiff, C., 1999. Schistosomiasis in newly reclaimed areas in Egypt. 2- Pattern of transmission. J. Egypt. Soc. Parasitol., 29:635 – 648.

5/29/2011