The Journal of Medical Entomology and Parasitology is one of the series issued quarterly by the Egyptian Academic Journal of Biological Sciences. It is an important specialist journal covering the latest advances in that subject.

It publishes original research and review papers on all aspects of basic and applied medical entomology, parasitology and host-parasite relationships, including the latest discoveries in parasite biochemistry, molecular biology, genetics, ecology and epidemiology in the content of the biological, medical entomology and veterinary sciences.

In addition to that, the journal promotes research on the impact of living organisms on their environment with emphasis on subjects such a resource, depletion, pollution, biodiversity, ecosystem…..etc.

www.eajbs.eg.net

Citation : *Egypt. Acad. J. Biolog. Sci. (E-Medical Entom. & Parasitology Vol.10(1)pp29-36 (2018)*

Egypt. Acad. J. Biolog. Sci., 10 (1): 29 – 36 (2018)

Egyptian Academic Journal of Biological Sciences
E. Medical Entom. & Parasitology

ISSN: 2090 – 0783
www.eajbs.eg.net

The Role of Helminths Infecting *Columba livia domestica*, Pigeon in Bioremediation of Heavy Metals Accumulation (Mn, Zn, Fe)

Ehssan A. Hassan
Zoology Department, Faculty of Science, Suez Canal University, Ismailia, Egypt
. ***Email:** ehssanmm_sci@yahoo.com

ARTICLE INFO
Article History
Received:15/1/2018
Accepted:25/2/2018

Key words:
C. livia domestica, Helminths, Heavy metals accumulation.

ABSTRACT

Columba livia domestica pigeons were collected from Ismailia city, Egypt, during the year 2017. They were found to be infected by intestinal helminths, two cestodes, *Raillietina echinobothrida* and *Cotugnia polyacantha* and a nematode, *Ascaridia columbae.* The heavy metals levels (Mn, Zn, and Fe) in pigeon's muscles and intestine, in addition to helminths, were measured. *R. echinobothrida* revealed the highest in heavy metals accumulation compared to *C. polyacantha* and *A. columbae*. Bioaccumulation factor was most obvious and dominant in muscles than intestine of infected pigeons in respect to *R. echinobothrida\ C. livia* model ranked in concentration from highest to lowest as follows: (Mn>Zn>Fe), followed by *A. columbae\ C. livia* model. *R. echinobothrida /C. livia* , *C. polyacantha/C. livia*, and *A. columbae /C. livia* are considered effective models for monitoring heavy metals pollution for Mn, Zn, and Fe, especially in areas where pollution levels are still relatively low, and have an essential role in bioremediation of heavy metals accumulation in pigeon's tissues. This study also emphasized how environmental science and parasitology might profit from each other. Further studies should be executed in studying the role of pigeon's helminths in monitoring heavy metals pollution.

INTRODUCTION

There is a necessity to evaluate the relationship between parasitism and pollution considering parasitism as a crucial factor in evaluating environmental stressors (Hudson *et al*., 2006; Sures, 2006). Heavy metals, although naturally occurring, are often mobilized into birds and the environment at faster-than-normal rates due to anthropogenic activities (Sharma and Agrawal, 2005).

Parasites respond to anthropogenic pollution in different ways which made it attracting attention as potential indicators of environmental quality (Sures, 2008; Vidal-Martínez, 2010). Heavy metals are considered as critical contaminants in the environment, due to their high potential to enter and accumulate in food chains (Erdogrul and Erbilir, 2007). Unfortunately, less literature is available on the use of pigeon's endoparasites in environmental impact studies. In the past two decades, manuscripts including studies of host-parasite models challenged by heavy metal exposure were increased (Barus *et al*., 2012; Nachev *et al*., 2013; Hassan *et al*., 2016; 2018).

Wild animals are normally exposed to heavy metals in their natural habitats. (Kalas *et al*, 2000). Birds are among the possible biomonitoring species, that are widely used to assess environmental contamination, and over the last decades, the feral pigeon (*Columba livia*) is assessed as a bio indicator of pollution (Nam *et al*., 2004; Klein *et al*., 2008). In this context, feral pigeons have a significant epidemiological role, since they can be reservoirs and potential vectors of a large number of zoonotic pathogens (Magnino *et al*., 2009; Karatepe *et al*., 2011).

