Copper and manganese in loggerhead turtles (Caretta caretta) tissues in the Mediterranean

ANTONIOU Z.K. University of Athens, Department of Chemistry Section III, Laboratory of Environmental Chemistry University Campus, 157 71 Athens

DASSENAKIS M. University of Athens, Department of Chemistry, Laboratory of Environmental Chemistry, Panepistimioupoli Zografou, 15771, Athens

PANAGOPOULOS D. ARCHELON, the Sea Turtle Protection Society of Greece Solomou 57, 104 32 Athens

SOFOULI E. ARCHELON, the Sea Turtle Protection Society of Greece Solomou 57, 104 32 Athens

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Z.K. ANTONIOU, M. DASSENAKIS, D. PANAGOPOULOS and E. SOFOULI

1 University of Athens, Department of Chemistry
   Section III, Laboratory of Environmental Chemistry
   University Campus, 157 71 Athens, Greece
   e-mail: edasenak@cc.uoa.gr

2 ARCHELON, the Sea Turtle Protection Society of Greece
   Solomou 57, 104 32 Athens, Greece

Abstract

This research concerns the determination of copper and manganese concentrations in tissues of loggerhead turtles (Caretta caretta) found injured in various locations of Greek waters. The specimens were transported through the National Stranding Network run by ARCHELON to the Sea Turtle Rescue Centre, and were treated there. Measurement of copper and manganese form the beginning of a further research that includes measurement of Cd, Pb, Fe and Ni. Our intention was to obtain initial data values in several tissues of (Caretta caretta) in Greek waters and detect any bioaccumulation trend. In general the highest concentrations for both Cu and Mn were measured in the liver. The lowest concentrations for Cu were found in the muscle samples and for Mn in the lung samples. There was no indication of bioaccumulation for either of the two metals or the examined tissues. However, a negative trend was observed between curved carapace length (CCL) and (a) intestine copper concentration and (b) liver and lung manganese concentration. The comparison between specimens from various territories showed that the results were in agreement, taking into account the size of the specimens.

Keywords: Caretta caretta; Copper; Manganese.

Introduction

Sea turtles are widely distributed in the world’s oceans, found in tropical, sub-tropical and temperate waters. From the seven remaining sea turtle species (LUTZ & MUSICK, 1997), only three are present in the Mediterranean Sea: Loggerhead (Caretta caretta), Green turtle (Chelonia mydas) and Leatherback (Dermochelys coriacea) (ARNOLD & BURTON, 1985). Chelonia mydas and Caretta caretta are the only species that nest in the Mediterranean basin (GROOMBRIDGE B., 1990). The most important nesting sites for Caretta caretta are...
located in Greece, Turkey, Cyprus and Libya, whereas fewer rookeries exist in Tunisia, Israel and Lebanon (MARGARITOULIS et al., 2003). According to TOMAS et al. (2001) the western Mediterranean loggerhead’s early to late juvenile population (34.0-69.0 cm CCL) feed upon fish, pelagic tunicates, crustaceans, mollusks and other invertebrates.

In the Mediterranean the loggerhead is considered to be threatened and is protected by international conventions, European Commission directives and national legislation (MARGARITOULIS D., 2000). The level of pollution in the Mediterranean is higher than in the open ocean, due to its semi-closed shape and to the fact that many large cities and industries are located along its coastline (GODLEY et al., 1995, WWF, 1989, HOBSON et al., 1997). There is also intense shipping activity (UNEP, 1996, GROOMBRIDGE B., 1990). Therefore, marine turtles are exposed to increased metal concentrations, mainly through the food chain, which could potentially affect their health (GODLEY et al., 1999). As SAKAI et al. (1995) point out there is a need for monitoring chemical pollutants towards an effort to conserve the loggerhead population as a whole.

