Distribution of *Schistosome* intermediate hosts in relation to aquatic plants and physico-chemical characteristics in different watercourses among Kafr El-Sheikh centers, Egypt

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Abstract: This study aimed to record the present status of schistosomiasis transmission in different watercourses among Kafr El-Sheikh Governorate. Snail survey incorporating 80 sites was conducted to determine the presence of intermediate host snails and ascertain whether active transmission was occurring within these areas. Aquatic plants at these sites were recorded, and the physico-chemical characteristics of the water were determined as well. Results showed that *Biomphlaria alexandrina* snails were found to be established in all types of watercourses (canals, drains and El-Borollos Lake) and in all centers with infestation percentage of 63.8% and density of 34.684 snails/site. Naturally infected *B. alexandrina* was observed in five centers exerting their highest infestation in Desouk, Baltim and El-Hamoul centers (37.5%). In the meantime *Bullinus truncatus* was observed in all types of watercourses and in all centers with infestation percentage of 25% and density of 4.10 snails/site. Naturally infected *B. truncatus* was observed only in Mottobis and Baltim centers with infestation percentage of 12.5 and 25%, respectively. *B. alexandrina* density was about 7 times that of *B. truncatus* and 3.3% of *B. alexandrina* and 0.9 % of *B. truncatus* were naturally infected. Results of physico-chemical parameters showed significant difference between centers in most parameters especially for conductivity, copper, sodium and iron levels. Baltim center showed the highest values in most of the examined parameters. In spite of the increased level of all Cu, Cd, K& Na means there was spreading of *B. alexandrina* and *B. truncatus* in all centers and those naturally infected in certain centers suggesting that chemical water pollution was not a limiting factor in these snails distribution. Highly significant correlation was observed between the moderate density of all the recorded plants and *B. alexandrina* infestation percentage while no significant correlation between the infestation pattern of *B. truncatus* and each of the examined plant densities.
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1.Introduction

Schistosomiasis is endemic in 74 countries in Africa, South America and Asia. Worldwide, an estimated 200 million people are infected, of which 20 million is assumed to suffer from more or less a severe form of the disease **(WHO, 2002 and 2012).** In Egypt, there are two types of schistosomiasis *Schistosoma mansoni* and *Schistosoma heamatobium* which transmitted through the intermediate hosts, *Biomphalaria alexandrina* and *Bulinus truncatus*, respectively. Numerous factors act to determine the rate of schistosomiasis transmission in a given location. These include biotic and abiotic features, such as climatic, physical and chemical factors, which affect the survival and development of schistosome parasites and snail host populations **(Sturrock, 1993)**, as well as socio-economic and behavioral characteristics of the human community, such as water contact behavior and the adequacy of water and sanitation, which affect the frequency and intensity of exposure to infected water **(Bundy and Blumenthal, 1990).**

The Egyptian freshwater habitat has been deteriorating primarily due to the discharge of municipal waste water, industrial and agricultural into various water bodies across the country. The correlation between the distribution and population density of *B. alexandrina* and *B. truncatus* in Egypt was studied in one hand and several environmental parameters on the other hand. **Abdel kader *et al.*, (2005)** compared the levels of soluble nitrogen (NO3+ NH4), soluble phosphate, iron, manganese, zinc, copper, boron, cobalt, lead, cadmium and nickel in 22 selected canal and drainages resembling Delta region and the River Nile. Data showed that *B. alexandrina* was more distributed in canal and drains in spite of showing significant elevations in most of the measured parameters, compared to the River Nile. Also, **Ibrahim *et al.*, (2005)** found that the water temperature was ranged from 13ºC in January to 29.1ºC in July, pH ranged from 8.1-8.5, conductivity ranged from 280-460 in the River Nile at Greater Cairo for one year from April 2001- March 2002.

The correlation of *Schistosomes* prevalence in snails and human was studied by **Sayed *et al.*, (2004)** who examined the relationship between epidemiology of *S. mansoni* infection and snail distribution. A systemic human random sample (704 persons) was checked for schistosome infection at a village, related to Giza Governorate. Also, snail collection was done from 35 sites along the water bodies related to the village. The results showed that prevalence of *S. mansoni* was 25% and *S. haematobium* was 0%. *B. alexandrina* infested 12 sites with density of 12.4 snails/site, while *B. 147runcates* infested 7 sites with density of 0.5 snails/site. Natural infection rates among collected snails were 3.7 among *B. alexandrina* and 0 for *B. 147runcates*. So, the pattern of *S. mansoni* human infection was closely related to snail distribution and infection. *S. haematobium* infection was absent from human, and was also absent in snails. Additionally, **Mostafa *et al.*, (2005)** found no infection with *S. haematobium* among 150 people participating in rice farming practices in El Gharbiya and Kafr El-Sheikh Governorates and at the same time found no natural infection among the *B. 147runcates* snails collected from canals and drainages localized in the same areas.