Monitoring the interactions between pollution and parasites have been increasing over the last years as some helminths are able to accumulate heavy metals in concentrations higher than their hosts (Sures, 2003; 2004). Directions have been shown to be highly promising and relevant, considering parasites as accumulation indicators for selected pollutants (Sures *et al.,* 2017)

Heavy metals pollution threats pigeon's tissues. Moreover, health risks accompanied with its consumption. Therefore, there an increasing world attention towards heavy metal contamination in pigeon's tissues (Begum and Sehrin, 2013). One of the most Known pigeons is *Columba livia* domestica. Considering the helminths/pigeon systems, the main target of the present study was to assess the accumulation of trace elements (Mn, Zn, Fe) in two cestodes *Raillietina echinobothrida* and *Cotugnia polyacantha*, and a nematode, *Ascaridia columbae* and in *C. livia* tissues in Ismailia city, Egypt, thus evaluating three models *R. echinobothrida* /*C. livia*, *C. polyacantha*/*C. livia*, and *A. columbae* /*C. livia* as promising bioindicator systems.

MATERIALS AND METHODS

1. Sample Collection:

Thirty *C. livia* pigeons were collected from Ismailia city, Egypt during year 2017. They were transferred to the laboratory, and euthanized, then dissected and the separated parts of the alimentary canal of the pigeons were taken in 0.85% normal saline solution to collect helminths parasites. Each section of gastrointestinal tracts of was opened separately. The removed contents were examined under a stereomicroscope for the presence of helminths. Identification of the species was confirmed on the basis of light microscopic examination according to Yamaguti (1961) and Soulsby (1982). Samples of muscles and intestine of infected and uninfected pigeons , in addition to helminths were collected , stored in glass vials and deep-frozen until later processing for trace element analysis (Danilewicz *et al*., 2002).

***2.* Heavy Metal Analysis**:

The samples were weighed (0.5 gm) in the small beaker; 3.5 ml of concentrated HNO3 and 10.5 ml of concentrated HCL were added and left for 24 hours. The samples were heated for digestion with more addition of HNO3 till the entire brown fumes disappeared. The digested samples were filtered and diluted with distilled water to 25 ml (Saleh and El Shenawy, 2001).The heavy metals concentrations in the digested intestine, muscles and helminths were measured by Plasma Optical Emission-Mass Spectrometer. Results were expressed as micrograms per gram (µg/g) wet weight.

3. Statistical Analysis:

Differences between element concentrations among the analyzed tissues were detected by ANOVA followed by Tukey’s test. Correlation analysis was used to detect relationships between toxic element levels in pigeon's tissues and parasites. Statistical analysis was performed using the SPSS 20 software package. For all tests, a significance level of $P<0.05$ was applied. The bioaccumulation factors (BFs) were determined as the ratio of the element concentration in the parasites to that in tissues.

RESULTS

1. Heavy Metals Concentrations in Pigeon's Tissues and Helminths:

All element levels were found to vary according to analyzed tissue and parasites (Figure 1). Considering the pigeon's tissues, mean concentration of Mn in muscles and intestine of uninfected pigeons was 1.03±0.01 µg/g; 1.905± 0.009 µg/g and that of the infected ones was 0.49±0.004 µg/g ; 1.617±0.01 µg/g, respectively (Figure 1,A). *R. echinobothrida* revealed a higher levels in concentrating Mn as many times as that in tissues of pigeons (126.15±1.13 µg/g), followed by *A. columbae* (28.25±0.39 µg/g) (P <0.001) and the lowest was recorded by *C. polyacantha* (21.75±0.14 µg/g) (Figure 1,D).

