Evaluation of Some Chemical Parameters as Potential Determinants of Fresh Water Snails with Special Reference to Medically Important Snails in Egypt

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Abstract**—**Seasonal survey of freshwater snails in different water courses in Egypt during two successive years included 13 snail species. They represented by *Biomphalaria alexandrina*, *Bulinus truncatus*, *Physa acuta*, *Helisoma duryi*, *Lymnaea natalensis*, *Planorbis pantries*, *Cleopatra bulimoides*, *Lanistes carinatus*, *Bellamya unicolor*, *Melanoides tuberculata*, *Theodoxus niloticus*, *Succinia cleopatra* and *Valvata nilotica*. *B. alexandrina* was most abundant during autumn and spring represented by 26and14 snails/site, respectively. *B. truncatus* was most abundant during winter (7.7and3.6snails/site) of the two years, respectively. *L. natalensis* was represented by 7snails/site in summer. The tolerance of different snail species to the chemical elements was determined seasonally and correlated to their abundance. In spring, autumn and winter, *B. alexandrina* was significantly found to live under the highest level of Pb, Cd,Cu, Na, K and Ca concentrations than the other species ($p<0.01$). Most snail species could be lived at approximately the same concentrations of Na, K and Ca during all seasons.

Keywords**—**chemical parameters, freshwater, snails, tolerance

I. Introduction

THE fresh water snails belong to phylum mollusca, class gastropoda. This class is the largest molluscan group, living under different sorts of environmental conditions. Fresh water gastropod is divided into two subclasses namely the Prosobranchia and the Pulmonata. These two subclasses are all represented in fresh water ecosystems all over Egypt [1]. Many authors studied fresh water molluscs of Egypt associated with the Nile and canals, especially certain species of snails which play an important role in transmitting diseases to man and his livestock, causing great loss of the national income [2]−[10].Thus, fresh water molluscs in Egypt have been studied overlong time, but most malacologists paid special attention to the principal snail groups which transmit schistosomiasis to man such as *Bulinus* spp. and *Biomphalaria* spp. as well as *Lymnaea* spp., which transmit fascioliasis (liver fluke) to cattle, sheep and also man. The least studied group of gastropods is the prosobranch snails, where most of them have no prominent medical or veterinary importance. However, they play an important role in the fresh water ecosystem and some of their local members were recently incriminated in transmitting serious human diseases [1]. Thus, Pulmonate and Prosobranche snails, being necessary hosts for parthenogenetic generations of digenetic trematodes, participate in transmission of all trematodoses important from medical point of view [11].Thus, certain aspects of the ecology of the snail hosts of the parasitic diseases are important to the dynamics of transmission of the parasites. In the planning of control operations, the whole ecology of the snail species involved must be thoroughly understood, including local distribution, seasonal changes in distribution and abundance, and population dynamics [2]−[3], [9], [12]−[16]. Investigations into the ecology of freshwater snails have shown that the population dynamics of these animals depend on the physical geography of a given region. Land contours, soil composition, hydrography, and climate all have a significant effect on snail population dynamics. Thus, physical, chemical and biological factors can have a significant effect on population dynamics of fresh water snails [17]. The present work aims to study the effect of the seasonal fluctuations in some chemical parameters (heavy and light elements) as potential determinates on the distribution and abundance of fresh water snails with emphasis to the snails intermediate hosts of human and animal diseases.

II. Materials and Methods

A. Study Area

This study was carried out in different water courses in Egypt; the River Nile, its branches (Damietta and Rosetta branches), main canals and some drains. These water courses represented in seven Governorates (Greater Cairo, Giza, Qalioubiya, Ismailiya, Baheria, Damietta and El-Menia).

B. Ecological survey

A regular seasonal survey of the water banks was carried out in a total of 643 sampling sites during two successive years from March 2008 to February 2010. The survey was done across the River Nile and its branches (utilizing a motorized boat), some selected main canals and some main

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drainage, from which live samples of snails were collected and their ecological conditions recorded. For each examined site, five consecutive dips was taken using a standard dip net [18] − [19] and the collected snails were placed in a numbered plastic aquaria. The collected snails from each sampling site were transferred to the laboratory, where they were sorted out, identified and counted according to [1].

C. Water sampling and analysis

Water samples were taken from different sites at different habitats under study. At the laboratory, the chemical parameters such as lead (Pb), cadmium (Cd), copper (Cu), sodium (Na), potassium (K), calcium (Ca), manganese (Mn), iron (Fe) and nickel (Ni) of each water sample were determined by Atomic Absorption Spectrophotometer (AAS).

D. Statistical analysis

Results were expressed as mean ± standard deviation of the mean (SD). Differences between groups were analyzed either by using the Chi Square test or Anova test for multiple group comparison, and non parametric test (Benferoni test) for comparison between two groups. The analysis system, SPSS, version 18.50.

III. Results

Field survey study showed that snails (class: gastropoda) were represented in all examined watercourses by 13 species belonging to both subclasses Pulmonata (*Biomphalaria alexandrina, Bulinus truncatus, Physa acuta, Helisoma duryi, Lymnaea natalensis* and *Planorbis planorbis*) and Prosobranchia (*Cleopatra bulimoides, Lanistes carinatus, Bellamya unicolor, Melanoides tuberculata, Theodoxus niloticus, Succinia cleopatra* and *Valvata nilotica*). Only one species of bivalve *Corbicula consobrina* was recorded. Results of the snail survey (during the first year 2008) indicated that *B. alexandrina* (Fig.1) was most abundant during autumn (26snails/site) followed by summer (10snails/site), spring (7snails/site) and represented by only 1specimen in one site during winter. In contrast, *B. truncatus* was most abundant during winter (7.7snails/site) followed by autumn (5snails/site), spring (3.9snails/site) and summer (1snail/site). While, *L. natalensis* was represented by 3snails/site in winter, 4.6snails/site in spring, 2.9snails/site in autumn and a large number in summer (7snails/site). It was found that the density of *B. alexandrina* was more highly significant higher than the other snail species during autumn followed by *H. duyri*. Meanwhile, this latter species represented by a higher density (20.75snails/site) than other species during summer. The snails survey carried out during the next year (2009) revealed that *B. alexandrina* was the most abundant snail species during spring (14 snails/site) but it completely absent during summer until appeared again during autumn by a considerable number (5.5 snails/site) comparing by only 2 snails/site during winter (fig. 2). Also, *B. truncatus* was most abundant during spring (5.6snails/site) followed by autumn (5.2 snails/site), spring (3.6snails/site) and summer (2.2snail/site). *L. natalensis* was represented by 4snails/site during winter, 4.6snails/site in spring and the same number 2.4 snails/site in summer and autumn. The density of the other snail species was fluctuated in numbers during the different seasons. The bivalve *C. consobrina* showed a higher number during summer compared to its appearance in the other seasons.

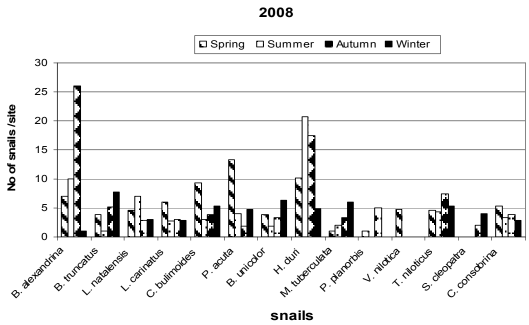

Fig. 1 Seasonal fluctuation in the number of different snail species and bivalve collected from different water bodies in certain governorates in Egypt during the year 2008-2009

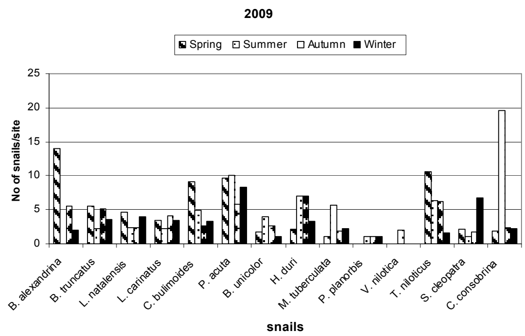

Fig. 2 Seasonal fluctuation in the number of different snail species and bivalve collected from different water bodies in certain governorates in Egypt during the year 2009-2010

