CATRINA (2019), 18 (1): 65-70

Human Health Risk via Cadmium Concentration in Different Tissues of Domesticated Japanese Quail (*Coturnix japonica*) and Wild Common Quail (*Coturnix coturnix*)

Basma M. Sheta [1*], Hazem T. Abd El-Hamid [2], Muhammad A. El-Alfy [2]

[1] Zoology Department, Faculty of Science, Damietta University, 34517 New Damietta, Egypt

[2] Marine pollution Department, National Institute of Oceanography and Fisheries, Egypt

ABSTRACT

Quail hunting is a major socioeconomic practice in Egyptian coastal areas. The accumulation of cadmium in feathers (chest and tail), muscle, kidneys and livers were analyzed and compared in both wild migratory and domesticated Japanese quails using atomic absorption spectrophotometry. Domesticated Japanese quail recorded higher concentrations of cadmium than the wild one. Cadmium concentration was higher in kidneys and livers than that in the pectoral muscle and feathers. To assess potential risk to human health, daily intake (EDI) and target hazard quotient (THQ) were calculated. The EDI in all tissues was within the permissible tolerable daily intake (PTDI) limit except for kidney values in domesticated species. THQ of all tested organs was less than one, indicating that harmful impacts are not expected. People should avoid eating kidneys and livers of quail in their diets but can safely feed on muscles as they accumulate low percentage of the toxic cadmium.

Keywords: Cadmium, EDI, Health risk, THQ and Quail.

INTRODUCTION

Wild quail (*Coturnix coturnix*) is a small undomesticated. This migratory bird quail migrate annually between breeding area in sub-Saharan Africa and wintering area in the south of Eurasia. They founded widely from central Siberia to Africa and distributed in west and south Europe (Johnsgard, 1988). Currently, there is an observed sever drop of the migratory population number (Derégnacourt *et al*., 2005). This led to place the common quail on the red list and evaluate it as of least concern in the present International Union for Conservation of Nature (IUCN) classification. *Coturnix coturnix* is considered as a migratory species recorded in Egypt and its breeding status is unclear. Hunting common wild quail was and still remains along the Mediterranean Sea all over Egypt in Autumn season each year. Autumn migration begins in mid-August, peaks in September, and continuous until November (Goodman *et al*., 1989). Damietta coastal area is considered one of the main hotspots for common quail hunting every year (Sheta *et al*., 2010). On the other side, domesticated Japanese quails are raised for meat and egg production around the world, and quail products are often consumed as a delicacy in festive occasions (Minvielle, 2004). Unlike the wild one, domestic Japanese quail has transferred to sedentary bird rather than migrated birds.

Many factors shapes the accumulation of heavy metals, such as geographical location, time of exposure, interactions with other toxins, form of the metal, species differences in physiology, sex, age, or intraspecific variations in diet. Migration patterns must also be considered, because some birds stopover in areas of high local contamination more than others (Lewis and Furness, 1993).

Cadmium (Cd) is an element that has a toxicological effect on both animals and Human as well. It is found at low concentrations throughout the environment, especially in big cities with high industrial activities and near to highways. Cd is present in soils (Wang *et al*., 2015), and transferred from soil to plants, especially rice (Sebastian and Prasad, 2014), one of the main human daily meal component. Industrial activities add quantities of cadmium to the surrounding environment as air, water and food pollutants. Cd has a severe impact on human health, like its effect on hypertension and cardiovascular diseases (Nigra *et al*., 2016) and on women reproductive health (Pollack *et al*., 2014). Exposure to Cd has a carcinogenic effect and can cause prostate and breast cancer (Pan *et al*., 2010) and kidney diseases, and can lead to diabetes (Li *et al*., 2017).

Damietta is one of the main industrial governorates in Egypt. The increase in urbanization, people settlements and wastewater drainages provide a good source for heavy metal accumulation in general and cadmium in specific. Our primary objective was to determine the differences in cadmium levels between migratory wild and domesticated quail. We have analyzed its concentration in the chest and tail feathers, muscle, kidney and liver and estimated the severity and hazards due to consumption of quail to human health.