The concentrations of Zn in uninfected and infected tissues of pigeon did not vary significantly. *R. echinobothrida* is also the highest in accumulation of Zn (76.69±0.26 µg/g) concerning uninfected and infected pigeons tissues and parasites (P <0.001) (Figure 1, B), followed by *A. columbae* (12.69±0.29 µg/g), while *C. polyacantha* was the least (10.91±0.18 µg/g) (Figure 1, D).

The average content of Fe was 1.21±0.01 µg/g in the uninfected pigeon, while it was 0.39±0.01 in muscles of infected pigeons (p<0.001). Similarly, for intestine, the mean concentration of Fe in the intestine of uninfected pigeons was 2.75 ± 0.03 µg/g, while in the infected pigeon's intestine; it recorded 0.94±0.01 µg/g accumulating capacity (Figure 1, C). The role of *R. echinobothrida* is always evident as, it has high tendency to concentrate Fe compared to uninfected pigeons tissues (8.26±0.17 µg/g) (P <0.001).

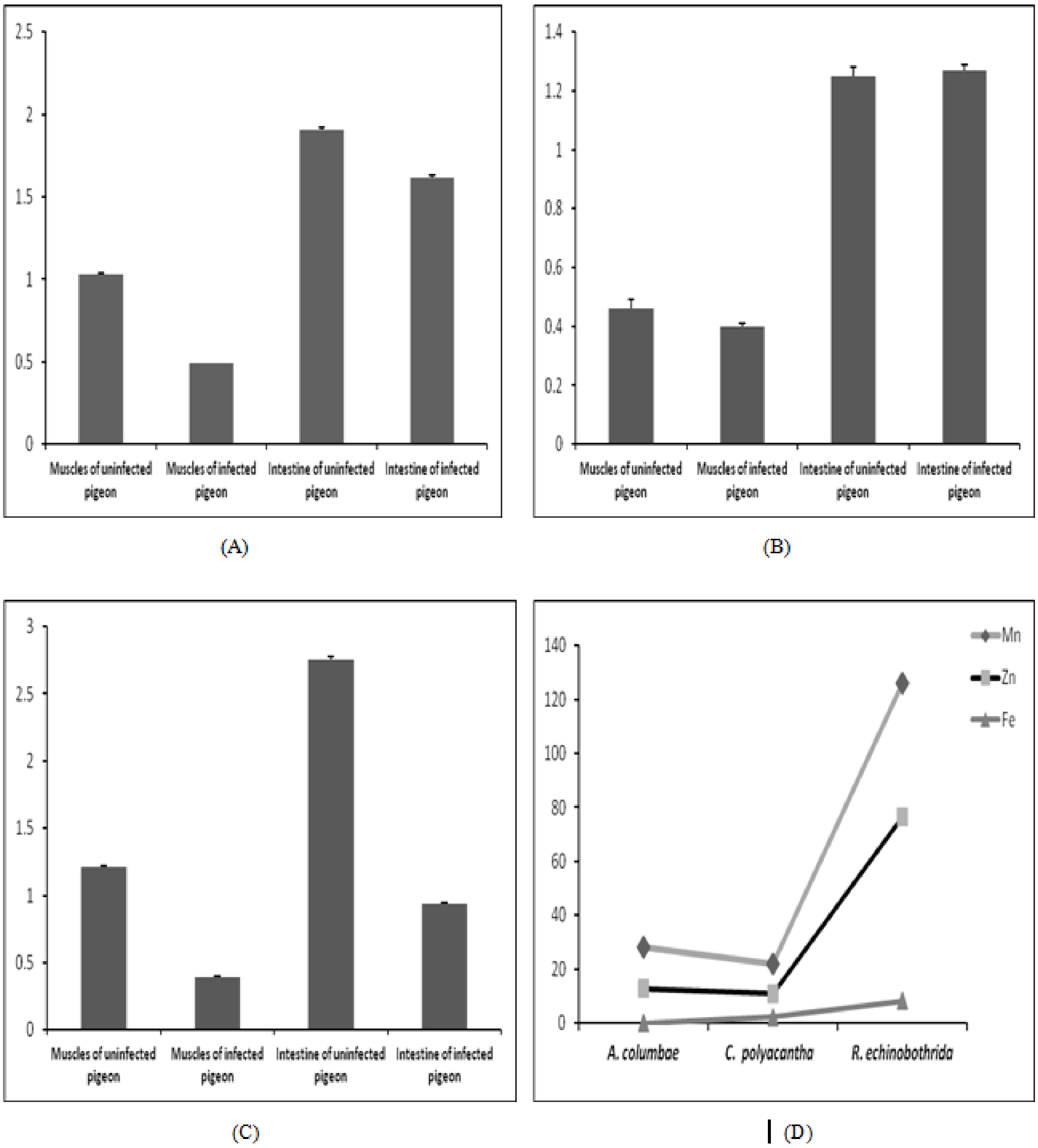

Figure 1. (A) Mean concentration of Mn in muscles and intestine of uninfected and infected pigeons. **(B)** Mean concentration of Zn in muscles and intestine of uninfected and infected pigeons. **(C)** Mean concentration of Fe in muscles and intestine of uninfected and infected pigeons. **(D)** Mean concentration of Mn, Zn, and Fe in *R. echinobothrida*, *C. polyacantha* and *A. columbae,* (µg/g , wet weight)

2. Relations between heavy metals concentrations in pigeon's tissues and helminths:

Positive and negative correlations were observed between the evaluated heavy metals in pigeon's tissues and helminths (Table 1). There was a positive correlation between the levels of Zn in *A. columbae* and Fe in muscles (R=0.999, P< 0.02). Also, the relation between Mn levels in *R. echinobothrida* and *A. columbae* (R=1, P< 0.02). Furthermore, a