The tolerance of different snail species to the chemical elements was determined seasonally in all examined water courses during two years (figs: 3-11). Results in fig.(3) showed that two major peaks of mean lead (Pb) concentrations 13.9ppb± 19.7and 27.8 ppb ±0 were recorded in sites harboring *B. alexandrina* and *P. planorbis*, respectively during spring 2008. This indicated that *B. alexandrina* was significantly ($p<0.01$) most tolerant to this element than *B. truncatus* and *L. natalensis*. However, during spring 2009, *L. natalensis* was more tolerant to this element which lived under concentration up to 124.5 ppb. During summer seasons, the pattern was different in which prosobranchia snails (*B. unicolor, M. tuberculata* and *C. bulimoids*) were the most tolerant to the high level of Pb concentrations. In autumn and winter, *B. alexandrina* was found to live under the highest level of Pb concentrations. The concentration of cadmium (Cd) in the sites harboring snails during different seasons was recorded in fig.(4). In spring 2008, the mean concentrations were approximately the same for all snail species which ranged between the lowest value 1.8 ppb±13.5 for *B. alexandrina* and the highest ones 2.8± 4.8 & 2.8± 3.7ppb for each of *B. truncatus* and *L natalensis*, respectively. The same manner was observed for spring 2009 in which all snail species were lived under the lowest mean concentrations (from 0.5 to 0.8 ppb) except *P. acuta* which tolerant the high concentration of Cd up to 14.9 with a mean value of 1.3±2.8 ppb. During summer 2008, *B. truncatus* and *L. natalensis* were more tolerant to Cd (the mean concentration was 1.83±1.85 and 1.76±1.7ppb, respectively) than *B. alexandrina* (0.32±0.45ppb). The highest value was recorded for *C. bulimoids* followed by *P. acuta* and *L. carinatus* (2.76±2.86, 2.45±3.7 and 2.12±1.76ppb, respectively). However, in summer 2009, *B. truncatus* was tolerant the concentration of Cd up to 3.12ppb in one site but with the lowest mean concentration (0.07±1.04ppb), the highest peak was recorded for *M. tuberculata* (the mean value was 2.6±4.35ppb). *M. tuberculata*, *C. bulimoids* and *P. acuta* shared the same level of tolerance towards Cd concentration (up to 11.38 ppb). During autumn 2008 and 2009, *B. alexandrina, H. duyri* and *S. cleopatra* were the most tolerant snail species to high concentrations of Cd. In autumn 2008, *B. alexandrina* was more tolerant to Cd (2.3±2.8 ppb) than *B. truncatus* and *L. natalensis* with mean concentration of 0.58±0.59ppb and 1.12±1.22ppb respectively. However, in autumn 2009, *L. natalensis* and *B. truncatus* was observed in few sites of higher value (up to 6.9ppb and 2.92ppb, respectively) of Cd than *B. alexandrina* (2.076ppb). In winter 2008 the highest mean concentration of Cd was observed in sites containing *P. acuta* (2.73±7.14ppb) followed by *B. alexandrina* (1.6±0.24ppb). During winter 2009, all snail species were lived at a low level of Cd concentrations (below 1ppb). Fig. (5) showed that in spring 2008, *B. alexandrina* and *P. planorbis* were the most tolerant snail species to the high concentrations of Cu (up to 28 ppb). However, the tolerance level of snails to Cu concentrations during spring 2009 was different in which although *B. alexandrina* lived under a higher mean concentration (38.6±18.01ppb) than *B. truncatus* (36.1±47.9ppb) and *L. natalensis* (25.5±7.6ppb), it was found that *B. truncatus* could tolerant the higher concentration of Cu in one site reached to 247ppb. In turn, it was also tolerant a very high concentrations of Cu in autumn and summer 2008 (up to 4941.8 and 83.4 ppb, respectively). In winter 2008 and autumn 2009, *B. alexandrina* was significantly ($p<0.01$) tolerated a higher concentration of Cu than the other snail species (33.8±36.8 and 18.6±0ppb, respectively). Fig. (6) showed that the mean concentration of sodium (Na) in different sites harboring snails was approximately as the same during different seasons except some snail species. Meanwhile, in spring 2008, *B. alexandrina* was tolerant Na concentration up to 112.6 ppm. In spring 2009, *L. natalensis* and *P. acuta* were lived under a high concentrations of Na up to 380 and 219ppm, respectively. It was found that during autumn 2009, winter 2008 and 2009, *B. alexandrina* lived in sites with higher Na concentrations than other snail species (the mean value was 32.12±0.0, 53.8±19.45 and 66.3±0.0ppm, respectively). As shown in case of Na, fig. (7) showed that most snail species could be lived at approximately the same concentrations of Potassium (K) during all seasons. However, one peak with high K concentration was appeared in sites harboring *B. alexandrina,* this tolerance range of mean concentrations was varied between 10.4±3.8ppm in winter 2008 and 50.3±5ppm in spring 2009. Results in fig. (8) showed that *B. alexandrina* was found in most of sites with high calcium (Ca) concentration. It represented by a peak in autumn and winter 2008 (the mean value was 12.7±4.5 and 3.5±0.2ppm, respectively) and another peak in spring, autumn and winter 2009 (the mean value was 21.3±9.3, 17.6±0.0 and 22.3±0.0ppm, respectively).The other snail species were lived approximately under the same level of Ca concentration except one peak in each of summer 2008 and 2009 for sites containing *C. bulimoids* and *H. duyri* (22.3±54.7 and 20.4±31.7ppm, respectively). The most tolerant snail species to the high level of manganese (Mn) concentration were *L. carinatus* and *C. bulimoids* during spring 2008 which could be lived under the same value up to 107.1ppb, (Fig. 9). Whereas, *L. natalensis* was found to be lived in sites with the higher mean concentration of Mn (54±18.8ppb) than other species. *L. natalensis, L. carinatus, C. bulimoids*, *H. duyri*, *S. cleopatra* and *P. acuta* were shared the same maximum level of Mn concentration reached up to 361ppb in spring 2009 and from 2297to 3639ppb in winter 2009. It was observed that *B. truncatus* and *L. natalensis* were lived in sites with higher mean concentration of Mn than *B. alexandrina* in all seasons except in winter 2008 in which the later snail species was the most tolerant ones to high level of Mn with a mean concentration of 34.9±29.4ppb. Fig. (10) showed that *B. truncatus* and *L. natalensis* were more tolerant to the high level of iron (Fe) than *B. alexandrina* in all seasons. However, the highest mean value of Fe concentration compared to the other snail species under which *B. alexandrina* lived recorded in autumn 2009 (29.8±0.0ppb), for *B. truncatus* was found in spring 2009 (69.7±98.8ppb) and for *P. acuta* in summer 2009 (874.7±624.9ppb). Results in fig.(11) showed that *B. alexandrina* lived under the highest mean value of nickel (Ni) concentration during spring and autumn 2009, autumn 2008 (11.7±6.7, 30.7±0.0 and 37.6±3.6ppb, respectively). However, *B. truncatus* and *L. natalensis* were more tolerant to the highest value of Ni concentration than *B. alexandrina* during spring, summer, winter 2008 and 2009. *L. natalensis* lived under the highest mean concentration of Ni (87.8±417.3ppb) compared to the other snail species during winter 2009. While, in summer 2009, the mean concentration of Ni in sites containing *P. acuta and L. carinatus* (165.4±757.9 and 173.14±1185.7ppb, respectively) was significantly ($p<0.01$) higher than those of the other sites harboring other snail species.