Some metals like copper and manganese are essential for marine organisms in adequate concentrations (CLARK, 1999). Vertebrates require copper as a catalytic cofactor for biological processes such as respiration, iron transport, oxidative stress protection, peptide hormone production, pigmentation, blood clotting and normal cell growth and development (PUIG & THIELE, 2002). Manganese also plays many roles in biological systems ranging from acting as a simple Lewis acid catalyst to being an element that can transverse several oxidation states to carry out water oxidation (YOCOM & PECORARO, 1999). However, exposure to these metals is known to cause toxic effects. Copper participates in redox reactions that generate the hydroxyl radical, which causes catastrophic damage to lipids, proteins and DNA (PUIG & THIELE, 2002) and manganese blocks Ca$^{2+}$ channels, and thus affects neuromuscular transmissions in both vertebrates and in benthic marine invertebrates (BADEN & NEIL, 2003).

The purpose of this research was to determine the levels of copper and manganese in several tissues of specimens of Caretta caretta that live in the eastern Mediterranean. An attempt was made to detect the bioaccumulation trend for these two metals.

Materials and Methods

The studied specimens were transported injured to the ARCHELON Sea Turtle Rescue Centre through the National Stranding Network run by ARCHELON during the period December 2000-January 2002. The animals died at the Rescue Centre and, during routine necropsies, various tissues were extracted and stored in polyethylene bags at -8°C until further analysis. The tissues were liver, muscle, lung and intestine (two spleen samples and one kidney, one ovary and one brain tissue were also taken). Information about the location where the individuals were found, their sex, their biometry, the cause of death and the storing period is shown in Table 1. The samples were lyophilized and five aliquots of approximately 200-300 mg of each sample were digested in PTFE vessels with a mixture of 5 ml HNO$_3$ 65% and 0.2 ml HClO$_4$ 70-72% at 80°C. After the mixture was diluted the vessels were tightly closed and left for 2h on the plate. The residue was collected using HNO$_3$ 0.3N solution, to 25ml plastic bottles. Copper and manganese were determined by Graphite Furnace Atomic Absorption Spectrometer Varian SpectrAA 640Z with Zeeman background correction. Two reference materials: Bovine BCR No 184 and Tuna fish IAEA-350 (1989-1991), were analyzed using the same procedure for analytical quality control. The results were in good agreement with the certified values (Table 2).

Results and Discussion
The range and mean concentrations of copper and manganese in the various tissues of the *Caretta caretta* examined are presented in Figure 1 (in μg/g dry tissue weight). The liver samples gave the highest values for both Cu and Mn. The high Cu value of the single brain sample is a result that requires further investigation, although SAKAI et al. (2000a) also found comparatively high Cu concentrations in the brain tissues of adult *C. caretta*.
loggerheads (n=7). Elevated Mn values were obtained for testes and intestine. The muscle samples (along with the ovary and kidney samples) gave the lowest copper values while the lung samples (along with the ovary) gave the lowest manganese values. An increased range was observed for copper in liver samples and for manganese in liver, testes and intestine samples. Values for Cu in spleen tissues (n=2) were higher than the mean for the Japanese individuals (SAKA1 et al., 2000a). One of the two spleen Mn values was six times higher than the average for the Japanese individuals (SAKA1 et al., 2000a).

Table 3 presents the correlation between the metal concentrations and the CCL. The CCL is used because there is a relation between CCL and the age of the individuals, although there is no standard method of age determination for sea turtles (BJORNDAL et al., 1998). It is obvious that there is not any positive correlation and thus no

<table>
<thead>
<tr>
<th></th>
<th>liver</th>
<th>muscle</th>
<th>lung</th>
<th>testes</th>
<th>intestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>0.175</td>
<td>0.120</td>
<td>-0.393</td>
<td>-0.180</td>
<td>-0.855</td>
</tr>
<tr>
<td>Mn</td>
<td>-0.807</td>
<td>-0.027</td>
<td>-0.740</td>
<td>0.061</td>
<td>-0.053</td>
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</tbody>
</table>

Fig. 1: Distribution of copper and manganese (in µg/g dry weight) in the tissues of the Caretta caretta individuals examined (mean and min-max values).
bioaccumulation trend for the two metals. On the other hand there is a negative correlation between intestine copper concentration and the curved carapace length and between liver and lung manganese concentration and the CCL. This negative correlation could be attributed to detoxification processes involving metallothionein, a metal binding protein (SAKAI et al., 2000b).