MATERIALS AND METHODS

Study Area

Damietta is one of the Nile Delta governorates and suited in the northeastern part of Egypt coastal area with moderate climate. Includes over 1.5 million of human population. It is characterized by typical Mediterranean fairly cool rainy winter and warm dry summer with small diurnal temperature variations. Precipitation occurs mostly in winter. The observed amount of average rainfall in the study area is estimated at about 107 mm. Maximum air temperature approaches 30^{o}C in July while the minimum air temperature falls to 8.4^{o}C in January. Wind blows from the northwestern direction most of the year throughout the coastal zone of the Nile

* *Corresponding author e-mail: basmasheta@du.edu.eg*

Delta. However, some other directions, such as the southwest and the northeast significantly occur, particularly during winter and spring, respectively (Fig. 1).

Samples collection

Samples were collected during quail hunting season in autumn 2016. Feathers (chest and tail), muscles, kidney and liver tissue were collected from each individual. Totally, ten migratory quail were collected from Damietta bird market. Also, ten domesticated quail were collected from Damietta poultry market.

Analysis of Cadmium concentrations

Tissue samples (100 mg) were oven dried at 70 °C for 24 h or until a constant dry mass was achieved. Then, the dried samples were pulverized, using a mortar. A known weight of sample tissue was taken in gm. Each sample was placed in a mixture of 70% nitric acid and 30% hydrogen peroxide (2:1) for digestions at room temperature overnight, according to a standard analytical method (AOAC, 1984). After cooling, the solution was diluted to 50 ml with deionized water. Following digestion, the solutions were filtered through a 0.45 µm acid-resistant filter paper. The samples were stored at 4°C for subsequent metal analyses in labeled, acid-washed, metal-free bottles. All glassware used in the Cd assessment was soaked in 10% nitric acid solution for 48 h and rinsed with deionized water prior to use. The concentration of Cd was determined by the Flame Atomic Absorption Spectrophotometer. Duplication of each analysis was taking place; blank and standard samples were analyzed every 20 samples.

Assessment of human health risk

Target Hazard Quotients (THQ)

Health risk to Egyptian population from quail intake was characterized by Target Hazard Quotient (THQ). This is the Proportion between the exposure and the reference doses (RFD). RFD means the daily standardized acceptable oral dose of a toxin in which the people may be exposed over a lifetime in a continuous way without an appreciable risk of harmful effects (Akoto *et al*., 2014). RFD value for Cd is 0.001 µg/g bw/day (USEPA, 2006). There is no risk to the human population if the ratio is less than 1 while the human population will suffer potential health risk if the ratio is equal or greater than 1. The following equation is used (Chien *et al*., 2002):

$$\text{THQ} = \frac{EF \times ED \times FIR \times C}{RFD \times BW \times AT} \times 10^{-3}$$

Where THQ is the target hazard quotient; EF is exposure frequency (365 days/year); ED is the exposure duration (average lifetime); FIR is the food ingestion rate; C is the heavy metal concentration in poultry (µg/g); RFD is the reference dose (0.001 µg/g bw/day); BW is the average adult body weight; and AT is the averaging exposure time (365 days/ year × number of exposure years). The THQ is the proportion of daily intake to the RFD amount. If THQ is less than one, toxic effects are not expected to occur. THQ > 1.0 means a health risk associated with that contaminating metal (Khan *et al*., 2008).

Estimated daily intake of metals (EDI)

According to Singh *et al*. (2010), the estimated daily intake of metals was determined by the following equation:

$$\text{EDI} = \frac{C \times D}{BW}$$

Where C is the metal concentration in bird tissue (µg/g), D is the food intake (g/individual), and BW is the average body weight.

Statistical Analysis

Statistical analysis of data was performed using SPSS version 19 statistical package programs. A one-way analysis of variance (ANOVA) was performed. A statistical difference between 2 groups was calculated using t-test. A difference in mean values was considered statistically significant if $P < 0.05$.

