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Presence of Heavy Metals in Purple Crab (*Platyxanthus orbignyi*) Tissues in Southern Peru

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ABSTRACT

Heavy metals (iron, copper, and zinc) were quantified in purple crab (*Platyxanthus orbignyi*) tissues collected in winter (September 2021), spring (November 2021), and summer (March 2022) at three beaches (Tres Hermanas, Fundición, and El Diablo) in Ilo Harbour (Moquegua), South Peru. The rank order of heavy metal concentrations in purple crab tissues and sediments was similar; iron (Fe) was followed by Copper (Cu), and this last one was followed by Zinc (Zn). The heavy metal concentrations in tissue crabs from the three beaches differed from each other spatially and seasonally. In addition, Fundición Beach was the zone with the highest concentration of those three metals during the summer.

INTRODUCTION

Ocean and sediments naturally present heavy metals (Fe, Zn, Cu, Hg, Ni, and Cd) in their composition as a result of rock weathering, upwelling processes, volcanic activity, river discharge, and atmospheric dust (Krishnaja et al. 1987, Castro & Huber 2019). Some of these metals, in small quantities, such as iron (Fe), zinc (Zn), nickel (Ni), and copper (Cu), are essential for the proper functioning of biochemical and physiological processes in marine life, even humans (Bandara & Manage 2022, Hao et al. 2019). Nevertheless, anthropic activities (e.g., agriculture, local fisheries, petrochemical industry, mining, and domestic activities) dump wastewater in rivers containing heavy metals, which afterward will enter the coastal and marine environments, increasing their concentrations (Bastami & Esmailian 2012, Koski 2012, Patel et al. 2018).

Marine invertebrates (e.g., mollusks and crustaceans) from coastal environments exhibit a variety of feeding habits (e.g., suspension feeding, filtration feeding, and deposit feeding) (Sastre et al. 1999, Jędruch et al. 2019) efficiently adapted to take advantage of nutrients from seawater and sediments, which increase the risk of accumulating heavy metals in their soft tissues and organs (Lu & Wang 2018, Castro & Huber 2019, Raza'i et al. 2022). The organ that largely bioaccumulates heavy metals is the hepatopancreas, which is in charge of detoxification (Irnidayanti 2015, Liu et al. 2021) and secondarily, muscle tissues, which are the edible part in most marine invertebrates (Lyla & Khan 2011). It has been well documented that heavy metal bioaccumulation has negative effects on different levels of marine invertebrates and represents a potential hazard for humans who consume these organisms (Bat et al. 2020, Gong et al. 2020, Ariano et al. 2021, Tanhan et al. 2023).

Crabs are a diverse group of crustaceans with species on all the coasts of the planet, where they play an important role in the marine food chain (Ruppert et al. 2004, Castro & Huber 2019), as well as in the daily diet of people since they represent a source of proteins of excellent quality and high nutritional value (Hao et al. 2019, Gong et al. 2020, Tanhan et al. 2023). Nonetheless, its feeding habits facilitate heavy metal bioaccumulation in their tissues, which could represent a public health issue (Stoner & Buchanan 1990, Ololade et al. 2011, Laitano et al. 2013, Vogt et al. 2018).

Ilo Harbor, located in the Moquegua region in south Peru, is characterized by a coastline oceanographically influenced by the Humboldt current, which explains its high productivity and biodiversity (Gonzales et al. 2022). However, anthropic activities that dump their wastewater into the ocean are raising the heavy metal (Pb, As, and Cu) concentrations close to the limit, representing a hazard for benthic species (Boon et al. 2001, Gonzales et al. 2022) and humans (Tanhan et al. 2023). Purple crab (*Platyxanthus orbignyi*) is a filter feeder and omnivorous scavenger in juvenile and adult stages, respectively (Oliva et al. 1997), which plays an important role in the marine trophic chain of the Peruvian coasts, being food for octopus, otters, sea lions, sea birds, and fish. Likewise, it represents one of the main items of the artisanal fishery that supplies local markets (Rathbun 1910, Fischer & Thatje 2016, Dillehay 2017, Iannacone et al. 2022).