positive correlation was detected between levels of Fe in *R. echinobothrida* and Mn *levels in C. polyacantha* (R=1, P< 0.001). Contrarily, negative correlations were detected concerning the levels Mn in *C. polyacantha* , Fe (R= - 0.998, P< 0.04) and Zn (R= - 0.997, P< 0.04) in muscles. In addition to the levels of Fe in *R. echinobothrida* and Zn in muscles (R= - 0.997, P< 0.04).

Table 1. Correlations among element levels, tissues of *C. livia*, and helminths.

Helminths - pigeons tissues	R	P<
A. columbae Zn * Fe muscles	0.999	P<0.02
C. polyacantha Mn * Fe muscles	-0.998	P<0.04
C. polyacantha Mn * Zn muscles	-0.997	P<0.04
R. echinobothrida Fe. * Zn muscles	-0.997	P<0.04
R. echinobothrida Mn * Mn *A. columbae*	1.000	P<0.02
R. echinobothrida Fe * Mn *C. polyacantha*	1.000	P<0.001

3. Bioaccumulation factors:

Bioaccumulation factors were most obvious and effective in muscles than intestine of infected pigeons with R. *echinobothrida\ C. livia* model being the most conspicuous (Figure 2). The highest BF registered was by *R. echinobothrida* as it accumulates Mn 257.45 times than that in *C. livia* muscles, Zn (191.73) and Fe (21.18). Similarly for the ratios between accumulation of *R. echinobothrida* and the intestine ranked in concentration from highest to lowest as follows: (Mn>Zn>Fe) (78.01, 60.39, 8.79) , respectively. The *A. columbae* \ *C. livia* model revealed also high rates of BFs. The highest BF was for Mn, as *A. columbae* accumulates Mn 57.65 times than muscles followed by Zn 31.73. On the other hand, *C. polyacantha* \ *C. livia* model revealed low BFs for Mn (44.39), Zn (27.28) and Fe (5.85) compared to *R. echinobothrida* and *A. columbae*. The same pattern was verified in the intestine (Mn>Zn>Fe) (13.45, 8.59, 2.43), respectively.

