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Heavy Metals in the Tissues of the Sea Turtle *Lepidochelys olivacea* from a Nesting Site of the Northwest Coast of Mexico

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Five of the seven species of marine turtles of the world have been recorded along the Mexican coasts, where sea turtle protection programs are enforced. Among these, the olive ridley *Lepidochelys olivacea* is a source of ecological concern, because it is considered an endangered species by CITES.

The main threats to sea turtles are accidental fishing, the impact of coastal development on nesting sites, egg and adult predation and marine debris. A further potential threat is marine pollution (Maffucci et al. 2005), that could play a role in the decline of their populations (Sakai et al. 2000). In particular, heavy metals have been associated with recent fibropapilloma epidemics (Aguirre et al. 1994), and for this reason knowledge of trace metal levels in the tissues of marine turtles may be important to assess their potential impact on these endangered organisms (Storelli et al. 2005).

Recently, Frías-Espericueta et al. (2005a,b) observed a tendency to increasing metal concentrations in some coastal lagoons of NW Mexico, probably related to the increasing amounts of anthropogenic discharges in coastal waters (Soto-Jiménez et al. 2003).

The purpose of this study was to assess the concentration of Cd, Cu and Pb in muscle, liver, kidney and heart of *Lepidochelys olivacea* collected at a nesting site located in the northwest coast of Mexico.

MATERIALS AND METHODS

Stranded (dead) specimens of *Lepidochelis olivacea* were collected during summer 2005 with regular weekly patrols along the nesting area of Ceuta beach (Sinaloa State, NW Mexico) (Fig. 1).

Immediately after detection, each turtle was measured (n = 7, CCL = 80 cm) and dissected to obtain samples of liver, kidney, heart and muscle tissues. These were placed in individual glass containers to avoid any contamination, frozen immediately after collection and stored at -45 °C until analysis (Maffucci et al. 2005, Storelli et al. 2005).

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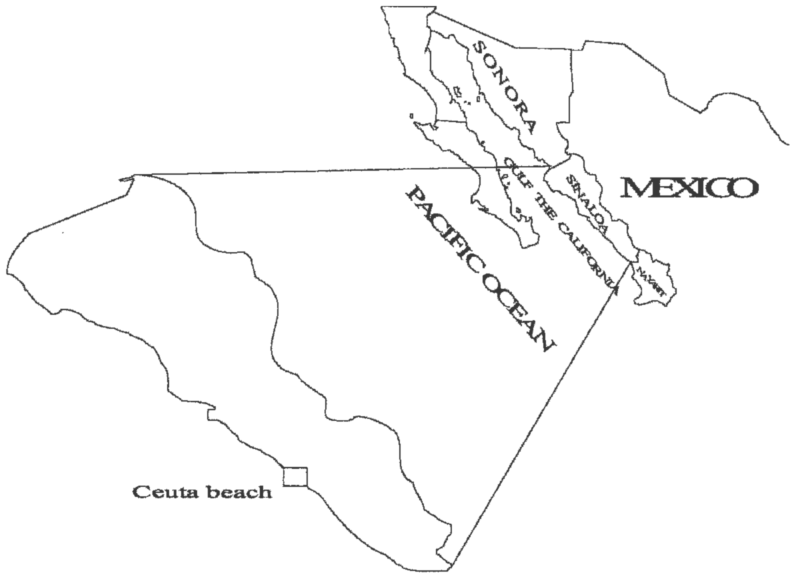

Figure 1. Location of the sampling beach (nesting site).

The samples, not separated by sex, were freeze-dried for 72 h and ground and homogenized in a Teflon mortar. Triplicate subsamples of known dry weight were digested in concentrated nitric acid, evaporated slowly to dryness (90 °C) and the residue was dissolved in 2M nitric acid. After this, the samples were centrifuged and the metals were analyzed by flame atomic absorption spectrophotometry using the multiple standard addition method (Miller and Miller 1988). All materials used in sampling and heavy metal analysis were acid-washed (Moody and Lindstrom 1977).