Therefore, the present work aimed to study the distribution of the snail intermediate hosts of schistosomiasis in different watercourses among the 10 centers of Kafr El-Sheikh Governorate as a measurable indicators for transmission. In addition, the correlation between snail distribution and a aquatic plants type and density and water physicochemical parameters were determined.

2.Materials and Methods

Study area:

This study was conducted in the ten centers of Kafr El-Sheikh Governorate (Fuwwah, Desouk, Mottobis, Baltim, Kafr El-Sheikh, El-Hamoul, Sidi Salem, Biyala, El-Reyad and Qullin). Eight sites in each center were involved in the study. The watercourses included irrigation canals, agricultural drains and the Borolos Lake.

Snail survey:

Snail sampling was carried out from May to September 2010, in 80 sites located within the ten center of Kafr El-Sheikh Governorate. Snail sampling was performed through three visits per site using a standard dip net **(Jobin, 1970;** Yousif ***et al.*, 1992).** The collected *Biomphalaria* and *Bulinus* snails from each sampling site were placed in ice boxes and transferred to the laboratory. Non target snails were sorted and recorded in field survey sheet **(El-Emam and Roushdy, 1981)** and **(Yousif *et al.*, 1998a & b).** In the laboratory, snails were examined individually at weakly intervals for one month for their natural trermatode infection. Thus, snails were distributed in test tubes containing de-chlorinated tap water, placed under artificial light for about two hours, then were examined for cercarial shedding **(Favre *et al.*, 1995 and Yousif *et al.*, 1998a).** The snail aquaria of the collected snails were inspected daily to detect snails with signs of distress or mortality, and then the detected ones were crushed between 2 slides and inspected microscopically for schistosome sporocysts **(Olivier, 1973).** The natural schistosome infection rate was estimated for each host snail species in each study site, to be equal to the sum of cercariae shedding snails plus those have schistosome sporocyst divided by the total of collected snails.

Physico-chemical parameters of water:

Water temperature and conductivity were measured directly in the selected watercourses to the nearest o C and µs/cm, respectively using temperature conductivity meter (HANNA instrument, HI 9635). Also, Hydrogen ion concentration (pH) was measured by pH meter electrode (HI 9124 and HI 9125). All the physical parameters were measured between 11: 00 am to 3: 00 pm and were recorded in the field survey sheets. Water samples were collected from the watercourses 5 cm below the water surface immediately afterwards, the samples were filtrated, and kept at 4 o C till analysis. Samples were analyzed for concentrations of sodium (Na), potassium (K), calcium (Ca), cadmium (Cd), lead (Pb), copper Cu, iron (Fe), manganese (Mn) and nickel (Ni), using atomic absorption spectrophotometer (AVANTA)

Aquatic plants:

Existed aquatic plants in selected watercourses were sorted and their densities (low, moderate and high) were recorded in the field survey sheet **(El-Emam and Roushdy, 1981; Yousif *et al.*, 1998a & b).**

Statistical analysis:

All analyses were performed using SPSS version 18 (SPSS, Inc., Chicago, IL) using test for difference between two groups proportion. P values < 0.05 were considered statistically significant.

3.Results

Snail distribution and density:

Snail survey was done during the period from May-September /2010 in 80 sites representing the ten centers of Kafr El-Sheikh Governorate (8 sites/center). Results of *B. alexandrina* and *B. truncatus* distribution and density are summarized in Tables (1&2). They showed that *B. alexandrina* snails were found established in all types of watercourses and in all centers with infestation percentage of 64%. The highest percentage of infestation was in Fuwwah and Baltim centers, recording100%, while the lowest was in Qullin, representing 12.5%. Desouk, Baltim and Fuwwah centers were characterized by the highest snail density (92.13, 75.5, and 58.25 snails/site,

respectively). Test for difference between proportions was used to compare the infestation pattern of *B. alexandrina* between centers. Fuwwah center was very highly significant with Qullin center, highly significant with El-Reyad and significant with each of Mutubis & Biyala. Also, Desouk center was highly significant with Qullin center while significantly different from Mutubis and El-Hamoul centers. In addition, Mutubis was highly significant with Baltim center and Baltim was highly significant with each of El-Reyad, Kafr El-Sheikh and Qullin centers. Desouk, Baltim and El-Hamoul centers were the mostly infested with naturally infected *B. alexandrina* (37.5 %) while Biyala and Baltim showed the highest density of naturally infected snail (5.88 and 4.0 snails/site, respectively). Biyala center showed the highest percentage of natural infection (26.6%). Desouk center showed least percentage of natural infection (0.4%) in spite of characterizing by the highest snail density. On the other hand, Mutubes, Kafr El-Sheikh, Sidi Salem and El-Reyad centers were free of naturally infected snails. In the case of *B. truncatus*, snails were found in all centers in canals, drains and the lake with infestation percentage 25%. Mutubes center showed the highest infestation percentage as well as the highest snail density (percentage of infestation was 62.5% and the snail density was 23.5 snail/site). Statistical analysis showed that *B. truncatus* infestation pattern was significantly different only between Fuwwah & Mutubes centers. Naturally infected *B. truncatus* snails were observed only in Baltim and Mottobis centers (The percentage of infestation of naturally infected snails was 25% and 12.5%, respectively and their density were 0.125 and 0.286 snail/site, respectively). Baltim center showed the highest percentage of naturally infected snails (33.3%). Comparing both snail species in Kafr El –Sheikh Governorate revealed that the density of *Biomphalaria* was about 7 times that of *Bulinus* and the total percentage of naturally infected snails was higher among *B. alexandrina* snails (3.3%) than *B. truncatus* snails (0.9 %). The study of non-target snails' distribution observed eight snail species that naturally associated with *B. alexandrina* and *B. truncatus*. Results indicated that *Cleopatra bulimoide* and *Bellamya unicolor* were the mostly infested and found in all centers with infestation percentage 77.5% and 57.5%, respectively while *Planorbis planorbis* and *Helisoma duryi* showed the least infestation percentage (6.3% and 5%, respectively). *P. planorbis* was recorded in three centers and *H. duryi* was recorded in two centers. The other four species, *Lanistes carinatus*, *Lymnaea natalensis*, *Physa acuta*, and *Melanoides tuberculata* were found in most centers showing approximately the same infestation percentages (36.3, 35.0, 32.5 & 28.8%, respectively as shown in Table (3).