IV. Discussion

Under natural conditions, snails are exposed to several environmental factors which produce a collective effect on the snails, and it is extremely difficult to separate the effect of any of these factors to determine which of them is more critical

[20]. Leaving-water and avoiding-toxicants are two behavioral adaptations by which snails can survive and struggle for persistence against different types of pollutants found in their habitats. The tendency of snails to leave water is a phenomenon which may be linked to a survival mechanism enabling the snails to endure adverse environmental conditions [21]. The present study was carried out accordance to the other studies in which the distribution of snails is established by systematic search of all potential snail habitats [2]−[6], [8] − [10]. Thereafter the present study tried to determine chemical habitat characteristics for different snails as the sites that harbored each snail species in all the examined watercourses were grouped seasonally and their chemical assessment were determined. Results of snail survey revealed that *B. alexandrina* was the most abundant during autumn 2008 and spring 2009 as their density was more highly significant higher than the other snail species followed by *H. duyri*. Meanwhile, this latter species represented by a higher density than other species during summer. The density of the other snail species was fluctuated in numbers during the different seasons. If these results were correlated to the present investigation about the tolerance of different snail species determined by their chemical habitat characteristics, it was found that the snail´s density may be affected with the tolerance limit of each snail species to these chemical elements. During spring and autumn (except in spring 2009), *B. alexandrina* was most tolerant to lead (Pb) concentration as it could be lived under the highest level of Pb concentrations. During autumn seasons, *B. alexandrina, H. duyri* and *S. cleopatra* were the most tolerant snail species to the high concentrations of Cd. Also, the two major peaks of mean Pb concentrations were recorded for *B. alexandrina* and *P. planorbis* during spring 2008 indicating the high tolerance of these two species. During spring 2009, *L. natalensis* was more tolerant to this element, which lived under concentration up to 124.5 ppb. During summer seasons, the pattern was different in which Prosobranche snails (*B. unicolor, M. tuberculata* and *C. bulimoids*) were the most tolerant to the high level of Pb concentrations. In autumn and winter, *B. alexandrina* was found to live under the highest level of Pb concentrations. The concentration of (Cd) in the sites harboring snails during different seasons indicated that during spring seasons, the mean concentrations were approximately the same for all snail species in which all they were lived under the lowest mean concentrations except *P. acuta.* During summer 2008, *B. truncatus* and *L natalensis* were more tolerant to Cd than *B. alexandrina*. In winter 2008 the highest mean concentration of Cd was observed in sites containing *Ph. acuta* followed by *B. alexandrina*. During winter 2009, all snail species were lived at a low level of Cd concentrations (below 1ppb). *B. alexandrina* and *P. planorbis* were the most tolerant snail species to the high concentrations of Cu (up to 28 ppb). So, from all these finding it was obvious that different snail species showed difference in their tolerance to chemicals which is different seasonally and some snail species could withstand very high chemical concentration and these could be related to the presence or absence of helpful factors. Mahmoud [22] and El-Khayat *et al.* [23] summarized these helpful factors against the adverse effects of water pollution on snail biology to biotic factors including food supplies, aquatic plants, behavioral and physiological adaptation". Jurberg *et al.* [21] cleared that leaving-water and avoiding-toxicants are two behavioral adaptations by which snails can survive and struggle for persistence against different types of pollutants found in their habitats. Also, Lefcort *et al.* [24] studied the avoidance behavior of an aquatic pulmonate snail, in a pond that has been polluted with heavy metals for 120 years. The authors hypothesized that as toxicants in polluted environments are often patchily distributed, the snails are able to persist because they have evolved the ability to minimize their exposure to metals by actively avoiding metals in their environment. The present tolerance results confirm the other ones carried out by several authors. Recently, Yang *et al.* [25]reported that heavy metals, included Pb , zinc (Zn), Cu, Cd and mercury (Hg) may produce distress or death of snails if their concentrations are higher than tolerance limits of snails. In Egypt, Abdel-Kader *et al*. [26] investigated that snails tolerate the high concentration of some elements such as cobalt, lead and also nitrogen. Snail habitats and those free of snails (canals and drains) are characterized by a significant decrease in copper, compared to Nile water. In addition., Ahmed *et al*.[27] found four metals of ecotoxicological importance (copper, zinc, lead and manganese) during a survey in Qalyubia Governorate. These metals played a role in the distribution and life cycle of snails. However, survey sites near factories tended to show higher copper levels (0.04 ppm or more) and did not harbour any vector snails. Moreover, the exposure of adult snails, eggs and newly hatched snails to water obtained from these later sites caused higher toxic effect to these developmental stages of snails. El-Hawary [28] stated that the distribution and reproduction of snails may be affected by the presence of different pollutants such as pesticides and toxic elements. These chemical elements may kill the snails or make the environment conditions unsuitable for their life. Moreover, he found that *B. alexandrina* tolerated comparatively high concentrations of different ions. However, he disagree with the present results as he found that *B. truncatus* disappeared from habitats characterized by elevation of some toxic ions such as copper and zinc. Also, Caquet [29] found that habitats showed higher concentration of Cu were completely free from snail species. Present results showed that most snail species could be lived at approximately at the same concentrations of Na, K and Ca during all seasons. Meanwhile, *L. natalensis*, *P. acuta* and *B. alexandrina* were lived under a high concentrations of Na up to 380, 219 and 112.6 ppm, respectively. However, Caquet [29] suggested that in the habitat of snails, water with a high concentration of Na is not favorable to snails. Also, most of sites harboring *B. alexandrina* were represented by high peaks of K and Ca concentration. The present results go well with those of Rhoades [12] who reported that in Colorado River, habitat harboring snail vectors are characterized by high concentrations of calcium and potassium and comparatively high concentration of some elements such as cobalt and lead

that were tolerated by snail vectors. Thus, significant differences in water characteristics were found between habitats harboring different snail species and those completely free of snails for calcium and potassium that are higher in snail habitats [26]. Kriajev *et al.* [30] stated that calcium was the most important substance affecting the mollusks ′life. Also, El- Gindy [31] reported that the presence of calcium in the water is important for the snails since it is essential for the construction of the shells. Moreover, calcium salts may play certain effects in regulating the osmotic pressure of the snail tissues as it helps to control the permeability. In conclusion, the present work revealed that the heavy and light chemical element contents of freshwater might be affect the distribution and abundance of the fresh water snails if their concentrations are higher than tolerance limits of snails, which varied seasonally and ecologically.

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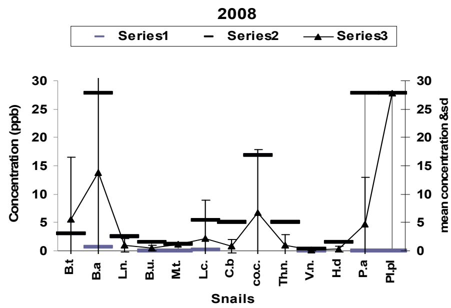
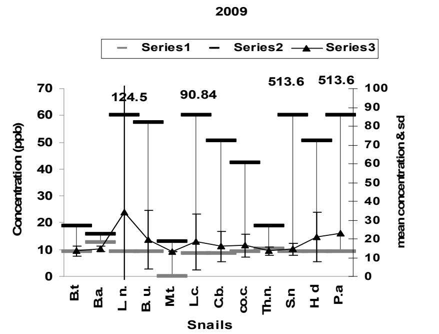
Spring





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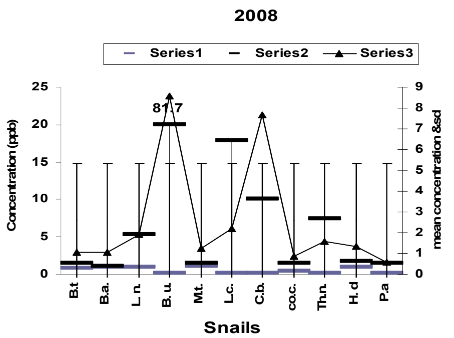

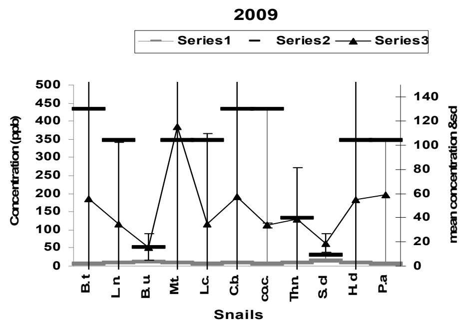

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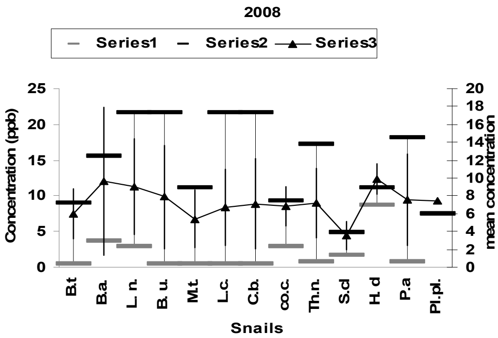

