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Full Length Research

Comparative study of the metallic contamination assessment of a *Paracentrotus lividus* (lmck, 1816) macrobenthic community in Algerian west coast

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ABSTRACT: This study assesses the characteristics of the metallic trace elements (Fe, Cd, Cu, Pb and Zn) in the *Paracentrotus lividus* gonads. The physiological indices evolution (RIm and GIm) was adopted in order to determine the laying period of this echinoid; and to support the hypothesis that this species may be considered as an excellent bioindicator in the marine environment. For this purpose, two edible sea urchin populations with a diameter between 41 and 71 mm were sampled. This samples were taken from two different sites, Salamandre area (presence of rocky seabed rich of photophilic algae, with less biodiversity), and Sidi Lakhdarin area (presence photophilic algae and *Posidonia oceanica*, more biodiversity). Each sample was evaluated by the coupled plasma mass spectrometry (ICP-MS) method. The results obtained show that there is a significant variation ($p<0.005$) of physiological indices (RIm and GIm) over time. Besides, an important spawning increase is observed during spring and autumn. The results revealed that gonads metallic contaminations were present in all samples, with very heterogeneous concentrations. Also, it demonstrates that the metallic contamination existed in all seasons, with a clear demarcation of zinc and iron. The zinc quantity is 2.159 mg/l in Sidi Lakhdar and 1.413 mg/l in Salamandre; and the iron quantity is 2.088 mg/l in Sidi Lakhdar and 1.888 mg/l in Salamandre. Unlike zinc and iron, copper and cadmium have small amounts in the two sites. In the autumn, the cadmium quantity is 0.005 mg/l in the two sites; and the copper quantity is 0.068 mg/l in Sidi Lakhdar and 0.065 mg/l in Salamandre. Consequently, this marine species accumulates large quantities of these toxic metals according to the bioavailability of the pollutant in the surrounding environment.

Keywords: Biodiversity, GIm, metallic trace elements pollution, *P. lividus,* RIm, Salamandre, Sidi Lakhdar.

Abbreviations: E: Water, **F:** Female, **GIm:** Average gonadal index, **RIm:** Average repletion index, **G:** Gonad, **Lmck:** Lamarck, **M:** Mars, May, Males, **P:** Weight, **ppm:** Part per million, **ICP-MS:** Coupled Plasma Mass Spectrometry.

INTRODUCTION

The coastal continental plateau is a region of a variety of economic activities; that is what has been happening over the last few decades in Algeria. Coastal areas have been the scene of accelerated development and demographic pressure (Zerki, 2013) that constitutes a large and an important origin of natural and anthropogenic substances that have toxic properties. This is due to the water circulation on the surface of the continents. The rivers, direct terrestrial inflows, the runoff, and leaching in the emerged lands in coastal areas bring numerous pollutants into the littoral waters thus causing a marine pollution (Ramade, 2000; Barbeault, 2003).

The growing contamination of the biosphere affects the environment from the one hand and affects human beings from the other hand. Among the pollutants that affect the biosphere are Pb, Cd, Zn, Cu, Fe etc. which are charac-

Figure 1. Map of the study area reporting the sampling sites.

terized by their persistence, toxicity and capacity for accumulation (Couvray, 2016). These metals can negatively damage the metabolism and organs of living creatures. The contamination of humans has a relation with the consumption of the products of the sea, since some elements can be transferred by bioaccumulation and biomagnification in the food web and accumulate in living matter (Kucuksezgin et al., 2002).

Among these marine organisms, *Paracentrotus lividus* is a fundamental element of coastal ecosystems (Fernandez, 1996); a bio model widely used in various scientific fields. And a sentinel species giving its sedentary lifestyle and its resistance to metal pollutants (Laaidi et al., 2002).

The objectives of this research were to quantify the metal contamination level of *P. lividus* milt, and to assess the quality of the biotopes for the two sites, then determine the laying period.

MATERIALS AND METHODS

Study area and sampling methods

The experimental study was conducted from August 2013 to July 2014 and 1176 specimens with a diameter between 41 and 71 mm were chosen as samples for the period (1 year) at a depth of 3 m in two sites. This is because there is a strong presence of sea urchin, with a geographical position and different structure. One is located at (35° 54' 37'', 38°N) latitude and (0° 03' 14'', 78°E) longitude in the Salamandre, with substrate rocky and of photophilic algae. The second, at (36° 12' 40'', 63°N) latitude, and (0° 23 '20'', 78°E) longitude in Sidi Lakhdar lying under the watershed of the Wadi seddaoua, in the north-east of the state of Mostaganem (west of Algeria); an area characterized by a loose substrate rich in photophilic algae, and the presence of the Magneliophyte *Posidonia oceanica.* (Figure 1) (Dermeche, 2010; Boukhelf, 2012).