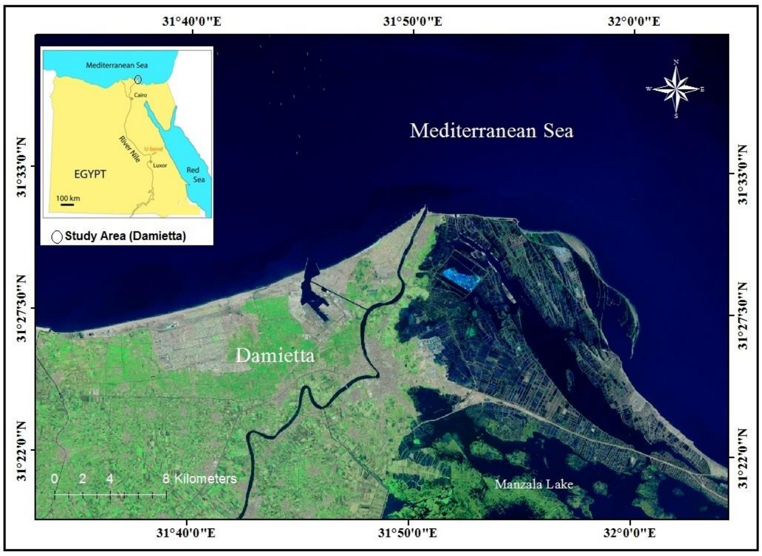

Figure (1): A map showing the studied area.

RESULTS

Quail is one of the birds that inhabit in coastal areas and it represents a favorable diet to most populations. Coastal areas suffered from variable contaminants in last decades. Spread of industrial and other anthropogenic activities in these areas negatively affected the biodiversity and food quality for those populations. Human activities considered the main source of cadmium in the surrounding environment around us. Cadmium is a non-essential element, has a harmful impacts on birds like oogenesis, damage of testis, oviduct and kidney (Malik and Zeb, 2009).

Higher concentrations of Cd may also affect the metabolic processes through replacement of essential elements at the active sites of biologically important molecules, thus indirectly inducing nutritious deficiencies (Furness, 1996). Our data revealed differential deposition of cadmium in different organs of both tested bird samples. As shown in (Fig. 2), the mean concentrations of Cd in domesticated Japanese quail were 153.94 ± 81.03, 69.05 ± 18.26, 15.30 ± 3.18, 12.05 ± 3.09 and 40.21 ± 9.03 µg/g of dry weight (mean ± SEM) for kidney, liver, muscles, tail and wing feathers and chest feathers, respectively. Cadmium was more accumulated in the kidneys and liver of domesticated Japanese quail bird whereas muscles and tail and wing feathers showed the lowest accumulation. The mean concentrations of Cd in wild common quail were 91.66 ± 41.66, 18.74 ± 4.13, 5.35 ± 1.84, 11.43 ± 2.48 and 23.89 ± 4.16 µg/g of dry weight for kidney, liver, muscles, tail and wing feathers and chest feathers, respectively. Cadmium was accumulated mostly in kidneys and tail and wing feathers of wild common quail whereas muscles and liver accumulated lower amounts. This difference between different tissues may be attributed to the nature of each tissue in the potentiality of metal accumulation (Begum and Sehrin, 2013). However, among different tissues in both species the concentration of Cd was with no significant difference. Also, the high concentration of Cd in kidneys in both species could be attributed to the temporary deposition of Cd and the role of this organ in detoxification of toxic metals (Johansen *et al.*, 2006).

The comparison of Cd in organs of both quail species (Fig. 2) revealed the following: 1) Cadmium concentration was higher in all measured organs of domestic quail than in the corresponding organs of wild quail. 2) Muscles of wild quail the part that can be eaten contained the lowest level of cadmium among all organs of both species.

Muscles of domesticated quail contained significantly higher level of Cd than that of wild species, but this level was still low, and lower than that in some other organs. 3) The concentration in tail and wing feathers, which reflects the direct immediate contact with the surrounding environment, was identical in both species, while it was higher in the newly grown chest feather that reflects the cadmium status in the animal. Again, it was higher by tendency in chest feathers of domestic quail (40.21 ± 9.03 µg/g) than that of wild quail (23.89 ± 4.16 µg/g).

