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Heavy metal distribution in blood, liver and kidneys of Loggerhead (*Caretta caretta*) and Green (*Chelonia mydas*) sea turtles from the Northeast Mediterranean Sea

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ABSTRACT

The aim of the present study was to determine the concentrations of the most investigated environmentally relevant heavy metals in two highly endangered sea turtle species (*Caretta caretta* and *Chelonia mydas*) from the important nesting area on the Northeast Mediterranean Sea. The highest mean concentration was of Fe, while Hg and Pb were lowest. All tissue concentrations of Al, As, Fe and Mn were significantly different between the species. In particular, As, Cd, Cu, Mn, Ni, Se, Zn concentrations were lower in *Caretta caretta* and Cd, Hg, Mn, Zn concentrations were lower in *Chelonia mydas* than those reported in other parts of the world. Compared to studies conductud in other parts of the Mediterranean, Cd was lower.

1. Introduction

Marine pollution caused by the chemical pollutants (heavy metals, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, organochlorine pesticides, pharmaceuticals etc.) are having a more adverse effect on the marine ecosystem and cause toxic effects (immunopathologic, carcinogenic, teratogenic, neural, cardiovascular, renal, reproductive and endocrine etc.) on its wildlife members (Bucchia et al., 2015; Ley-Quiñónez et al., 2011; Yarsan and Yipel, 2013; Yipel et al., 2017). Due to their extensive use and long-range transport (by rivers and air), heavy metals are one of the most common pollutants in the marine ecosystem. On the other hand not biodegradable and accumulates up the trophic levels of the food chain are increases their potential toxicity and ecotoxicological importance (Bucchia et al., 2015; D'Ilio et al., 2011; EC, 2008; Ley-Quiñónez et al., 2011; Mattei et al., 2015; Yarsan and Yipel, 2013; Yipel et al., 2016). Despite increasing numbers of national and international environmental policies and agreements, the marine environment continues to be contaminated by anthropogenically originating heavy metals, such as mercury (Lamborg et al., 2014; Mitchell, 2016). Sea turtles have been recognized as being both a priority and potential bioindicators of good environmental status for marine pollution (Camacho et al., 2014a). Also, they included on the Red List of the World Conservation Union (IUCN, 2014) and being protected all around the world (Andreani et al., 2008; Camacho et al., 2014a; D'Ilio et al., 2011; Guerranti et al., 2014; Ley-Quiñónez et al., 2011). The *Cheloniidae* family members, Green turtle (*Chelonia mydas*) (*Cm*) and loggerhead turtle (*Caretta caretta*) (*Cc*) use the Mediterranean Sea for their main nesting areas (Andreani et al., 2008; D'Ilio et al., 2011; Mattei et al., 2015; Olgun et al., 2016). Because *Cc* and *Cm* are long-living vertebrates, they accumulates heavy metals through diatery intake (*Cc* is carnivorous and *Cm* is herbivorous), or directly from the water environment (Andreani et al., 2008; D'Ilio et al., 2011; Mattei et al., 2015). Therefore, the adverse effects of metals and other chemical pollutants on turtles (at the level of individual, population, and ecosystem) means determining tissue levels is becoming an increasingly researched topic (Andreani et al., 2008; Bhat, 2013; Camacho et al., 2014a; D'Ilio et al., 2011; EC, 2008; Mattei et al., 2015; Storelli et al., 2005). The Mediterranean Basin is one of the most exposed semi-enclosed sea to anthropogenic activities due to common use by 22 countries and heavy sea-transport traffic (Andreani et al., 2008; Bucchia et al., 2015; Mattei et al., 2015; Storelli et al., 2005). Yet, no studies on blood metal levels of sea turtles from the Turkish coasts. Thus, the present study aimed to determine concentrations of the most investigated environmentally relevant heavy metals in blood, kidney and liver tissues of two highly endangered sea turtle species (*Cc* and *Cm*) in the Mediterranean Sea on the southeast coast of Turkey, to provide baseline data for future monitoring studies.

