

Physiological Indices and Nutritive Values of the Sea Urchin *Paracentrotus lividus* (Lamarck, 1816) (Echinodermata Echinoidea) of the Algerian West Coast

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ABSTRACT

Seasonal variation in the physiological indices and biochemical composition of the sea urchin *Paracentrotus lividus* (Lamarck, 1816) (Echinodermata Echinoidea) from the west coast of Algeria were studied between March 2016 and February 2017 from three stations of different nature and geographical position: Sidi Lakhdar (S1), Cap Carbon (S2), and Benisaf harbor (S3). Two spawning period occurred in spring and autumn, resulting in a fall in gonad indices to a low level with values between 2.14 and 3.65%. The seawater temperature in the three sampling stations revealed that the latter had a spawning rate at 9–15 °C in spring and 24 and 11 °C in autumn corresponding to the two peaks of spawning. The biochemical composition of the gonads protein contents, carbohydrates and lipids were recorded with a high percentage for proteins between (25.80 and 45.23%) followed by that of lipids (9.21 and 14.40%) and finally carbohydrates (3.49 and 7.39%). In accordance with the gonad cycle, sea urchin lipids and proteins show a marked seasonal variation with a decrease in their percentages during the spawning period. Protein levels had an inverse profile with carbohydrates, with their values at a minimum when carbohydrates were at their maximum. The profile of the total components in the gut content is almost the same as in the gonads with minus values. A relationship has been found between the biochemical components of the gonads and the digestive tract during gametogenesis, the latter seems to be an organ that tends to store nutrients, indicating that populations of sea urchin *P. lividus* are in good nutritional conditions.

KEY WORDS

Mediterranean Sea; Biochemical composition; Physiological indices; Sea urchin.

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INTRODUCTION

The reproductive cycle of the sea urchin *Paracentrotus lividus* (Lamarck, 1816) (Echinodermata Echinoidea) has been extensively studied in Ireland (Byrne, 1990), in Brittany (Allain, 1972; Spirlet et al., 1998), in the Canary Islands (Girard et al., 2006), in Morocco (Bayed et al., 2005), in Algeria (Dermeche et al., 2009; Dermeche et al., 2012;

Boukhelf 2012; Belkhedim, 2010, 2015; Belkhedim, 2010, 2015 et al., 2014), and across the Mediterranean Sea (Fenaux, 1968; Lozano et al., 1995; Guettaf, 1997; Sánchez-España et al., 2004).

Several studies have been carried out on biochemical composition of sea urchin gonads in different parts of the world in order to evaluate and improve the important nutrients for these species (Keats et al., 1984; Fernandez, 1998; Montero-Tor-

reiro & Garcia Martinez, 2003, Epherra, 2010; Arafa, 2012).

Studies on the biochemical composition and nutritional value in Algeria are non-existent despite the global economic importance of this echinid due to its gonads as seafood, hence the interest of the study by the strategy of the reproduction of *P. lividus* through the monitoring of gonad index and repletion index (GI, RI) in relation to the variations in the biochemical composition of the gonads and gut of sea urchins in different substrate media and floristic components to detect possible adaptations or changes in the behavior of this species as a result of changes in environmental conditions that may significantly affect the physiology of the sea urchin.

MATERIAL AND METHODS

Study area

The study area extends along the west coast of Algeria (Figure 1). Three sampling stations were selected by contribution to their characteristics: the first site, Sidi Lakhdar (S1), being under the influence of the watershed of wadi seddaoua North East of Mostaganem wilaya (36°12'40,63"N - 0°23'20,78"E), a zone characterized by a soft substrate and rich in photophilic algae and by the presence of the sparse beds of the *Posidonia oceanica* phanerogam, (Dermeche et al., 2010; Boukhelf, 2012); the second site, Cap Carbon (S2), located at



Figure 1. Geographical location of the sampling stations on the western coast of Algeria: Sidi Lakhdar (S1), Cap Carbon (S2), and Benisaf harbor (S3).

the Arzew golf (35°54'05.71"N - 0°20'20.98"W), characterized by a rocky habitat rich in macrophyte (Kouadri, 2014; Boudjella, 2015); the third site, Benisaf harbor (S3), (35°18'16.8"N - 1°23'37.9"W) is characterized by a rocky substrate rich in photophilic algae and also by the presence of organic matter (Benguedda-rahall, 2011–12).