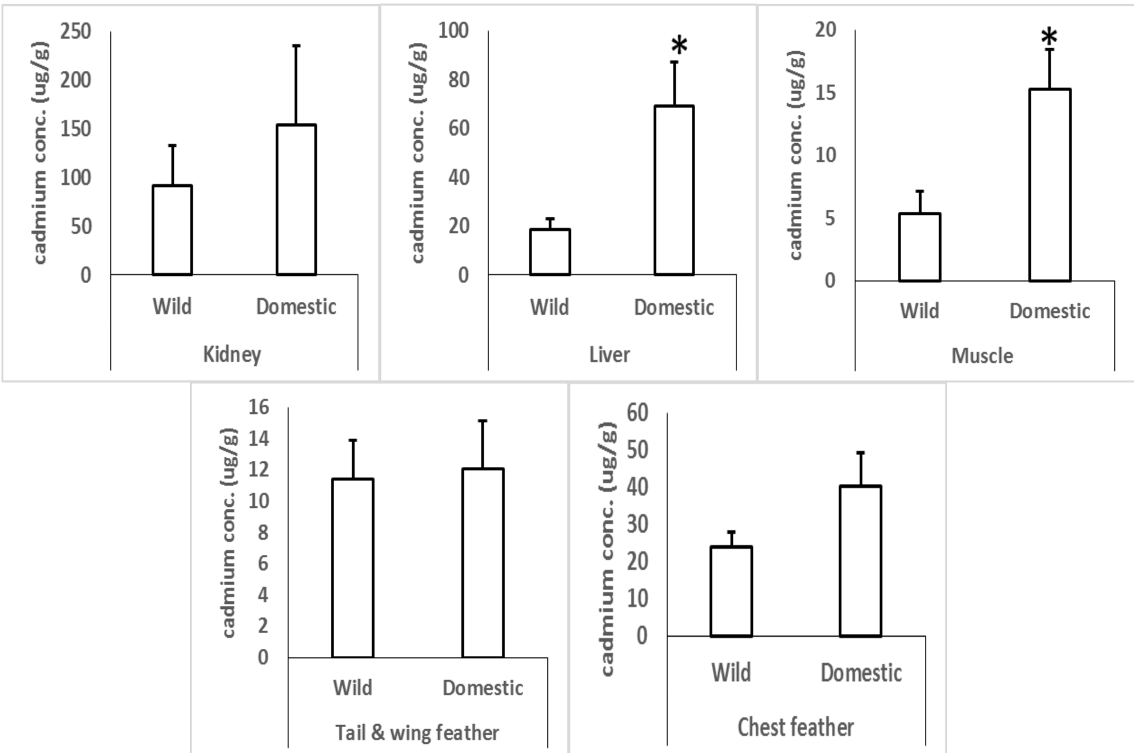

Figure (2): Comparison of cadmium concentrations (µg/g dry weight) in different organs between domesticated Japanese quail (*Coturnix japonica*) and wild common quail (Coturnix *coturnix*). Data are mean ± SEM of n =10. Statistical analysis: the * indicates statistically significant difference between both groups (student's t-test).

Target hazard quotient (THQ)

Estimate of health risk was determined in the present study based on the metal levels found in the kidney, liver and muscles of domesticated and migratory wild quails. To estimate the human health risk that can result from consuming contaminated tissues of quail, the reference dose of Cd (0.001 µg/kg bw/day) was used to determine the hazard quotients (THQs). Different levels of exposure to these metals were considered based on the frequency of quail consumption.

The THQ of domesticated Japanese quail from Cd contaminated tissues in a frequency of quail consumption seven days a week was 0.25 ± 0.12, 0.09 ± 0.03 and 0.03 ± 0.01 for kidney, liver and muscles, respectively. On the other hand, THQ of wild common quail from Cd contaminated tissues in a frequency of quail consumption seven days a week was 0.15 ± 0.07, 0.03 ± 0.01 and 0.02 ± 0.01 for kidney, liver and muscle, respectively. Comparison of THQ between wild and domesticated quails (Fig. 3) showed higher values in domesticated than in wild migratory quails. However, the difference was significant only between livers of both species. The values of THQ were below the risk level in all samples for both species. According to the results, the calculated THQ values indicate no risks to human health caused by exposure to Cd for quail kidney, liver and muscle. These individual characterizations can be excellent indicators of potential problems related to contaminants, but not sufficient to express the combined risk of Cd in tissues. Values of THQ were higher than those calculated by Mahmoud and Abdel-Mohsein (2015) for liver and lower than Muscles.

Estimated Daily Intake (EDI)

Cadmium intake may cause kidney damages including tubular dysfunction, evidenced by an increased excretion of low molecular weight proteins or enzymes (Satarug *et al*., 2018). Skeletal damages were first reported in Japan in the 1950s as the itaiitai syndrome (a combination of osteomalacia and osteoporosis), and were reported to happen in moderately low cadmium exposure, demonstrated by low bone mineral density (osteoporosis) and fractures (Nordberg *et al*., 2002). The estimated intakes of diet in this study were compared with those in the recommendations of FAO/ WHO (2011) to determine the toxicological potential health risk of Cd, which settled a reference value for the tolerable intake of metals.

