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Association pattern among different snails and other macroinvertebrate species at certain freshwater courses in Egypt

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ABSTRACT

The objective of the present work is to study the association among snail species, as well as between gastropods and other macroinvertebrates. The study was accomplished in three governorates; Giza, Damietta and Minya from spring (2009) till winter (2010). A total of 26 macroinvertebrates taxa representing 14 orders were recorded at 18 investigation sites, included Ephemeroptra, Plecoptera, Trichoptera, Diptera, Cleoptera, Odonata, Hemiptra, Gastropoda, Bivalva, Decapoda, Amphipoda, Oligochaeta, Arachnids and Hirudinea. The present data, revealed that the snails were the most dominant, comparing to other macroinvertebrates taxa in all stations of the study, which recorded 34.56% followed by shrimps (28.34%). *Lanistes carinatus*, *Cleopatra bulimoides* and *Physa acuta* were the most dominant snail species during the whole study. According to Diversity Index (H′) rank, the status of the present investigated sites ranged from poor to bad status. Moreover, Evenness Index (J) indicated that individuals at S5 (1.0), S4 and S17 (0.9) were distributed equally, while individuals at S3 (0.3), S10 (0.4) and S18 (0.41) were not. *Biomphalaria alexandrina* was the only species which maximally associated with leeches and this indicates its higher tolerance than other snails. All sensitive taxa (Ephemeroptra, Plecoptera and Trichoptera) were negatively correlated with Hirudinea. Meanwhile, Gastropoda was negatively correlated with Cleoptera, Hemiptra and Hirudinea. *Lymnaea natalensis* and *Bulinus truncatus* snails were found highly associated with damselflies and dragonflies, which reflect the sensitivity of these snails. Cluster analysis showed a similarity level between macroinvertebrates orders. This study concluded that most snail species were associated with moderately to somewhat pollutant tolerant macroinvertebrates, which reveals that the strength of this group in different mechanisms to tolerate pollution and other stresses.

INTRODUCTION

There are a huge number of invertebrates; worms, insects, snails and crustaceans live in water, providing food for other animals and serving as part of a very important aquatic food (Covich*et al.*, 1994; Garcia *et al*., 2006; Andrew and Michael, 2007). Recently several Investigators used freshwater macroinvertebrates for biological assessments of water quality (Sandin and Hering, 2004; Ducrot *et al*., 2005; Buss and Borges, 2008).

Macroinvertebrates are considered an important component in the ecological dynamics of lotic environments that they play significant roles in energy fluxes and nutrient cycles (Choubisa and Sheikh, 2013; Blagojević *et al.,* 2014). In addition, gastropods are common and conspicuous elements of the freshwater macroinvertebrates taxon. Also, they serve as sensitive bioindicator-organisms of aquatic ecosystem pollution (Jagtap *et al*., 2011; Ali *et al*., 2012; Hookham *et al*., 2014; Lewin, 2014). Freshwater molluscs are known to play significant role in public and veterinary health (Husein *et al.,* 2011; Saddozai *et al.,* 2013). Some species of snails have a medical important role in transmission of some endemic diseases. In Egypt, schistosomiasis is transmitted to human by snail intermediate hosts *Bulinus truncatus* for *Schistosoma haematobium* and *Biomphalaria alexandrina* for *Schistosoma mansoni*, which are prevalent in both Upper and Lower Egypt (El-Emam *et al*., 1996; WHO, 2012) and *Lymnaea natalensis* intermediate host for fascioliasis (Kaplan, 2001). Predation, competition and commensalism relationships occurred between all communities that live in the same habitat. Competitive interaction between snails and other macroinvertebrate algaivores is strong. In addition to the physical competition for food and other resources one would ordinarily expect as density increases and beyond the general degradation of the environment by waste products and oxygen depletion (Dillon, 2000). Freitas and Santos (1995) and Giovanelli *et al.* (2005) studied the snail-snail interactions, with special emphasis on competition, stated that *Melanoides tuberculatus* is capable to reach high densities; hence, competition for space is also possible. However, the outcome of the interactions between *M. tuberculatus* and *Biomphalaria* spp. seems to be related to the habitat type where both species occur in Kenya (Mkoji *et al.,* 1992). The multiple-predator approach not only reflects nature well, but also provides a richer ecological framework where by adaptive trade-off between predators ultimately can be connected to other aspects of ecology, particularly to higher order community effects (Karieva, 1994). Generally, molluscs may face many predators of other macroinvertebrates at least four functional classes, such as carnivorous leeches, certain crustaceans (crab, crayfishes and ostracods), aquatic *Cleoptera*, dystiscid beetles and fish (Cibrowski and Corkum, 2003). The leech *Glossiphonia complanata* does not appear to have substantial impact on snail populations, but this may be due to most studies focusing on adult snails rather than juvenile snails. Thus, there was a comparatively large effect of leech predation on newly-hatched snails, due to a high probability of encounter and high predation rates (Brönmark, 1992).

