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Metal Levels in *Serranus atricauda* and *Sparisoma cretense* from the North-Eastern Atlantic Ocean—Contribution to Risk Assessment

Alberto Gutiérrez [1], Enrique Lozano-Bilbao [2], Ángel J. Gutiérrez-Fernández [1,*], Soraya Paz-Montelongo [1], Dailos González-Weller [1,3], Carmen Rubio-Armendáriz [1], Daniel Niebla-Canelo [1], Samuel Alejandro-Vega [1] and Arturo Hardisson [1]

[1] Área de Toxicología, Universidad de La Laguna, 38071 La Laguna, Spain; albertogutierrezrv@gmail.com (A.G.); spazmont@ull.edu.es (S.P.-M.); dgonzal@ull.edu.es (D.G.-W.); crubio@ull.edu.es (C.R.-A.); alu0100798203@ull.edu.es (D.N.-C.); alu0100992397@ull.edu.es (S.A.-V.); atorre@ull.edu.es (A.H.)
[2] Grupo de Investigación en Ecología Marina Aplicada y Pesquerías (EMAP), Instituto de Investigación de Estudios Ambientales y Recursos Naturales (i-UNAT), Campus de Tafira, Universidad de Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain; lozaenr@gmail.com
[3] Canarian Public Health Service, Central Laboratory, 38006 Santa Cruz de Tenerife, Spain
* Correspondence: ajguti@ull.edu.es; Tel.: +34-922318905; Fax: +34-922626497

Abstract: The objective of this study was to study whether the metal concentrations in *Sparisoma cretense* and *Serranus atricauda* differ between different coastal areas around the island of Tenerife, Canary Islands and to study whether these species are good bioindicators of pollution. Thirty samples of each species were collected from three parts of the coastline around the island, and samples of muscle and liver tissue were taken from the collected specimens. The determination of the metal content (Al, Cd, Pb, Ca, K, Mg, Na, B, Ba, Cr, Cu, Fe, Li, Mn, Mo, Ni, Zn) was performed by inductively coupled plasma optical emission spectrometry (ICP-OES) before conducting a PERMANOVA analysis. The mean metal concentration was significantly higher in the liver tissue than in the muscle tissue of the two species studied. *S. atricauda* specimens had a larger number of metals with a higher concentration, and the samples from the northern and eastern zones were found to have a higher concentration of elements than those from the southern zone. The northern and eastern zones were found to have a higher concentration of metals and trace elements than the southern zone, which could be explained by the fact that these zones are more polluted due to their higher population density.

Keywords: metal content; pollution; ICP-OES; Canary Islands

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1. Introduction

The world's oceans have been polluted by intensive anthropic action for many decades, and the chemical compounds discharged into them enter the trophic networks, which are then assimilated and accumulated by marine organisms, from primary producers such as phytoplankton to predators [1–3]. Many of the compounds are discharged through submarine outfalls and coastal runoff from crop fields, and it is the coastal areas with the highest populations that have the highest concentrations of metals and trace elements [4–6]. These elements, in small concentrations, can cause a fertilization effect in the environment, but when the concentrations increase above a certain threshold, characteristic of each metal, each organism and each ecosystem, they have harmful effects [7–10]. The danger of heavy metals is greater, as they are not chemically or biologically degradable. Once released, they can remain in the marine ecosystem for hundreds of years because they enter the food web [11–13].

Among marine organisms and due to their high consumption by the population, fish are important indicators of pollution because the high concentrations of metals in their tissues and organs are directly related to water pollution and the bioaccumulation of contaminants in the food chain [14–17]. *Sparisoma cretense* (Linnaeus, 1758) is an omnivorous species that feeds on algae on rocks and its benthic animals and on sea grass and microinvertebrates, especially crustaceans and small mollusks. It belongs to the group of herbivores that have developed special muscles and bones in the pharynx, which function as a crusher, and it uses these plates in the pharyngeal area to grind all the food it eats, which results in a reddish-brown paste in its intestines [18–20].

Serranus atricauda (Günther, 1874) plays an important role in coastal marine ecosystems where it is an active predator of small fish, crustaceans, bivalves, gastropods and urochordates of the thaliacea family. It is a solitary and territorial fish that usually lives on the coastline and in sub-littoral areas on shallow rocky bottoms, up to 350 m deep. It hides among rocks, caves or any cavity if it feels threatened [21–23].

Bearing in mind all the above, the objective of this study is to study whether the metal concentrations in *S. cretense* and *S. atricauda* differ between different coastal areas around the island of Tenerife, Canary Islands and to study whether these species are good bioindicators of coastal pollution.