Samples collection

The study was conducted from March 2016 to February 2017. Sea urchins (≈ 20 specimens) per station with a diameter ranging between 45 and 60 mm were monthly collected from the intertidal zone at 0.5 meters up to 2 meters deep. The temperature was measured on the surface of the sea. Each sea urchin is opened by cutting the oral cap, the gonads and the gut were previously extracted, drained and weighed for the study of physiological indices, then frozen at -80 °C for a biochemical analysis.

Physiological indices. The individual total wet weight (TWW) was measured before dissection, gonad weight (GW) and gut content weight (GCW) were measured for each organism to the nearest 0.01 g for physiological index determination.

Repletion index (RI) and gonad index (GI) were calculated for each individual using the following equations: $RI = (GCW/TWW) \times 100$ and $GI = (GW/TWW) \times 100$ (Fenaux et al., 1977; Carboni et al., 2015).

Biochemical analysis. For proteins, the method of Lowry et al. (1951) was applied after extraction in phosphate buffer using bovine serum albumin (BSA) as the standard. For carbohydrate, the sample was assayed according to the method of Dubois et al. (1956) using glucose as a standard. Total lipids were extracted and quantified according to the method of (Folch et al., 1957).

Statistical analyzes

Results are presented as the means \pm standard deviations (mean \pm SD). Homogeneity of the data was explored with the Levene test, a post hoc multiple comparison analysis of Duncan was chosen to determine the differences between the independent factors.

For better interpretation, the data were analyzed by Pearson correlation. All statistical analyses were

performed with the use of the software package Statistica 6.0 and SPSS 20.

RESULTS

The average monthly gonad index (GI) and repletion index (RI) as a function of seawater temperature are shown in figure 2.

Evolution monitoring of the physiological index at the three stations shows a significant average monthly variation (Anova $F = 3.41$) $p < 0.001$. The highest values of the RI in order of $18.88 \pm 2.14\%$ (May) is registered at site 1 and $15.87 \pm 2.84\%$ (May) at site 2 and $16.52 \pm 1.49\%$ (April), at site 3, against minimum values used for all individuals recorded one month before spawning in order of $7.28 \pm 3.51\%$ (September), $6.64 \pm 2.21\%$ (March), and $7.25 \pm 1.84\%$ (February) for the three sites respectively. In terms of gonadal index, average percentages were significantly affected by season (Anova $F = 3.90$) $p < 0.05$, the highest values being observed in September at the S1 with $11.67 \pm 1.42\%$ and in January at both site 2 and site 3 with values of $9.31 \pm 1.74\%$ and $9.47 \pm 0.68\%$ respectively. While the lowest values translate into a sharp drop in the percentage of GI, being from $2.14 \pm 1.33\%$ (March) and $3.18 \pm 1.29\%$ (November) at site 1, ($3.4 \pm 0.68\%$) in April and ($2.26 \pm 0.76\%$) in September at site 2, and for populations at site 3, values are recorded at April ($2.19 \pm 1.22\%$) and October ($3.65 \pm 1.31\%$).

The monthly sampling of the seawater temperature among the three study stations reveals its importance in the physiology of reproduction, hence the values between 9°C and 24°C favored the development of the different populations of individuals by the action of gamete spawning. We note that our results reveal that this abiotic factor has an importance on the spawning phenomenon which is recorded for a temperature between 9°C and 15°C for spring and 24°C to 11°C for autumn, which is confronted by the values of IGM which fall during these two seasons (Fig. 2).

Variance analysis of the biochemical composition of the gonads and the gut of different populations of *P. lividus* reveal that the interaction of factors (site, season, organ) significantly affects the protein contents ($F = 1.80$), carbohydrates ($F = 1.76$) and lipids ($F = 2.63$) $p < 0.05$.

The gonadal protein content at the first site (S1) is significantly elevated ($p < 0.05$) in winter ($45.23 \pm 2.54\%$ WW) compared to spring ($26.73 \pm 6.33\%$ WW) and autumn ($30.81 \pm 3.34\%$ WW), however no difference was recorded in summer ($37.76 \pm 3.34\%$ WW).

For lipids, their percentage in spring ($9.58 \pm 0.94\%$ WW) and autumn ($10.12 \pm 3.97\%$ WW) are significantly lower by contribution to summer ($14.25 \pm 1.55\%$ WW) and winter ($14.40 \pm 1.39\%$ WW). Concerning percentages of carbohydrate, summer ($3.72 \pm 0.96\%$ WW) and winter ($4.10 \pm 0.56\%$ WW) are significantly lower compared to spring ($7.21 \pm 0.59\%$ WW) and autumn ($6.83 \pm 0.56\%$ WW).