The association pattern between the snail intermediate hosts and non-target snails is presented in Table (4). The highest association percentage of each of *B. alexandrina* and *B. truncatus* were with *C. bulimoide* (percentage of association was 50% and 21.3%, respectively) followed by *L. carinatus*, *L. natalensis*, *P. acuta*, and *B. unicolor*. In the meantime, both snails showed the lowest association with *M. tuberculata*, *P. planorbis* 1.3% then *H. duryi*, 3.8%.

Physical and chemical parameters:

Results of physico-chemical parameters were recorded and their means in each center were presented in Tables (5&6). Statistical comparison between centers using T-test showed that significant difference in most of chemical parameters. All Pb, Mn, Ni & Ca fluctuated around the same levels and didn't exceed the maximum of low able concentration (MAC) recommended by National Recommended Water Quality Criteria. All Cu, Cd, K& Na means exceeded the level of concern, Cu ranged between 14.7 in Desouk – 47.4 ppb in Kafr El-Sheikh, Cd ranged between 6.8 in Mottobis – 225.9 ppb in Biyala, K ranged between 8.2 in Hamoul – 27.3 ppm in Baltim and Na ranged between 63.9 in Fuwwah – 834.6 ppm in Baltim. In the meantime Fe concentration ranged between 24.55 in Hamoul – 49.39 ppb in Mottobis.

The studied sites were divided into four categories, the first category included sites that harbored *Biomphalaria* snails, the second category harbored *Bulinus* snails, the third category harbored the non-target snails and the latest category includes sites that free from all snail types. The comparison of the physico-chemical parameters in these habitats are presented in table (7). Statistical analysis using ANOVA analysis revealed very highly significant in temperature between habitats of *B. alexandrina* and that of *B. truncatus* ($F= 7.415$ & $P <0.001$), and highly significant difference between habitat of *B. truncatus* and that of non-target snails ($F= 2.86$ & $P <0.003$). Habitats free from snails showed non-significant higher recordings of field observations and certain chemical concentrations Cd, Na and K than other categories while habitats harboring *B. alexandrina* and *B. truncatus* were more tolerant than non-target snails and *B. alexandrina* was more tolerant than *B. truncatus* to some of the examined parameters. Also, site category of *B. alexandrina* and that of *B. truncatus* was subdivided to habitat of negative snails and those naturally infected ones to compare the same physiochemical parameters. Statistical comparison between habitat characteristics of naturally infected *B. alexandrina* and *B. truncatus* and those negative ones using ANOVA test revealed significant difference

between naturally *B. alexandrina* and those negative in Na and Ca levels ($P < 0.01$, T=2.56 & d.f=30 and $P < 0.05$, T= -2.03& d.f = 37, respectively) while no significant difference was observed between the two habitats of *B. truncatus*. Also, habitats of naturally infected *B. alexandrina* and negative *B. truncatus* were very highly significant in Cu level ($P < 0.001$, T= 2.53 & d.f = 47 (Table, 8).

Aquatic plants:

The survey study observed four aquatic plant species, *Eichhornia crassipes*, *Lemna gibba*, *Ceratophyllum demersum* and *Jussiae sp*. *E. crassipes* and *L. gibba* were the mostly infested and found in the all centers with infestation percentage ranged between 50 – 100%, 12.5 –75%, respectively. The association pattern between the snail intermediate hosts and the observed aquatic plants is presented in Table (9). Results showed that *B. alexandrina* and *B. truncatus* were mostly associated with *E. crassipes* with percentages of 51.3% and 21.3, respectively. On the other hand, was mostly associated with *E. crassipes* and *C. demersum*16.3%, respectively. The correlation between two densities of the recorded aquatic plants, moderate and high densities, and the infestation percentage of *B. alexandrina* and *B. truncatus* in different centers was examined using test for difference between proportions (two proportion groups) SPSS Program (18). Results showed that significant correlation between *B. alexandrina* infestation and high density of *E. crassipes* in Fuwwah, Baltim & Sidi salem centers and high density *L. gibba* in Fuwwah & Baltim. Also, highly significant correlation was observed between the moderate density of all the recorded plants and *B. alexandrina* infestation percentage in Fuwwah center, *E. crassipes*, *L. gibba* and *C. demersum* in Blatim center, *E. crassipes* and *L. gibba* in Desouk and Sidi Salem center. On the other hand, no significant correlation between the infestations pattern of *B. truncatus* and each of the two examined plant densities were observed.