According to FAO/WHO (2011), the Permissible tolerable daily intake (PTDI) for 70 kg person is 70 µg/day for Cd Daily intake of Cd was higher in liver than kidney and muscles. Mean EDI of domesticated Japanese quail was 78.51 ± 41.32, 28.23 ± 9.44 and 7.84 ± 1.86 µg/day for kidney, liver and muscles, respectively. Mean EDI of wild common quail was 46.74, 7.66 and 5.49 µg/day for kidney, liver and muscles, respectively (Fig. 4). These results indicate that all mean values of EDI were lower than the permissible tolerable daily intake except for kidney in domesticated species. These values were higher than those for muscles and liver observed by Mahmoud and Abdel-Mohsein (2015).

We conclude that domesticated and migratory quail species have different potentialities to accumulate concentrations of Cd in their tissues that might be due to interspecific speciation. It is obvious that kidneys of both species accumulate Cd more than other organs. Calculated THQ and EDI of the dietary exposure of the population revealed no imminent risk to health from exposure to excess consumption of quail meat when eating kidneys or livers is avoided.

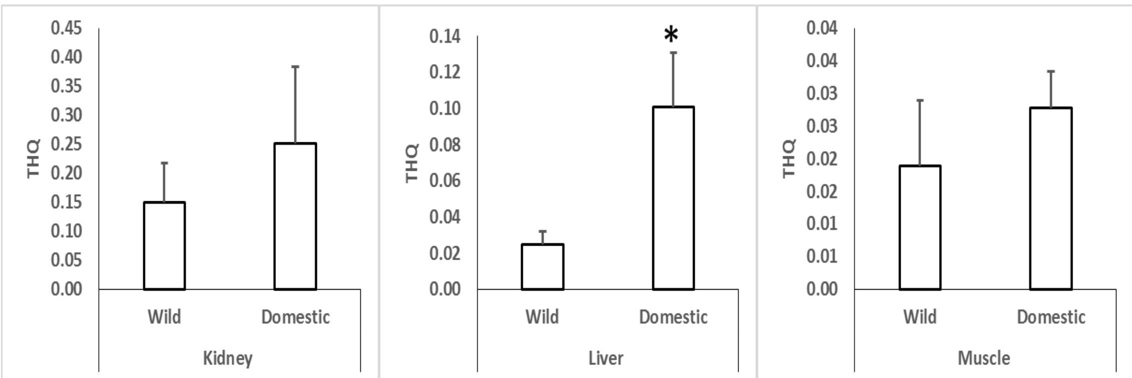

Figure (3): Comparison of Target Hazard Quotient (THQ) in different organs between domesticated Japanese quail (*Coturnix japonica*) and wild common quail (Coturnix *coturnix*). The calculation equation of this quotient is mentioned in the Material and Methods section. Data are mean ± SEM of n =10. Statistical analysis: the * indicates statistically significant difference between both groups (student's t-test).

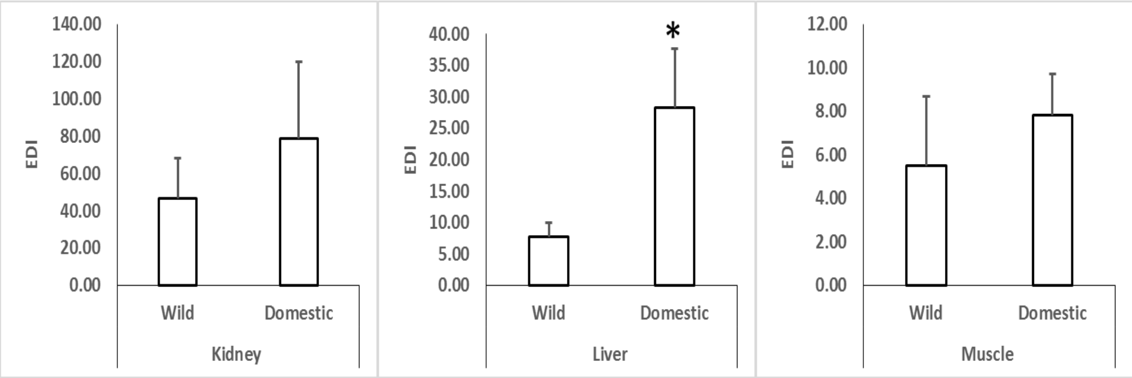

Figure (4): Estimated daily intake (EDI) of cadmium in different organs of domesticated Japanese quail (*Coturnix japonica*) and wild common quail (Coturnix *coturnix*). The estimation method is mentioned in the Material and Methods section. Data are mean ± SEM of n =10. Statistical analysis: the * indicates statistically significant difference between both groups (student's t-test).