At the Cap Carbon site (S2), there is a significant difference in protein percentage where values are low in spring ($23.88 \pm 5.62\%$ WW) and autumn ($26.81 \pm 4.37\%$ WW) compared with winter ($39.79 \pm 4.58\%$ WW) whereas the latter did not show any difference with summer ($36.56 \pm 3.37\%$ WW). For lipids, the summer season ($13.89 \pm 1.09\%$ WW) recorded a significantly high difference compared with the spring season ($9.52 \pm 2.44\%$ WW) and autumn season ($9.65 \pm 0.56\%$ WW), but no difference with the winter season ($13.19 \pm 0.66\%$ WW). As for carbohydrates, their percentage is significantly low in summer ($3.83 \pm 1.26\%$ WW) compared to spring ($6.79 \pm 1.60\%$ WW) and autumn ($7.35 \pm 1.89\%$ WW), however no difference was recorded in winter ($4.38 \pm 1.74\%$ WW) ($p < 0.05$).

About the Benisaf (S3), the protein percentages are significantly high in the summer season ($41.80 \pm 5.04\%$ WW) and winter season ($43.30 \pm 2.98\%$ WW) compared to the spring season ($26.21 \pm 2.59\%$ WW) and autumn season ($27.56 \pm 2.84\%$ WW).

For lipids, the summer season ($14.06 \pm 1.28\%$ WW) is significantly elevated by contribution to the spring season ($9.25 \pm 1.08\%$ WW), however no significance has been obtained with the autumn season ($10.13 \pm 0.75\%$ WW) and winter season ($13.12 \pm 0.66\%$ WW). About carbohydrates, the summer season is significantly low ($3.49 \pm 0.52\%$ WW) compared to other seasons (Fig. 3).

Concerning the gut, no significant difference was recorded by contributing to the seasonal variation in biochemical components at S1 and S2. Regarding the S3, the percentages of proteins are significantly lower in winter ($23.24 \pm 6.33\%$ WW)

compared with spring ($36.33 \pm 5.06\%$ WW), however no difference is recorded in summer ($27.58 \pm 5.74\%$ WW) and autumn ($32.77 \pm 3.04\%$ WW) (Fig. 4).

For clarity in our results, using the Pearson correlation revealed a significant difference between the percentages of the repletion index and carbohydrates ($r_s = 0.45$) and is very significant with the percentages of proteins ($r_s = 0.85$) and lipids ($r_s = 0.85$) at S1.

The same, significant difference is recorded between the percentages of the repletion index and the carbohydrates ($r_s = 0.45$), and very significant with the percentages of the proteins ($r_s = 0.85$) and lipids ($r_s = 0.79$). For the S2, the explanation is that the percentages, the repletion index and the biochemical components grow in the same direction, but this increase is not significant.

The annual variance analysis of the biochemical composition of the gonads and gut content of the edible sea urchin *P. lividus* populations revealed no significant differences between the three study stations.

DISCUSSION

The fluctuations of the physiological index (GI, RI) make it possible to follow the gonadic activity according to the approach of the trophic evolution of this Echinid.

The evolution of GI fluctuates from one season to another with a decrease in spring and autumn for the three populations of sea urchins indicating the presence of a double spawning within the populations of *P. lividus* frequenting different stations of the West Algerian coastal fringe. These results obtained are consistent with those of the Spanish and North Mediterranean populations (Guettaf, 1997; Guettaf et al., 2000; Sanchez-España et al., 2004; Sellem & Guillou, 2007; Dermeche et al., 2010; Belkhedim, 2015; Sartori et al., 2015).

Sea urchins tend to have a period of accumulation of nutritive reserve, before each laying, this will allow to store these reserves and to use them during the phase of gametic maturity or there will be consumption of biochemical components stored in the gonads as source of energy (Byrne, 1990; Lozano et al., 1995), from which this phenomenon is seen at its peak in winter and summer.

Fluctuations in RI reveal that during its elevation this would indicate a supply of energy for a gametic maturity, the more the sea urchin feeds, the more it develops its gonads (Lawrence et al., 1989). In Echinoidea, the feeding rate is low when the gonads are highly developed (Lawrence, 1975, 1987; Sellem 1990; Lumingas 1994; Lozano et al., 1995). According to Leighton (1968), the development of the gonads causes a physical decrease in the space of the coelomic cavity, therefore the space available is insufficient for the gut and its content, resulting in a fall of the repletion index (Fig. 5).