Table 4 shows results of studies that concern the same species in Japan (SAKAI et al., 2000a) and on the Atlantic coasts of France (CAURANT et al., 1999), as well as common dolphins in Portugal (ZHOU et al., 2001). The values of the present study were transported to μg/g wet tissue weight so that they could be compared to the other research values. Copper values in Mediterranean liver samples were significantly lower than those found in Japan and somewhat lower than those measured in France. As for Mn, the values lie slightly lower than those found in Japan and significantly lower than those found in common dolphins in Portugal (ZHOU et al., 2001). The twofold values of Cu that were obtained in the measured intestine and lung samples are noteworthy, while the concentration in muscle samples is only slightly higher. The Mn values for muscle and lung are similar, while intestine samples gave slightly higher values compared to Japanese specimens. Common dolphins from Portuguese waters gave lower Cu concentrations in liver, almost twofold values for Cu in muscle samples and for Mn in liver samples, while no Mn was detected in muscle samples.

The results of the present research indicate that despite a few variations in the studied metal concentrations between Mediterranean turtles and sea turtles from Japanese waters, there is no significant danger to them by trace metal bioaccumulation. In all cases the trace metal concentrations do not seem to pose toxic health danger to the sea turtles as they fall into the ranges reported by other researchers and as STORELLI and MARCOTRIGIANO (2003) underline that such values are not likely to be high enough to affect the health of these endangered species. However, relative concentrations of Cu in muscle samples from Mediterranean turtles are noteworthy, while the concentration in muscle samples is only slightly higher. The Mn values for muscle and lung are similar, while intestine samples gave slightly higher values compared to Japanese specimens. Common dolphins from Portuguese waters gave lower Cu concentrations in liver, almost twofold values for Cu in muscle samples and for Mn in liver samples, while no Mn was detected in muscle samples.

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<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Tissue n=samples</th>
<th>Mean Copper</th>
<th>Dev Copper</th>
<th>Range Copper</th>
<th>Mean Manganese</th>
<th>Dev Manganese</th>
<th>Range Manganese</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caretta caretta</td>
<td>Japan</td>
<td>Liver (n=6)</td>
<td>17.7</td>
<td>8.93</td>
<td>NA</td>
<td>2.18</td>
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<td>NA</td>
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</tr>
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<td>17.9</td>
<td>8.17</td>
<td>6.47-33.9</td>
<td>2.07</td>
<td>0.50</td>
<td>1.44-2.94</td>
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<tr>
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<td>Liver (n=7)</td>
<td>8.25</td>
<td>6.59</td>
<td>2.32-20.9</td>
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<td>NA</td>
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<td>Caurnt et al., 1999</td>
</tr>
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<td>Liver (n=7)</td>
<td>7.39</td>
<td>2.28</td>
<td>4.51-11.08</td>
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<td>1.03</td>
<td>0.85-3.96</td>
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<td>Liver (n=24)</td>
<td>5.73</td>
<td>0.28</td>
<td>nd-9.01</td>
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<td>Muscle (n=6)</td>
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<td>0.28</td>
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<td>Muscle (n=7)</td>
<td>0.73</td>
<td>0.45</td>
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<td>NA</td>
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<tr>
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<td>1.14</td>
<td>0.38</td>
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<td>0.72</td>
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<td>Intestine (n=6)</td>
<td>0.71</td>
<td>0.23</td>
<td>NA</td>
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<td>Intestine (n=5)</td>
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<td>0.98-2.17</td>
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<td>0.38</td>
<td>NA</td>
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</tr>
<tr>
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<td>Spleen (n=2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.68-2.00</td>
<td>-</td>
<td>0.28-1.86</td>
<td>Present study</td>
</tr>
</tbody>
</table>

NA: Not Available, nd: not detected
research has to be continued along with research on physiological effects of chemical pollutants on sea turtles, since there is inadequate information on these fields.

References

SAKAI, H., SAEKI, K., ICHIHASHI, H., SUGANUMA, H., TANABE, S. & TATSUKAWA, R., 2000a. Species-Specific Distribution of Heavy Metals in Tissues and Organs of Loggerhead Turtle (Caretta caretta) and Green Turtle (Chelonia mydas) from Japanese Coastal Waters. Marine pollution Bulletin, 40, (8) : 701-709