The choice of two selected sites in this study was based on the identification of the Environment Inspection of the state of Mostaganem located in the North West of Algeria. The two areas are affected by the different forms of pollution such as urbanism, industries, various spills, strong amenities etc. (Direction of the environment, 2012).

The study was done on the coastal area of the Salamandre, a site located in the Gulf of Arzew west of Mostaganem. Salamandre region is characterized by a high level of pollution from the gas plant and other types of factories waste such as chlorine, milk, paper etc. In addition, agricultural and urban pollutants also contribute to the pollution level in this area (Figure 2) (Dermeche, 1998; Dermeche et al., 2012; Boukhelf, 2012).

On the other hand, Sidi Lakhdar, is a town located in east of Mostaganem, which is less polluted. The only type of pollution found in this region is by wastewater discharge located in Oued Abid, due to the fact that Sidi Lakhdar has less inhabitants, with presence of forest and vast farming areas (Figure 2) (Direction of the environment, 2012).

The Salamandre wastewater spills

No spill of sewage in Sidi Lakhdar

Economic and passenger port at 1 km east of La Salamandre

Small fishing port 100 m east of the Sidi Lakhdar sampling area

Figure 2. Characterization of tow sampling sites (Salamandre and Sidi Lakhdar) the scale is one cm on a map that corresponds to 30 km (Google Map, 2012).

Metal analysis and physiological indices

The study of 14 sea urchin samples per month was used to quantify the heavy metal pollution of both sites (Salamandre and Sidi Lakdar). After dissection at the oval portion of the sea urchin and separate the male and female gonads, then gonads were recovered and mineralized using nitric acid for one hour at 95°C in the mineralizer according to the method of Amiard et al. (1987). Then, subsequent reading by the Coupled Method of plasma mass spectrometry Perkin Elmer, Optima 8000 DV model (ICP-MS) was performed (Figure 3)

For the physiological indices study, in addition to 14 sea urchins used for heavy metals, 35 sea urchin adults were collected per month and per site. After dissection, the fresh weight of the intestines and gonads were taking and then dry in an oven for 48 hours. Thereafter, the dry weights of both organs were taken and the physiological indices for the repletion index was calculated as follows:

$$\mathrm{RIm} = \frac{\text{Dry weight of the digestive contents } (\mathrm{mg/cm^3})}{(\text{Horizontal diameter of the test})^3 \ (\mathrm{cm^3})}$$

Moreover, for the gonad index it is expresses as follows:

$$\mathrm{GIm} = \frac{\text{Dry weight of the gonads } (\mathrm{mg/cm^3})}{(\text{Horizontal diameter of the test})^3 \ (\mathrm{cm^3})}$$

The above calculation was based on the works of Nedelec (1983), Regis (1978), Lawrence and Lane (1982), Semroud et al. (1987), San Martin (1990), Sahnoun (2009), Belkhedim (2009) and Dermeche (2010).

Statistical treatments

The Student t test was taken into consideration for the treatment of metallics concentrations. The variance test