Table (1): The distribution and population density of *Biomphalaria alexandrina in* the examined watercourses among the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Centers (8 sites) Items	Fuwwah	Desouk	Mottobis	Baltim	Kafr El-Sheikh	El-Hamoul#	Sidi Salem	Biyala	El-Reyad	Qullin	Total
No. of infested sites	8	7	3	8	3	6	6	5	4	1	51
% of infestation	100%	87.5%	37.5%	100%	37.5%	75%	75%	62.5%	50%	12.5%	63.8%
Total no. of snails	466	737	59	604	21	274	153	177	183	94	2759
% of center sample	16 %	6.7%	2.1%	21.9%	0.76	9.9%	5.5%	6.4%	6.6%	3.4%	79.3%
Snail density	58.25	92.125	7.375	75.5	2.625	34.25	19.125	22.125	22.875	11.750	34.684
No. of transmission sites	1	3	0	3	0	3	0	2	0	0	18
% of infestation of transmission sites	12.5%	37.5%	0	37.5%	0	37.5%	0	25%	0	0	22.5%
No. of naturally infected	3	3	0	32	0	5	0	47	0	0	90
Naturally infected snail density (infected snails/site ±SD)	0.375 ±1.061	0.429 ±0.535	0 ±0	4.00 ±6.990	0 ±0	0.625 ±1.061	0 ±0	5.875 ±16.217	0 ±0	0 ±0	1.139 ±5.670
% of Naturally infected snails	0.64%	0.4%	0	5.3%	0	1.8%	0	26.6%	0	0	3.3%

Table (2): The distribution and population density of *Bulinus truncatus in* the examined watercourses among the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Centers Items	Fuwwah	Desouk	Mottobis	Baltim	Kafr El-Sheikh	El-Hamoul	Sidi Salem	Biyala	El-Reyad	Qullin	Total
No. of infested sites	1	2	5	2	1	2	3	4	1	4	20
% of infestation	12.5%	25%	62.5%	25%	12.5%	25%	37%	50%	12.5%	50%	25%
No. Of transmission sites	0	0	1	2	0	0	0	0	0	0	3
% of infestation of transmission sites	0	0	12.5%	25%	0	0	0	0	0	0	3.8%
Total no. of snails	2	10	188	3	8	6	6	46	2	57	328
Snail density (snail/site ±SD)	0.250	1.250	23.500	0.375	1.00	0.750	0.750	5.750	0.250	7.125	4.100
No. of infected snails	0	0	2	1	0	0	0	0	0	0	3
Infected snail density (infected snails/site ±SD)	0 ±0	0 ±0	0.286 ±0.756	0.125 ±0.354	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0 ±0	0.038 ±0.252
% of Naturally infected snails	0	0	1.1%	33.3%	0	0	0	0	0	0	0.9 %

Table (3): Infestation percentage of non target snails species in the examined watercourses among the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

	Percentage of infestation										
Centers/Non target snails	**Fuwwah**	**Desouk**	**Mottobis**	**Baltim**	**Kafr El-Sheikh**	**El-Hamoul**	**Sidi Salem**	**Biyala**	**El-Reyad**	**Qullin**	**Total**
Lymnaea natalensis	**75**	**25**	**37.5**	**25**	**25**	**50**	**50**	**37.5**	**0**	**0**	**35**
Lanistes carinatus	**0**	**37.5**	**25**	**0**	**12.5**	**75**	**62.5**	**37.5**	**75**	**75**	**36.3**
Physa acuta	**25**	**37.5**	**50**	**0**	**62.5**	**12.5**	**25**	**12.5**	**25**	**25**	**32.5**
Cleopatra bulimoide	**62.5**	**62.5**	**87.5**	**100**	**100**	**87.5**	**87.5**	**62.5**	**62.5**	**62.5**	**77.5**
Bellamya unicolor	**62.5**	**62.5**	**50**	**50**	**37.5**	**25**	**75**	**75**	**75**	**75**	**57.5**
Helisoma duryi	**0**	**12.5**	**0**	**12.5**	**0**	**0**	**0**	**0**	**0**	**0**	**5**
Melanoides tuberculata	**37.5**	**25**	**12.5**	**62.5**	**25**	**25**	**25**	**0**	**25**	**25**	**28.8**
Planorbis planorbis	**0**	**12.5**	**12.5**	**37**	**0**	**0**	**0**	**0**	**0**	**0**	**6.3**