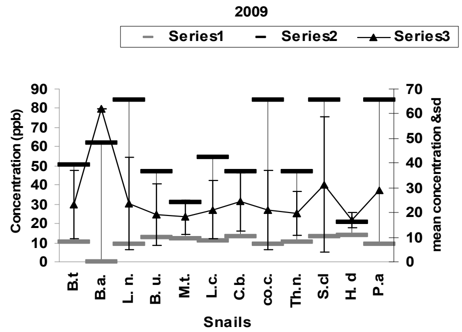

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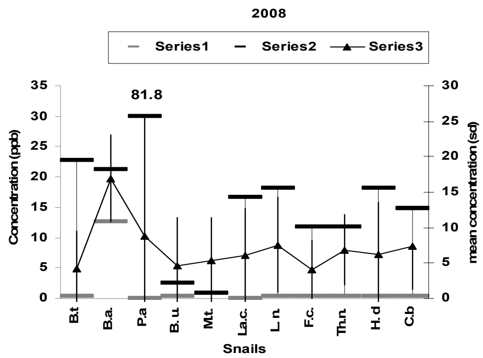

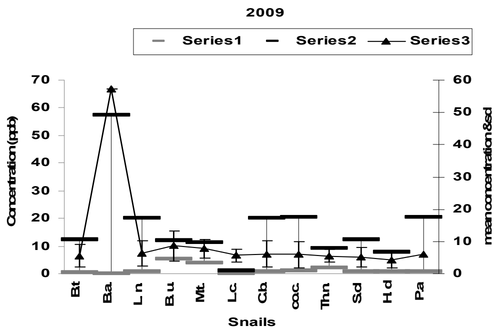

Fig.3 Tolerance ranges and mean concentration of Lead (Pb) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

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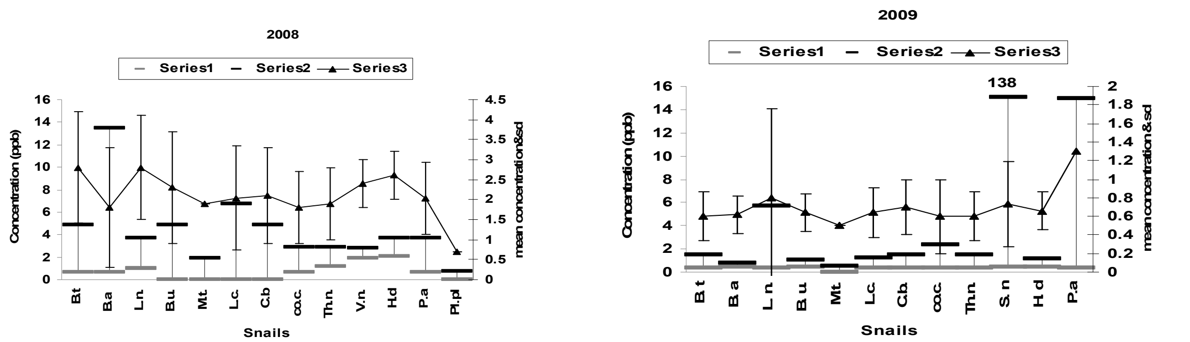

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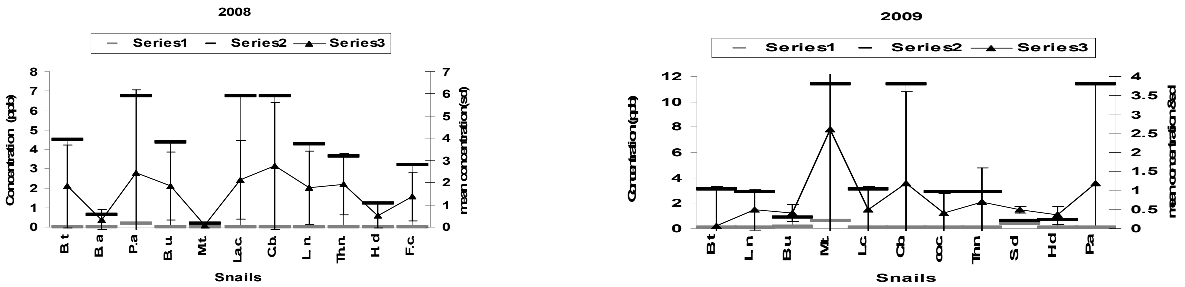

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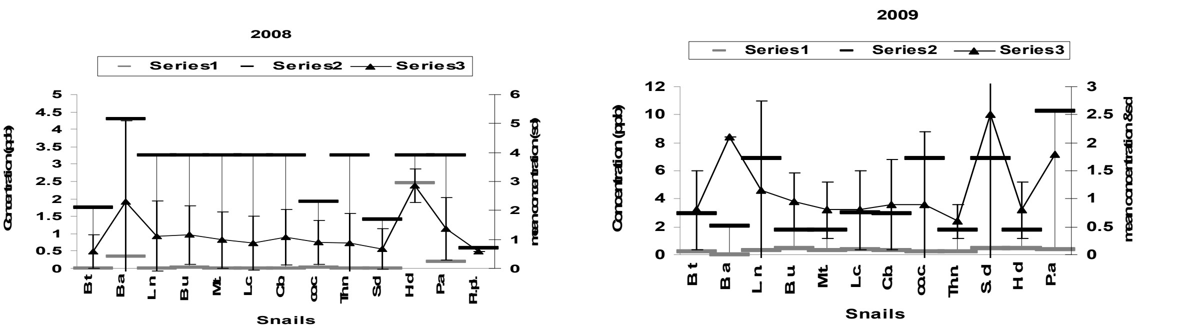

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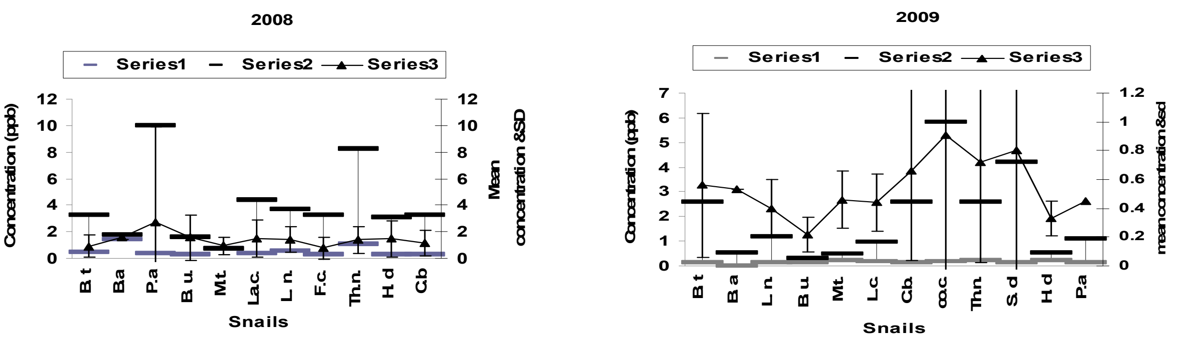

Fig. 4 Tolerance ranges and mean concentration of Lead (Cd) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

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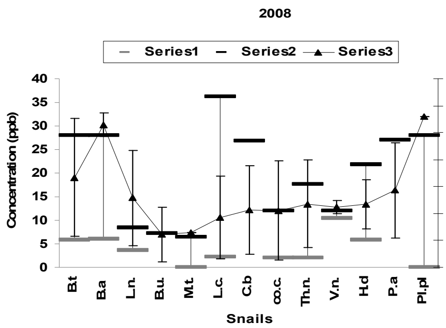