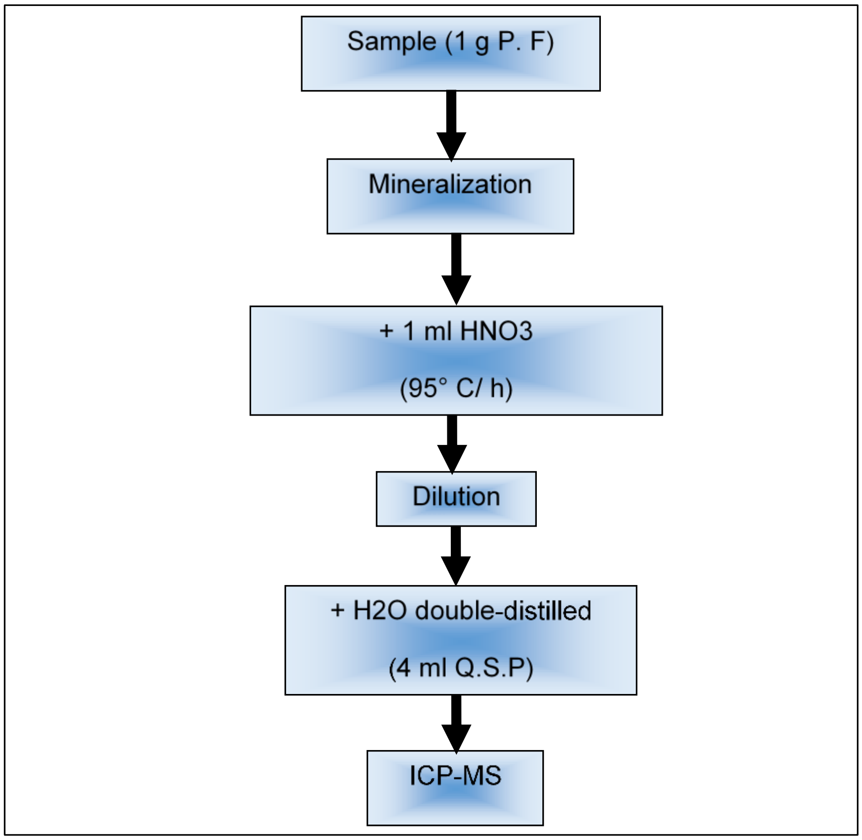

Figure 3. Synoptic of the protocol for mineralization and determination of trace metals in ICP-MS coupled plasma mass spectrometry (Amiard et al., 1987).

Table 1. Seasonal averages (± standard deviation) and variances moneymen (var) of the physiological indices (mg / cm^3) of *P. lividus* of Sidi Lakhdar and Salamandre.

Station	Autumn (A)	Var	Winter (H)	Var	Spring (P)	Var	Summer (E)	Var
Sidi Lakhdar								
RIm	29.13 (9.29)	151.23	20.01 (4.5)	28.97	24.68 (6.76)	67.62	26.7 (20.9)	498.00
GIm	9.27 (7.47)	27.74	9.34 (2.91)	11.65	4.41 (1.88)	18.45	9.21 (1.28)	1.82
Salamandre								
RIm	23.34 (7.32)	78.56	13.46 (6.05)	37.39	17.73 (5.74)	49.62	11.5 (4.75)	27.05
GIm	4.25 (1.97)	1.9	3.87 (0.84)	0.95	4.26 (1.48)	4.80	5.11 (4.3)	19.51

and the Fischer Snedecor test for physiological indices (Dermeche 2010; Nakiba, 2010, Dermeche et al., 2012; Boukhelf, 2012; Kouadri, 2013).

RESULTS

Evolution of physiological indices

The study of the trophic behavior of *P. lividus* has a direct relation with gonad index. The values of RIm demonstrate high consumption phases. In fall period, the following results were obtained: 23.34 ± 7.32 mg/ for the IRm and GIm 4.25 ± 1.97 in the Salamandre site and 29.13 ± 9.29 mg/cm^3 for RIm and GIm 9.27± 7.47 in Sidi Lakhdar site. (Table 1).

It was found that the gonadal index shows peaks when the values of the repletion index are low. Different results were obtained from the two sites. For instance, in Sidi lakhdar the RIm: 20.01 ± 4.50 mg/cm^3 and GIm: 9.34 ± 2.91 mg/cm^3 were obtained. Similar results were observed in the Salamandre with RIm: 13.46 ± 6.05 mg/cm^3 and GIm:

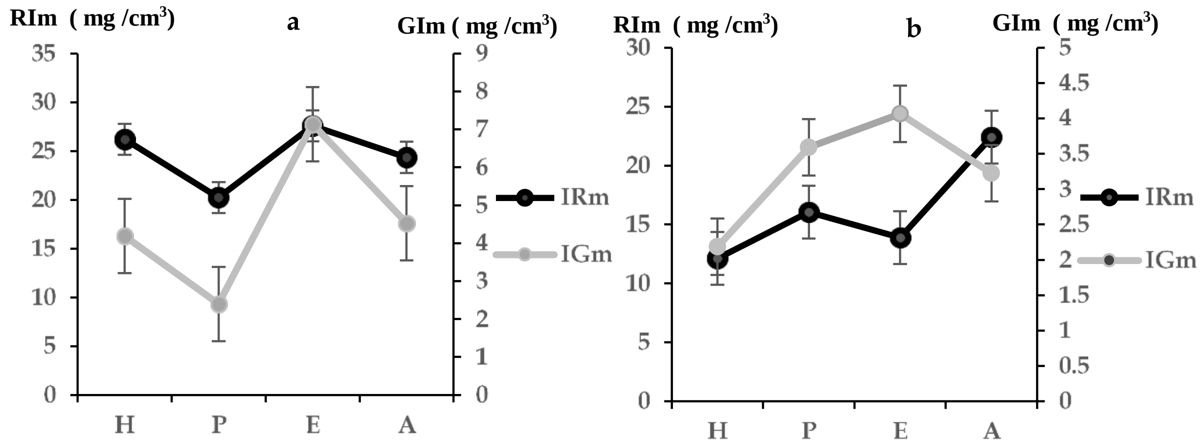

Figure 4. Seasonal averages of physiological indices (RIm and GIm) of sea urchins in Salamandre (b) and Sidi Lakhdar (a). E: Summer, A: Autumn, H: Winter, P: Spring.

Table 2. Results of the analysis of variance of the mean replication indices (RIm) and gonadic index (GIm) obtained in *P. lividus*.