Table (4): The association percentage of Biomphalaria alexandrina and Bulinus truncatus with non target snails species in the examined watercourses among the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Non target snails	*Biomphalaria alexandrina*	*Bulinus truncates*
Bellamya unicolor	**26.3%**	**12.5%**
Cleopatra bulimoide	**50%**	**21.3%**
Lanistes carinatus	**22.5%**	**15%**
Lymnaea natalensis	**21.3%**	**17.5%**
Helisoma duryi	**1.3%**	**3.8%**
Melanoides tuberculata	**16.3%**	**3.8%**
Physa acuta	**11.3%**	**13.8%**
Planorbis planorbis	**3.8%**	**2.5%**

Table (5): The Physicochemical characteristics of the examined watercourses among the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Centers Parameters (MAC)	Fuwwah	Desouk	Mottobis	Baltim	Kafr El-Sheikh	El-Hamoul	Sidi Salem	Biyala	El-Reyad	Qullin
Temperature (>25ºC)	26.38 ±0.52	26.38 ±0.92	25.63 ±6.61	29.04 ±0.74	28.33 ±0.85	27.54 ±0.82	28.08 ±0.53	26.33 ±4.68	27.95 ±0.79	24.50 ±3.88
Conductivity (≥ 800 µmoh/cm)	531.58 D ±141.08	846.71 ABC ±272.95	626.88 CD ±143.69	705.25 BCD ±145.53	944.88 AB ±334.22	856.42 ABC ±240.44	967.79 AB ±371.03	720.63 BCD ±254.36	1003.67 A ± 115.78	634.71 CD ±232.92
pH (6.5-9)	7.41 C ±0.18	7.49 C ±0.11	7.55 BC ±0.05	7.78 A ±0.33	7.56 BC ±0.15	7.48 C ±0.16	7.55 BC ±0.15	7.49 C ±0.15	7.69 AB ±0.12	7.46 C ±0.07
Cd (2 ppb)	7.43 B ±241	10.16 B ±4.30	6.84 B ±1.48	225.91 A ±116.09	11.69 B ±5.26	11.78 B ±5.84	12.95 B ±5.01	9.74 B ±4.35	14.13 B ±4.83	9.77 B ±4.67
Pb (65ppb)	18.74 abc d ±11.86	14.12 abc d ±8.27	8.78 d ±6.80	6.85 d ±4.46	29.35 a ±25.02	19.67 abc d ±10.21	27.13 ab ±22.63	10.04 c d ±8.24	25.17 abc ±18.92	12.15 bc d ±8.41
Fe (1000 ppb)	38.88 a b ±13.32	25.53 b ±11.30	49.39 a ±10.92	45.44 a ±26.37	36.57 a b ±16.14	24.55 b ±10.14	25.89 b ±6.51	28.22 b ±14.78	36.89 a b ±19.57	38.75 a b ±13.35
Cu (13 ppb)	29.51 B ±10.68	14.70 B ±11.76	26.33 B ±15.29	26.88 B ±4.71	47.41 A ±16.67	29.79 B ±3.29	24.87 B ±14.03	26.99 B ±15.88	28.92 B ±21.97	28.38 B ±11.54
Mn (1400 ppb)	7.71 D ±4.60	8.13 D ±3.88	58.48 B C ±11.92	114.40 A ±68.66	38.04 B C D ±37.75	59.32 B C ±36.400	27.33 C D ±10.92	13.69 D ±7.69	16.98 D ±9.57	65.44 B ±43.20
Ni (450 ppb)	11.27 B ±7.20	20.47 B ±4.88	356.03 A ±269.21	262.22 A ±190.19	10.88 B ±9.94	10.70 B ±10.02	14.69 B ±9.29	750 B ±5.88	6.54 B ±2.89	8.65 B ±6.94
Na (25 ppm)	63.94 B ±35.07	93.28 B ±39.96	64.46 B ±29.58	834.63 A ±427.88	166.73 B ±98.50	90.45 B ±86.91	217.74 B ±184.27	92.96 B ±66.17	131.14 B ±57.14	84.51 B ±61.12
K (6 ppm)	10.44 B C ±4.13	10.08 B C ±2.73	8.37 C ±1.1	27.32 A ±10.57	9.12 B C ±2.37	8.21 C ±1.66	13.54 B C ±6.40	10.84 B C ±5.36	14.95 B ±7.21	8.44 C ±1.21
Ca (100 ppm)	11.31 C D ±3.09	14.03 B C ±1.29	10.97 C D ±2.05	22.66 A ±4.48	11.59 C D ±3.61	13.60 B C ±4.70	15.89 B ±5.16	10.21 C D ±2.62	13.98 B C ±2.83	9.53 D ±2.86

a, b Means having different letter exponents among rows are significantly different ($P \leq 0.05$).
A, B Means having different letter exponents among rows are significantly different ($P \leq 0.01$).
*The maximum of allowable concentration: (MAC).