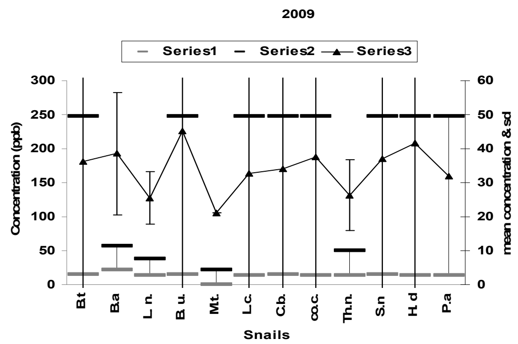

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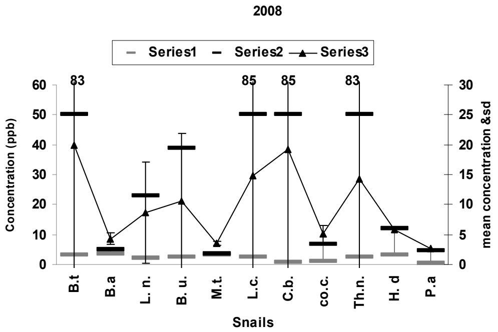

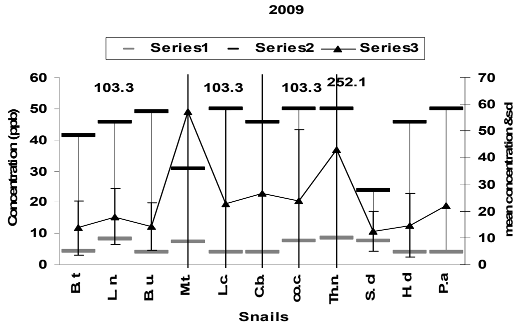

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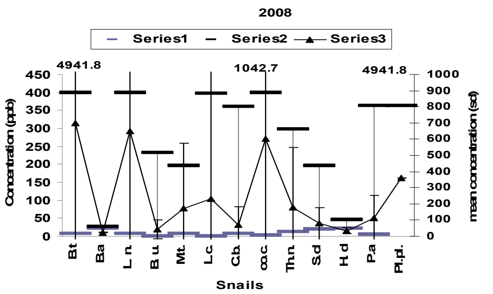

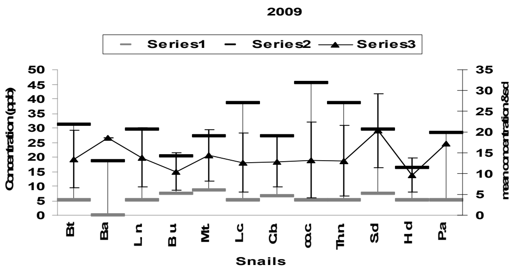

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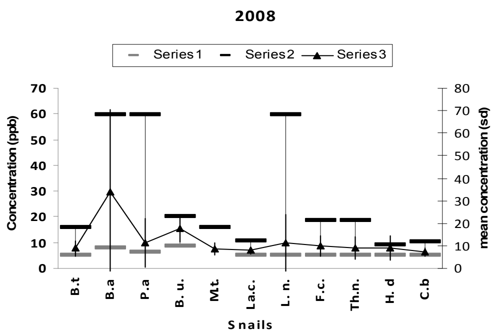


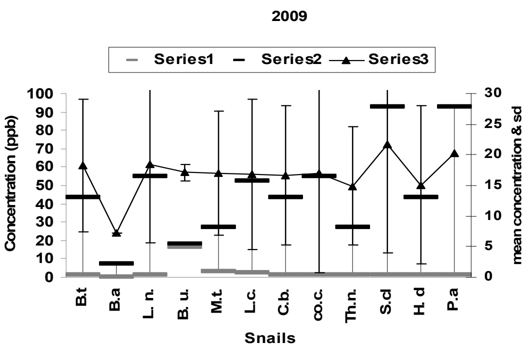
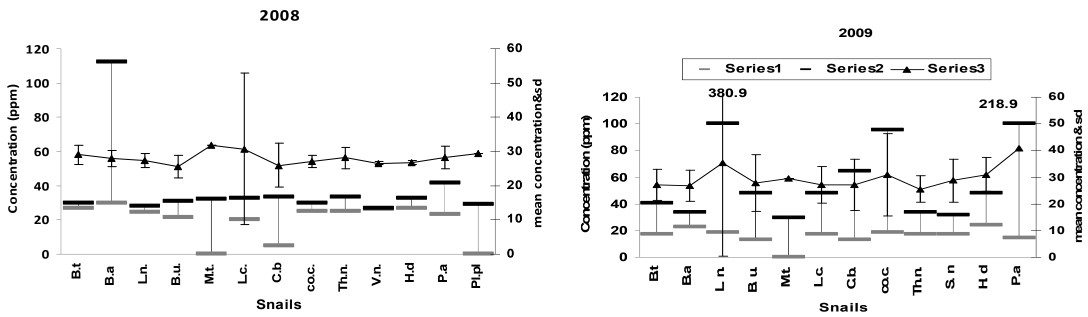


Fig. 5 Tolerance ranges and mean concentration of Lead (Cu) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

Spring



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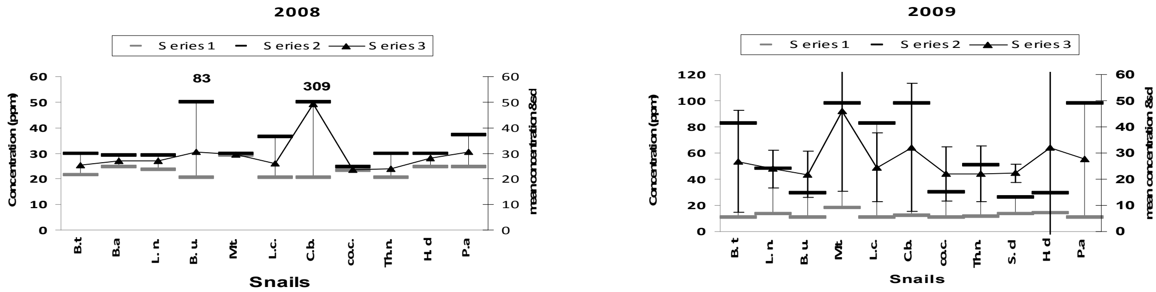

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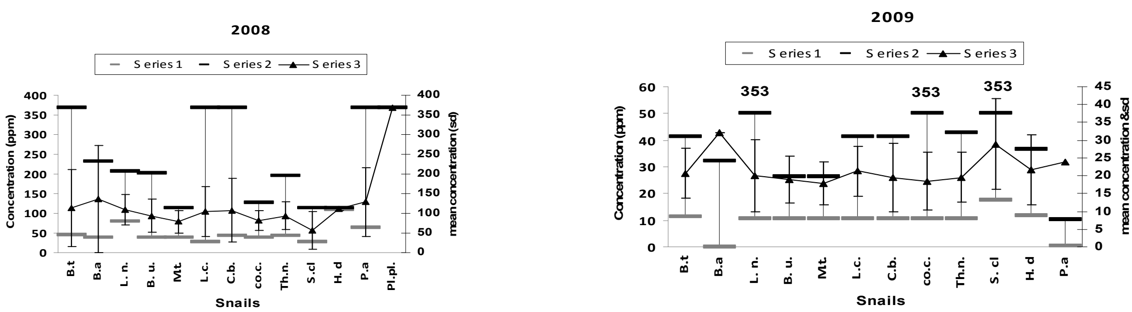

