Levels of trace metals in three fish species *Decapterus macarellus*, *Decapterus macrosoma* and *Decapterus russelli* of the family carangidae from the Gulf of Aqaba, Red Sea, Jordan

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ABSTRACT

Fishes of the family Carangidae, *Decapterus macarellus*, *Decapterus macrosoma*, and *Decapterus russelli*, were collected from the Jordanian Aqaba coast during 2008-2009 for the determination of their metal concentrations in various organs (muscle, liver, kidney, gonads, gills, and stomach food contents) using flame atomic absorption spectrometry (AAS). The results showed significant differences in metal concentration between species. The present study indicated significant differences of heavy metal elements among different organs of the same species. The results did not reveal any significant differences between male and female organs, and the only significant difference were found for Pb in *Decapterus macrosoma* and for Cu in *Decapterus russelli*. The low metal concentrations found in muscle tissue (in all studied species) has implications for human health.

Keywords: Trace Metals; *Decapterus* Fish; Gulf of Aqaba; Jordan

1. INTRODUCTION

Fish is widely consumed by many people of the world because it has high protein content and low saturated fatty acids such as omega fatty acids, which support good health [1]. *Decapterus macarellus*, *Decapterus macrosoma*, and *Decapterus russelli* of the family Carangidae were popular among commercial fishes, representing approximately 14.5% of the marine Jordanian catch [2].

Human activities such as metal-related industries have greatly increased the input of heavy metals into the aquatic systems, where these metals are accumulated by aquatic organisms and may be further transferred up to top trophic levels [3]. Many plant and animal species have been suggested as bioindicators for monitoring a variety of contaminants in the marine ecosystem [4,5]. Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water [6]. Fish is constantly exposed to pollutants through water and food, which can result in bioaccumulation and biomagnifications occurring in different fish organs. Fish have been found to be good indicator for heavy metal contamination in aquatic systems [7,8].

Several studies on metal concentrations in fish have been reported from the Jordanian coast of the Gulf of Aqaba [9-15]. The aim of this work was to determine the concentrations of Cu, Ni, Mg, Pb, Zn, Cd and Fe in the muscle, liver, kidney, gonad and gills of the fishes *Decapterus macarellus*, *Decapterus macrosoma*, and *Decapterus russelli* collected from the Gulf of Aqaba.

2. MATERIAL AND METHODS

2.1. Study Area

The Gulf of Aqaba is a partially enclosed water body that constitutes the eastern segment of the V-shaped northern extension of the Red Sea (Figure 1). It is located in a sub-tropical arid area between longitude 34°25’E to 35°00’E and latitude 28°00’N to 29°33’N. The Gulf of Aqaba is 180 km long and has a maximum width of 25 km, which decreases at the northern tip to about 5 km. It is connected to the Red Sea through the Straits of Tiran, which has a depth of about 252 m [16]. The present study area lies within the Jordanian portion of the Gulf of Aqaba, which is situated at the northern tip of the Gulf and extends south for about 27 km to the Saudi Arabia boarder.
2.2. Fish Species

The fish species which were under investigation in this study are Decapterus macarellus, commonly known as Mackerel Scad, and D. macrosoma commonly known as Shortfin Scad usually form large schools mostly in open water, feeding primarily on zooplankton, zoobenthos and other planktonic invertebrates and D. russelli known as Indian Scad, form large schools in deep water from middle to benthic zones, feeding mainly on zooplankton, zoobenthos, benthic crustaceans and nektoms [17,18].

2.3. Sampling Design and Sampling Processing

The fishes were collected during 2008 and 2009 in the northern Gulf of Aqaba. All species were caught by gill-net. The fishing gear was set up with a local fisherman using a small boat of 7 m length provided with a 40-horse-power engine approximately 2000 m from the northern beach. Immediately after capture, the fishes were kept in an ice-box and transferred to the laboratory of the Marine Science Station in Aqaba. The specimens
were identified to species level. After measuring total length, each fish was dissected using a plastic knife. The sex of each specimen was determined, and samples of muscle, liver, kidney, gonads, gills, and stomach food contents were taken, rinsed with distilled water, and oven dried at 85°C to constant weight. Sub-samples of each organ were homogenized, and a weight of 0.5 to 1.0 g was taken in a porcelain crucible and ash dried at 540°C. Samples were mixed with 5 ml of 2M HCL, heated in the crucible on a hot plate at 100°C for half hour, and cooled to room temperature, after which the sample solution was filtered through a Whatman No. 43 filter paper into a 25 ml volumetric flask and filled to the mark with deionized water. Final metal concentrations of (Cu, Ni, Mg, Pb, Zn, Cd and Fe) were measured using Flame Atomic Absorption Spectrometer available at the University of Jordan/Chemistry Department. One-way analysis of variance (Table 3) showed significant differences between different organs of D. macarellus for Cu (p = 0.03), Mg (p = 0.0001), Cd (p = 0.0001) and Fe (p = 0.0001). Whereas, Pb (p = 0.5) and Zn (p = 0.41) did not show any significant differences.