Several studies performed around the world report the presence of heavy metals in crabs of commercial interest from coastal regions. Liu et al. (2020), for instance, assessing the species *Portunus trituberculatus* in Zhejiang Province (China), found high concentrations of Zn in muscular tissue. A similar study in São Paulo (Brazil) assessing the species *Ulcides cordatu* detected high concentrations of Cu and Zn (Salvador et al. 2007). Tanhan et al. (2023), studying three crab species from Pattani Bay (Thailand), found high levels of Zn, Cu, and Fe in this order for *Portunus pelagicus* and *Scylla olivacea*, as well as high levels of Zn, Fe, and Cu for *Scylla paramamosain*. Araujo et al. (2021), in a study developed in the protected area of Iguape-Peruíbe (Brazil), evidenced a high concentration of heavy metals in hepatopancreas, suggesting that even protected areas are not exempt from heavy metal pollution. As we see, many crab species of commercial interest from coastal areas are helpful as bioindicators to assess the environmental quality and the possible hazards for human health (Ololade et al. 2011).

This pilot study represents the first work in purple crab (*Platyxanthus orbignyi*) from south Peru that identifies the presence of heavy metals in edible muscular tissue. In addition, this work proves the need for implementing long-term monitoring to assess the benthic invertebrate community state to identify possible hazards for the Ilo population in the future.

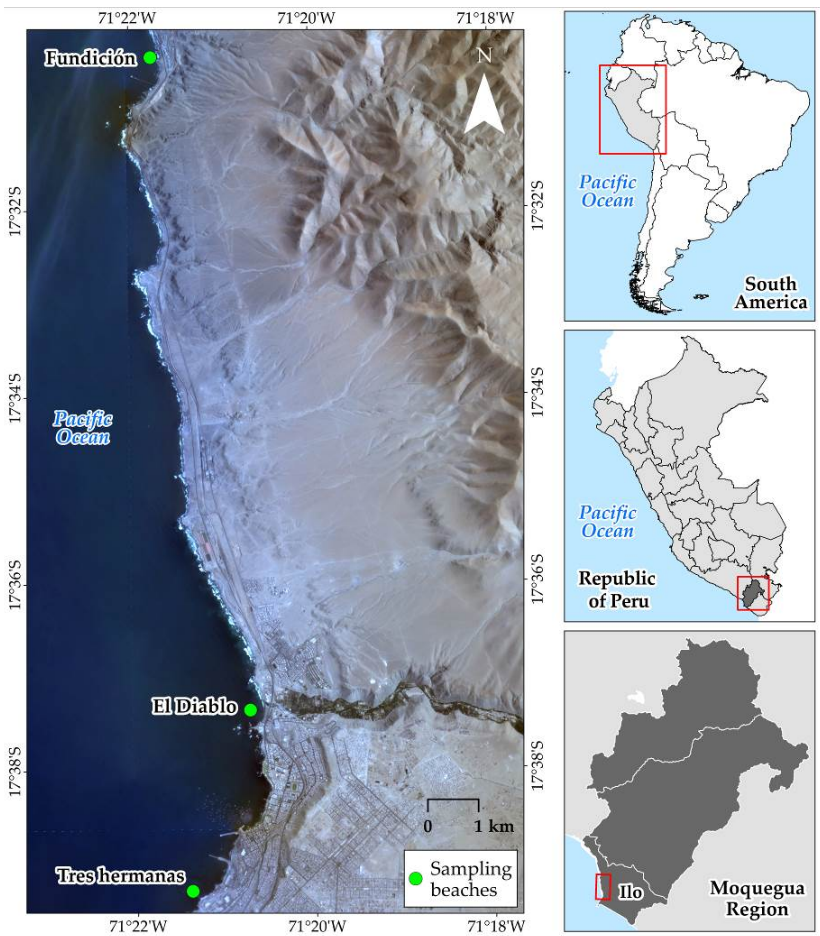

Fig. 1: Map showing the study area and the sampling zones.

MATERIALS AND METHODS

Study Area

This study was performed on three beaches in the Ilo harbor, located on the south coast of Peru: Tres Hermanas Beach (17°39′18’’ S, 71°21′23″ W), El Diablo Beach (17°37′22″ S, 71°21′23″ W), and Fundición Beach (17°30′22″ S, 71°21′45″ W) (Fig. 1).