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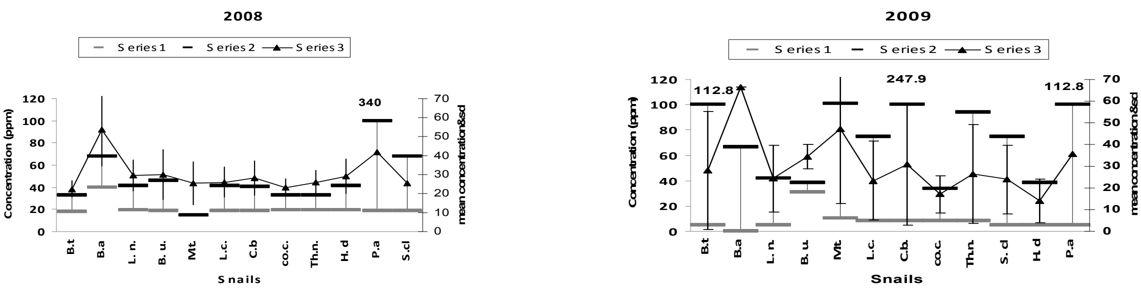
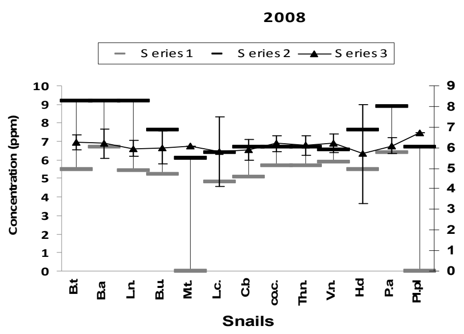
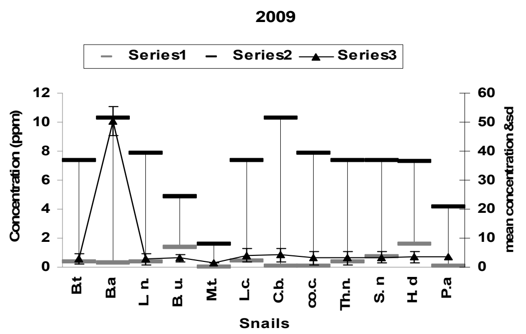


Fig. 6 Tolerance ranges and mean concentration of Lead (Na) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

Spring





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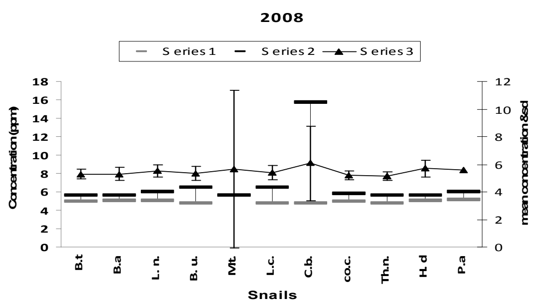

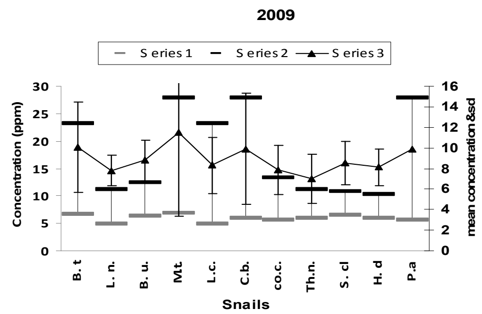

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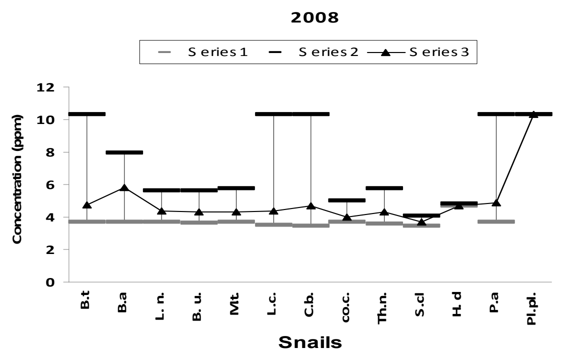

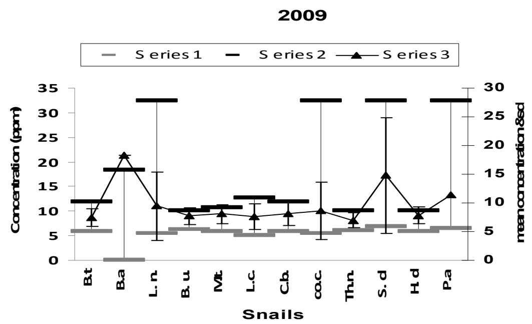

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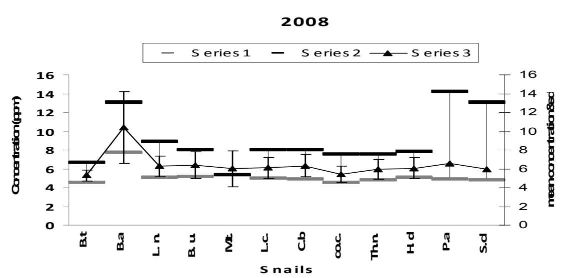

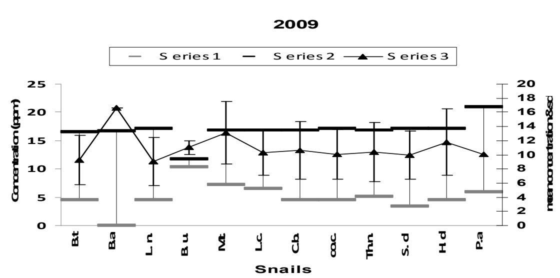

Fig. 7 Tolerance ranges and mean concentration of Lead (K) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD).

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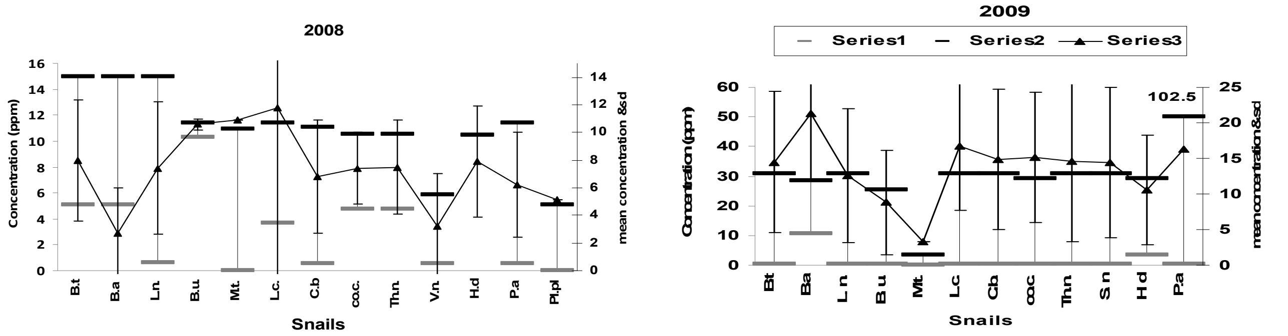

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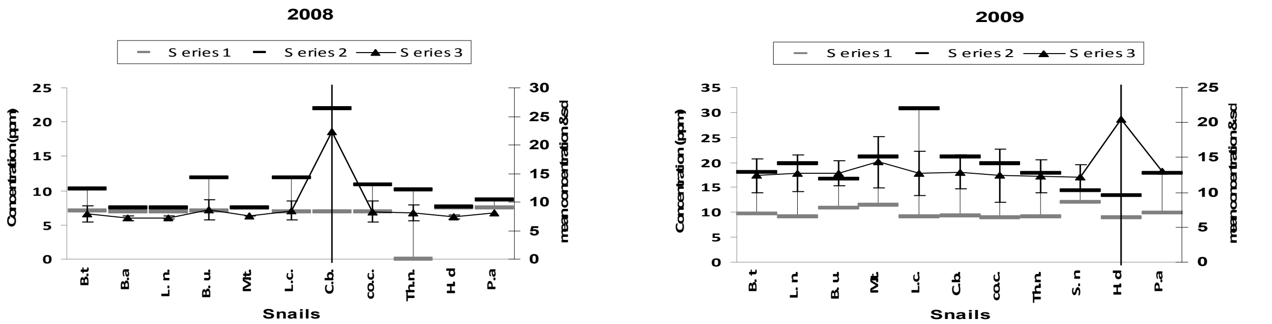

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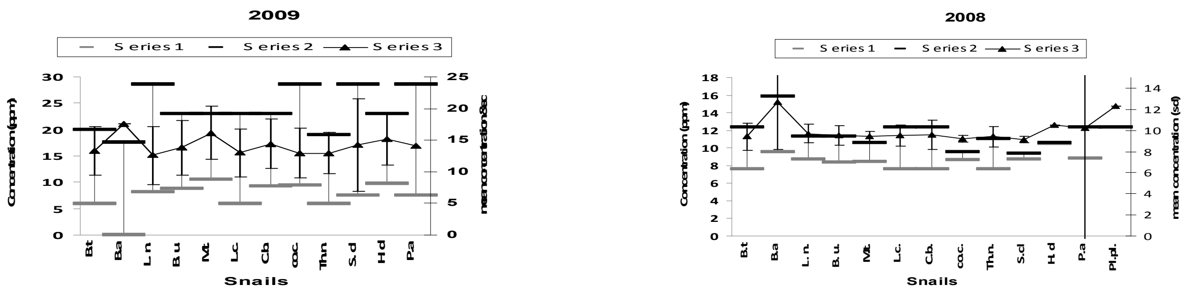

