HEAVY METAL CONCENTRATIONS IN CESTODE PARASITE (*Raillietina micracantha*) AND ITS HOST PIGEON (*Columba livia*)

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Abstract

The present study revealed the accumulation of arsenic, lead, cadmium, chromium, zinc, and copper in the cestode *Raillietina micracantha* infecting *Columba livia* collected from five different rural areas of Bangladesh. The parasite was collected from 60 infected hosts. The heavy metals were analyzed by using an Atomic Absorption Spectrometer. The mean of the measured concentrations (μg/g dry weight) in the muscle and liver tissues of *C. livia* and in the parasite, *R. micracantha* were as follows: arsenic: 0.04, 0.05 and 0.16, respectively; lead: 0.49, 2.30 and 3.00, respectively; cadmium: 0.04, 1.09 and 2.08, respectively; chromium: 1.05, 2.13 and 4.68, respectively; zinc: 181.86, 239.61 and 266.74, respectively; copper: 6.82, 35.31 and 15.08, respectively. The results revealed that the mean concentrations of the heavy metals were higher in the parasite than in the pigeon.

Key words: Parasite, cestode, *Raillietina micracantha*, pollution, heavy metals, pigeon, bioindicators.

INTRODUCTION

Large quantities of pollutants have continuously been introduced into different cities as a consequence of anthropogenic activities, such as urbanization, traffic, and industrial processes. 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, Olojo *et al.* 2005). These can accumulate in different organs of animals and also parasites inside the body. In the body, the metals have adverse effects on various physiological systems including endocrine systems. In case of human, these are a matter of great concern. Assessing the metallic pollutants in different components of ecosystem is an important task for the researchers (Gragnaniello *et al.* 2001). Birds are used as bioindicators of detecting heavy metals (Cohen *et al.* 2000). The study of birds has, therefore, led to the development of bio-monitoring schemes that use indicator species to estimate the levels of heavy metal pollution.

It is generally difficult to find a bird species suitable as biological indicator. In a few studies, pigeons have been used as biological indicators, as they occupy a wide range of trophic levels in different food chains (Klein *et al.* 2008, Nam *et al.* 2004). The use of bird parasites as bio-indicators of environmental pollution has been scarcely studied. A parasite in its natural place within the host is affected by the occurrence of pollution by heavy metals (Popiolek *et al.* 2007, Selda and Ismail 2007, Sures 2008, Eira *et al*. 2009, Shahat *et al.* 2011). Some studies have reported that some helminth parasites are able to accumulate much more heavy metals than their hosts (Sures 2004). There is an intrinsic relationship between parasitism and pollution. The internal parasites decrease the sensitivity and resistance of hosts to toxic pollution resulting in increase in the spread of parasites through life cycles stages of the hosts (Eissa *et al.* 2011). Heavy metals pollution has become health risk, not only because of the threat to parasite in pigeon, but also in pigeon tissues consumption. Therefore, the problem of heavy metal contamination in the tissues of pigeon is increasing globally.

In Bangladesh, studies on heavy metals are difficult in the tissues of pigeons (Begum and Sehrin 2013). The aim of this study was to evaluate the accumulation of heavy metals in muscle scare tissue and liver tissue of pigeon, and these were compared with respective to maximum permissible limits established by law in order to ascertain whether this food could be considered suitable for human consumption. In addition, the present study aims at establishing a baseline data about the levels of toxic metals in the muscle tissues of resident pigeon and its parasites collected from the different places of Bangladesh. The finding would draw attention to the scientists about the possibility of using it as a bio-monitor for heavy metal pollution.