Crayfish primarily attack snails via the aperture (Alexander and Covich, 1991; Stephanie *et al.,* 2001). In addition, anecdotal information suggests that relatively large crayfish may sometimes also use shell-crushing or spire-snapping attacks (Vermeij and Covich, 1978).

Predators attack *Physa* primarily through shell entry (by crayfish, *Orconectes obscurus*) and shell crushing (by fish, *Lepomis gibbosus, Cyprinus carpio*, *Carrasiu sauratus*). The narrow apertures associated with elongate shells were expected to restrict apertures access by crayfish (DeWitt *et al*., 2000).

The present study aims to investigate the association in-between snail species in some freshwater courses of Egypt and the association between snails and other species of macro-invertebrates predators or competitors.

MATERIALS AND METHODS

Study area:

Samples were collected from 18 sites in Giza, Damietta and Minya governorates from spring (2009) till winter (2010). The watercourses included River Nile, branches and drains as follows: sites from Giza governorate (S1: El-Ayyat; S2: El-Saff; S3: El- Warrak- ;S4: El-Koratten; S5: El-Kanater, S6: Gezert El-Sayala and S7: El-Hooddrainage), Damietta governorate (S8: Bostan; S9: Adlyia; S10: Damietta; S11: El-kashf and S12: El- Sarw drainage) and Minya governorate (S13:Menia, S14: Samaloot; S15: Matay; S16: BaniMazar, S17: Maghagha and S18: El- Moheet drainage) (Fig. 1).

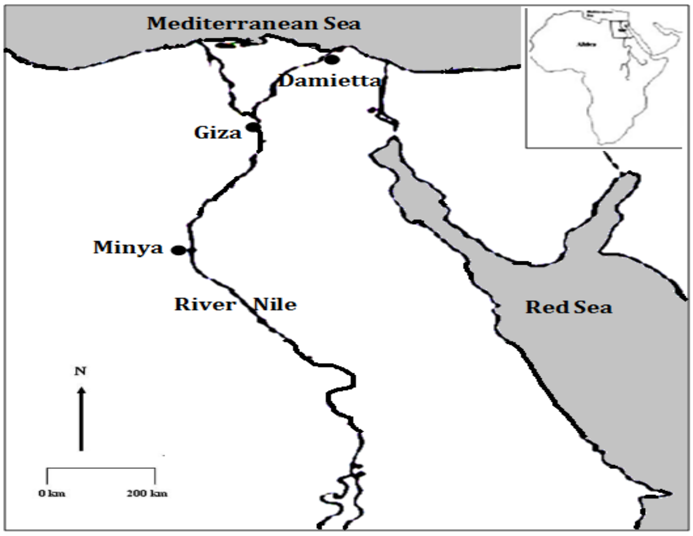

Fig. 1: A map of Egypt showing Minya, Giza and Damietta governorates.