The results in Table 4 showed significant differences between different organs of D. macarellum in different fish organs such as gills, gonads, kidney, liver and muscle are given in Table 5. The results included significant differences between different organs of D. macarellum for Cu (p = 0.03), Mg (p = 0.0001), Cd (p = 0.0001) and Fe (p = 0.0001). In contrast, Cu (p = 0.56) and Pb (p = 0.67) did not show any significant differences (Table 5).

The results in Table 4 showed significant differences between different organs of D. macarellum and D. macarellus for Cu (p = 0.02), Mg (p = 0.0001), Zn (p = 0.0001), and Fe (p = 0.0001). There were no significant differences for Ni (p = 0.94), Pb (p = 0.7) and Cd (p = 0.17). In general the low metal concentrations were found in muscle tissue, whereas the highest concentrations of Cu, Pb, Cd and Fe were identified at species level.

### 3. RESULTS

#### 3.1. Comparison between SPECIES

The mean metal concentration for Ni and Mg in the three fish species D. macarellus, D macrosoma and D. russelli showed significant differences (p = 0.0002 and p = 0.0129, respectively). The highest Ni concentration was found in D. macarellus (4.16 μg/g), followed by D. macrosoma (3.17 μg/g) and D. russelli (0.60 μg/g), whereas the highest Mg concentration was found in D. russelli (1034 μg/g), followed by D. macarellus (872 μg/g) and D. macrosoma (671 μg/g). On the other hand Cu, Pb, Zn, Cd and Fe did not show any significant differences (Table 1).

#### 3.2. Comparison between Organs

Mean metal concentrations for Cu, Ni, Mg, Pb, Zn, Cd and Fe in D. macarellus in different fish organs such as gills, gonads, kidney, liver and muscle are given in Table 2. The results showed significant differences between different organs of D. macarellum for Cu (p = 0.03), Mg (p = 0.0001), Cd (p = 0.0001) and Fe (p = 0.0001). Whereas, Pb (p = 0.5) and Zn (p = 0.41) did not show any significant differences.

The results in Table 3 showed significant differences between different organs of D. macrosoma for Ni (p = 0.0001), Mg (p = 0.0001), Zn (p = 0.0001), Cd (p = 0.03) and Fe (p = 0.0001). In contrast, Cu (p = 0.56) and Pb (p = 0.67) did not show any significant differences (Table 3).

The results in Table 4 showed significant differences between different organs of D. russelli for Cu (p = 0.02), Mg (p = 0.0001), Zn (p = 0.0001), and Fe (p = 0.0001). There were no significant differences for Ni (p = 0.94), Pb (p = 0.7) and Cd (p = 0.17). In general the lowest metal concentrations were found in muscle tissue, whereas the highest concentrations of Cu, Pb, Cd and Fe were identified at species level.

### Table 1. Mean metal concentration in μg/g of the fish samples collected from the Jordanian coast/Aqaba, Red Sea and the p-value.

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Cu X ± SD</th>
<th>Ni X ± SD</th>
<th>Mg X ± SD</th>
<th>Pb X ± SD</th>
<th>Zn X ± SD</th>
<th>Cd X ± SD</th>
<th>Fe X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>D. macarellus</td>
<td>7.37 ± 0.96</td>
<td>4.16 ± 0.75</td>
<td>872.75 ± 90.30</td>
<td>5.68 ± 1.56</td>
<td>142.8 ± 20.53</td>
<td>2.22 ± 0.23</td>
<td>483.78 ± 40.61</td>
</tr>
<tr>
<td>D. macrosumas</td>
<td>6.56 ± 0.30</td>
<td>3.17 ± 0.54</td>
<td>671.03 ± 35.94</td>
<td>1.80 ± 0.28</td>
<td>94.57 ± 8.12</td>
<td>2.32 ± 0.15</td>
<td>377.06 ± 23.59</td>
</tr>
<tr>
<td>D. russelli</td>
<td>7.98 ± 0.82</td>
<td>0.60 ± 0.09</td>
<td>1034.28 ± 75.10</td>
<td>1.06 ± 0.15</td>
<td>106.51 ± 10.56</td>
<td>1.74 ± 0.13</td>
<td>383.53 ± 20.47</td>
</tr>
<tr>
<td>p-value</td>
<td>0.83</td>
<td>0.00</td>
<td>0.01</td>
<td>0.12</td>
<td>0.18</td>
<td>0.62</td>
<td>0.13</td>
</tr>
</tbody>
</table>