Sampling

A total of 30 commercial-size male purple crab (*P. orbignyi*) (70 mm) samples were collected, 10 per beach, by freediving

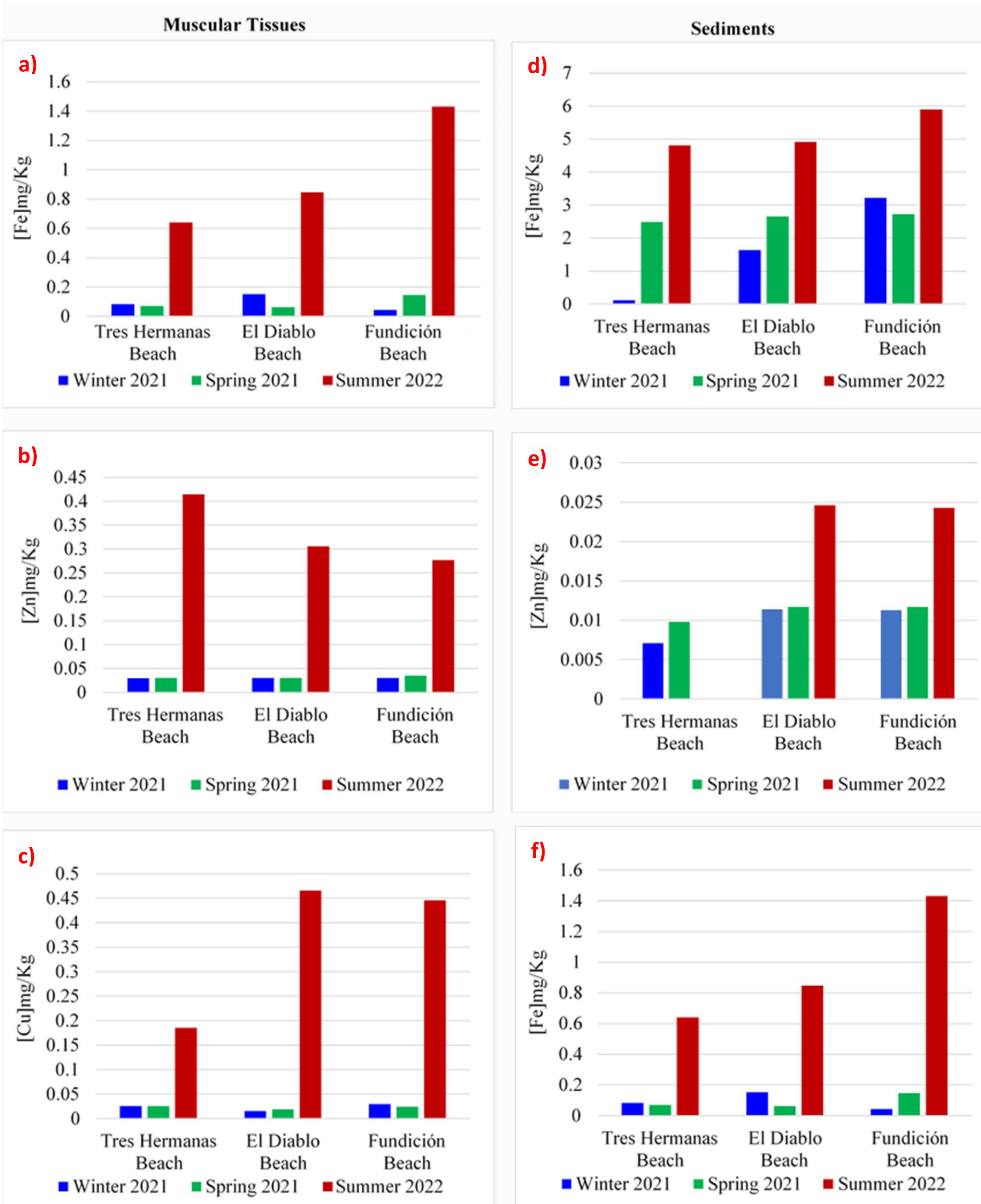

Fig. 2: Levels of heavy metal concentrations (Fe, Zn, and Cu) in samples of muscular tissues (a–c) and sediments (d–f) from Fundición Beach, El Diablo Beach y Tres Hermanas Beach during Winter 2021, Spring 2021, and Summer 2022.

at the end of winter (September 2021), spring (November 2021), and summer (March 2022). In the field, the crab samples were washed with distilled water to remove the sand and other particles from the exoskeleton. The dissection process was done carefully to avoid contamination; after breaking the exoskeleton, muscle tissue samples were removed and weighed until they reached 100g. The tissue samples were packed in Ziplock polyethylene bags, labeled, and transported in coolers at 51°C to be analyzed at the Research and Services laboratory LABINVSERV of the National University of San Agustín. X-ray fluorescence was the technique used by the laboratory for the analysis (Lorber 1986). Moreover, a sediment sample was taken from each beach in the study. In addition, temperature data were taken in each sampling carried out for each season with a HANNA HI98194 multiparameter.

Data Analysis

The results from the laboratory analysis were organized in tables, and the data was analyzed in an Excel program. To visualize the differences between beaches and seasons, the data was represented in bar graphs.