MATERIAL AND METHODS

Sample collection

The tissues and parasites from 60 pigeons were collected from households after slaughtering for daily consumption from five different geographical locations (viz. Manikgonj, Sripure, Tangail, Munshigonj and Daud kandi) of Bangladesh. Special care was taken to make sure that the collected pigeons were the adults more or less of the same of age. The pigeons were collected on monthly basis at regular intervals from July 2012 to June 2013. The muscular and liver tissues and cestode parasites in the pigeons were collected and frozen. The frozen samples were cleaned and washed with deionized water and chopped into pieces with the aid of a stainless steel knife which had been cleaned with acetone and hot distilled water prior to use. The samples were dried in an oven at 65^{o}C for 48 hours. The dried samples were powdered and finally dried at 105^{o}C in an oven until a constant weight was obtained (dry weight). The dried powders were preserved in clean bottles for subsequent analyses.

Chemical analysis

Two grams of the dried muscle, liver tissues and parasites samples were treated with 10ml of 14M nitric acid, 5ml of 13M perchloric acid and 5ml of demineralized water in a Teflon decomposition vessel. The vessel was put in a stainless steel container and heated for two hours at 150^{o}C in an electric oven. After decomposition, the solution was concentrated to 5ml in a Teflon beaker by heating on a hot plate. Finally, the solution was transferred to a 100ml volumetric flask and diluted upto the mark with demineralized water and 0.1N perchloric acid. The aqueous digest was analyzed directly using a Pye Unicam SP-2900 flame Atomic Absorption Spectrometer for Pb, Cd, Cr, Zn and Cu, and Hydride Generation Atomic Absorption Spectometer (HG–AAS) for As (Begum *et al.* 2005).

The accuracy of the analytical procedure was checked by analyzing the standard reference material (National Research Council, Canada; DORM-2 dogfish muscle).

RESULTS AND DISCUSSION

The elemental concentrations thus determined were in good agreement with the certified values, as shown in Table 1. All data were expressed in µg/g dry weight (dw).

Table 1. Comparison of the experimental values with certified values of standard reference materials DOMR-2 (Dogfish muscle) (µg/g dry weight basis).

Heavy metals	Concentration (µg/g)		Deviation (%)
	Certified values	Experimental values*	
As	18.00±1.10	17.56±0.52	2.51
Pb	0.065±0.007	0.067±0.021	2.99
Cd	0.043±0.008	0.041±0.014	4.88
Cr	34.70±5.50	35.53±4.50	2.39
Zn	25.60±2.30	26.37±2.65	2.92
Cu	2.34±0.16	2.30±0.15	1.74

*Average of three determination

The mean concentrations of the heavy metals detected in the muscle, liver and *R. micracantha* parasites of *C. livia* are presented in Table 2. There are differences in analyzed heavy metals which were observed among different tissues, but not among the locations. This research showed that heavy metal concentrations were significantly higher in the cestode parasites than the host tissues. The present results are in agreement with those observed by several investigators (Torres *et al.* 2010, Malek *et al.* 2007, Begum *et al.* 2013) in Table 3.

Table 2. Heavy metal concentrations (µg/g dry weight ± standard deviation) in the different tissues and the parasites of pigeons, *C. livia*.

Tissues/ Parasites	Locations	Arsenic	Lead	Cadmium	Chromium	Zinc	Copper
Muscle	Manikgonj	0.04	0.46	0.03	1.93	256.65	8.64
	Sripure	0.03	0.65	0.04	0.25	156.03	7.61
	Tangail	0.04	0.27	0.05	1.59	131.40	4.68
	Munshigonj	0.05	0.65	0.03	0.52	173.22	7.34
	Daud Kandi	0.02	0.42	0.03	0.96	192.00	5.81
	Range	(0.02–0.05)	(0.42–0.65)	(0.03–0.05)	(0.25–1.93)	(131.40–256.65)	(4.68–8.64)
	Mean	0.04±0.001	0.49±0.021	0.04±0.006	1.05±0.086	181.86±0.00	6.82±0.00
Liver	Manikgonj	0.03	1.74	1.37	1.68	259.80	27.19
	Sripure	0.07	2.57	0.75	1.83	180.67	32.10
	Tangail	0.04	3.20	2.14	3.08	210.50	36.87
	Munshigonj	0.07	2.18	0.23	2.36	275.07	34.35
	Daud Kandi	0.05	1.83	0.94	1.68	272.00	46.06
	Range	(0.03–0.07)	(1.74–3.20)	(0.23–2.14)	(1.68–3.08)	(180.67–275.07)	(27.19–46.06)
	Mean	0.05±0.010	2.30±0.010	1.09±0.086	2.13±0.00	239.61±0.248	35.31±0.135
Parasite	Manikgonj	0.19	5.02	1.48	2.86	292.51	23.94
	Sripure	0.25	2.33	2.58	7.98	270.74	12.16
	Tangail	0.16	2.80	1.99	1.58	333.60	16.79
	Munshigonj	0.08	2.98	2.85	1.55	212.52	18.67
	Daud Kandi	0.12	1.88	1.48	9.45	224.31	18.94
	Range	(0.08–0.25)	(1.88–5.02)	(1.48–2.85)	(1.55–9.45)	(212.52–333.60)	(12.16–23.94)
	Mean	0.16±0.025	3.00±0.179	2.08±0.052	4.68±0.357	266.74±1.074	15.08±1.074