### Table 2. Mean metal concentration in μg/g of selected fish organs: Gill, gonads, kidney, liver and muscle of D. macarellum collected from Jordanian coast/Aqaba, Red Sea.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Cu X ± SD</th>
<th>Ni X ± SD</th>
<th>Mg X ± SD</th>
<th>Pb X ± SD</th>
<th>Zn X ± SD</th>
<th>Cd X ± SD</th>
<th>Fe X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>3.87 ± 0.31</td>
<td>9.81 ± 0.83</td>
<td>1637.76 ± 84.00</td>
<td>2.03 ± 0.23</td>
<td>97.76 ± 8.38</td>
<td>0.16 ± 0.05</td>
<td>331.11 ± 15.25</td>
</tr>
<tr>
<td>Gonads</td>
<td>3.31 ± 0.25</td>
<td>2.79 ± 0.28</td>
<td>563.40 ± 20.46</td>
<td>14.26 ± 2.16</td>
<td>223.80 ± 8.42</td>
<td>0.25 ± 0.04</td>
<td>215.45 ± 4.85</td>
</tr>
<tr>
<td>Kidney</td>
<td>7.45 ± 0.50</td>
<td>4.10 ± 0.81</td>
<td>933.48 ± 62.31</td>
<td>7.07 ± 0.26</td>
<td>168.91 ± 5.62</td>
<td>1.95 ± 0.27</td>
<td>1035.56 ± 20.44</td>
</tr>
<tr>
<td>Liver</td>
<td>19.73 ± 0.87</td>
<td>1.66 ± 0.22</td>
<td>501.00 ± 11.19</td>
<td>3.72 ± 0.50</td>
<td>110.10 ± 3.94</td>
<td>8.38 ± 0.98</td>
<td>732.77 ± 5.83</td>
</tr>
<tr>
<td>Muscle</td>
<td>2.56 ± 0.06</td>
<td>2.48 ± 0.09</td>
<td>725.32 ± 13.66</td>
<td>1.31 ± 0.17</td>
<td>114.35 ± 9.44</td>
<td>0.35 ± 0.08</td>
<td>103.81 ± 7.68</td>
</tr>
<tr>
<td>p-value</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.50</td>
<td>0.41</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Table 3. Mean metal concentration in μg/g of selected fish organs gill, gonads, kidney, liver and muscle of *Decapterus macarosoma* collected from Jordanian coast, Aqaba, Red Sea.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Cu X ± SD</th>
<th>Ni X ± SD</th>
<th>Mg X ± SD</th>
<th>Pb X ± SD</th>
<th>Zn X ± SD</th>
<th>Cd X ± SD</th>
<th>Fe X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>5.15 ± 0.20</td>
<td>9.58 ± 1.20</td>
<td>1385.48 ± 20.18</td>
<td>2.28 ± 0.42</td>
<td>94.59 ± 2.15</td>
<td>0.99 ± 0.04</td>
<td>500.46 ± 10.03</td>
</tr>
<tr>
<td>Gonads</td>
<td>3.00 ± 0.38</td>
<td>1.25 ± 0.06</td>
<td>266.96 ± 8.16</td>
<td>1.39 ± 0.05</td>
<td>174.06 ± 8.62</td>
<td>1.17 ± 0.05</td>
<td>152.52 ± 7.82</td>
</tr>
<tr>
<td>Kidney</td>
<td>7.51 ± 0.96</td>
<td>2.86 ± 0.68</td>
<td>435.36 ± 10.36</td>
<td>2.86 ± 0.04</td>
<td>95.97 ± 8.17</td>
<td>4.30 ± 0.51</td>
<td>611.50 ± 8.87</td>
</tr>
<tr>
<td>Liver</td>
<td>11.06 ± 0.86</td>
<td>1.09 ± 0.25</td>
<td>328.61 ± 8.00</td>
<td>1.34 ± 0.66</td>
<td>87.90 ± 4.17</td>
<td>3.86 ± 0.36</td>
<td>514.74 ± 28.66</td>
</tr>
<tr>
<td>Muscle</td>
<td>6.11 ± 0.15</td>
<td>1.09 ± 0.35</td>
<td>438.77 ± 12.77</td>
<td>1.12 ± 0.23</td>
<td>20.30 ± 1.35</td>
<td>1.26 ± 0.15</td>
<td>106.08 ± 6.15</td>
</tr>
</tbody>
</table>