Field samples:

From each site macro-invertebrates, including freshwater snails were collected by 500 µm-mesh D-Form dip net with a fixed number of five filled net strikes. The five samples were then pooled, representing a single sample for each site (Noumi, 2008). In the laboratory, samples were washed in a 500 µm-mesh sieve to remove sand and macro-invertebrates were sorted and all taxa were separated; enumerated and identified under a binocular dissecting microscope. Macro-invertebrates were identified to the latest taxonomical level (Leska, 1998; Bouchard, 2004). While snails sorted, counted and identified according to Ibrahim *et al.* (1999).

Statistical analysis:

Diversity Index (H′) was used according to Shannon-Wiener (1949) formula:

$$H' = -\sum [ni/N] \ln [ni/N]$$

Where ni is the number of individuals in each species, N equals the total number of individuals in the sample,ln = natural logarithm and ∑ equals the total number of species in the sample. Results are generally between >4 = high status, 3- 4= good status, 1- 2= poor status and <1 =bad status.

Evenness Index (J) was used according to Pielou (1966) formula: $J = H'/ \ln S$

H′= Shannon– Wiener diversity index, ln = natural logarithm and S = total number of species in the sample. The values are between 0– 1.When the value is getting closer to 1, it means that the individuals are distributed equally.

Cluster analysis and correlation coefficients between macro-invertebrates' orders were performed. Data for each snails' site group were analyzed linear by linear association analysis and Chi square test. The data were considered significant if *P-value* was ≤0.05, highly significant if $P<0.01$ and very highly significant if $p<0.001$. All statistical analysis was performed using SPSS computer program (version 18 windows).

RESULTS

Distribution and density of macroinvertebrates community in the study sites:

Results of the distribution and density of collected macroinvertebrates are summarized in Table (1). A total of 26 macroinvertebrates taxa representing 14 orders were recorded from 18 investigation sites, during the study period; included Ephemeroptra, Plecoptera, Trichoptera, Diptera, Cleoptera, Odonata, Hemiptra, Gastropoda, Bivalva, Decapoda, Amphipoda, Oligochaeta, Arachnids and Hirudinea. Generally, the most dominant macroinvertebrates taxa were aquatic snails and shrimps, which recorded 561 and 460, respectively. 13 freshwater snail species of gastropods and one bivalve belonging to class Pelecypoda, family Corbiculidae were identified from the investigated sites during two successive years. Snail species were, *Biomphalaria alexandrina, Bulinus truncatus, Lymnaea natalensis, Lanistes carinatus, Cleopatra bulimoides, Helisoma duryi, Bellamya unicolor, Planorbis planorbis, Physa acuta, Melanoides tuberculata, Theodoxus niloticus, Valvata nilotica, Succinea cleopatra* and the bivalve species *Corbicula consobrina*.

Data in Fig. (2) shows the total number of different snail species collected during the study. The most abundant species were *L. carinatus*(109 specimens), *C. bulimoides* (102 specimens) and *P. acuta* (96 specimens).