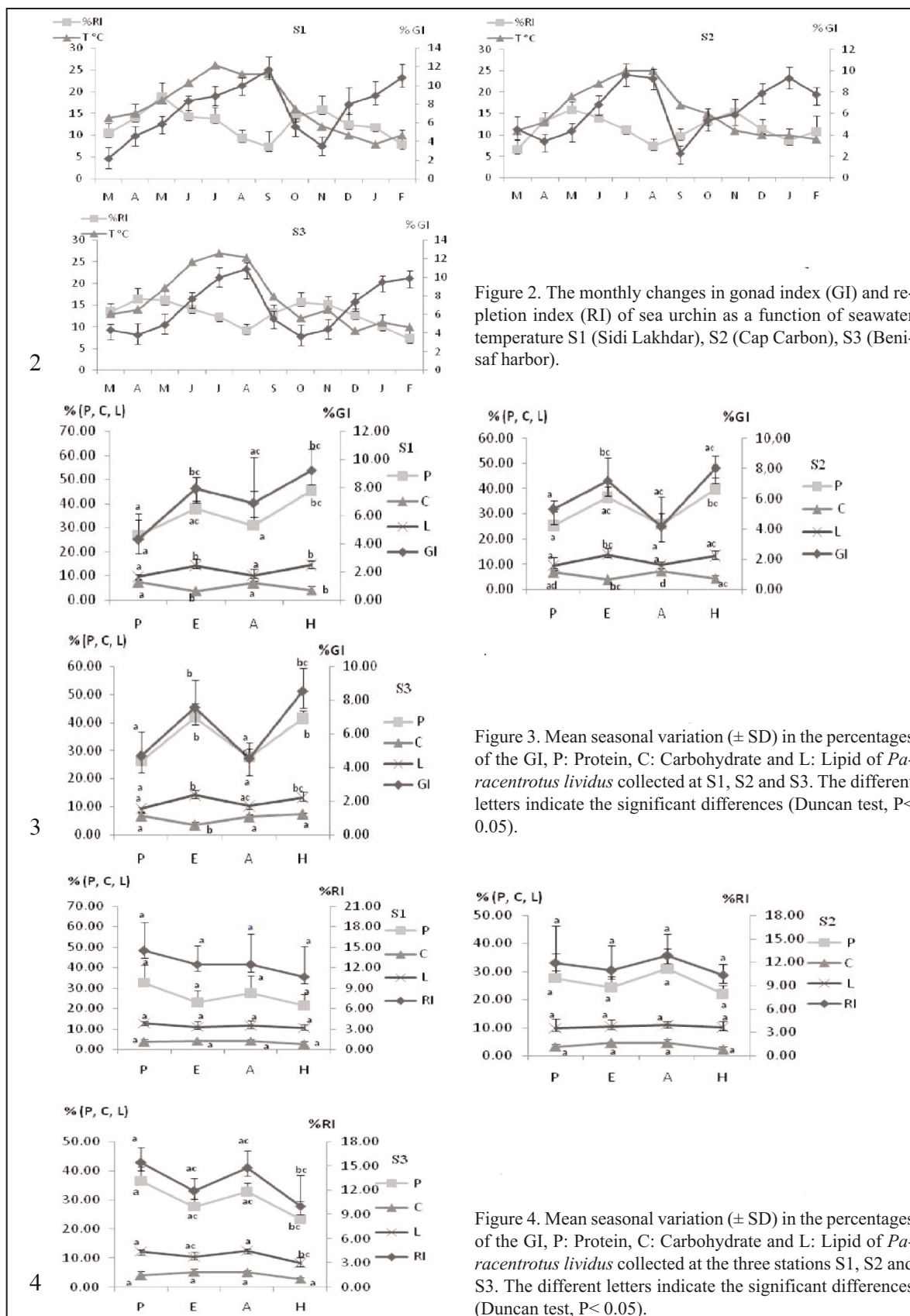
However, Lawrence & Lane (1982) suggested that variations in the intestinal index reflected the amount of food consumed. In *Arbacia lixula*, variations in gonadal and intestinal indices were positively correlated and the gonads were not voluminous, so the gut would have a coelomic space for its development (Tavares, 2004).

Edible sea urchin populations are under the influence of the abiotic parameters of the surrounding environment (Fenaux, 1968) and the measurement of the seawater temperature at the three sampling stations revealed that the latter induce spawning between 9 and 15 °C in spring and 24 and 11 °C in autumn.