Compliance with ethical standards

Conflict of interest: The authors declare that they have no competing interests.

Ethical approval: This article does not contain any studies with human participants performed by any of the authors.

REFERENCES

AKOTO, O., E.F. BISMARK, G. DARKO, AND E. ADEI. 2014. Concentrations and Health Risk Assessments of Heavy Metals in Fish from the Fosu Lagoon. Int. J. Environ. Res. 8(2): 403-410

AOAC. 1984. Association of official analytical chemists. In official methods of association of official analytical chemists. Washington, DC: AOAC, pp 418.

BEGUM, A., AND S. SEHRIN. 2013. Levels of Heavy Metals in Different Tissues of Pigeon (*Columba livia*) of Bangladesh for Safety Assessment for Human Consumption. Bangladesh Pharmaceutical Journal 16(1): 81-87.

CHIEN, L.C., T.C. HUNG, K.Y. CHOANG, C.Y. YEH, P.J. MENG, M.J. SHIEH, AND B.C. HAN. 2002. Daily intake of TBT, Cu, Zn, Cd and as for fishermen in Taiwan. The Sci. Tot. Environ., 285(1-3): 177-185.

DEREGNACOURT, S., J.C. GUYOMARC'H, AND M. BELHAMRA. 2005. Comparison of migratory tendency in European quail Coturnix c. coturnix, domestic Japanese quail Coturnix c. japonica and their hybrids. Ibis 147: 25- 36.

FAO/WHO. 2011. (Food and Agriculture Organisation, World Health Organization). 2011. Evaluations of certain contaminants in food. Seventy-second report of the Joint FAO/WHO Expert Committee on Food Additives. Series 959.

FURNESS, R.W. 1996. Cadmium in birds. In: Beyer, W.N., Heinz, G.H., Redmom-Norwood, A.W. (Eds.), Environmental Contaminants in Wildlife: Interpreting Tissues Concentrations. Lewis Press, Boca Raton, pp. 389-404.

GOODMAN, S.M., P.L. MEININGER, S.M. BAHA EL DIN, J.J. HOBB, AND W.C. MULLIE (EDS.). 1989. The birds of Egypt. Oxford: Oxford Unive-rsity Press.

JOHANSEN, P., H.S. PEDERSEN, G. ASMUND, AND F. RIGET. 2006. Lead shot from hunting as a source of lead in human blood. Environ. Pollut. 142: 93.

JOHNSGARD, P.A. 1988. The quails, partridges, and francolins of the world. Oxford University Press, Oxford.

KHAN, S., Q.Y.Z. CAO, Y.G. HUANG, AND Y.G. ZHU. 2008. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environ. Pollut., 125(3): 686-692.

LEWIS, S.A., AND R.W. FURNESS. 1993. The role of eggs in mercury excretion by Quail *Coturnix coturnix* and the implications for monitoring mercury pollution by analysis of feathers. Ecotoxic-ology, 2: 55-64.

LI, Y., Y. ZHANG, W. WANG, AND Y. WU. 2017. Association of urinary cadmium with risk of diabetes: a meta-analysis. Environ Sci. Pollut. Res. 24: 10083-10090.

MAHMOUD, M.A.M., AND H.S. ABDEL-MOHSEIN 2015. Health Risk Assessment of Heavy Metals for Egyptian Population via Consumption of Poultry Edibles. Advances in Animal and Veterinary Scien-ces, 3(1): 58-70.

MALIK, R.N., AND N. ZEB. 2009. Assessment of environmental contamination using feathers of Bubulcus ibis L., as a biomonitor of heavy metal pollution, Pakistan. Ecotoxicology, 18: 522-536.

MINVIELLE, F. 2004. The future of Japanese quail for research and production. Worlds Poult Sci J, 60: 500-507.