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Table 1
Curve Carapace length (CCL) (cm), body weight (kg) (mean ± SD), sex and life stages of *C. caretta* and *C. midas*.

Species	n	Sex		Life stage		CCL		Body weight	
		Famele	Male	Juvenile	Adult	mean ± SD	Range	mean ± SD	Range
C. caretta	10	10	–	5	5	64.55 ± 6.79	56.00–75.00	58.74 ± 8.16	46.00–71.00
C. midas	3	2	1	–	3	74.50 ± 5.27	69.00–79.50	65.93 ± 4.41	61.00–69.50
Total	13	12	1	5	8				

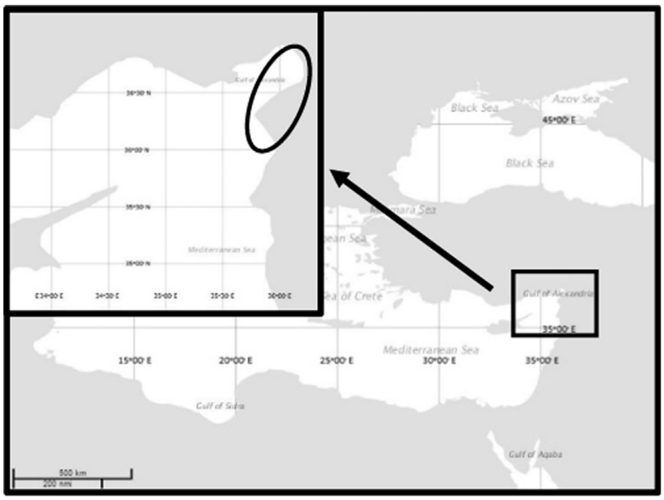

Fig. 1. Locations of found *Cc* and *Cm* (FAO, 2016).

2. Materials and methods

Blood samples (5 ml from the cervical sinus) of live (found injured), kidney and liver samples taken during necropsy or recently (< 12 h) found dead *Cc* and *Cm* sea turtles (Table 1) on the southern coast of Turkey (Samandağ 36.31 N-35.91E and Dörtyol 36.71 N-36.13E) (Fig. 1) were collected (permit HADYEK No: 2015-2-19/5). All animals that were stranded, mostly due to traumatic injures, were rescued and submitted to the Mustafa Kemal University, Sea Turtle First Aid, Treatment, Recovery, Application and Research Center (DEKIYM; Hatay, Turkey). All sea turtles body weights and curved carapace lengths (CCL) were measured (Table 1) and then identified as junenile (CCL < 64 cm) or mature/adult (CCL > 64 cm) (Guerranti et al., 2014).

Homogenized tissue sample was placed in a microwave oven (CEM; Mars X press, Matthews, NC). Then analyses by inductively coupled plasma optical emission spectrophotometer (ICP OES-Optima 3000DV Perkin-Elmer-Norwalk, USA). The recovery values ranged between 95 and 108% and were satisfactory. The limits of detection (LOD) for each element and expressed as were (ng g^{-1}): Al 3.0, As 3.6, Cd, Cr, Cu 0.6, Fe, Mn, Zn 0.3, Hg 2.7, Ni 0.9, Pb 2.1, Se 4.5.

One-way analysis of variance (ANOVA), along with Duncan's method, was carried out to and presented in Table 2. Mann–Whitney *U* test used for the comparison of metal concentrations, and P values of < 0.05 were considered statistically significant.

3. Results

Concentrations of heavy metal in blood, liver and kidney tissues of *Cc* and *Cm* are presented in Table 2.