Site	Physiological indices	VA	ddl	VB	ddl	F cal	F théo	Significance (5%)
Sidi Lakhdar	RIm	186 .46	2	153.70	33	32.76	3.23	+
	GIm	14.92	2	12 .63	33	2.29	3.23	-
Salamandre	RIm	48.16	2	94.93	33	46.77	3.23	+
	GIm	6.79	2	7.97	33	1.18	3.23	-

3.87 ±0.87 mg/cm^3 (Figure 4).

The analysis of the physiological indices of the two stations were analyse by the analysis of variance that indicates a significant difference of (1. 76 < 1.96) ($p< 0.005$); with a major spawning that takes place in spring and autumn for all sea urchin populations.

For clarity in the interpretation of the results, an analysis of the variance at two factors (physiological indices and station) along the entire sampling year indicates that there is a significant difference ($p <0.05$), where the repletion index of the specimens of Sidi Lakhdar is significantly higher than the sea urchins of the Salamandre (F = 46.77 to 32.76, $p<0.05$).

Whereas the reverse is observed for the gonad index where the difference is significant at the level of living sea urchins at the Salamandre and at Sidi Lakhdar station (F = 2.29 to 1.12, $p <0.05$) (Table 2). This could be explained by the distribution and the abundance of the species in the milieu. Indeed, the site of Sidi Lakhdar is characterized by the abundance of photophilous algae constituting the preferential food of *P. lividus*, and therefore an important wealth of the milieu can optimize their gonadal reproduction.

Metallic contamination of *P. lividus*

The evolution of metallic mean concentrations in the sea urchin according to the evolution of the two physiological indices at the level of both sexes of the edible sea urchin is recorded in Table 3. The diversity in these metal tenors prove the existence of metals (Fe, Cu, Cd, Zn, Pb) which are influenced by sex. These metals exist with higher level for female (F) sea urchins, than for the males (M) urchins. Gonads (G) GF: 2.159 mg/l and GM: 0.466 mg/l for Sidi Lakhdar and GF: 1.413 mg/l and GM: 0.735 mg/l for the Salamandre).

A significant concentration ($p <0.05$) of iron for male and female urchins was obtained. Whereas no significant difference is observed for copper (Cu) and cadmium (Cd) ($p <0.05$). The student test t is t = 1.23, compared to the theoretical test of the table. The results of this study are higher, so there is a significant difference ($p <0.05$) between the amount of metals present in the two sites.

Seasonal average metallic contamination of *P. lividus* to function evolution in physiological indices

Seasonal variations seem to regulate the distribution of heavy metals. Indeed, it was latter noticed that there was considerably fluctuate in the gonads during spring and autumn period. From this study, it was observed that there is a drop in average tenors of all pollutants measured during the spring: 0.057 ± 0.045 mg/l for copper, 0.005 ± 0.0021 mg/l for cadmium, 1.98 ± 0.80 mg/l for iron and

Table 3. Seasonal averages of metal concentrations (ppm PF) at the male (GM) and female (GF) gonads of edible sea urchin *P. lividus* with standard deviation.

Station	PF	Annual conc. in gonads (G)		Seasons							
				A		H		P		E	
		GM	GF	GM	GF	GM	GF	GM	GF	GM	GF
Sidi. Lakhdar	Fe	2.088 (0.132)	1.981 (0.063)	1.837 (1.103)	1.890 (0.989)	2.37 (0.813)	2.005 (1.587)	1.98 (0.80)	2.114 (0.514)	2.167 (0.403)	1.917 (0.936)
	Cu	0.087 (0.002)	0.069 (0.004)	0.068 (0.037)	0.0717 (0.029)	0.154 (0.146)	0.06 (0.037)	0.064 (0.045)	0.078 (0.0163)	0.061 (0.035)	0.066 (0.025)
	Zn	0.466 (0.101)	2.159 (1.384)	0.345 (0.280)	0.136 (0.026)	0.215 (0.141)	0.441 (0.416)	0.581 (0.491)	5.665 (5.60)	0.725 (0.695)	2.398 (2.30)
	Cd	0.0048 (0)	0.005 (0.0001	0.005 (0.002)	0.0057 (0.001)	0.0043 (0.004)	0.0045 (0.003)	0.005 (0,002)	0.005 (0.0021)	0.005 (0.002)	0.005 (0.0021)
	Pb	0.199 (0.002)	0.196 (0.0001	0.198 (0.038)	0.193 (0.05)	0.205 (0.116)	0.205 (0.024)	0.194 (0.046)	0.193 (0.0495)	0.198 (0.038)	0.192 (0.051)
Salamandre	Fe	1.888 (0.004)	1.923 (0.038)	1.801 (1.179)	1.837 (1.103)	2.007 (0.743)	1.947 (0.860)	1.87 (1.032)	2.018 (1.560)	1.877 (1.02)	1.893 (0.983)
	Cu	0.102 (0.087)	0.069 (0.024)	0,065 (0,044)	0.0763 (0.017)	0.061 (0.035)	0.054 (0.039)	0.058 (0.042)	0.057 (0.045)	0.224 (0.202)	0.09 (0.0262)
	Zn	0.735 (0.028)	1.413 (0.089)	0.398 (0.355)	0.165 (0.035)	0.178 (0.068)	0.69 (0.382)	2.225 (2.005)	4.231 (4.20)	0.138 (0.017)	0.565 (0.570)
	Cd	0.005 (0)	0.0054 (0.001)	0.005 (0.001)	0.005 (0.002)	0.005 (0,002)	0.0045 (0.0014)	0.007 (0.0014)	0.006 (0.002)	0.005 (0.002)	0.006 (0.0021)
	Pb	0.194 (0.000)	0.159 (0.003)	0.194 (0.047)	0.194 (0.046)	0.198 (0.038)	0.053 (0.030)	0.193 (0.048)	0.193 (0.049)	0.192 (0.051)	0.198 (0.339)