Two types of tissue were used to determine the levels of toxic heavy metals and trace elements. Muscle tissue was chosen because of its high consumption by the human population and liver tissue because it is the main target organ for the accumulation of heavy metals in *S. cretense* and *S. atricauda*.

2. Materials and Methods

A total of thirty samples of both *Sparisoma cretense* and *Serranus atricauda* were used in the study. Ten specimens of each species were acquired from the following three areas of Tenerife: the north, the south and the east. The eastern zone is where the densely populated capital of the island of Tenerife, Santa Cruz is located.

The division into zones was based on geographical reasons (Figure 1) The southern zone is where there is the most tourism activity and the northern zone is where the tides and currents are strongest, which also has large stretches of steep coastline that is difficult to access. These zones were chosen due to the geomorphology of the island of Tenerife, as it has three slopes with different oceanographic conditions.

Approximately 10–15 g of muscle and liver were placed in capsules and dried in an oven at 70 °C for 24 h. The samples were then incinerated in a muffle furnace for 24 h at 450 °C ± 25 °C, until white ash was obtained. The white ashes were filtered with a 1.5% HNO3 solution (Merck, Darmstadt, Germany) made up to a total volume of 25 mL for the subsequent determination of the metal content by inductively coupled plasma optical emission spectrometry (ICP-OES) measured in mg/kg. A quality control solution was used to assess the accuracy of the determinations every ten samples. Furthermore, certified reference materials (DORM-2, fish muscle and DORM-4, fish protein) were used to ensure the precision and accuracy of the results. All data are presented as milligrams per kilogram, wet weight. Blanks and standard reference materials were run together with the samples. The metals and trace elements sampled were the following: Al, Cd, Pb, Ca, K, Mg, Na, B, Ba, Cr, Cu, Fe, Li, Mn, Mo, Ni, Zn [24].

A statistical analysis was conducted using a multivariate permutational analysis of variances (PERMANOVA) with Euclidean distances [25] in order to determine whether there were variations in the content of heavy metals and trace elements among the analyzed samples.

In all the analyzes, nine-unit permutations and posterior comparisons were used to determine the differences between the levels of the significant factors according to the concentrations of metals and trace elements (p-value < 0.05) [26]. The PRIMER 7 and PERMANOVA + v.1.0.1 statistical packages were used for the statistical analyses. The pairwise analysis was designed with the fixed factors “Species” with two levels (*Sparisoma cretense* and *Serranus atricauda*) and “Zones” with three levels (north, south and east) using the muscle and liver concentration of metals and trace elements.

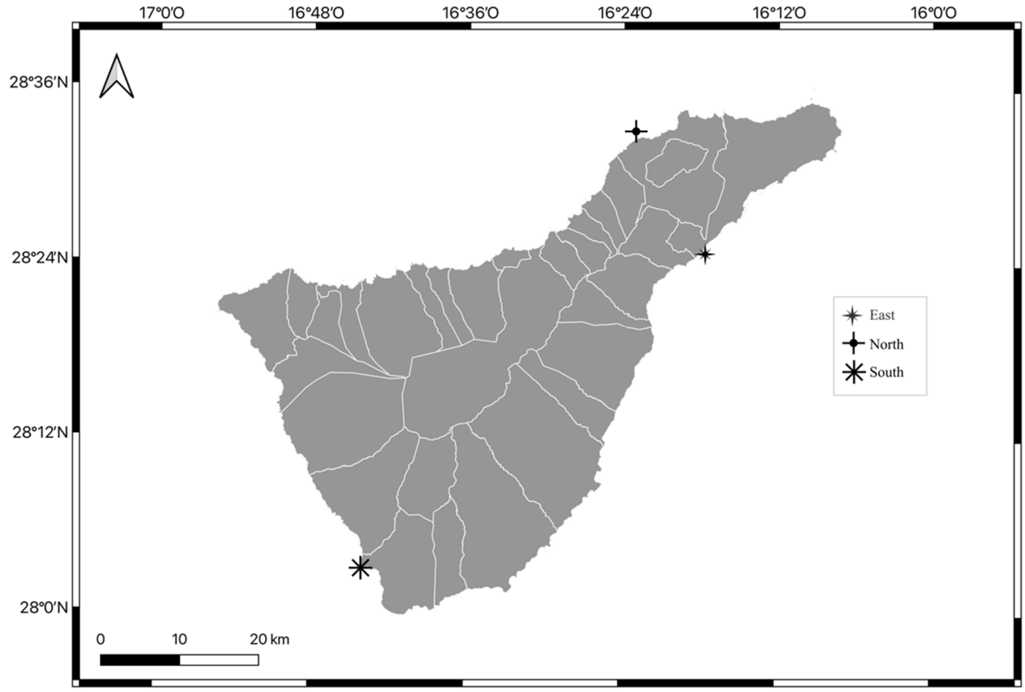

Figure 1. Map of the sampling zones around the island of Tenerife.