The temperature of seawater in the natural environment of *P. lividus* varies from 18 °C to 25 °C (Boudouresque & Verlaque, 2007). Le Gall et al. (1990) reported that somatic growth of *P. lividus* was enhanced at temperatures ranging from 18 °C to 20 °C. Fernandez (1996) achieved the best results with the same temperatures. Shpigel et al. (2004) reported that temperature fluctuations between 18-22 °C improve both gonad growth and development, while by increasing temperature to 24 °C, growth slows.

According to Régis (1979) and Byrne (1990), the fall in temperature during the coldest and the shortest months of the year triggers the growth of the gonads of the Mediterranean and Irish populations, whereas Spirlet et al. (1998) reports that the increase in seawater temperature in spring triggers gametogenesis. Thus, temperature is a factor influencing the reproductive modalities of *P. lividus* populations (Fenaux, 1968).

Another factor that has been found to be very important in the gonadal development process is the availability of food, which allows them increased access to food (Byrne, 1990), and other factors such as the quality of the biotope, phytoplankton bloom,



Site	Organ	Gonad			Gut		
		% P	% C	% L	% P	% C	% L
S1	P	26.73±6.34	7.21±1.17	9.58±0.94	32.52±8.64	3.74±1.25	12.74±1.06
	E	37.76±3.34	3.72±0.96	14.25±1.47	23.04±5.76	4.23±0.19	11.07±2.67
	A	30.81±14.4	6.83±2.07	10.12±4.01	27.35±8.68	4.17±1.00	11.51±2.55
	H	45.23±2.54	4.13±0.86	14.40±1.40	21.43±5.45	2.46±1.54	10.42±1.74
S2	P	25.22±5.62	6.79±1.61	9.52±2.45	27.61±8.74	3.17±0.85	9.67±3.38
	E	36.56±4.12	3.83±1.26	13.89±1.09	24.33±3.94	4.39±0.61	10.23±2.57
	A	25.80±4.37	7.32±1.43	9.65±0.56	30.93±7.22	4.46±1.25	10.98±1.40
	H	39.79±4.58	4.38±1.74	13.19±0.66	21.91±3.06	2.12±1.05	10.08±2.15
S3	P	26.21±2.59	6.60±1.58	9.21±1.09	36.33±5.07	4.06±1.34	12.16±0.7
	E	41.80±5.04	3.49±0.52	14.06±1.28	27.58±5.74	5.22±1.15	10.35±1.83
	A	27.56±2.84	6.37±1.39	10.13±0.75	32.77±3.04	5.12±0.71	12.44±0.61
	H	41.30±2.97	7.39±0.63	13.12±0.66	23.24±6.34	2.87±0.53	8.17±2.09

Table 1. Percentage of seasonal soft tissue biochemical components of sea urchin populations at the three study stations S1 (Sidi Lakhdar), S2 (Cap Carbon), S3 (Benisaf harbor).

photoperiodism, depth and hormones will also influence this physiological process (Himmelman, 1986; Pearse et al., 1988). Not only the accumulation of nutrients by the nutritive phagocytes, but also the accumulation of gametes contribute to gonad growth and weight.

The growth of the gonads, mainly depends on the type of food available, in quantity and quality, as well as the organic matter ingested. According to Regis (1979) and Rico (1989), invertebrates can apparently use as an energetic resource organic matter dissolved in water by absorbing it with their quills (sestenophagy).

In Table 2, the different percentage values of proteins, carbohydrates and lipids are indicated. According to our results, protein is the main component of the gonads and gut followed by lipids and finally carbohydrates with lower proportions.

Such results in the distribution of biochemical components are similar in all echinid species, which vary with the seasons (McClintock et al., 1987; Lawrence et al., 1989; Rowley, 1990; Frantzis & Grémare, 1993; Fernandez, 1996; Fernandez, 1998), quality and quantity of food intake (Cook et al., 1998; Montero-Torreiro & Garcia-Martinez, 2003), temperature variations (Spirlet et al., 1998) and the reproductive cycle (Fenaux et al., 1977; Fernandez, 1998).

The results of the biochemical components obtained in *P. lividus* are close to those of other echi-

noids, as the case with *Arbacia lixula* (Fenaux et al., 1975, 1977) and *P. lividus* in a lagoon environment (Fernandez, 1996).