0.581 ± 0.491 mg/l for zinc in Sidi Lakhdar for females and males at both sites (laying period) (Figure 5).

The concentration of different metals reveals that zinc and iron for females' gonads have the highest level of pollution in both sites during spring and summer (Figure 5 and Table 4). While during the other two seasons, the concentrations are lower. On the other hand, the level of concentrations in males are higher for cadmium and copper.

The graphs (Figure 5) illustrate the relation between sexual test with the trophic of urchins; which is a phase of gametogenesis characterized by increased accumulation of nutrient reserves. So, the trophic of urchins during spring and summer, and the laying period during the same period permit to store nutrition automatically.

DISCUSSION

Physiological indices

The peaks of the gonad index represent the spawning period that are generally observed in spring and autumn for *P. lividus* frequenting the Mediterranean waters (Régis, 1979; Leoni et al*.,* 2001; Guettaf, 1997; Sahnoun, 2009; Belkhdim, 2009).

Temperature and hydrodynamics conditions have an important role in the gonads construction during the spawning period (summer), and the gonads release during (autumn) (Marie et al., 2014). Also, the density of a given population plays a role in gonad growth despite eating an equivalent food. The gonad index is high when the density is low (Andrew, 1986; Byrne, 1990; Guettaf and San Martin, 1995; Fernandez, 1996; Dermeche, 2012).

The development of gonads causes a decrease of the space of the coelomic cavity; therefore, the available space is insufficient for the digestive tract and its content and this result to a drop in the repletion index (Leighton, 1968). Increasing size leads to a decrease in spawning, even a complete drop in the gonad index (Fuji, 1967; Conor, 1972; Pearse & Cameron, 1991; Semroud, 1993; Lumingas, 1994; Lozano et al., 1995; Fernandez, 1996; Belkhedim, 2013).

It was concluded that there is a relationship between the two physiological indices; when RIm increases, the GIm decreases. The variations of the repletion index show that there is a phase of low consumption in summer, for the Salamandre individuals while it is higher at the level of Sidi Lakhdar. The same finding was made by Semroud et al. (1987), Belkhedim (2009), Dermeche (2010), Dermeche et al. *(*2012), Boukhelf (2012), Kouadri (2013) and Belkhedim (2013).