3. Results and Discussion

Table 1 shows the means of the standard length (cm) and the weight (g) of the specimens of each species. *Sparisoma cretense* is both heavier and longer than *Serranus cabrilla*.

Table 1. Biometric means of the study species.

Species	Weight (g)	Length (cm)
Sparisoma cretense	158.3 ± 52.37	21.05 ± 2.57
Serranus cabrilla	97.67 ± 29.36	19.41 ± 2.43

Table 2 shows the mean metal concentrations of the two species in each study area, observing that the liver tissue has a higher concentration of metals and trace elements because this is a target organ for toxins and it is where most metals accumulate [27].

Table 2. Means and standard deviations (in mg/kg) of *Serranus atricauda* and *Sparisoma cretense* according to study area.

	Serranus atricauda			*Sparisoma cretense*		
	North	**East**	**South**	**North**	**East**	**South**
Al Muscle	1.97 ± 2.981	0.893 ± 0.425	1.2 ± 1.647	1.432 ± 0.899	1.125 ± 0.46	1.663 ± 1.088
Al Liver	18.57 ± 10.07	39.97 ± 46.11	15.12 ± 10.31	44.64 ± 23.77	55.66 ± 29.82	12.18 ± 6.063
B Muscle	0.562 ± 0.987	0.064 ± 0.049	0.107 ± 0.037	0.177 ± 0.112	0.06 ± 0.026	0.082 ± 0.04
B Liver	1.397 ± 1.131	1.116 ± 1.12	1.029 ± 0.471	1.787 ± 0.594	1.33 ± 0.92	0.452 ± 0.188
Ba Muscle	0.217 ± 0.492	0.083 ± 0.036	0.085 ± 0.018	0.478 ± 0.47	0.209 ± 0.015	0.073 ± 0.033
Ba Liver	1.487 ± 1.232	0.618 ± 0.509	0.514 ± 0.23	1.14 ± 0.991	4.4781 ± 5.579	0.196 ± 0.128
Ca Muscle	3230 ± 1321	3477 ± 1335	3978 ± 1224	3411 ± 2270	2188 ± 760.7	2174 ± 1226
Ca Liver	1837 ± 3492	445.8 ± 675.5	428.4 ± 234.1	1086 ± 1060	1020 ± 1587	75.35 ± 74.69
Cd Muscle	0.007 ± 0.002	0.008 ± 0.005	0.007 ± 0.003	0.003 ± 0.003	0.008 ± 0.004	0.007 ± 0.003
Cd Liver	0.894 ± 0.65	1.19 ± 1.118	0.653 ± 0.381	0.29 ± 0.727	0.063 ± 0.074	0.01 ± 0.014
Cr Muscle	0.075 ± 0.026	0.095 ± 0.031	0.103 ± 0.036	0.132 ± 0.11	0.149 ± 0.266	0.071 ± 0.019