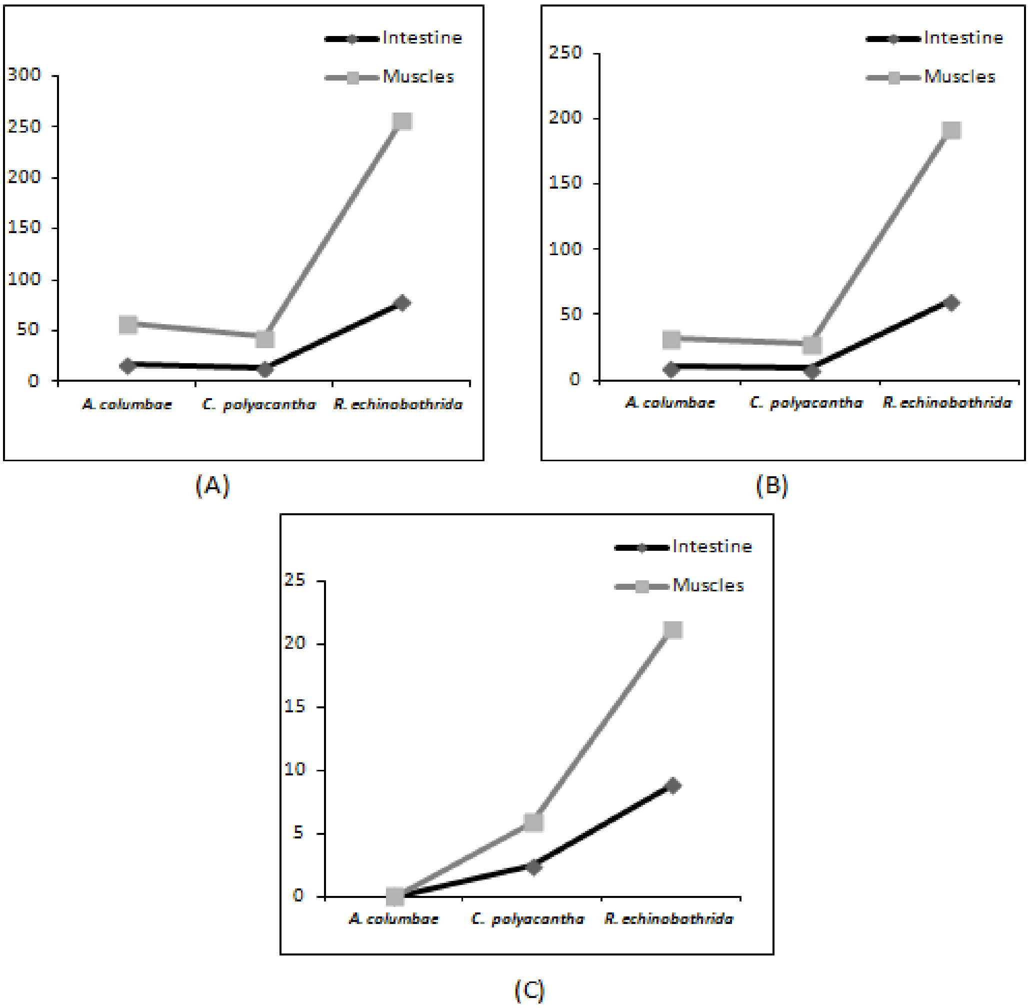

Fig.2. Bioaccumulation of Mn (A), Zn (B), and Fe (C) concerning helminths / *C. livia* models

DISCUSSION

Ignoring parasites in the assessment of pollution on organisms is now recognized as a potential bias in studies, which may then lead to false conclusions (Evans *et al*., 2001). Recently, evaluating environmental pollution has emerged via the role of parasites ability to concentrate inorganic elements, particularly, heavy metals at much higher levels compared to free-living organisms (Taraschewski, 2000). They have the ability to concentrate heavy metals levels that are up to 2,000% above background levels (Sures, 2003; 2004).