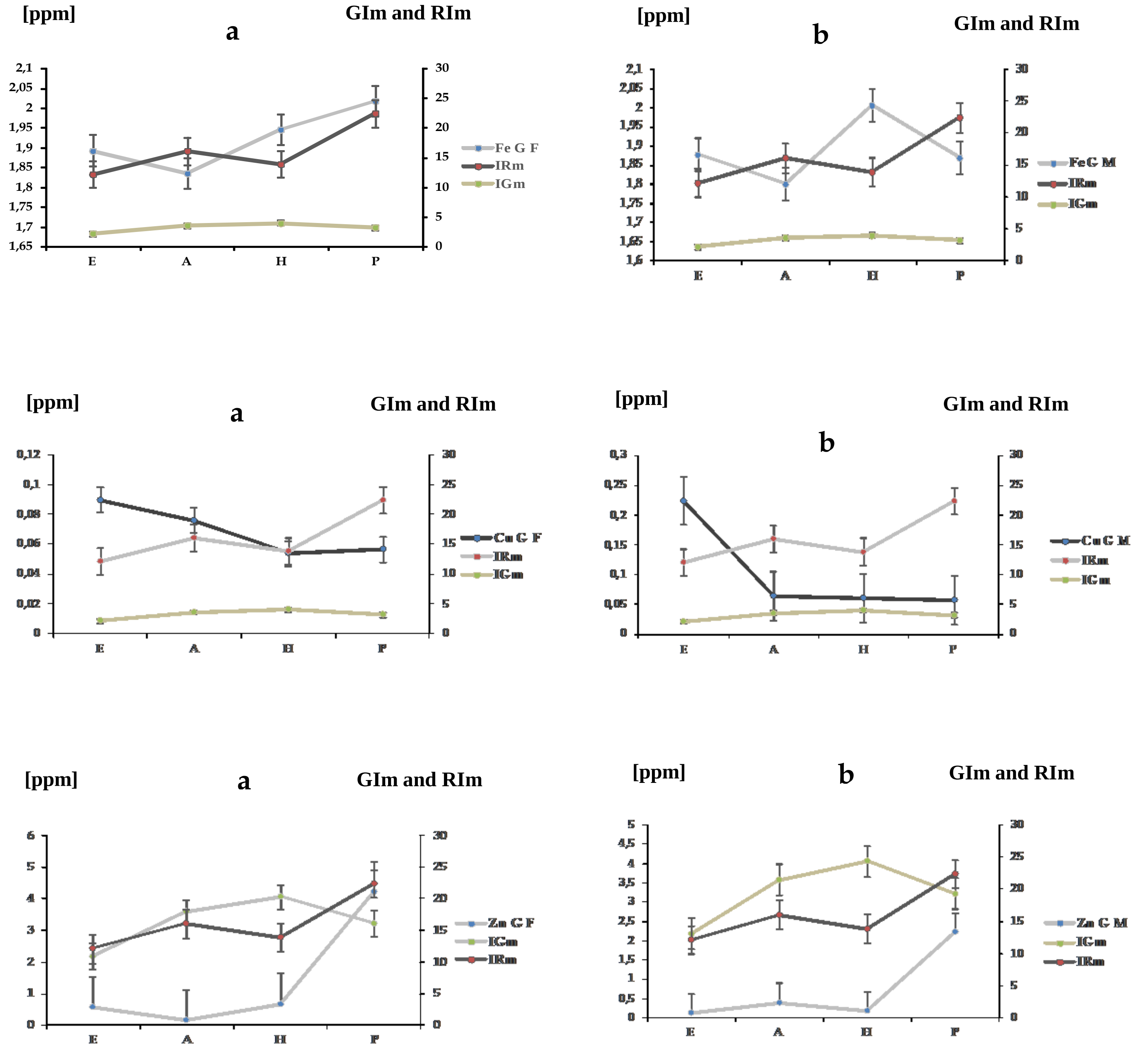

Figure 5. Evolution of the average concentrations of heavy metals according to the evolution of the physiological indices (RIm and GIm mg / cm^3) at the gonads (G) females (F) (a) and males(M) (b) of the Salamandre.

The sea urchin in Sidi Lakhdar consume much more than those of the Salamandre. This high consumption is due to the richness of the substrate of Sidi lakhdar area. This has already been observed in Algeria by Sahnoun (2009), Belkhedim (2009), Dermeche (2010), Boukhelf (2012) and Belkhedim (2013).

The sea urchin population growth in Sidi Lakhdar is connected to its good ecological index and its good quality waters, compared to Salamandre sea urchins with the water body polluted with neighbouring industrial and urban discharges (Dermeche, 2010; Dermeche et al., 2012; Boukhelf, 2012; Kouadri, 2013; Belkhedim, 2013).

Metallic contamination

The important trace metals appear at the spring and autumn level because the laying period for this Echinoderm mostly takes place in this same moment from where the values was observed (Semroud, 1993;