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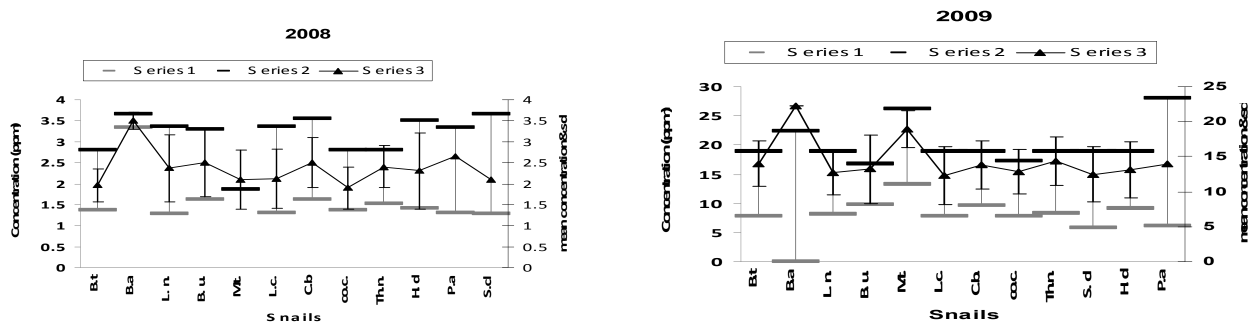

Fig. 8 Tolerance ranges and mean concentration of Lead (Ca) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD).

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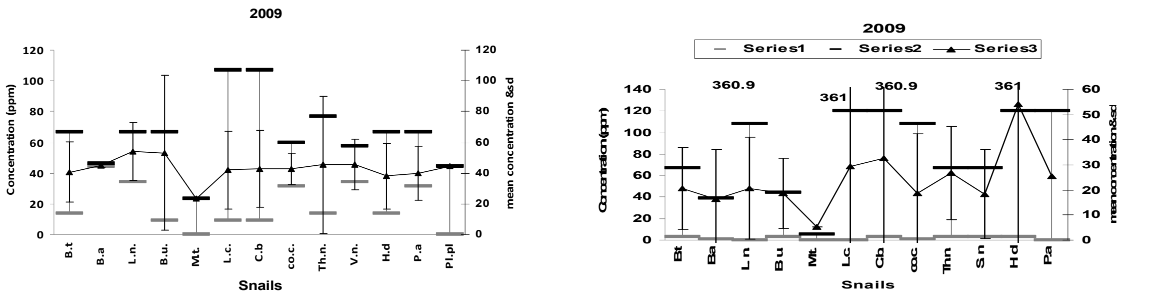

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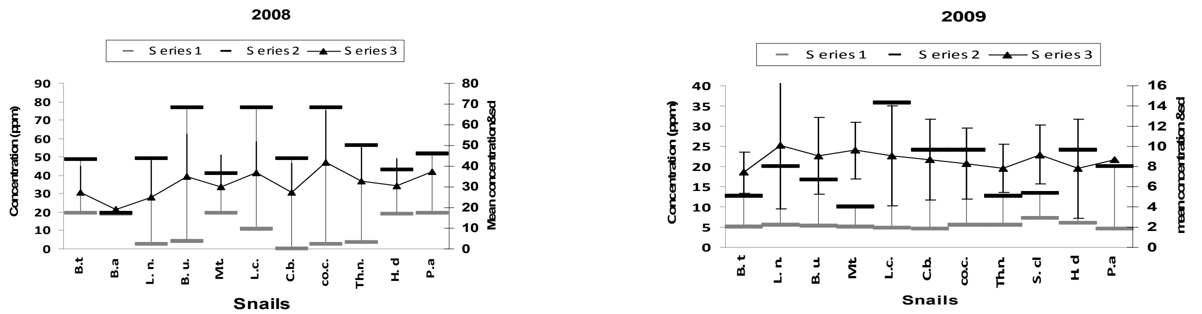

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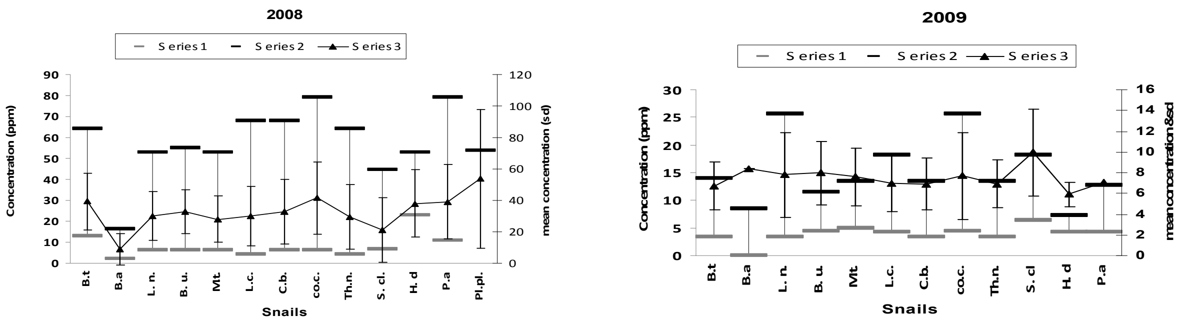

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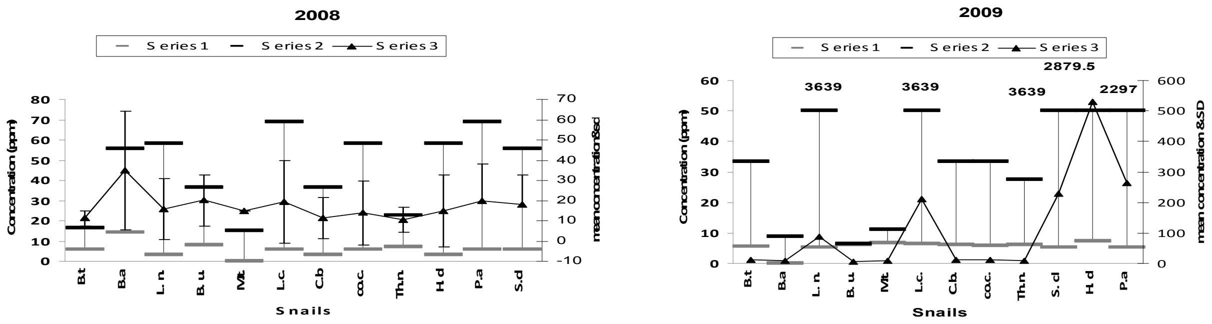
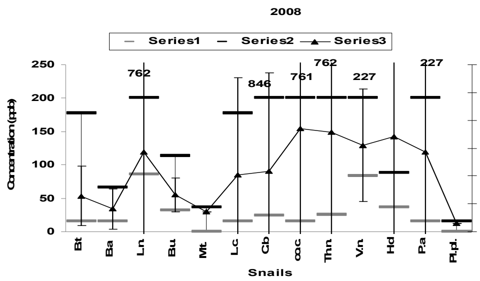
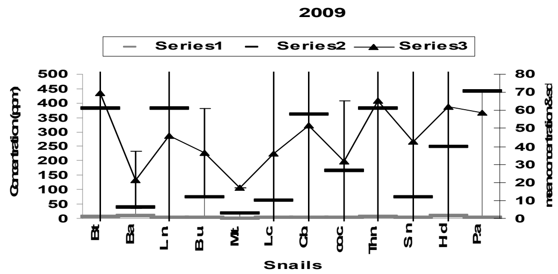


Fig. 9 Tolerance ranges and mean concentration of Lead (Mn) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