Table 3. Comparison of heavy metal concentrations (µg/g dry weight) in the tissues and parasites of pigeon, *Columba livia* reported from different region of the world.

Location	Tissues/parasites	As	Pb	Cd	Cr	Zn	Cu	Reference
Spain	Muscle	0.22	0.37	0.02	2.01	40.33	13.28	
	Liver	0.19	0.96	0.36	1.72	135.00	11.24	Torres *et al.* 2010
	Raillietina micracantha	0.43	5.72	0.04	1.19	162.29	1.99	
Persian Gulf	Muscle		0.056	0.0017				
	Liver	–	0.039	0.066	–	–	–	Malek *et al.* 2007
	Paraorigmatobothrium sp.		2.57	0.065				
Persian Gulf	Muscle		0.056	0.0016				
	Liver	–	0.033	0.0019	–	–	–	Malek *et al.* 2007
	Anthobothrium sp.		1.55	0.059				
Bangladesh	Muscle	0.03	0.39	0.03	0.91	145.69	5.48	Begum *et al.* 2013
	Liver	0.05	2.85	1.10	3.37	239.75	35.02	
Bangladesh	Muscle	0.04	0.49	0.04	1.05	181.86	6.82	
	Liver	0.05	2.30	1.09	1.59	239.61	35.31	Present study
	Raillietina micracantha	0.16	3.00	2.08	4.68	266.74	15.08	

The results of a recent research suggest that arsenic act as an endocrine disruptor at extremely low concentrations (Stoica *et al.* 2000). In the present study, the arsenic concentrations were 0.04, 0.05 and 0.16 µg/g in the muscle, liver tissues and *R. micracantha*, respectively. Arsenic concentration was significantly higher in cestode parasite than the host muscle and liver tissues of the pigeon. The same distribution pattern of arsenic concentrations was reported in the pigeon of Spain (Torres *et al.* 2010).

Previously, lead was detected in *C. livia* resulted from the use of alkyl lead as an antiknocking agent in automobile gasoline (Nriagu 1990). Similarly lead is a ubiquitous pollutant which could find its way into the environment through discharge of industrial wastes from various industries and other sources. Similar behaviour has been reported (mean lead concentrations were 0.056, 0.033 and 1.55 µg/g in the muscle, liver and *Anthobothrium* spp.) in the shark from Persian Gulf (Malek *et al.* 2007). Since, the lead content in the muscle of pigeon in the present work correspond to 1.62 µg/g wet weight, careful attention should be paid to edible pigeon in Bangladesh.

In the present study, the highest concentration of cadmium was observed in the *R. micracantha* (2.08 µg/g) than the liver (1.09 µg/g) and muscle (0.04 µg/g) of *C. livia*. The different distribution pattern of cadmium concentrations was reported higher with 0.36 µg/g in the liver than the *R. micracantha* (0.04 µg/g) and the muscle (0.02 µg/g) in other pigeon from Spain (Torres *et al.* 2010). The maximum admissible value of cadmium for pigeon is 0.05 µg/g wet weight (European Commission 2001).