Table 2. *Cont.*

	Serranus atricauda			*Sparisoma cretense*		
	North	**East**	**South**	**North**	**East**	**South**
Cr Liver	<LD	<LD	<LD	<LD	<LD	<LD
Cu Muscle	0.549 ± 0.142	0.518 ± 0.149	0.61 ± 0.11	0.61 ± 0.251	0.408 ± 0.086	0.419 ± 0.097
Cu Liver	4.637 ± 4.501	4.804 ± 3.066	3.911 ± 1.906	5.083 ± 2.485	7.012 ± 3.078	1.759 ± 0.812
Fe Muscle	2.946 ± 2.532	2.583 ± 0.615	3.447 ± 1.032	2.675 ± 1.369	2.201 ± 0.899	2.78 ± 1.567
Fe Liver	124.1 ± 138.47	145.2 ± 197.5	129 ± 92.3	133.2 ± 47.512	100.9 ± 140.8	27.8 ± 16.66
K Muscle	1860 ± 488	2462 ± 319	2501 ± 112	2357 ± 912.6	2222 ± 63.5	2564 ± 239.7
K Liver	2127 ± 870.2	3508 ± 3048	3486 ± 1931	3507 ± 1400	3129 ± 668.3	874.3 ± 467.2
Li Muscle	0.186 ± 0.105	0.265 ± 0.122	0.272 ± 0.1	0.308 ± 0.24	0.191 ± 0.087	0.225 ± 0.129
Li Liver	3.675 ± 3.32	3.793 ± 4.742	2.398 ± 1.251	2.678 ± 2.427	4.918 ± 5.362	2.72 ± 2.086
Mg Muscle	396.9 ± 157.4	328.3 ± 67.58	333.3 ± 23.05	323.3 ± 177	289 ± 20.4	387.8 ± 187.7
Mg Liver	536.8 ± 587	340 ± 298.9	345.7 ± 154	720.2 ± 749.8	249.9 ± 139.2	157 ± 95.52
Mn Muscle	0.272 ± 0.257	0.245 ± 0.13	67.84 ± 144.2	0.724 ± 0.459	69.69 ± 217.6	0.576 ± 0.36
Mn Liver	0.8 ± 0.399	2.033 ± 2.114	1.569 ± 0.88	2.815 ± 2.893	1.749 ± 1.434	0.411 ± 0.38
Mo Muscle	0.013 ± 0.003	0.014 ± 0.002	0.014 ± 0.002	0.013 ± 0.006	0.015 ± 0.003	0.013 ± 0.003
Mo Liver	0.158 ± 0.082	0.207 ± 0.203	0.239 ± 0.119	0.263 ± 0.154	0.254 ± 0.128	0.12 ± 0.085
Na Muscle	936.5 ± 355.5	758.5 ± 153.1	893.1 ± 125.1	965.8 ± 427.2	701.3 ± 60.6	825.9 ± 271.5
Na Liver	1651 ± 804.5	1724 ± 845.3	2008 ± 844.4	2872 ± 1022	1887 ± 509.2	712.3 ± 327.8
Ni Muscle	0.029 ± 0.016	0.025 ± 0.016	0.021 ± 0.011	0.036 ± 0.034	0.043 ± 0.05	0.015 ± 0.013
Ni Liver	0.206 ± 0.26	0.372 ± 0.886	0.061 ± 0.088	0.336 ± 0.171	0.438 ± 0.233	0.126 ± 0.099
Pb Muscle	0.036 ± 0.046	0.042 ± 0.049	0.018 ± 0.003	0.022 ± 0.01	0.02 ± 0.004	0.021 ± 0.009
Pb Liver	0.185 ± 0.139	0.158 ± 0.125	0.098 ± 0.074	0.168 ± 0.091	0.497 ± 0.462	0.047 ± 0.024
Zn Muscle	3.951 ± 0.618	4.499 ± 0.705	4.007 ± 0.212	2.87 ± 1.111	3.434 ± 0.334	3.079 ± 0.281
Zn Liver	22.883 ± 6.919	30.48 ± 20.91	29.59 ± 12.44	22.5 ± 8.67	20.05 ± 14.58	9.134 ± 5.123

The PERMANOVA analysis did not show significant differences in the content of metals and trace elements in the muscle of the species in each location (Table 3). However, the species showed significant differences in the metal content of *Serranus atricauda* and *Sparisoma cretense* in the eastern zone in the PERMANOVA analysis of the metal content in the muscle in each zone (Table 4). Table 5 shows the pairwise comparisons between the two species for each metal and trace element in the three study areas. The eastern area is where most metals (Ba, Ca, Cu, K, Mn, Pb and Zn) have significant differences and *S. atricauda* has the highest concentration of Ca, Cu, K, Pb and Zn. The southern zone resembles the eastern since it also has significant differences in Ca, Cu and Zn, with *S. atricauda* having the highest concentration of these metals. There were significant differences in Ca, Mn and Zn in the northern zone, with *S. atricauda* containing the highest concentrations of Cd and Zn. *S. atricauda* had a higher number of metals with a higher concentration in the three study areas than *S. cretense*, and this may be due to the fact that *S. atricauda* is a benthic predator species [28]. Therefore, it feeds on benthic organisms [29], whereas *S. cretense* is an omnivorous species that feeds in different habitats, so its diet does not depend exclusively on the seabed [30].

Table 3. Results of the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in muscle tissue in species according to study zone, considering the level of the factor "Species".

	Serranus atricauda	*Sparisoma cretense*
North, East	0.117	0.523
North, South	0.067	0.4116
East, South	0.266	0.4366

$p > 0.05$.

Table 4. Results of the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in muscle tissue in species according to study zone, considering the level of the factor "Zones".

	North	East	South
Serranus atricauda *Sparisoma cretense*	0.86	0.009 *	0.056

$p > 0.05$. * Statistical significative diferences.

Table 5. Results of pairwise tests examining the significant factor of 'Zones' obtained in the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in muscle tissue in species according to study zone, considering the level of the factor "Zones".