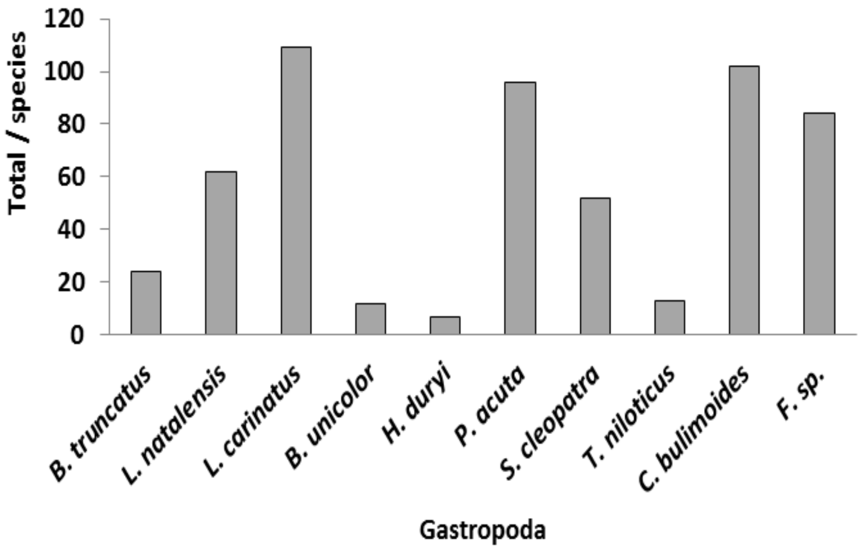

Fig. 2: Total number of collected snails' species during the study period.

According to Diversity Index (H′) rank the status of the present investigated sites ranged from poor to bad status. While the highest H′ index value was recorded (2.25) at S5, the lowest value was (0.456) at S18. However, Evenness Index (J) indicated that individuals at S4 (0.9), S5 (1.0), S9 (0.8) and S17 (0.9) were distributed equally, while individuals at S3 (0.3), S10 (0.4) and S18 (0.41) were not (Fig. 3).

Table 1: Distribution and density of macroinvertebrates at studied sites.

Macroinvertebrates		**Giza sites**								**Damietta sites**						**Minya sites**				**Total/taxa**
Order	**Taxa**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	
Ephemeroptra	**Mayfly**	0	0	3	11	19	10	0	1	3	0	0	0	1	0	1	0	11	0	**60**
Plecoptera	**Stonefly**	0	0	4	1	3	3	0	3	0	0	2	2	0	0	0	0	0	0	**18**
Trichoptera	**Caddisfly**	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	3	0	**8**
Diptera	**Midge**	1	0	0	3	4	7	0	0	0	0	0	0	0	0	0	0	1	1	**17**
Cleoptera	**Riffle beetle**	0	0	0	0	1	0	0	0	0	4	0	0	1	1	2	0	0	0	**9**
	Water penny	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Whirligig beetle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Crawling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	Diving dytiscidae	0	1	0	0	2	0	4	0	0	0	0	0	0	0	0	1	3	0	**11**
Odonata	**Damselfly**	2	2	6	18	18	8	0	6	12	1	3	4	2	1	1	4	8	0	**96**
	Dragonfly	3	2	1	1	8	37	1	1	7	0	2	2	1	13	2	1	8	0	**90**
Hemiptra	**Water strider**	0	0	0	2	0	3	7	0	0	0	0	2	0	3	0	0	2	1	**20**
	True bugs	3	0	0	1	5	0	15	1	6	2	1	11	0	9	0	6	0	19	**79**
	Water scorpion	0	1	0	0	0	0	0	1	9	0	0	0	0	0	1	0	0	1	**13**
	Water boatman	0	0	0	2	2	0	5	1	2	0	1	3	1	0	0	2	0	0	**19**
	Backswimmer	0	0	0	0	0	0	3	0	0	0	0	1	0	0	0	0	5	0	**9**
Gastropoda	**Aquatic Snails**	60	40	89	44	32	51	37	54	30	3	2	5	41	6	25	17	25	0	**561**
Bivalva	**Bivalves**	0	0	2	15	18	39	0	0	0	0	4	0	0	1	0	0	14	0	**93**
Decapoda	**Shrimps**	5	12	2	74	57	81	0	31	56	0	7	0	12	65	11	32	15	0	**460**
	Crayfish	0	0	0	1	0	0	0	1	0	0	1	0	2	1	3	0	0	0	**9**
Amphipoda	**Scuds**	0	0	0	0	0	0	0	0	0	9	0	1	0	0	0	0	0	0	**10**
Oligochaeta	**Aquatic worms**	6	0	0	21	0	1	0	0	0	0	0	0	0	0	2	0	0	0	**30**
Arachnids	**Fishing spider**	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	**3**
Hirudinea	**Leeches**	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**4**
	Rat-tailed maggots	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	**4**
Total / site		**82**	**58**	**108**	**195**	**169**	**240**	**73**	**102**	**126**	**19**	**24**	**31**	**64**	**103**	**48**	**63**	**95**	**23**	**1623**
Total/ governorate		**925**								**302**						**396**				