Table (6): The Physicochemical characteristics of different habitats of the intermediate hosts of schistosomiasis, *Biomphalaria alexandrina* and *Bulinus truncatus*, non-target snails and that free from snails among watercourses in the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Items (MAC)	*B. alexandrina* *	*B. truncatus* *	Non-target *	Free
Temperature (>25ºC)	27.24±2.57	24.72±1.8 ******	27.63±1.1** **	28.5±0.7
Conductivity (≥ 800 µmoh/cm)	815.42±262.60	677.64±72.9	781.188±64.0	1012.333±48.7
pH (6.5-9)	7.52±0.15	6.727±0.50	7.423±0.3	7.767±0.1
Cd (2 ppb)	54.418±13.80	45.042±15.40	11.423±1.2	82.876±71.4
Pb (65ppb)	23.54±3.50	19.757±3.60	23.337±5.7	13.920±1.3
Fe (1000 ppb)	32.98±18.02	35.16±17.79	32.38±17.88	24.33±0.3
Cu (13 ppb)	28.09±2.00	27.720±2.80	30.238±5.5	30.500±2.2
Mn (1400 ppb)	69.43±19.10	108.382±41.50 **	18.641±8.3	34.170±25.3
Ni (450 ppb)	45.70±6.90	55.420±10.80	35.205±7.9	50.017±16.6
Na (25 ppm)	240.97±46.40	179.383±43.20	103.390±13.3	451.123±32.57
K (6 ppm)	13.38±1.20	10.794±1.20	9.527±0.5	20.204±12.4
Ca (100 ppm)	15.35±1.10	12.891±1.00	17.713±6.1	17.072±3.4

*= Significant (< 0.05), **: highly significant (< 0.01), ***: very highly significant (< 0.001).
*The maximum of allowable concentration: (MAC).

Table (7): The Physicochemical characteristics of habitat *Biomphalaria alexandrina* (negative & naturally infected) and *Bulinus truncatus* (negative & naturally infected) among watercourses in the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010. The maxi

Items (MAC).	*B. alexandrina*		*B. truncatus*	
	Negative *	Naturally infected *	Negative *	Naturally infected
Temperature (>25ºC)	26.2±6.817	25.6±7.987	25.1±8.565	28.5±1.378
Conductivity (≥ 800 µmoh/cm)	804.709±351.462	704.111±317.191	699.357±378.089	537.167±57.770
pH (6.5-9)	7.070±1.800	6.886 ±2.111	6.656±2.398	7.567±0.121
Cd (2 ppb)	9.54±4.74	26.71±16.82	9.69±4.68	7.65±2.45
Pb (65ppb)	18.83±16.54	19.70±12.83	13.09±8.22	1.524±0.74
Fe (1000 ppb)	36.30±19.019	22.50±10.15	33.93±18.05	46.23±14.25
Cu (13 ppb)	30.93±13.77	19.52±12.83 **	28.38±14.53 * ***	19.778±6.48
Mn (1400 ppb)	9.13±6.55	25.29±23.88	18.86±209.352	25.85±22.53
Ni (450 ppb)	38.49±38.83	63.50±57.44	50.28±49.87	116.99±104.94
Na (25 ppm)	69.82±42.06 ****	126.24±81.96 ****	83.77±58.38	35.72±14.71
K (6 ppm)	13.23±8.82	14.170±7.46	10.42±5.54	15.251±11.91
Ca (100 ppm)	14.96±8.36 **	16.83±5.69	12.61±4.97	16.227±9.41

*= Significant (< 0.05), **: highly significant (< 0.01), ***: very highly significant (< 0.001). * *The maximum of allowable concentration: (MAC).

Table (8): The distribution of aquatic plants expressed by infestation percentage and densities among watercourses in the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Centers (10 examined sites) Aquatic plants			Fuwwah	Desouk	Mottobis	Baltim	Kafr El-Sheikh	El-Hamoul	Sidi Salem	Biyala	El-Reyad	Qullin
Ceratophyllum demersum	No. of infested sites		1	0	3	1	0	0	1	2	3	3
	% of infestation		12.5%	0	37.5%	12.5%	0	0	12.5%	25%	37.5%	37.5%
	Densities	+	0%	0	12.5%	12.5%	0	0	12.5%	12.5%		0%
		++	12.5%	0	12.5%	0%	0	0	0%	12.5%		25%
		+++	0%	0	12.5%	0%	0	0	0%	-		12.5%
Eichhornia crassipes	No. of infested sites		8	6	4	6	7	7	5	6	5	5
	% of infestation		100%	75%	50%	75%	87.5%	87.5%	62.5%	75%	62%	62%
	Densities	+	37.5%	0%	12.5%	12.5%	50%	25%	37.5%	37.5%	25%	50%
		++	12.5%	25%	25%	25%	0%	37.5%	12.5%	25%	25%	12.5%
		+++	50%	50%	12.5%	37.5%	37.7%	25%	12.5%	12.5%	12.5%	0%
Jussiae sp	No. of infested sites		1	0	0	0	1	1	1	1	3	0
	% of infestation		12.5%	0	0	0	12.5%	12.5%	12.5%	12.5%	37.5%	0
	Densities	+	12.5%	0	0	0	12.5%	12.5%	12.5%	12.5%	37.5%	0
		++	0%	0	0	0	0	0	0	0	0	0
		+++	0%	0	0	0	0	0	0	0	0	0
Lemna gibba	No. of infested sites		4	4	3	3	1	1	3	2	6	5
	% of infestation		50%	50%	37.5%	37.5%	12.5%	12.5%	37.5%	25%	75%	62%
	Densities	+	12.5%	0%	12.5%	25%	12.5%	12.5%	37.5%	12.5%	0%	25%
		++	25%	25%	12.5%	0%	0%	0%	0%	12.5%	25%	12.5
		+++	12.5%	25%	12.5%	12.5%	0%	0%	0%	0%	50%	25%