NIGRA, A.E., A. RUIZ-HERNANDEZ, J. REDON, A. NAVAS-ACIEN, AND M. TELLEZ-PLAZA. 2016. Environmental Metals and Cardiovascular Disease in Adults: A Systematic Review Beyond Lead and Cadmium. Curr Envir Health Rpt. 3: 416.

NORDBERG, G., T. JIN, A. BERNARD, S. FIERENS, J.P. BUCHET, T. YE, Q. KONG, AND H. WANG. 2002. Low bone density and renal dysfunction following environmental cadmium exposure in China. Ambio. 31(6): 478-481

PAN, J., J.A. PLANT, N.VOULVOULIS, C.J. OATES, AND C. IHLENFELD. 2010. Cadmium levels in Europe: implications for human health. Environ Geochem Health. 32:1-12

POLLACK, A. Z., S. RANASINGHE, L.A. SJAARDA, AND S.L. MUMFORD. 2014. Cadmium and Reproductive Health in Women: A Systematic Review of the Epidemiologic Evidence. Curr. Envir. Health Rpt., 1: 172-184

SATARUG, S., W. RUANGYUTTIKARN, M.

NISHIJO, AND P. RUIZ. 2018. Urinary Cadmium Threshold to Prevent Kidney Disease Development. Toxics, 6, 26, doi:10.3390/toxics6020026.

SEBASTIAN, A., AND M. PRASAD. 2014. Cadmium minimization in rice. A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 34 (1): 155-173. .

SHETA, B.M., M.A. BEDIR, G. ORABI, M.M. ELBOKL, AND L.Z. HABBAK. 2010. Impact of some human activities on bird species biodiversity at Damietta region-Egypt. CATRINA. 5(1): 49-61

SINGH, A., R. SHARMA, M. AGRAWAL, AND F. M. MARSHALL. 2010. Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. Tropical Ecology, 51(2S): 375-387.

USEPA. 2006. United States, Environmental Protection Agency, Integrated Risk Information System, [http://www.epa.gov/iris/substS].

WANG, L., X. CUI, H. CHENG, F. CHEN, J. WANG, X. ZHAO, C. LIN, AND X. PU. 2015. A review of soil cadmium contamination in China including a health risk assessment. Environ. Sci. Pollut. Res., 22 (21): 16441-52

المخاطر الصحية للانسان لتركيز عنصر الكادميوم في الأنسجة المختلفة للسمان البلدي (*كوتيرنيكس جابونيكا*) و السمان المهاجر (*كوتيرنيكس كوتيرنيكس*)

بسمة محمد شتا [1]، حازم طة عبد الحميد [2]، محمد عبد الهادى الألفي [2]

[1] قسم علم الحيوان، كلية العلوم، جامعة دمياط، مصر
[2] قسم التلوث البحري، شعبة البيئة البحرية، المعهد القومي لعلوم البحار و المصايد-مصر

الملخص العربي

يعتبر صيد السمان في موسم الخريف واحد من اهم الممارسات الاجتماعيه والاقتصادية على امتداد ساحل مصر الشمالي. تم تحليل تركيز عنصر الكادميوم في الريش (الصدرى والذيلى) والعضلات و الكليتين والكبد في كل من السمان البلدي والسمان المهاجر وذلك باستخدام جهاز الامتصاص الذري. سجل السمان البلدي المستأنس نسبه أعلي من عنصر الكادميوم من السمان المهاجر البري. كان تركيز الكادميوم أعلي في الكلي والكبد أكثر من تلك التى في العضلات الصدرية والريش. لتقييم المخاطر المحتمله على صحة الانسان، تم حساب المدخول اليومي (EDI) والخطر المستهدف (THQ) في كل الأعضاء محل الدراسة. كان المدخول اليومي (EDI) في جميع الأنسجة فى إطار الحد المسموح به باستثناء القيم المسجلة في كلية السمان البلدي المستأنس. وكان الخطر المستهدف (THQ) في جميع الأعضاء محل الدراسة اقل من واحد، مشيرا الى الى أن الأثار الضارة ليست متوقعة حتى تاريخ هذه الدراسة. يجب على الناس تجنب تناول كلي وكبد السمان في وجباتهم الغذائية ولكن يمكنهم التغذية بأمان على العضلات وذلك لتراكم الكادميوم بنسبه قليله فيها.