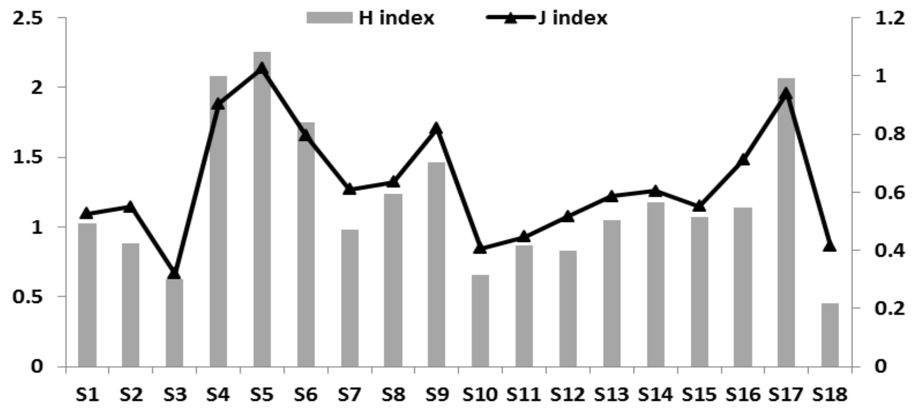

Fig. 3: Diversity Index (H′) and Evenness Index (J) for studied sites.

Association between snails and other macroinvertebrates:

Results of association pattern between different snail's species and 15 different macroinvertebrates throughout the study period are represented in Table (2). No association was detected between *B. alexandrina* and each of mayflies, caddisflies and water strider and the least association percentage with each of midge flies and riffle beetle whereas the maximum association was detected with true bugs (38%) and leeches (13%) which are somewhat pollutant tolerant, respectively consequently this snail species has the same ability of tolerance and so their association attributed to habitat preference.

B. truncatus was found associated with all different macroinvertebrates, and the maximum association was detected with each of damselflies (21%) and dragonflies (19%) and all of them are predators.

L. natalensis was found in association with all different macroinvertebrates, and the maximum association was detected with each of riffle beetle (27%), damselflies (27%), dragonflies (25%) then true bugs (23%) and so the association pattern approximately like *B. truncatus*. Also, *T. niloticus* shared the approximately same pattern with these snail species but with exception that no association with leeches was recorded. In addition, *H. duryi* snails shared with them the same pattern but they maximally associated with crayfish.

B. unicolor approximately equally associated with most macroinvertebrates and was recorded no association with water penny and backswimmer. *M. tuberculata*was found in association with most macroinvertebrates while the maximum association was detected with each of damselflies, dragonflies, true bugs, water boatman and crayfish which are predator except water boatman which is omnivorous. *M. tuberculata* did not associate with water penny and leeches). *P. planorbis*has limited distribution associated only with damselflies while maximally associated with crayfish followed by dragonflies and stoneflies then each of mayflies, damselflies and true bugs and at last with riffle beetle. So, each of caddisflies, midgeflies, water penny, water strider, true bugs, water scorpion, water boatman, backswimmer and leeches were not recorded in association with *P. planorbis*. It maximally associated with stoneflies then each of caddisflies, damselflies, dragonflies and crayfish whereas did not associate with the rest of macroinvertebrates. As with *P. planorbis,C. consobrina* was found in association with all macroinvertebrates except water penny, and the maximum association was detected with each of stoneflies, damselflies, dragonflies, mayflies, true bugs and crayfish. *B. alexandrina* was the only species which maximally associated with leeches.

Table 2: Association pattern between macroinvertebrates and different snail species during the study period.