Spring





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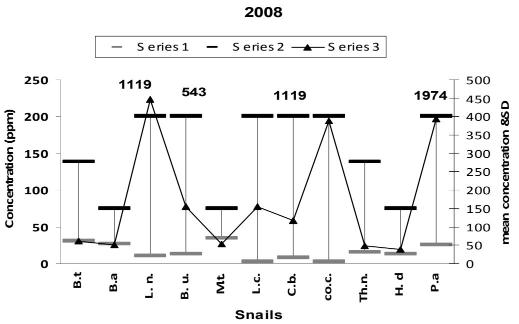

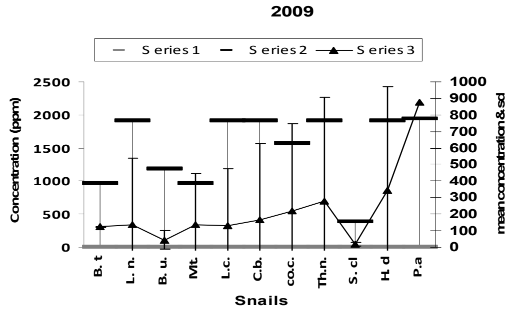

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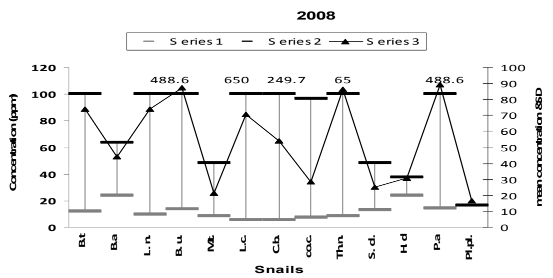

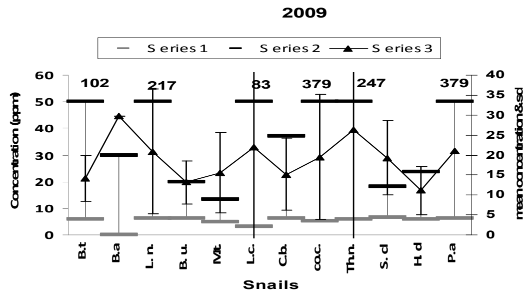

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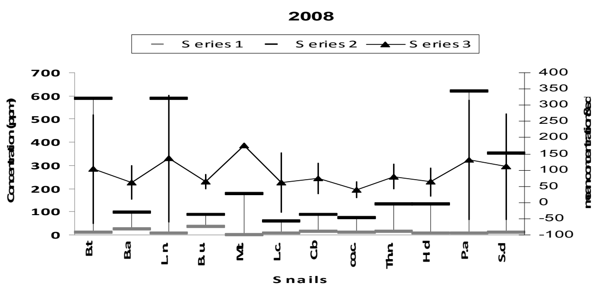

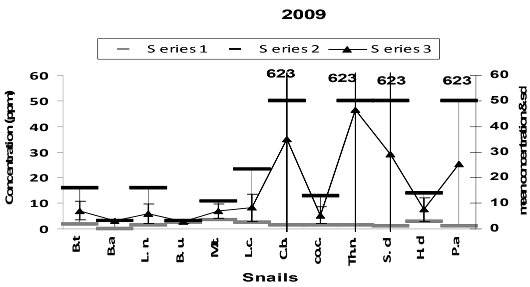

Fig. 10 Tolerance ranges and mean concentration of Lead (Fe) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)

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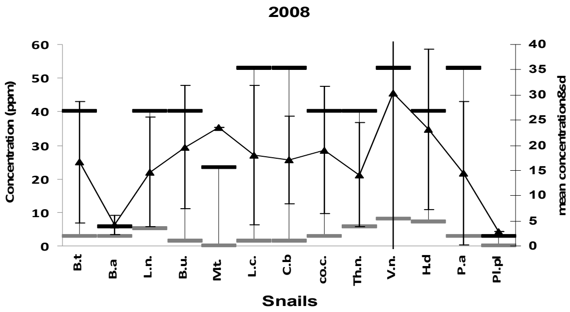

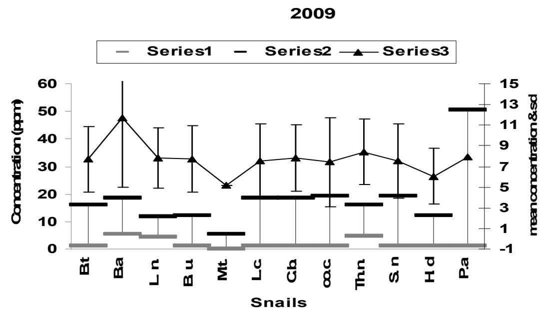

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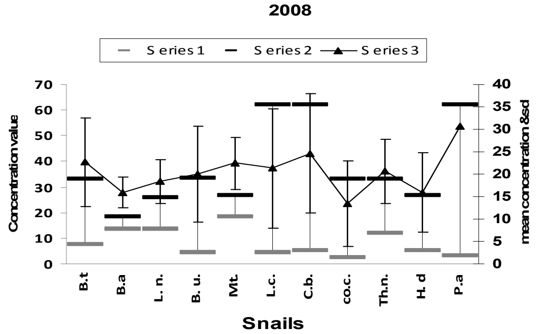

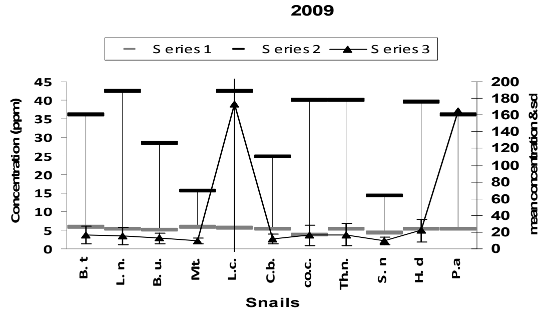

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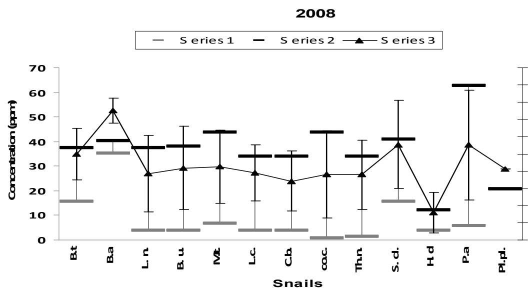

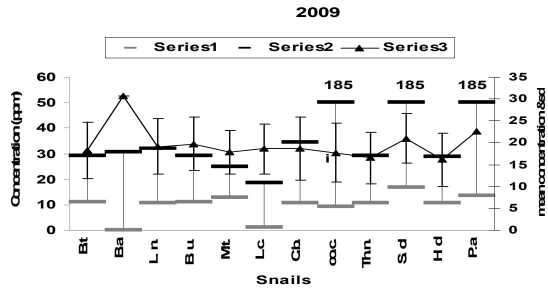

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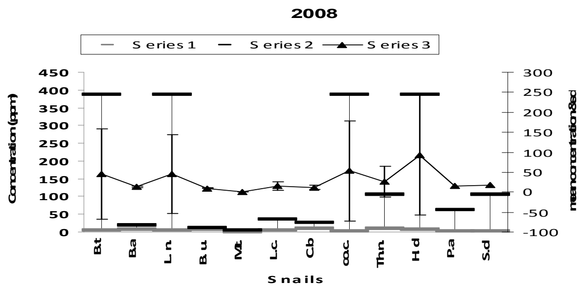

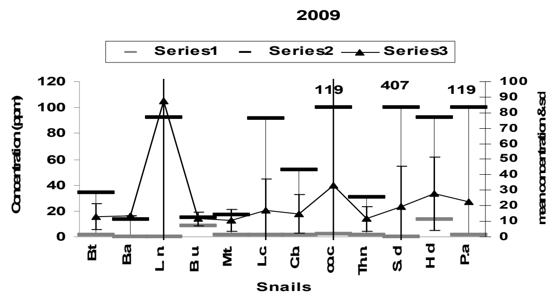

Fig. 11 Tolerance ranges and mean concentration of Lead (Ni) of some fresh water snails collected from River Nile, main branches and canals in Egypt during two years 2008 and 2009, (series1:: min value, series2: max value, series3:mean concentration ± SD)