*** (+: low, ++: intermediate & +++: high)**

Table (9): The association percentage of *Biomphalaria alexandrina* and *Bulinus truncatus* with different species of aquatic plants among watercourses of the ten centers of Kafr El-Sheikh Governorate during the period from May-September 2010.

Aquatic plants	The snail intermediate hosts	
	Biomphalaria alexandrina	*Bulinus truncatus*
Ceratophyllum deresum	7.5%	16.3%
Eichhornia crassipes	51.3%	21.3 %
Jussiae sp.	5%	1.3%
Limma gibba	27.5%	8.8%

4.Discussion

The pattern of *Schistosomes* snail intermediate hosts distribution and their prevalence of infection are among the measurable indicators that reflect the magnitude of transmission **(Sayed *et al.*, 2004). Mostafa *et al.*, (2005)** studied the status of distribution of snail vectors of schistosomiasis and the transmission of the disease in 240 sites in Kafr El-Sheikh. The authors found that *B. alexandrina* was found in 5% of the examined sites, showing density of 11.25 snails/site while *B. truncatus* was found in 17.95% of the examined sites. Our findings of snail distribution and percentage of natural infection are higher than that observed by other authors. **Habib (2010)** studied the effect of geographical distribution of *B. alexandrina* snails on their susceptibility to *Schistosoma mansoni* infection in some localities in Egypt and found very low natural *S. mansoni* infection, 0.38% among the collected snails**.** Also, **El-Homossany (2006)** revealed that natural snail infection can occur in Nile especially in sites where fishing and agricultural activities, but mostly by low ratio, for *B. alexandrina* and *B. truncatus* snails was (0.71% and 0.29, respectively). In addition**, El-Khayat *et al.* (2005)** indicated that the natural infection among field *B. alexandrina* snails collected from different localities was low (1.1). Furthermore, **Haristone (1973)** concluded that low percentage of natural infection is the rule (1-2%), however high percentage (3.3-7.5) may be recorded in summer period suggestion that the proportion of snails infected with schistosome at any time depends upon complex interaction of different factors. The present survey observed association between *B. alexandrina* and *B. truncatus* and the most distributed non-target snails, *C. bulimoid* and *L. carinatus*. Also, many authors studied the association pattern between *B. alexandrina* and *B. truncatus* snails and the other non-target snails. **Yousef *et al.* (1998a)** found that *B. alexandrina* snails were positively associated with *L. carinatus*, and *C. bulimoides* while *B. truncatus* snails were found to be positively associated with *p. acuta* snails. Also, **Abdel Kader *et al*. (2001&2005)** reported that *B. alexandrina* snails mostly existed with *L. carinatus* and *Physa acuta* snails. However, **Frandsen (1976), Frandsen & Christensen (1977), Madsen & Frandsen (1979) and Madsen (1985)** found that the presence of *H. duryi* caused an important reduction in the growth of infected *Biomphalaria pfeifferi*, *B. glabrata, B. camerunensis* and *B. alexandrina* when they were in a direct competition situation. The present determined data of physiochemical parameters were processed to compare water quality in different examined centers and characteristics for different snail habitats. Results showed significant difference between centers in most parameters especially for conductivity, copper, sodium and iron levels. Baltim center showed the highest values in most of the examined parameters and this may be attributed to the include of this center to all types of watercourses; Borollos Lake, Kotshenar drains and El-Ayash, El-Sagheir and El-Gadida canals. All the means of Cd, Cu, Na and K exceeded the MAC that recommended by National Water Quality Criteria and represented risks for health. In spite of the increased level of these chemicals there was spreading of *B. alexandrina* and *B. truncatus* in all centers and those naturally infected in most centers suggesting that chemical water pollution was not a limiting factor in these snail distribution. This suggestion was reinforced by **Khairy (1998)** who studied the distribution of *B. truncatus* and *B. alexandrina* in two villages, El-Garda and Salamoniya, in Menoufia Governorate that differed greatly in the degree of chemical and faecal pollution of the watercourses. This was probably due to the existence of the sewage disposal system in El-Garda village and its absence in Salamoniya. In spite of the high pollution of watercourses in Salamoniya, both *Bulinus* and *Biomphalaria* snails were found and were often infected. On the other hand, in El-Garda, in spite of the lower pollution of its water courses, which would have been expected to be associated with higher snail counts, particularly in Kafr Tambidy canal which was less chemically polluted, *B. truncatus* was the only snail found and in very low counts. Also, **El-Hawary (1990) and Abdalla *et al.* (1997)** reported that snails exposed to Pb, Cd and Hg continued to be reproductively active and no significant effect of heavy metal exposure was demonstrated under all tested concentrations. **El-Emam and Roushdy (1981)** revealed that optimum temperature for these mollusca lies between 22-26 o C. Whereas in the present study,