Serranus atricauda, Sparisoma cretense	**North**	**East**	**South**
Al	0.81	0.255	0.194
B	0.086	0.806	0.162
Ba	0.12	0.012 *	0.236
Ca	0.802	0.012 *	0.009 *
Cd	0.003 *	0.754	0.786
Cr	0.254	0.998	0.016 *
Cu	0.991	0.049 *	0.001 *
Fe	0.78	0.237	0.202
K	0.656	0.038 *	0.492
Li	0.342	0.181	0.299
Mg	0.303	0.098	0.499
Mn	0.034 *	0.001 *	0.458
Mo	0.91	0.483	0.285
Na	0.884	0.352	0.387
Ni	0.892	0.38	0.206
Pb	0.472	0.006 *	0.48
Zn	0.006 *	0.001 *	0.001 *

$p > 0.05$. * Statistical significative diferences.

The PERMANOVA analysis showed significant differences in the content of metals and trace elements in the liver in *S. cretense* in the southern zone with respect to the northern and eastern zones (Table 6). The analysis of the pairwise comparisons between the locations for each species shows that all metals and trace elements, with the exception of Li, have statistically significant differences in the case of *S. cretense* in the southern zone with respect to the other study areas (Table 7). In the case of *S. cretense*, no metal or trace element was found with the highest concentration in the southern zone, with the specimens from the northern zone containing the highest concentrations of B, Ba, Ca, Cd, Fe, K, Mg, Mn, Mo, Na and Zn and the highest concentrations of Al, Cu, Ni and Pb were found in specimens from the eastern zone (Figures 2 and 3). Although there is a high level of tourism activity in the south of Tenerife [17], the highest population density is found in the northern and eastern parts of the island where the capital and the port are located. The population of the capital and the port produce large quantities of discharge, which are responsible for the high concentrations of Al and Pb.

The PERMANOVA analysis of the metal content in the liver of *S. cretense* and *S. atricauda* in each sampling zone identified statistically significant differences between the two species from the southern zone (Table 8).

Table 9 shows the pairwise comparisons between the two species for each metal and trace element in each locality, with significant differences in the southern zone for all the metals except Al and Li. *S. atricauda* had a higher metal concentration than *S. cretense* in all the metals and trace elements except Ni (Figure 3), and this may be due to the fact that *S. atricauda* is a benthic predator species [28]. Therefore, it feeds on organisms that have accumulated higher concentrations of metals, since many of these settle on the seabed [29].

However, *S. cretense* is an omnivorous species that feeds in different habitats, so its diet does not depend exclusively on the seabed [30,31].

The liver contains a large quantity of essential metals, which, a priori, could lead one to think that this organ is of much interest from the nutritional point of view. However, on the other hand, the concentration of toxic metals in the liver tissue is thirty-five times the concentration in the muscle, and, because of this, the consumption of liver could be potentially dangerous; furthermore, the concentrations of trace metals that could be potentially toxic in large amounts are notably higher in the liver [32–35].