In *Cc*, Al, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se and Zn levels were greater in the liver, whereas As and Cd levels were greater in the kidney. In *Cm*, Al, Cu, Fe, Hg, Mn, Ni, Se and Zn levels were greater in the liver, whereas Cd and Cr levels were greater in the kidney. Among the examined metals, Fe concentrations were highest, while Hg and Pb were lowest. The accumulation trend of metals in both turtle species samples was liver > kidney ≥ blood for Al, Cu, Fe, Hg, Mn, Ni, Pb, Se and Zn, while for As and Cd, it was kidney > liver ≥ blood. The range of concentration (μg g^{-1}) for the elements of interest in wet specimens were as follows: for *Cc*, Al 0.90–19.70, As 0.01–3.54, Cd < LOD–5.29, Cr 0.02–0.31, Cu 0.09–8.21, Fe 11.74–550.41, Hg 0.01–0.16, Mn 0.03–4.30, Ni 0.23–9.21, Pb 0.01–0.18, Se 0.20–22.20, Zn 1.89–38.00; and for *Cm*, Al 0.11–1.67, As < LOD, Cd < LOD–6.10, Cr < LOD–0.11, Cu 0.82–4.37, Fe 3.58–346.30, Hg < LOD–0.12, Mn 0.01–1.80, Ni 0.92–7.17, Pb 0.01–0.09, Se < LOD–0.92, Zn 1.90–6.63.

In *Cc*, Cd and Mn concentration between kidney, liver and blood, Fe concentrations between liver and kidney-blood, Pb concentrations between liver-kidney and blood, and Zn concentrations between liver and blood were significant ($p < 0.05$). In *Cm*, Cd concentration between kidney and liver-blood, Fe and Mn concentrations between liver and kidney-blood were significant ($p < 0.05$). Statistical significance between species were observed in all tissues for Al, As, Fe and Mn concentrations, in blood and kidney tissues for Se concentration, in blood tissues for Hg concentration and in liver tissues for Cr concentration ($p < 0.05$).

4. Discussion

The main reason for differences in metal concentrations between *Cc* and *Cm* is diet, which differs in sea turtle species and is also the main to exposure (Andreani et al., 2008; Gardner et al., 2006). In particular, *Cc* is carnivorous and feeds on marine invertebrates, whereas *Cm* is herbivorous and feeds on marine algae and grasses (Andreani et al., 2008; D'Ilio et al., 2011). Furthermore, heavy metal levels in fish, crustaceans and molluscs, (Çoğun et al., 2005; Türkmen et al., 2013; Yüzereroğlu et al., 2010) have been reported as high in the area by some researchers which leads to biomagnification (Firat et al., 2008; Duysak and Dural, 2015; Manasirli et al., 2015; Kaymacı and Altun, 2016), whereas the algae have been reported as low (Topcuoğlu et al., 2010). Metal accumulation also varies by individual between the turtles, according to age and feeding location (Andreani et al., 2008; Gardner et al., 2006; Mattei et al., 2015). The observation that metal concentrations are often higher in *Cc* than in *Cm*, with the exception of Cu in blood and kidney, is similar to those reported by other study that have compared metal levels between *Cc* and *Cm* (Sakai et al., 2000), which is an expected result from eating habits and trophic levels (Andreani et al., 2008; Gardner et al., 2006; Mattei et al., 2015). The higher Cu concentrations in *Cm* than *Cc* may be releated to the comsumption of algae, which is the main diet of *Cm*. Algae also accumulates metals from water in high levels (Gardner et al., 2006). This is similar to reports from other study that compared metal levels between *Cc* and *Cm* (Sakai et al., 2000). In contrast to the current study, in a study, Pb levels in blood and liver were higher in *Cm* than in *Cc* (Sakai et al., 2000).

In the present study, Al concentrations were lower than described by some authors (Camacho et al., 2014b; Torrent et al., 2004), while they were higher in the kidney of *Cc* (Torrent et al., 2004). As concentrations were lower than described in some studies (Bucchia et al., 2015; Camacho et al., 2014b; Torrent et al., 2004), but they were higher in the kidney and liver of *Cc* than in some studies (García-Fernández et al., 2009; Sakai et al., 2000; Storelli et al., 2005). For both *Cc* and *Cm*, Cd concentrations were lower than described by some