The accuracy and precision of the method were assessed as detailed in Frías-Espericueta et al. (2005a,b), analyzing reference materials and were within the limits established by IAEA (1987). The mean concentrations of the different tissues were compared by one-way analysis of variance (ANOVA) with $\alpha = 0.05$ and Tuckey's multiple comparison tests (Miller and Miller 1988).

RESULTS AND DISCUSSION

All metal concentrations are given as µg/g of tissue (ppm) on a dry weight basis. The highest concentration of Cu (44.9 ± 4 µg/g) was in heart and the second highest in liver. The lowest was in muscle (15.5 µg/g) and there was no difference between muscle and kidney ($p > 0.05$) (Fig. 2).

High hepatic Cu concentrations have been reported in loggerhead turtles (*C. caretta*) by Sakai et al. (2000) who pointed out that, although the reason for the difference of Cu content between liver and muscle was not fully understood, the most probable explanation was that liver of several marine species has a storage function. In addition, it appears that the elevated Cu levels of liver of marine

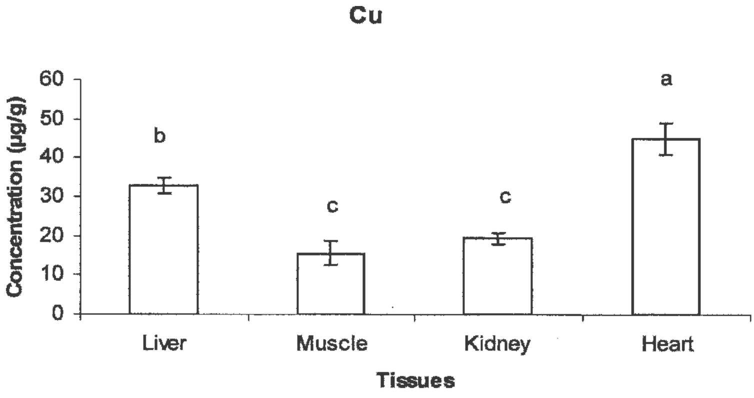

Figure 2. Mean Cu concentrations (µg/g dry weight) in the tissues of the sea turtle *L. olivacea*. Different letters indicate significant difference (one way ANOVA, $\alpha = 0.05$).

turtles are the consequence of some specific and as yet unexplained physiological feature (Storelli and Marcotrigiano 2003, Franzelletti et al. 2004).

Caurant et al. (1999) found that liver and kidney of the loggerhead and leatherback turtles (*Caretta caretta* and *Dermochelys coriacea*) had higher Cu concentrations than heart, that in turn had a higher Zn content, and similar results were observed in Japan in *C. caretta* by Sakai et al. (2000), whereas we found that heart had the highest mean value.

Several authors found a significant relation between the Cu and Zn contents of different tissues of several species, possibly because of the similar physical/chemical properties of these metals and of their interactions on various physiological mechanisms. Although Zn was not determined in our samples, this could explain the high values of Cu in the heart of *L. olivacea*.

There were no large differences in mean Pb concentration, but the higher contents (13.3 ± 2.1 and 13.4 ± 1.9 µg/g) were in liver and kidney and there was no difference between these tissues ($p > 0.05$; Fig. 3). The lowest value was that of muscle (8.9 ± 1 µg/g), without any difference ($p > 0.05$) with heart (10.1 ± 1.1 µg/g). These results are similar to those of Godley et al. (1999) who found a tendency to higher values of Pb in the liver and kidney of *C. mydas* and *C. caretta* from Cyprus, although the values were fairly similar in all tissues.