it was found that the snails tolerated to a wider range of temperature, 16- 35 o C. Also, **Kariuki *et al*.(2004)** did not find a significant link between snail abundance and water temperature. In addition, **Mahmoud (2001)** reported that in general, adverse effects of water pollution on snail biology were modified by biotic factors including food supplies, aquatic plants, behavioral and physiological adaptation. The present comparison of habitat characteristics for *B. alexandrina*, *B. truncatus***,** non-target snails and that free from snails showed very highly significant in temperature between habitats of *B. alexandrina* and that of *B. truncatus*, and highly significant difference between habitat of *B. truncatus* and that of non-target snails. Habitats free from snails showed non-significant higher recordings of field observations of certain elements concentrations, Cd, Na and K than other categories while habitats harboring *B. alexandrina* and *B. truncatus* were more tolerant than non-target snails and *B. alexandrina* was more tolerant than *B. truncatus* to some of the examined parameters. The suggestion of more *B. alexandrina* tolerance may explain why it is more distributed than *B. truncatus* in the present study (by about 7 times). **El-Khayat *et al.* (2011a)** found that *B. alexandrina* was significantly found to live under the highest level of Pb, Cd,Cu, Na, K and Ca concentrations than the other twelve snail species (p<0.01). Also, **El-Khayat *et al.* (2011b)** studied the habitat characteristics for different freshwater snail species biologically through macroinvertebrate information and concluded that *B. alexandrina* was more distributed than *B. truncatus* in sites that evaluated as very poor sites (23% and 9.4%, respectively). In addition, **Mahmoud (1994)** showed that habitat preferred by *B. alexandrina* snails contains higher concentration of various common ions (Na, K, Ca) and tolerated higher water conductivity as compared with habitat preferred by *B. truncatus*. **Didonato *et al.* (2003)** commented that snails can live in a wide range of mineral content in water till they are approached by certain limiting values**. El-Khayat *et al.* (2009**) found *B. alexandrina* and *B. truncatus* in habitats with Cd ranging from 4.298 -13.761 PPb; Pb around 28 PPb, Cu ranging from 59.847–1881.17 ppb. These ranges were around that determined in the present work; Cd ranging from 45.042-54.418 ppb, Pb ranging from 19.757-23.535 ppb and Cu around 28.0 ppb. In the same consequence, studies on the distribution and population density of *B. alexandrina* and *B. truncatus* in Egypt revealed no significant differences in various parameters such as water PH, conductivity, oxygen concentration and salinity between habitats harboring snails and those free of them **(Abdel Kaer, 2001; Abdel Kader *et al.*, 2005 and Ragab and Bakry, 2006).** The survey study observed four aquatic plant species, *Eichhornia crassipes* and *Lemna gibba* were the mostly infested aquatic plants and found in all centers, both *Biomphalaria* and *Bulinus* were mostly associated with *E. crassipes* with percentages of 51.3 and 21.3%, respectively. This high infestation of aquatic plants may be related to high infestation of *B. alexandrina* and *B. truncatus*. Also, **El-Khayat *et al.* (2009)** planned a study to elucidate the association between macrophytes, snails and some water quality parameters. Results showed that sites in which snails associated with macrophytes (64%) were characterized with higher ranges of chemicals, dissolved oxygen and conductivity than that observed in sites with snails only indicating the helpful role of macrophytes for increasing snail tolerance to unfavorable conditions. **Dazo *et al.* (1966)** reported that *B. truncatus* was most abundant in large canals while *B. alexandrina* was most abundant in drains. Both species were most abundant in the presence of aquatic vegetation, but they differed in their respective associations with the and *E. crassipes*. Similar observations were made by **Kader (2001)** for *B. alexandrina* and *B. truncatus* in Egypt, who reported different associations in relation to aquatic plants**. Kloos *et al.* (2004)** found a significant association between vegetation density and snail occurrence. However, they also found large populations of *B. glabrata* in calcium-rich limestone springs and wells with little or no macro vegetation. Also, the present study observed significant correlation between moderate density of all the recorded plants and *B. alexandrina* infestation in most centers. These findings were reinforced by **El-Homossany (2006)** who reported that when the density of aquatic plants were high, the number of collected snails was fewer, indicating that snails prefer low- medium density of aquatic plants. Also, **Appleton (1978) and Madsen (1981)** found that schistosome vector snails prefer water bodies with a moderate growth of aquatic plants.

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