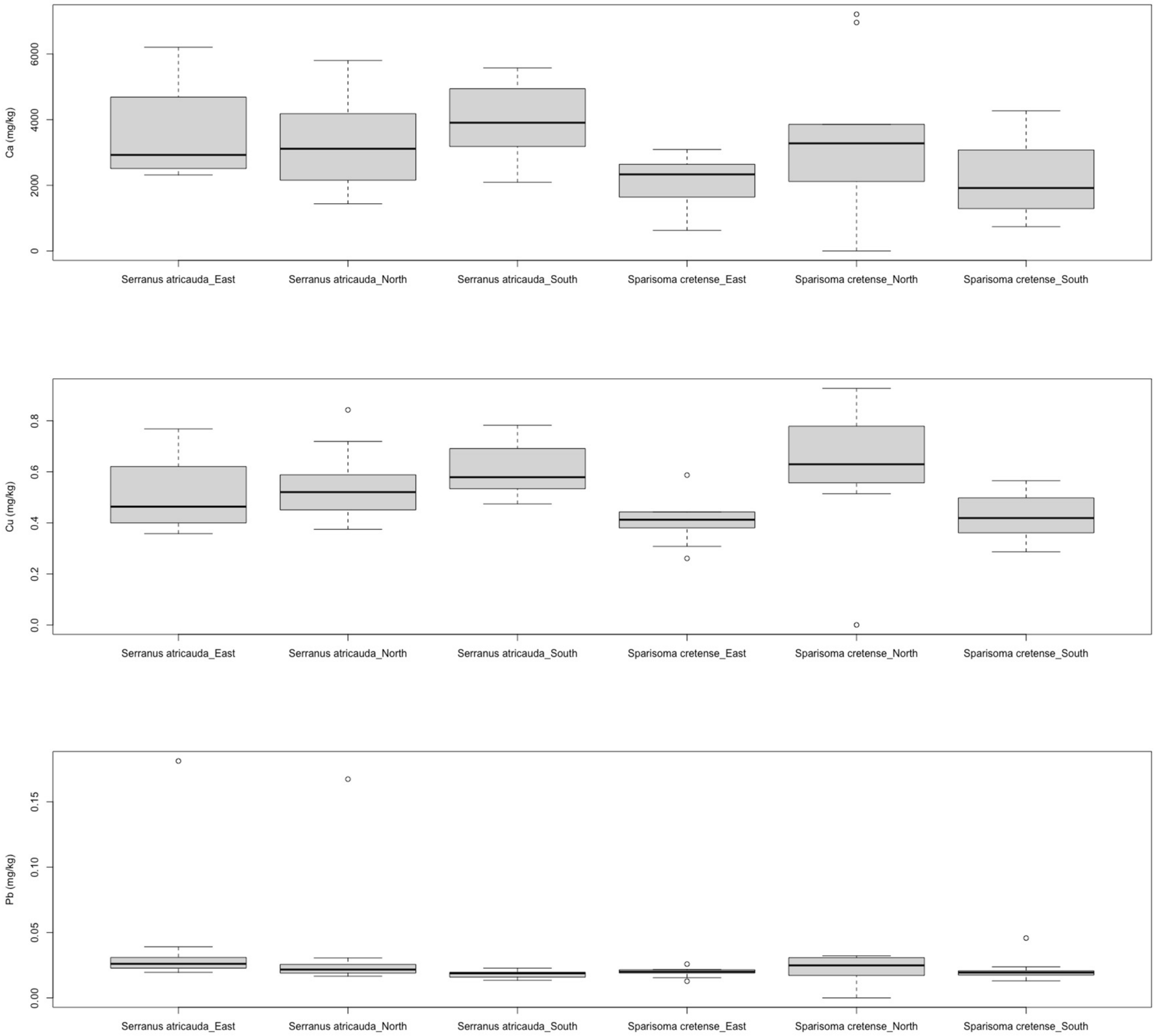

Figure 2. Boxplot of the two species in each sampling area for Ca, Cu and Pb.