Macroinvertebrates Order	**Taxa**	**Snails**													
		B.a	**B.t**	**L.n**	**L.c**	**B.u**	**C.b**	**P.a**	**H.d**	**V.n**	**P.p**	**M.t**	**T.n**	**S.c**	**C.c**
Ephemeroptra	**Mayflies**	0	11	9	8	10	8	8	14	0	6	7	11	7	11
Plecoptera	**Stoneflies**	8	6	5	6	9	8	8	5	7	13	3	5	9	8
Trichoptera	**Caddisfly**	0	1	1	2	5	2	2	3	3	0	1	2	1	2
Diptera	**Midge**	3	5	5	4	2	4	5	5	0	0	7	5	6	7
Cleoptera	**Riffle Beetle**	3	8	8	8	6	7	7	14	0	2	9	9	5	6
	Water Peny	7	1	0	1	0	1	2	1	0	0	0	1	2	1
Odonata	**Dameslfly**	**16**	**21**	**19**	**19**	**22**	**20**	**19**	**18**	3	**25**	**24**	**24**	**20**	19
	Dragon fly	**17**	**19**	**17**	**16**	**20**	**15**	**16**	**19**	3	**19**	**20**	**17**	14	15
Hemiptra	**Water strider**	0	5	3	5	4	7	6	4	0	0	6	4	2	3
	True Bugs	**38**	12	**17**	**16**	12	**15**	**17**	**20**	0	6	**20**	14	**19**	15
	Water Scorpion	8	9	6	5	5	4	5	4	0	0	7	3	7	4
	Water Boatman	6	8	7	7	10	6	6	8	0	0	9	7	5	7
	Backswimmer	3	1	1	2	0	2	1	0	0	0	2	1	1	0
Decapoda	**Cray fish**	5	11	9	11	11	13	12	14	3	**25**	**27**	8	13	11
Hirudinea	Leeches	13	0	2	2	1	1	2	1	0	0	0	0	0	1

Correlation between macroinvertebrates orders:

Mostly, macroinvertebrates orders were correlated whether positively or negatively as shown in Table (3). All sensitive taxa (Ephemeroptra, Plecoptera and Trichoptera) were negatively correlated with Hirudinea. Meanwhile, Gastropoda was negatively correlated with Cleoptera, Hemiptra and Hirudinea.

Table 3: Correlation among macroinvertebrates orders.

Order	**Ephem-eroptra**	**Plecop-tera**	**Tricho-ptera**	**Diptera**	**Cleop-tera**	**Odon-ata**	**Hemip-tra**	**Gastrop-oda**	**Decap-oda**	**Hirud-inea**
Ephemeroptra				0.636**	0.715**	0.570**	0.198	0.137	0.526**	-0.390**
Plecoptera		1	-0.343**	0.502**	0.323*	0.527**	-0.229	**0.423****	0.034	-0.273*
Trichoptera			1	1	0.536**	-0.339**	-0.334*	0.093	-0.379**	-0.081
Diptera				1	0.129	**0.977****	-0.088	0.314*	0.778**	-0.398**
Cleoptera					1	0.096	0.443**	-0.271*	0.015	-0.087
Odonata						1	-0.054	0.301*	0.780**	-0.220
Hemiptra							1	-0.596**	0.175	0.346**
Gastropoda								1	0.156	-0.155
Decapoda									1	-0.045
Hirudinea										1

*refer to significant correlation at P<0.05 and ** refer to highly significantcorrelation at P<0.01.

On the other hand, there were a highly significant positive correlation (*P<0.01*) between Diptera and Odonata (0.977) and Plecoptra and Gastropoda (0.423) and that confirmed by cluster analysis (Fig. 4), which showed a similarity level between the mentioned macroinvertebrates orders.