*p*-value 0.56 0.00 0.00 0.67 0.00 0.03 0.00

Table 4. Mean metal concentration in μg/g of selected fish organs gill, gonads, kidney, liver and muscle of *Decapterus russelli* collected from Jordanian coast/Aqaba, Red Sea.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Cu X ± SD</th>
<th>Ni X ± SD</th>
<th>Mg X ± SD</th>
<th>Pb X ± SD</th>
<th>Zn X ± SD</th>
<th>Cd X ± SD</th>
<th>Fe X ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gills</td>
<td>5.98 ± 0.28</td>
<td>0.69 ± 0.19</td>
<td>2190.87 ± 80.11</td>
<td>1.44 ± 0.24</td>
<td>95.50 ± 6.56</td>
<td>1.08 ± 0.08</td>
<td>258.71 ± 12.54</td>
</tr>
<tr>
<td>Gonads</td>
<td>5.21 ± 0.16</td>
<td>0.44 ± 0.08</td>
<td>586.31 ± 8.11</td>
<td>1.31 ± 0.09</td>
<td>262.44 ± 9.51</td>
<td>2.05 ± 0.29</td>
<td>1244.06 ± 12.40</td>
</tr>
<tr>
<td>Kidney</td>
<td>12.27 ± 1.08</td>
<td>0.80 ± 0.09</td>
<td>893.84 ± 20.03</td>
<td>1.16 ± 0.64</td>
<td>96.72 ± 2.78</td>
<td>2.23 ± 0.18</td>
<td>753.38 ± 6.67</td>
</tr>
<tr>
<td>Liver</td>
<td>11.90 ± 0.86</td>
<td>0.45 ± 0.02</td>
<td>767.00 ± 20.03</td>
<td>0.83 ± 0.22</td>
<td>74.55 ± 2.24</td>
<td>2.35 ± 0.18</td>
<td>574.52 ± 12.74</td>
</tr>
<tr>
<td>Muscle</td>
<td>4.36 ± 0.07</td>
<td>0.66 ± 0.08</td>
<td>703.52 ± 26.83</td>
<td>1.06 ± 0.24</td>
<td>23.60 ± 1.47</td>
<td>1.02 ± 0.12</td>
<td>100.44 ± 5.80</td>
</tr>
</tbody>
</table>

*p*-value 0.02 0.94 0.00 0.67 0.00 0.03 0.00

were mainly found in liver and kidney. Mg metal concentrations were highest in gills of all species, and that of Zn were highest in gonads of all species.

The present study indicated significant differences for most of the heavy metal elements among different organs of the same species, particularly the presence of low concentrations of Cu, Pb, Zn, Cd and Fe in the muscle of *D. macarellus* and low concentrations of Ni, Pb, Zn and Fe in the muscle of *D. macrosoma*. Similarly, in *D. russelli* the lowest concentrations of Cu, Pb, Zn and Cd were found in muscle. In contrast, the highest concentrations of Cu, Pb, Cd and Fe were mainly concentrated in liver and kidney. Mg metal concentration was highest in gills and Zn was highest in gonads.

4. DISCUSSION

The present investigation revealed significant differences in metal concentration between *D. macarellus*, *D. macrosoma* and *D. russelli*. Two of the species, *Decapterus macarellus* and *D. macrosoma*, occupy the same niche, feeding on similar food (zooplankton, zoobenthos and other planktonic invertebrates). In contrast, the third species, *D. russelli*, inhabits deep water from middle to benthic zones and feeds on zooplankton, zoobenthos, benthic crustaceans and nektons [17,18]. Our results are in accordance with the findings of Wahbeh [10], who found significant differences in heavy metal concentrations in six coral reef species from the same area. As in our study, they included species with different feeding habits, from piscivorous species such as the lizardfish (*Synodus variegates*) to those feeding on invertebrates, such as the goatfish (*Parupeneus barberinus*), or on algae, such as the Sergeant Major fish (*Abudefduf saxatilis*).

The general pattern was of significant differences for heavy metal concentrations between different organs for the three species *D. macarellus*, *D. macrosoma*, and *D. russelli*. This study revealed low heavy metal concentrations in muscle for most elements. Similar conclusions were reported by Abu Hilal [15], who found lower concentrations of metals in muscle versus liver, gonads, gills or stomach for three coral reef fish species collected from the Jordanian coast. Similarly Wahbeh [10] found that muscle contained lower metal concentrations than either liver or gonads.

In general, gills, liver and kidney contained relatively high metal concentrations for most elements. Similar conclusions were reported by Abu Hilal [15], who found lower concentrations of metals in muscle versus liver, gonads, gills or stomach for three coral reef fish species collected from the Jordanian coast. Similarly Wahbeh [10] found that muscle contained lower metal concentrations than either liver or gonads.

In general, gills, liver and kidney contained relatively high metal concentrations for the three *Decapterus* species studied during this investigation, indicating that these organs might be the major organs for metal uptake (gills) or final metal deposition (liver and kidney). These results are in agreement with those of previous studies [20-23]. In addition, our results indicated high metal concentrations of Cu in liver and kidney. High concentrations of Cu in fish liver has been reported to be asso-
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REFERENCES