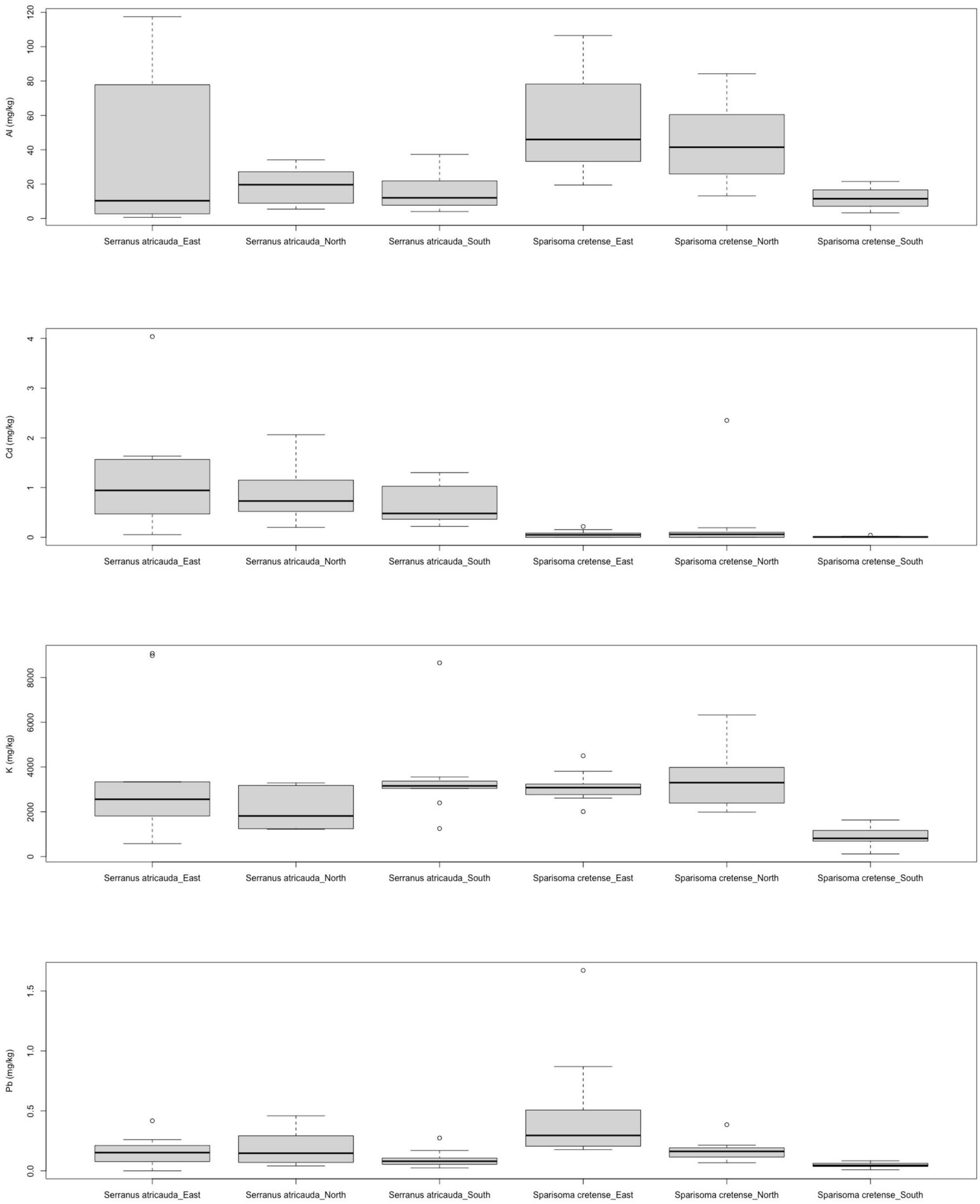

Figure 3. Boxplot of the two species in each sampling area for Al, Cd, K and Pb.

Table 6. Results of the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in liver tissue in species according to study zone, considering the level of the factor "Species".

	Serranus atricauda	*Sparisoma cretense*
North, San Andrés	0.414	0.124
North, South	0.266	0.001 *
San Andrés, South	0.813	0.001 *

* Statistical significative diferences.

Table 7. Results of pairwise tests examining the significant factor of 'Zones' obtained in the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in liver tissue in species according to study zone, considering the level of the factor "Species".

	Serranus atricauda			*Sparisoma cretense*		
	North, San Andrés	**North, South**	**San Andrés, South**	**North, San Andrés**	**North, South**	**San Andrés, South**
Al	0.627	0.412	0.43	0.319	0.001 *	0.001 *
B	0.393	0.423	0.744	0.162	0.001 *	0.024 *
Ba	0.048 *	0.019 *	0.835	0.003 *	0.001 *	0.001 *
Ca	0.309	0.449	0.579	0.469	0.001 *	0.023 *
Cd	0.58	0.368	0.221	0.459	0.023 *	0.042 *
Cu	0.83	0.816	0.602	0.142	0.002 *	0.001 *
Fe	0.905	0.745	0.89	0.153	0.001 *	0.008 *
K	0.29	0.027 *	0.747	0.56	0.001 *	0.001 *
Li	0.613	0.312	0.943	0.195	0.898	0.254
Mg	0.517	0.594	0.795	0.008 *	0.001 *	0.226
Mn	0.18	0.008 *	0.973	0.044 *	0.001 *	0.007 *
Mo	0.968	0.099	0.262	0.956	0.038 *	0.048 *
Na	0.721	0.342	0.412	0.15 *	0.001 *	0.001 *
Ni	0.929	0.104	0.409	0.299	0.004 *	0.001 *
Pb	0.569	0.1	0.375	0.003 *	0.001 *	0.001 *
Zn	0.41	0.197	0.893	0.43	0.002 *	0.001 *

* Statistical significative diferences.

Table 8. Results of the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in liver tissue in species according to study zone, considering the level of the factor "Zones".

	North	**San Andrés**	**South**
Serranus atricauda *Sparisoma cretense*	0.125	0.716	0.001 *

* Statistical significative diferences.

Table 9. Results of pairwise tests examining the significant factor of 'Zones' obtained in the two-way PERMANOVA analyzing the variation in the content of heavy metals and trace elements in liver tissue in species according to study zone, considering the level of the factor "Zones".

Serranus atricauda*, *Sparisoma cretense	**North**	**San Andrés**	**South**
Al	0.006 *	0.075	0.558
B	0.167	0.568	0.001 *
Ba	0.553	0.001 *	0.003 *
Ca	0.998	0.482	0.001 *
Cd	0.007 *	0.002 *	0.001 *
Cu	0.566	0.105	0.003 *
Fe	0.465	0.588	0.001 *
K	0.015 *	0.881	0.001 *
Li	0.42	0.382	0.874
Mg	0.378	0.339	0.002 *
Mn	0.002 *	0.98	0.001 *
Mo	0.205	0.347	0.018 *
Na	0.01 *	0.469	0.001 *
Ni	0.064	0.096	0.023 *
Pb	0.935	0.008 *	0.029 *
Zn	0.833	0.804	0.001 *

* Statistical significative diferences.

Table 10 shows the comparison with other authors; it should be noted that not many studies have analyzed the concentration of metals and trace elements in *S. cretense* and *S. atricauda* in the Atlantic Ocean. In fact, after reviewing the literature, the only data found for *S. cretense* in the Canary Islands [36,37] show that the concentrations reported more than 25 years ago in *S. cretense* are much higher than those obtained in the present study. In the case of toxic heavy metals such as Cd (0.077 mg/kg) and Pb (1.43 mg/kg), the concentrations are more than ten times higher than the data obtained in the present study. This may be explained by the fact that current environmental regulations and controls are stricter than those that were in force in the past, and, perhaps more importantly, because gasoline is no longer made with Pb.