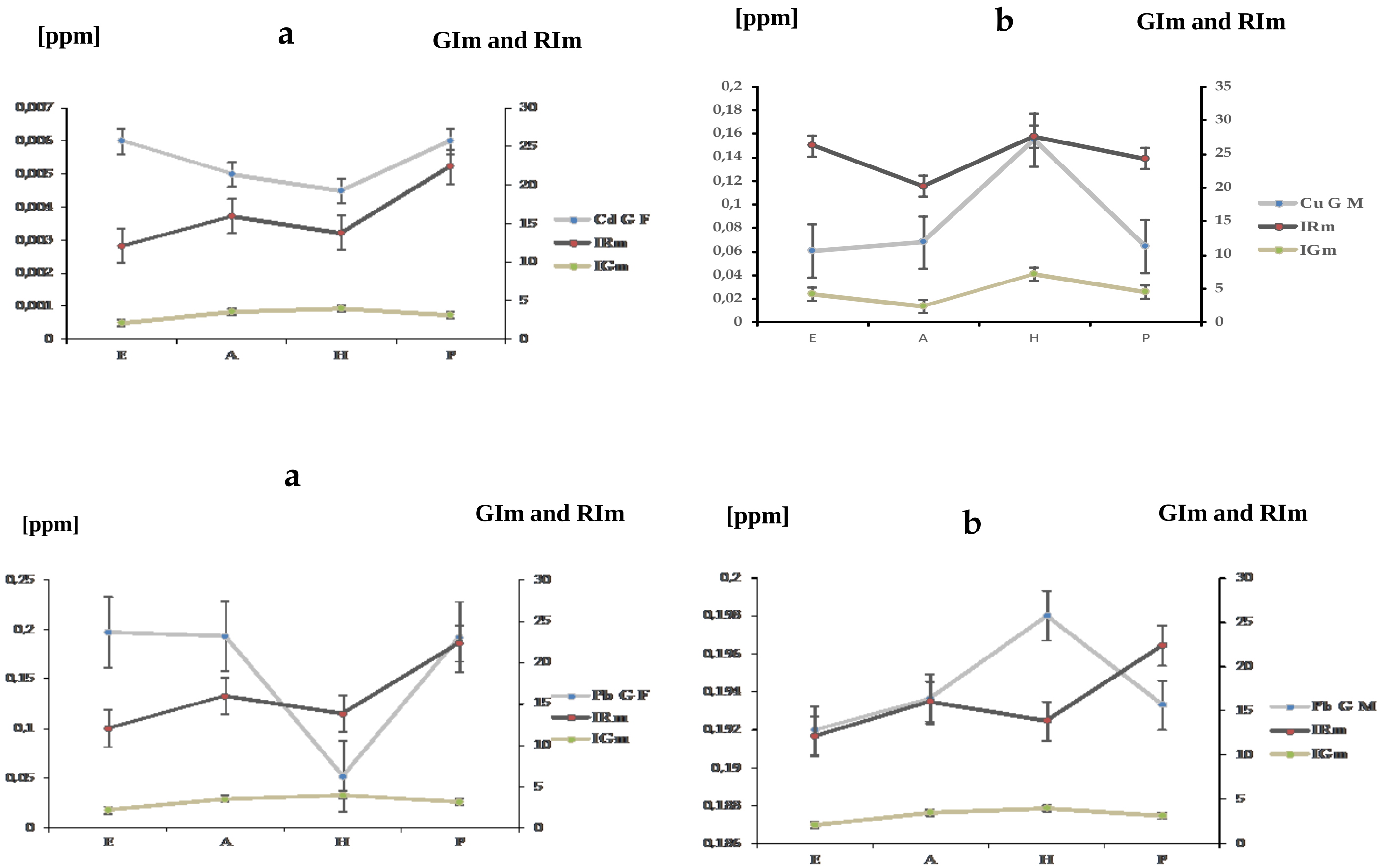

Figure 5 continued. Evolution of the average concentrations of heavy metals according to the evolution of the physiological indices (RIm and GIm mg / cm^3) at the gonads (G) females (F) (a) and males(M) (b) of the Salamandre.

Table 4. Metal concentrations (ppm P.S) observed in *P. lividus* gonads from different Mediterranean regions.

locate	Gonads females and males						References
	Zn		Cd		Cu		
	G.f	G.m	G.f	G.m	G.f	G.m	
Mostaganem (Alegria)	3.572	1.201	0. 0104	0.0098	0.138	0.189	Boukhelf, 2014
Oran (Alegria)	23.97	17.76	7.54	3.4	17.23	11.81	Bekhedim, 2013
Mostaganem (Alegria)	105.54	27.23	1	1.68	5.2	4.8	Boukhelf, 2012
Mostaganem (Alegria)	19.75	13.02	1.35	1.3	15.68	12.59	Dermeche, 2010
Mostaganem (Alegria)	13.45	7.74	0.53	0.26	1.53	1.04	Sahnoun, 2009
Alger (Alegria)	385.5	32.9	0.14	0.08	2.84	3.19	Soualili, 2008
Mohammedia (Morocco)	-	-	2.24	2.32	2.51	1.18	Bayed et al., 2005
Ponteau Fos Sur Mer (Marseille)	82		0.6		5.6		Neto et al., 1992
Côte Bleue (Franch)	109		3.51		0.19		Warnau et al., 1998
Baie d'Arzew (Alegria)	16.72		0.17		2.82		Dermeche, 1998
Italy	157.1		0.24		5.19		Storelli et al., 2001
Franch	327		0.8		3.6		San Martin, 1995

Fernandez, 1996; Soualili, 2008; Sahnoun, 2009; Dermeche, 2010). The phenomena of the biological cycle such as growth, nutrition, periods of deprivation, reproduction and excretion, synthesis and storage of carbohydrate, lipid and protein materials (Webb, 1997) have a significant impact on the bioaccumulation process.