The highest mean value of Cd was observed in kidney (15.84 ± 1.2 µg/g), but the difference with liver (13.12 ± 1.5 µg/g) was not significant ($p > 0.05$), whereas the minimum mean value was in muscle (2.48 ± 0.4 µg/g) (Fig. 4). The presence

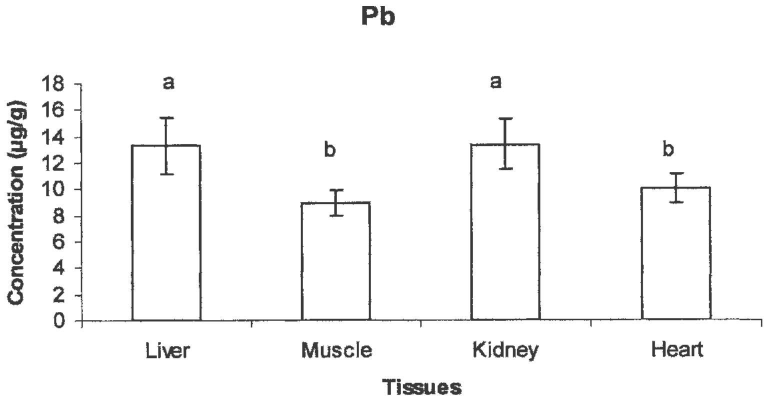

Figure 3. Mean Pb concentrations (µg/g dry weight) in the tissues of the sea turtle *L. olivacea*. Different letters indicate significant difference (one way ANOVA, $\alpha = 0.05$).

of Cd in the liver is noteworthy because it might alter several metabolic processes (Storelli and Marcotrigiano 2003) and it confirms the results of Caurant et al. (1999) and Sakai et al. (2000), who pointed out that liver and kidney are the main organs for the accumulation of heavy metals in marine turtles.

The origin of these high Cd values could be the oceanic food web, because food is probably the main source of heavy metals and other trace elements for top marine predators such as marine turtles, which have a long life span and occupy high trophic levels in the marine food web (Caurant et al. 1999).

Caurant et al. (1999) and Storelli et al. (2005) agreed in pointing out that marine turtles seem to be particularly prone to concentrate Cd, and commented that this tendency could be the consequence of the metabolism or physiology of these species, which would lead to a great accumulation of this metal.

Most of the available information on the metal content of sea turtles is given in µg/g of wet weight. After conversion into the same units using the water content determined in our samples (Franzelletti et al. 2004), the Cu concentrations in kidney and muscle of *L. olivacea* were higher than all the data available on *C. caretta* and *C. mydas*, whereas in liver they were significantly lower than *C. mydas* from Hawaii (Aguirre et al. 1994) and *C. caretta* from Japan (Sakai et al. 1995, 2000).

In addition, the Cd values found in the muscle and liver of *L. olivacea* were higher than those of other sea turtles collected from Cyprus, France, Italy and Japan, while those found in kidneys and liver of *L. olivacea* (Mexico) and *C. mydas* (Cyprus) were lower than all values summarized in table 1.

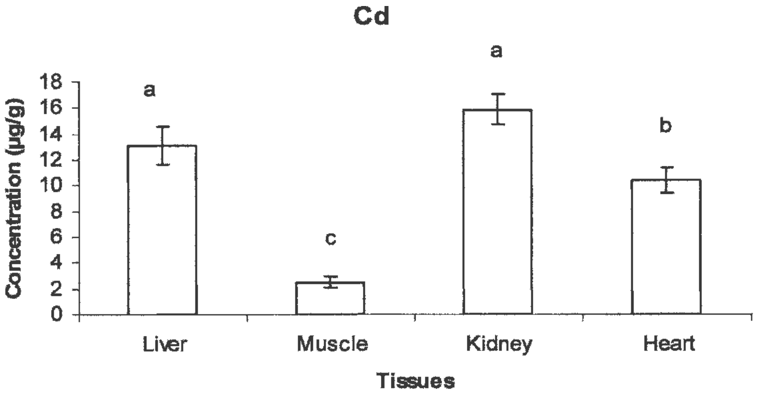

Figure 4. Mean Cd concentrations (µg/g dry weight) in the tissues of the sea turtle *L. olivacea*. Different letters indicate significant difference (one way ANOVA, $\alpha = 0.05$).