In the present study, we found out that pigeons infected with cestodes and nematodes had lower concentrations of heavy metals in muscles and intestine than that in the uninfected pigeons. In this context, Sures *et al*. (2002) concluded that some parasites of the terrestrial hosts accumulate toxic elements more efficient than their hosts. Similarly, Barus *et al.* (2003) reported that helminths of terrestrial mammals are not as effective as those from fishes and birds in the accumulation of heavy metals. Whereas, intestinal parasites accumulated more metals compared to parasites inhabiting the body cavity (Nachev *et al*, 2013). Torres *et al.* (2010) proposed the model *Raillietina micracantha* / *Columba livia* from the city of Santa Cruz de Tenerife (Canary Islands, Spain) as a promising bioindicator in evaluating environmental pollution with heavy metals particularly Pb and Mn.

There was species specificity in the response of helminths to heavy metal accumulation. *R. echinobothrida* and *C. polyacantha* have an effect different capacity in accumulation of heavy metals from their host tissues. Thielen *et al.* (2004) supported the hypothesis that parasites that haven't digestive tract concentrate metals in rates higher than that detected in host tissues. These results have coincided with that reported by Torres *et al.* (2006) that cestodes accumulate heavy metals effectively. Also, Cestodes have a higher metal accumulation capacity compared to nematodes that aren't suitable as sentinels (Lafferty, 1997). Also, Barus *et al.* (2007) reported that heavy metal accumulation in the host tissues wasn't influenced by nematodes presence.

The preference of parasites for bile absorption from their host gut is the main reason for achieving high levels of heavy metal concentration as most vertebrates minimize the impact of harmful substances by surrounding them with bile, thus parasites absorb the pollutants from their host gut and accumulate them in their bodies (Sures, 2003).

The essential role of helminths as a heavy metal sanitizer for the host has raised a controversial question of whether it might be beneficial to the vertebrate host to be infected by these worms (Sures and Siddall, 1999; Taraschewski, 2000; Malek *et al*, 2007). On another point of view, Szefer *et al.* (1998) adopted the opinion that the higher bioaccumulation by helminths may reflect the higher ability of the host to clear heavy metals. It's important to point out that the ability of the parasites to accumulate metals is affected by numerous factors including the nature of the metal itself (Sures *et al*., 1998).

In conclusion, *R. echinobothrida* /*C. livia*, *C. polyacantha*/*C. livia*, and *A. columbae* /*C. livia* are considered effective model in monitoring heavy metals pollution for Mn, Fe, and Zn especially in areas where pollution levels are still relatively low. In addition to the role of *R. echinobothrida* , *C. polyacantha* , and *A. columbae* in bioremediation of heavy metals accumulation in muscles and intestine of pigeons. The present outcome exhibited disparity between the accumulation capacities of helminths, as, there was species specificity in heavy metal accumulation, despite that *R. echinobothrida* and *C. polyacantha* are cestodes, and their bioaccumulation levels were different. This study also emphasized how environmental science and parasitology might profit from each other. The results obtained emphasize that not only does pigeons helminths appear to be a suitable bioindicator for Mn, Zn, and Fe, but it also indicates that pollution might have been underestimated in the past. Further studies should be executed in this field considering the type of metal as accumulation capacity was different in relation to Mn, Zn, and Fe.

REFERENCES

Barus, V., Tenora, F., Sumbera, R. (2003): Relative concentrations of four heavy metals in the parasites *Protospirura muricola* (Nematoda) and *Inermicapsifer arvicanthidis* (Cestoda) in their definitive host silvery mole-rat (*Heliophobius argenteocinereus: Rodentia*). Helminthologia, 40: 227 -232.

Barus, V., Jarkovsky, J., Prokes, M. (2007): *Philometra ovata* (Nematoda: Philometroidea): a potential sentinel species of heavy metal accumulation. Parasitol. Res., 100: 929-933.

Barus, V., Simkova, A., Prokes, M., Penaz, M., and Vetesník L. (2012). Heavy metals in two host-parasite systems: tapeworm vs. fish . Acta. Vet. Brno., 81: 313–317.

Begum, A. and Sehrin, S. (2013): Levels of Heavy Metals in Different Tissues of Pigeon (*Columba livia*) of Bangladesh for Safety Assessment for Human Consumption. BPJ, 16(1): 81-87.