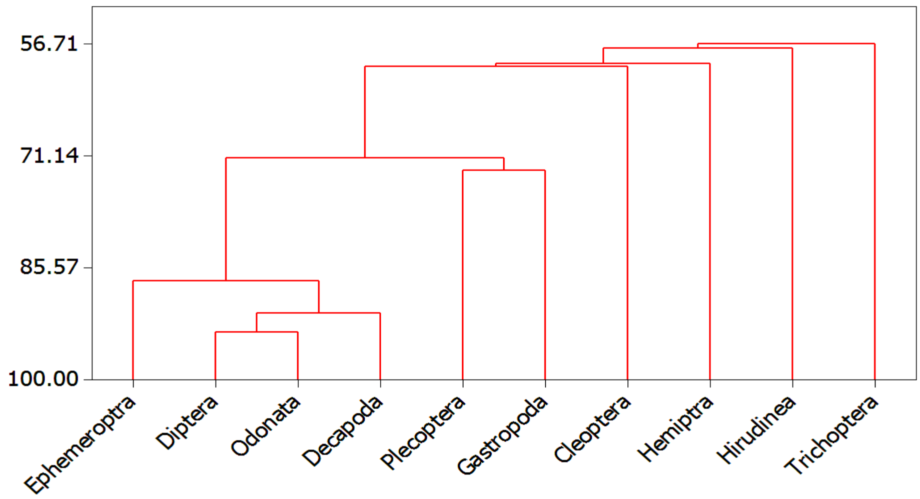

Fig. 4: Cluster analysis showed the similarity level between macroinvertebrates groups depending on correlation coefficient distance.

Freshwater molluscs play an important role in aquatic ecosystems, providing food for many fish species (McMahon and Bogan, 2001; Garcia *et al.*, 2006; Fagundes *et al*., 2008) and vertebrates (Cummins and Bogan, 2006). The fresh water molluscs were identified in the study sites (El-Minya, Giza and Damietta governorates, Egypt) as *B. alexandrina, B. truncatus, L. natalensis, L.carinatus, C. bulimoides, H. duryi, B. unicolor, P. planorbis, P.acuta, M.tuberculata, T. nniloticus, V. nilotica, S. cleopatra* and the bivalve species *C. consobrina*. This agrees with the observation reported by Ibrahim *et al*. (2004) who mentioned that the community of freshwater snails in Al-Salam canal comprised 11 species, namely: *L. carinatus, B. unicolor, M. tuberculta, C. bulimoides, Cleopatra cyclostomoides, Theodoxus niloticus, H. duryi, B. alexandrina, B. truncatus, P. acuta and L. natalensis*. Recently, Marie *et al.* (2015) demonstrated that 12 snail species namely; *B. alexandrina, P. acuta, L. natalensis, B. truncatus, S. cleopatra, B. unicolor, M. tuberculata, H. duryi, L. carinatus, C. bulimoides, P. planorbis* and *Biomphalaria glabrata* were recorded in selected sites from four Egyptian governorates (Giza, Ismailia, Menoufia and Gharbia). This gives an indication of stable coexistence found in the same habitat, which are capable of supporting mutually exclusive and conductive niches for different species population. The current study explored that the snails intermediate host of schistosomiasis, *B. alexandrina* and *B. truncates* were mostly found associated with *L. natalensis, P. acuta* followed by *C. bulimoides, L. carinatus and C. consobrina*then *S. cleopatra*. This coincides with Yousif *et al.* (1998) stated that both vector snails of schistosomiasis in his study areas were in many cases associated with several other snail spp such as the pulmonate *Planorbis planorbis, P. acuta* and *L. natalensis* and the prosobranchs *M. tuberculata, L. carinatus, C. bulimoides, B. unicolor* and *T. niloticus*. On the other hand, the present study in contrary with Giovanelli *et al.* (2005) who demonstrated that no association was observed between *Melanoides tuberculatus*, and *Physa marmorata* or *Biomphalaria tenagophila* although all three species were most frequently encountered on the same type of habitat. In addition, in Nigeria, Ndifon and Ukoli (1989) observed that *M. tuberculatus* was positively associated with *Physa waterloti* and *Biomphala riapfeifferi* .The occurrence of competitive interaction between *M. tuberculatus* and *Biomphalaria* spp. only in some specific environments is related to the different life strategies adopted by those species. As opposed to *Biomphalaria* spp., *M. tuberculatus* has low reproduction rates, low mortality rates, and a long life span (Pointier *et al.,* 1991). Other factors limited the efficiency of *M. tuberculatus* as a competitor for *Biomphalaria* spp. The presence of diverse microhabitats in heterogeneous environments may favor the coexistence of *M. tuberculatus* with *B. glabrata,* as it may allow both species to avoid competition (Choudhary and Ahi, 2015). The present investigation raveled that the habitat preference of *B. alexandrina* is different from *M. tuberculatus* because *B. alexandrina* found associated with somewhat pollutant tolerant macroinvertebrates this opposed to *M. tuberculatus* association with damselflies which reflects their sensitivity. This was confirmed by Giovanelli*et al.* (2002) who concluded that the possibility that *M. tuberculatus* be more sensitive to the molluscicide than *Biomphalaria* spp. may lead to a reduction of the competitive interaction between those species, thus indirectly stimulating the increase in the population of *Biomphalaria* spp. On the other hand, some environmental modifications may add to the instability of the environment, what would make room for the coexistence of *M. tuberculatus* and *Biomphalaria* spp. (Giovanelli *et al.,* 2005).