RESULTS AND DISCUSSION

This first pilot study provides evidence of the presence of heavy metals in purple tissue crab and sediments at Ilo Harbour. The results of this study showed that crab tissues bioaccumulate heavy metals in different concentrations, following the rank order of Fe (3.47 $mg.kg^{-1}$) > Cu (1.23 $mg.kg^{-1}$) > Zn (1.18 $mg.kg^{-1}$) (Fig. 2a–c) and it was similarly observed in sediments where de rank order was Fe (28.45 $mg.kg^{-1}$) > Cu (0.17 $mg.kg^{-1}$) > Zn (0.11 $mg.kg^{-1}$) (Fig. 2d-f).

Moreover, it was observed for sediments that iron (Fe) presented a high concentration, which was reflected in the high iron concentration in crab tissues. Nonetheless, for the other heavy metals, copper (Cu) and zinc (Zn), the relationship was opposite. Zaher et al. (2021), studying the bioaccumulation of heavy metals in raw crab from different markets, found a similar pattern to the present study when evaluating Cu and Zn. Those results are coherent with the literature, where it is mentioned that metals such as Fe are present in high concentrations in seafood tissues because this is an essential bioelement for the correct functioning of organisms (Jakimska 2011).

For each season (winter 2021, Spring 2021, and Summer 2022), the temperatures were, respectively, 15.5°C, 15.5°C, and 15.6°C. Sediment samples showed that iron (Fe) was highly concentrated during the summer of 2022 on three beaches, with a predominance at Fundación Beach (Fig. 2d). In the case of zinc (Zn) (Fig. 2e), it was present in high concentrations during the summer of 2022 at Diablo and Fundación Beaches. Finally, for copper (Cu), high concentrations were evident during the summer of 2022 at Fundación Beach (Fig. 2f). Moreover, high concentrations of iron (Fe), Zinc (Zn), and Copper (Cu) in purple crab tissues were observed at Tres Hermanas Beach, Diablo Beach, and Fundación Beach. In the case of iron (Fe), it was predominant in Fundación Beach (Fig. 2a), unlike zinc (Zn) and copper (Cu), which were superior in Tres Hermanas and Diablo Beach, respectively, during summer 2022 (Fig. 2b and 2c). The high values of heavy metals in those areas can be related to the development of different anthropogenic activities close to the coastal zone, mainly mining. This study shares similar seasonal patterns with other studies, which report high concentrations of heavy metals in crab tissues in the summer. For instance, Çoğun et al. (2017) reported high concentrations of Cu and Zn in soft tissues of *Callinectes sapidus*, and Firat et al. (2008) observed high concentrations of Zn, Cu, and Fe in this rank order for *Charybdis longicollis*. Heavy metals that come from wastewater from domestic and other activities are released into the ocean, where marine organisms take them up through the water column. However, the part that remains free goes down to the bottom, where the sediments act as a reservoir for them and organic matter in general (Bazzi 2014). Purple crabs are benthic organisms that feed on bottom surfaces, eating sediments and other items that facilitate the incorporation and bioaccumulation of heavy metals in their tissue bodies (Laitano et al. 2013, Vogt et al. 2018).

In this sense, the findings in this study are evidence of the importance of implementing long-term monitoring to evaluate the spatiotemporal variability of heavy metals in seafood in general, given that filter feeders such as bivalves (*Aulacomya atra* and *Mesodesma donacium*) are more efficient bioaccumulators of heavy metals than crabs. Despite the lack of robustness in this study, it proves the need to investigate aspects such as the presence and quantification of chemicals in different organs of seafood and the physiological, ecological, and biological impacts on marine biota and humans to prevent future hazards.

CONCLUSIONS

This study provided evidence for the first time of the presence of heavy metals such as iron, copper, and zinc in the muscular tissues of the purple crab and the sediments of three beaches in the port of Ilo, Peru. It was found that iron showed the highest concentrations in both compartments, suggesting the effective bioaccumulation of this metal from the environment by the crab. Likewise, metal levels varied between seasons and locations, being higher during summer and on beaches closer to anthropogenic activities such as mining. Given its filtering and predatory diet, the purple crab acted as a bioindicator of environmental quality in the area. These findings highlight the need for long-term monitoring of other filtering organisms and the spatiotemporal variability of heavy metal pollution to evaluate potential ecological and physiological impacts and risks to human health derived from the consumption of these marine species. The study serves as a basis for future research that delves deeper into these aspects in the port of Ilo.

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