Danielewicz, W., Raj, A. and Zientarski, J. (2002): Forest Ecosystems of the Karkonosze National Park. Karkonoski Park Narodowy, Jelenia Góra.

Erdoğrul, Ö. and Erbilir, F. (2007): Heavy metal and trace elements in various fish samples from Sir Dam Lake, Kahramanmaraş, Turkey. Environ. Monit. Assess., 130: 373-379.

Evans, D.W., Irwin, S.W.B., and Fitzpatrick, S. (2001): The effect of digeneans (Platyhelminthes) infections on heavy metal concentrations in *Littorina littorea*. J. Mar. Biol. Assoc.U.K., 81:349-350.

Hassan, A., Al-Zanbagi, N.A., and Al-Nabati, E.A. (2016) Impact of nematode helminthes on metal concentrations in the muscles of Koshar fish, Epinephelus summana, in Jeddah, Saudi Arabia.JOBAZ ,74: 56–61.

Hassan, A. , Moharram, S., and El Helaly, H. (2018). Role of Parasitic Helminths in Bioremediating Some Heavy Metal Accumulation in the Tissues of *Lethrinus mahsena.* Turk. J. Fish Aquat. Sci. 18: 435-443

Hudson, P.J., Dobson, A.P., and Lafferty, K.D. (2006): Is a healthy ecosystem one that is rich in parasites? Trends Ecol. Evol., 21: 381-385.

Kalas, J.A., Steinnes, E., and Lierhagen, S. (2000): Lead exposure of small herbivorous vertebrates from atmospheric pollution. Environ. Pollut., 107:21–29.

Karatepe, M., Kılıc, S., Karatepe, B., and Babur, C. (2011): Prevalence of *Toxoplasma gondii* Antibodies in Domestic (*Columba liviadomestica*) and Wild (*Columba livia livia*) Pigeons in Niğde region, Turkey. Turkiye Parazitol. Derg., 35: 23-26.

Klein, R., Bartel, M., Paulus, M., Quack, M., Tarricone, K., Wagner, G., Ball, M., Ru¨del, H., and Schluter, C. (2008): Pollution of urban industrial ecosystems in Germany—the use of bioindicators from different trophic levels. Environ. Bioindic., 3: 19.

Lafferty, K.D. (1997): Environmental parasitology: what can parasites tell us about human impacts on the environment? Parasitol. Today, 13: 251-255.

Magnino, S., Haag-Wackernagel, D., Geigenfeind, I., Helmecke, S., Dovc, A., Prukner-Radovcic, E., Residbegovic, E., Ilieski, V., Laroucau, K., Donati, M., Martinov, S., and Kaleta, E.F. (2009): Chlamydial infections in feral pigeons in Europe: Review of data and focus on public health implications. Vet. Microbiol., 135: 54-67.

Malek, M., Haseli, M., Mobedi, I., Ganjali, M.R., and MacKenzie, K. (2007): Parasites as heavy metal bioindicator s in the shark Carcharhinus dussumieri from the Persian Gulf. Parasitol., 134: 1053-1056.

Nachev, M., Schertzinger, G., and Sures, B. (2013): Comparison of the metal accumulation capacity between the acanthocephalan *Pomphorhynchuslaevis* and larval nematodes of the genus *Eustrongylides* sp. infecting barbel (*Barbusbarbus*). Parasites Vectors, 6: 1–8.

Nam, D.H., Lee, D.P.,and Koo, T.H. (2004): Factors causing variations of lead and cadmium accumulation of feral pigeons (*Columba livia*). Environ. Monit. Assess., 95: 23- 35.

Saleh, A.R. and El-Shenawy, N.S. (2001): *Anisops sardeus sardeus* Herrich-schaeffer (Heteroptera: Notonectidae) as a bioindicator of heavy metals in wastewater treatment plant at Ismailia, Egypt. J. Aquat. Biol. Fish., 5: 129-146.

Sharma, R.K. and Agrawal, M. (2005): Biological effects of heavy metals: an overview. J .Environ. Biol., 26(2): 301–313.