The present work revealed that a few *B. alexandrina* snails, the intermediate host of *S. mansoni*, persisted in site of *H. duryi*, which may be attributed to the inter-specific competition between that snail and *H. duryi*. Thus, many authors recommended that using *H. duryi* in the biological control of *B. alexandrina* and *B. truncatus* snails (Pointier and Augustin, 1999; Pointier and Jourdane, 2000; Ibrahim *et al.,* 2004). In addition, the association pattern of rest macroinvertebrates with different snail species may reflect either the physico-chemical habitat preference or may reflect negative correlation (due to predation or competition) or positive correlation (due to join or exchange relationships). *B. truncatus* was found associated with all different macroinvertebrates, and the maximum association was detected with each of damselflies and dragonflies. These macroinvertebrates are moderately pollutant tolerant and shared the habitat preference with *B. truncatus,* so, this confirmed the sensitivity of these snails. *L. natalensis* the intermediate host of *Fasciola hepatica* was found associated with all different macroinvertebrates, and the maximum association was detected with each of riffle beetles (27%), damselflies (27%), dragonflies (25%) then true bugs (23%).This association pattern approximately looks like *B. truncatus* with exception that, riffle beetles were not predators and their diet consists of microorganisms and debris, such as diatoms and true bugs were pollutant tolerant. Each of *L. carinatus, P. acuta*and *C. bulmoides* shared approximately the same pattern with *L. natalensis*. The results showed that *B. alexandrina* snails, were recorded a high value of persisting in site invaded by true bugs. The voracious behavior of water bugs is well known and it is the only species that feeds on snails during the larval and adult stages are belostomatids (Smith, 1977). Under laboratory conditions, Armuade and Estevez (2006) stated that *B. elongatum* showed a great ability to catch and feed on *Biomphalaria* sp. Moreover, Hofkin *et al*. (1991) and Mkoji *et al.* (1999) observed a strong negative association between the presence of medically important pulmonate snails and the cray fish *Procambarus clarkii* in freshwater habitats in Kenya. This agrees with the present study that *B. alexandrina* snails exist with low percent in the stations occupied by the cray fish *P. clarkia* which may be due to its predatory behavior on the snails.

CONCLUSION

This study concluded that most snail species were associated with predators and moderately to somewhat pollutant tolerant macroinvertebrates and reveals the strength of this group of animals, which originated from their reproduction strategy and their different mechanisms to avoid predators or struggle against pollution and other stresses. Since freshwater snails are common and conspicuous elements of the freshwater biota, an appreciation of freshwater gastropods cannot help but leads to an appreciation of freshwater ecosystems as a whole.

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