The work of Boyden and Phillips (1981) put to obviousness the existing relationships between the concentration of the metal in the organism, its age and sex. The concentration of metal in the organism is influenced by the growth and weight loss especially during the gonad-ripening period (Simpson, 1979; Cossa and Lassus, 1989; Fischer et al., 1995). This leads to the accumulation of metals studied and confirms that urchins release quantities of pollutants during spawning period (Semroud et al., 1987; Dermeche et al., 2007; Dermeche et al., 2012; Belkhedim, 2013). The same type of phenomenon for both sexes was observed during the study and for all sea urchins frequenting the Mediterranean Sea (San Martin, 1995; Dermeche, 1998; Boukhelf, 2012; Belkhedim, 2013). It is well known that this metal participates in the classification of the stems of sea urchin larvae; hence, there is a strong bioaccumulation (Auernheimer et al., 1996; Fichet et al., 1998; Dermeche, 2010; Dermeche et al., 2012; Boukhelf, 2012; Kouadri, 2013; Belkhedim, 2013).

Ueda et al. (1991) in San Martin (1995) explain that the difference in the concentration of Zn is because the body of males is more acidic than that of females; in a way the activity of the spermatozoa is repressed and the concentration of certain compounds is therefore different.

P. lividus behaves like an organism that tends to store these metals in non-toxic form, but their presence can cause a great variety of harm that effects the cellular, tissue or organs (Costa, 1998; Rojas et al., 1999; Waalkes et al., 2000; Bellés et al., 2002).

The findings of this research show that although urchins accumulate these metals, they cannot reduce pollution caused by man. Like the dumping of toxic waste without any pretreatment from the Mostaganem Paper Complex (Celpap) and Soachlore "Electrolysis unit" and the dumping wastewater discharges (Table 1) (Directorate of the Environment, 2007). These pose a serious threat to the marine environment. These tenors could also be explained by the fact that this zone is under the direct influence of the maritime traffic, which has also increased after the recent construction and innovation in the Salamander Fishing Port. The later nowadays does not only have economic activities but it has also become an important harbor for passengers, and this is one of the factors that has increased pollution in this site (Directorate of Fisheries, 2007).

The release of the various metals in sea water is done gradually and in a continuous way by the phenomenon of lixiviation, the latter contributes, in a non-negligible way, to the accentuation of this pollution (Monograph showing of the Wilaya of Motaganem, 2011)

Comparison of sea urchin contamination levels in different regions of the Mediterranean

The comparison of the heavy metal contents recorded in the *P. lividus* sea urchin caught in Mostaganem with those cited in subsequent work (Table 4) show that the results in this study are clearly lower than those found in sea urchin specimens in other Mediterranean regions. Indeed, these authors report levels of contamination exceeding by far those recorded at *P. lividus* in the region of Mostaganem, for the three target metals (Cd, Cu, and Zn) except for copper where the value found is greater (1.53 ppm P.S) to that detected by Warnau et al. (1998) in the sea urchin of the "Blue Coast" (French) which is 0.19 ppm P.S.

Conclusion and recommendations

This study acknowledged *P. lividus* biology of two different biotopes (Salamandre and Sidi Lakhdar). The presence of heavy metals was evaluated and found that the concentrations are slightly higher in Salamander site (area affected by industrial pollution and water wastes), compared to Sidi Lakhdar site, (area more natural and less polluted). The results show that the variation of the repletion index (RIm) allowed to characterize the sea urchin, which is distinguished by a phase of intense trophic activity. This activity increases in spring more than in autumn. Moreover, the seasonal variations of the gonad index (GIm) show that spawn period is relatively long, and spreads from spring to early summer and even in autumn in both sites.

Consequently, the bioaccumulation of heavy metals illustrates seasonal variation, which is closely related to the laying period and the high nutrition phase.

Indeed, the metals mentioned in the study exist in male and female gonads organs in different seasonal periods. A quantity of these metals is released during spawning period. This period when temperatures of sea water the increases which generates spawning (spawning period) of the sea urchin and discharge this quantity of metals that were accumulated in these organs in sea water.

It was concluded that more pollutants exist in the Salamandre than in Sidi Lakhdar area, and to avoid the same causes of pollution observed in the Salamandre, industrial activities and urbanization in coastal areas should be reduce and wastewater treatment plant should be built in Sidi Lakhdar in order to preserve this site.

The findings also reflect that the sea urchins can withstand pollutants which confirms that *P. lividus* has the status of an excellent bioindicator of metallic pollution and that this species has the ability to adapt to different marine biotopes.

Further researches are needed, first to have more information about the aspects of gonads and biology of sea urchins living in different biotopes and the behavior of the sea urchins at other depths. Also, a genetical study needed to be carried out on these species and their resistance to pollutants.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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