The study of Afonso et al. [15] on the island of Gran Canaria (Canary Islands) reports that the metal concentrations in *S. cretense*, with the exception of Pb (0.23 mg/kg), were lower than those obtained in the present study. Fernández-Echevarría, 2017 analyzed the trace elements in *Serranus cabrilla* from Tenerife (Canary Islands) and found higher concentrations of Al, Ba, Cd, Cu, Fe, Li, Ni and Pb. These values suggest that *S. cabrilla* bioaccumulates more metals than *S. atricauda*. Roméo et al. [38] studied the concentrations of *Serranus scriba* on the coast of Mauritania, identifying levels of 20 mg/kg of Zn, which is five times higher than the concentrations obtained in the present study, and this may be due to the fact that Mauritania is influenced to a greater degree than the Canary Islands by the Sahara Desert, which is rich in Zn, as the upwelling it creates brings nutrients to the surface waters [14,39–41].

Studies carried out in the Mediterranean Sea, in Egypt and in Turkey report values in all metals and trace elements greater than those in the present study, and this is because the Mediterranean Sea is a closed sea whose only opening to the Atlantic is the Strait of Gibraltar and, therefore, it has a notably low water renewal rate, causing pollutants to accumulate in organisms [42–45].

Table 10. Comparison with other authors (mg/kg).

	Atlantic Ocean								Mediterranean Sea		
	Canary Islands						Mauritania		Egypt		Turkey
	Serranus atricauda	*Sparisoma cretense*				*Serranus cabrilla*	*Serranus scriba*	*S. cretense*	*Serranus cabrilla*	*S. cretense*	*S. cabrilla*
Al	1.354	1.407	2.37			4.438				16.8	
B	0.245	0.106	0.16			0.138					
Ba	0.128	0.254	0.084			0.456					
Ca	3561	2591	105.21			562.1					2762
Cd	0.007	0.006	0.001	0.77		0.107	0.02	0.6			
Cr	0.091	0.117	0.13			0.010					
Cu	0.559	0.479	0.37	1.6	1.7	0.735	0.3	0.4	8.3		
Fe	2.992	2.552	2.21	9.41	9.3	7.026					
K	2275	2381	2054			2475					17,865
Li	0.241	0.241	0.42			1.201					
Mg	352.9	333.4	281.8			282.1					1331
Mn	22.78	23.66	0.09			0.172					
Mo	0.014	0.014	0.003			0.013					
Na	862	831	488.1			909.3					3723

Table 10. *Cont.*

	Atlantic Ocean								Mediterranean Sea		
	Canary Islands						Mauritania		Egypt		Turkey
	Serranus atricauda	*Sparisoma cretense*				*Serranus cabrilla*	*Serranus scriba*	*S. cretense*	*Serranus cabrilla*	*S. cretense*	*S. cabrilla*
Ni	0.025	0.031	0.029	0.71	0.87	0.143					
Pb	0.032	0.021	0.023	1.43		0.054					
Zn	4.152	3.128	2.43	5.26		3.729	20	7.4	14.1		19.93
	The present study	The present study	[15]	[36]	[37]	[46]	[38]	[47]		[48]	[49]

4. Conclusions

The mean metal concentration was significantly higher in liver tissue than in muscle tissue of the two species studied. The only exceptions are Ca, which had a significantly higher mean result in muscle tissue, and K and Mg, whose concentrations were statistically similar in both tissues.

Serranus atricauda specimens had a larger number of metals with a higher concentration in the three study zones than *Sparisoma cretense*, with higher concentrations of Ca, Cu, K, Pb and Zn being found in *S. atricauda*. The southern zone resembles the eastern zone, as it was also found to have significant differences in Ca, Cu and Zn concentrations, with *S. atricauda* having the highest concentrations of these metals. The northern zone was found to have significant differences in Ca, Mn and Zn concentrations, with *S. atricauda* containing the highest concentrations of Cd and Zn, which may be because *S. atricauda* is a benthic predator species. The northern and eastern zones were found to have a higher concentration of metals and trace elements than the southern zone, which could be explained by the fact that these zones are more polluted due to their higher population density.

These two species are of great fishing interest in the Canary archipelago, so it is vital to carry out a biannual monitoring of the content of metals and trace elements in order to develop nutritional studies, as well as to monitor risk assessment. It is important to know the areas with the lowest concentration of toxic metals in order to avoid them. A project for the elimination of this contamination in the affected areas should also be carried out.

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