Soulsby, E.J.L. (1982): Helminths, Arthropods and Protozoa of Domesticated animals. 7th Edition, London.

Sures, B. (2003): Accumulation of heavy metals by intestinal helminths in fish:

an overview and perspective. Parasitol., 126: 53-60.

Sures, B. (2004): Environmental parasitology: relevancy of parasites in monitoring environmental pollution. Trends Parasitol., 20: 170-177.

Sures, B. (2006): How parasitism and pollution affect the physiological homeostasis of aquatic hosts. J. Helminthol., 80: 151-157.

Sures, B. (2008): Environmental Parasitology: Interactions between parasites and pollutants in the aquatic environment. Parasite, 15: 434-438.

Sures, B. and Siddall, R. (1999): *Pomphorhynchus laevis*: the intestinal acanthocephalan as a lead sink for its fish host, chub (*Leuciscus cephalus*). Exp. Parasitol., 93: 66-72.

Sures., B, Jurges, G., and Taraschewski, H. (1998): Relative concentrations of heavy metals in the parasites Ascaris sum (Nematoda) and Fasciola hepatica (Digenea) and their respective porcine and bovine definitive hosts. Int. J. Parasitol., 28: 1173-1178.

Sures, B., Siddall, R., and Taraschewski, H. (1999): Parasites as accumulation indicators of heavy metal pollution. Parasitol. Today, 15: 16–21

Sures, B., Grube, K., and Taraschewski, H. (2002): Experimental studies on the lead accumulation in the cestode *Hymenolepis diminuta* and its final host, *Rattus norvegicus*. Ecotoxicol., 11: 365-368.

Sures, B., Scheef, G., Klar, B., Kloas, W., and Taraschewski, H. (2002): Interaction between cadmium exposure and infection with the intestinal parasite *Moniliformis moniliformis* (Acanthocephala) on the stress hormone levels in rats. Environ. Pollut., 119: 333-340.

Sures, B. , Nachev, M., Selbach , C., and Marcogliese D. (2017): Parasite responses to pollution: what we know and where we go in 'Environmental Parasitology. Parasit Vectors, 10: 65.

Szefer, P., Rokicki, J., Frelek, K., Skora, K., and Malinga, M. (1998): Bioaccumulation of selected trace elements in lung nematodes, *Pseudalius inflexus*, of harbor porpoise (*Phocoena phocoena*) in a Polish zone of the Baltic Sea., Sci. Total Environ., 220: 19-24.

Taraschewski, H. (2000): Host-parasite interactions in Acanthocephala: a morphological approach. Adv. Parasit., 46: 1-179.

Thielen, F., Zimmermann, S., Baska, F., Taraschewski, H., and Sures, B. (2004): The intestinal parasite *Pomphorhynchus laevis* (Acanthocephala) from barbel as a bioindicator for metal pollution in the Danube River near Budapest, Hungary. Environ. Pollut., 129 (3): 421-429.

Torres, J., Foronda, P., Eira, C., Miquel, J., and Feliu, C. (2010): Trace element concentrations in *Raillietina micracantha* in comparison to its definitive host, the feral pigeon *Columba livia* in Santa Cruz de Tenerife (Canary Archipelago, Spain). Arch. Environ. Contam. Toxicol., 58: 176-182.

Torres, J., Peig, J., Eira, C., and Borras, M. (2006): Cadmium and lead concentrations in Skrjabinotaenia lobata(Cestoda: Catenotaeniidae) and its host, Apodemus sylvaticus (Rodentia: Muridae), in the urban dumping side of Garraf (Spain). Environ. Pollut. 143: 4–8.

Vidal-Martínez V.M., Pech D., Sures B., Purucker S.T., and Poulin R. (2010): Can parasites really reveal environmental impact?. Trends Parasitol., 26(1): 44-51.

Yamaguti, S. (1961): Systema Helminthum. Vol **III**. The Nematodes of Vertebrates. Interscience Publishers Inc. New York. 679 pp.