These interspecific differences in heavy metal concentrations could be due to differences in physiology, although the most marked are likely to be caused by ecological and/or biological factors such as age and diet (Godley et al. 1999, Franzelletti et al. 2004).

The fact that three soft tissues of *L. olivacea* inhabiting the NW coast of Mexico showed higher concentrations of Pb than those of marine turtles from other areas of the world is of ecological concern, in view that Storelli and Marcotrigiano (2003) pointed out that Pb tends to be higher in calcified tissues, and further studies about this topic are required in the olive ridley turtle.

In addition, Storelli et al. (2005) pointed out that only Pb values < 0.5 µg/g (wet weight) may be considered low; and this value is far lower than the 1.78-4.46 µg/g wet weight found in the present study, although the lack of ecotoxicological data describing the threshold levels above which the toxic effects of this trace metal occur does not allow to judge the real impact of these relatively high levels (Storelli and Marcotrigiano 2003).

Mexico has a high number of nesting sites of different turtle species and several are located along the Pacific Mexican coasts, where we found evidence of heavy metals impact (Páez-Osuna et al. 2002), but the data on the heavy metal content of sea turtles are insufficient for a reliable estimate of their effect on the turtle populations of the Mexican coasts. In this context, more investigation is required in terms of environmental/biological conservation

Table 1. Comparative heavy metal concentrations (µg/g, wet weight) in tissues of marine turtles.

Species	Site	Cd	Cu	Pb	Reference
Liver					
C. caretta	Japan	9.29	17.9	BLD	Sakai et al. (1995)
C. mydas	Hawaii	9.30	87.9		Aguirre et al. (1994)
C. caretta	France	2.58	8.25		Caurant et al. (1999)
C. mydas	Cyprus	5.89		BLD	Godley et al. (1999)
C. caretta	Cyprus	8.64		BLD	Godley et al. (1999)
C. caretta	Japan	9.74	17.7	0.08	Sakai et al. (2000)
C. caretta	Italy	2.84	7.4		Franzellitti et al. (2004)
C. caretta	Italy	3.36	7.69	0.16	Storelli et al. (2005)
L. olivacea	Mexico	3.28*	8.20*	3.32*	This study
Kidney					
C. caretta	Japan	39.4	1.30	BLD	Sakai et al. (1995)
C. mydas	Hawaii	26	3.6		Aguirre et al. (1994)
C. caretta	France	13.3	2.21		Caurant et al. (1999)
C. mydas	Cyprus	3.46		1.81	Godley et al. (1999)
C. caretta	Cyprus	30.5		2.45	Godley et al. (1999)
C. caretta	Japan	38.3	1.30	0.16	Sakai et al. (2000)
C. caretta	Italy	8.35	1.21	0.12	Storelli et al. (2005)
L. olivacea	Mexico	5.28*	6.4*	4.46*	This study
Muscle					
C. caretta	Japan	0.06	0.83	BLD	Sakai et al. (1995)
C. caretta	France	0.08	0.73		Caurant et al. (1999)
C. mydas	Cyprus	0.37		BLD	Godley et al. (1999)
C. caretta	Cyprus	0.37		2.46	Godley et al. (1999)
C. caretta	Japan	0.06	0.81	0.02	Sakai et al. (2000)
C. caretta	Italy	0.07	0.59	0.04	Storelli et al. (2005)
C. caretta	Italy	0.36	1.5		Franzellitti et al. (2004)
L. olivacea	Mexico	2.6*	3.10*	1.78*	This study

* values converted to wet weight using the mean water content obtained in the present study : liver 75.5 %, kidney 62.7 % and muscle 80.8 %.

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