The chromium level in the muscle, liver and parasite of *C. livia* were 1.05, 2.13 and 4.68 µg/g, respectively, which is higher than the results observed by Torres *et al.* (2010) and Begum *et al.* (2013) as shown in Table 3. According to these results, it could be suggested that there is a dense chromium pollution that might have resulted from the effluents of different industries like the tannery industry (Mohanta *et al.* 2010, Ahmed *et al.* 2011) the effluents of which have adversely affected pigeon consumption of the local people of Bangladesh.

In the present study, zinc concentration was found in the muscle and liver (181.86 and 239.61 µg/g), while the highest concentration (266.74 µg/g) was detected in *R. micracantha* of the pegion. Similar distribution pattern was reported by Torres *et al.* (2010) who observed that zinc concentration in the muscle, liver and *R. micracantha* of pegion were 40.33, 135.00 and 162.29 µg/g, respectively.

Copper mean concentrations were 6.82 µg/g in the muscle and 35.31 µg/g in the liver, with the lowest levels 15.08 µg/g found in *R. micracantha* (Table 3). A significantly higher level of copper in the muscle than liver and *R. micracantha* has been observed by Torres *et al.* 2010, although our present value presented an opposite finding.

This research showed that the cestode parasite have almost higher metal concentrations than the muscle and liver tissues of pegion, except copper. It can be suggested that cestode parasite was the target organ, showing the detoxification and accumulation role of the parasite. The muscle is generally considered to have a weak accumulating potential (Erdogrul and Erbilir 2007, Uysal *et al.* 2009). Such pattern has been observed in a number of other studies, covering a wide spectrum of pigeon (Torres *et al.* 2010, Malek *et al.* 2007, Begum *et al.* 2013).

In Bangladesh, the recent average per capita consumption of fish/meat was 21 g/person/day for males and females of all ages (Begum *et al.* 2005). Since only the elemental concentration in the muscle of pigeon was measured in the present study, the dietary intake of elements from pigeon for Bangladeshi people cannot be estimated. However, in order to know the contribution of the dietary intake from pigeon to the recommended dietary allowance (RDA), we were forced to come up with an estimation using a calculation which employed the recent average per capita consumption (21 g). Compared to the RDA proposed by the NRC (1989) and the JECFA (2000), the estimated dietary intake from muscle of pigeon would constitute 0.08–6.80 % (0.15 % for arsenic, 1.14 % for lead, 0.33 % for cadmium, and 6.80 % for chromium). Therefore, it seems that the contributions of the dietary intake from pigeon to the

RDA do not become a serious problem. The ranges of international standards (Yamazaki *et al.* 1996) are 0.1–5, 0.5–10, 0.05–2, and 1 μg/g fresh weight of the muscle of pigeon for arsenic, lead, cadmium, and chromium, respectively. The arsenic, lead, cadmium, and chromium contents in the muscle of pigeon corresponded to 0.13, 1.62, 0.13 and 3.47 μg/g wet weights, respectively. This research showed that heavy metal concentrations in the muscle of pigeon were at acceptable levels for human consumption. On the other hand, the negative relations detected for heavy metal concentrations between muscle and *R. micracantha* emphasize a possible role of the cestode in heavy metals detoxification in host tissues.

The results of present research showed that the cestode parasite *R. micracantha* carried higher concentration of heavy metals than the muscles of *C. livia*. The concentrations of heavy metals in the muscles were not found to exceed the acceptable level for human consumption. The results strongly support the view that helminth parasites are extremely sensitive early warning bioindicators of heavy metal pollution, particularly in sensitive environments under threat where pollution levels are still relatively low. We further suggest that the cestode parasites of pigeons or birds could be useful indicators of heavy metal pollution in remote environment including Bangladesh where pigeons are a major component of the fauna. They may also have a beneficial effect on the health of their hosts by acting as heavy metal filters.

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