Protein levels in the gonadal tissues show significant variations over the study period, corresponding to the highest level with the highest values of the GI, which would be an indication of the protein requirements in gonads during gametogenesis period.

Proteins are considered to be the main nutrient-rich food nutrient involved in reproduction, leading to increased somatic and gonadal growth rates, the latter due to the accumulation of gametes or nutrients (Fernandez & Boudouresque, 1997, 2000; Cook & Kelly, 2007). Gonad weight growth is mainly associated with the ingestion of nutrients, the quantity and quality of food ingested (Lawrence & Lane 1982; Cuesta - Gomez & Sánchez-Saavedra, 2014).

The profile of the total proteins in the digestive content is practically the same as in the gonads, unlike other works, in which the levels have remained practically constant. These facts could be explained by the importance of the diet in the biochemical composition of the digestive content, as well as, by the inverse relationship observed in *P. lividus* between the intake and absorption rates of the food, when conditions are more favorable for the development of algae, coincide with the phase of gametogenesis.

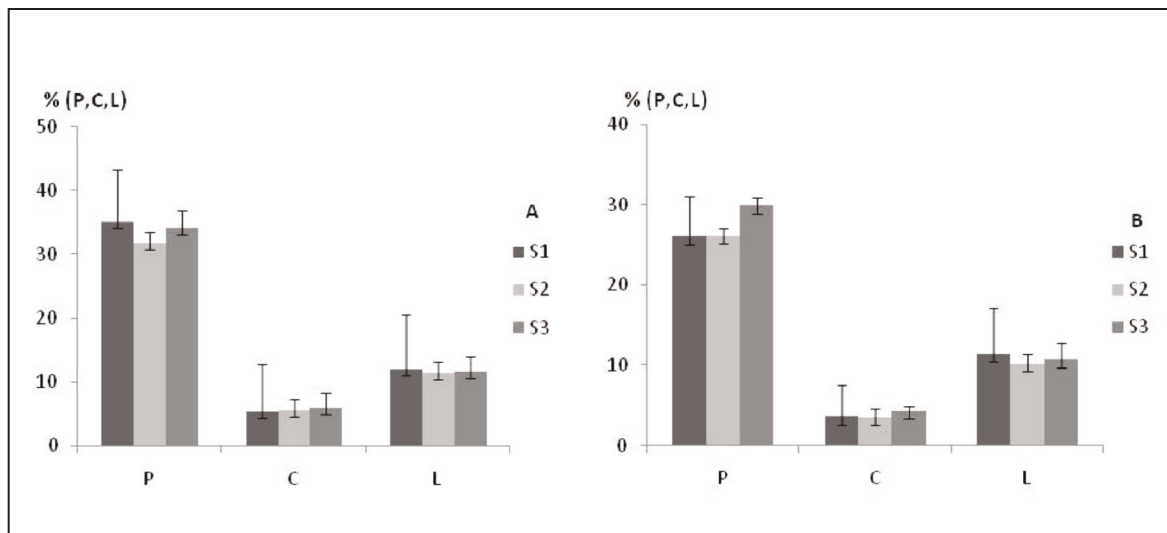


Figure 4. Comparative inter-site study of variation in percentages of biochemical components measured at the n of the gonads (A) and gut content (B). S1 (Sidi Lakhdar), S2 (Cap Carbon), S3 (Benisaf harbor). P: Protein; C: Carbohydrate; L: Lipid.

The maximum protein percentages of the gut content will appear because of the high consumption of macrophyte, but this Echinidae could not absorb such a quantity of proteins, because of the rare musculature associated with *P. lividus*, so the proteins would be retained in the digestive system (Frantzis & Grémare, 1992).

Before initiating gametic development, sea urchin gonads accumulate nutrients in nutrient phagocytes for later use (Walker et al., 2001). In order to carry out gametogenesis, Jangoux & van Impe (1977) observed a decrease in the amount of protein in the *Asterias rubens* Linnaeus, 1758 (Echinodermata Asteroidea), when the gonadal demand in structural material, in the form of amino acids, was high. Gametogenesis requires so much energy that sea urchins prepare for this event, both nutritionally and physiologically (Ferguson, 1975).

As for carbohydrate levels in the gut, they are lower than those of gonadal tissue, a fact that has already been proven in other species of echinids. However, in another study conducted by Fernandez (1998), in *P. lividus*, carbohydrate values in the gut found similar to those of gonadal tissue, which were justified by the role of the digestive tract as an organ reserve.

In contrast, in the gonads, where carbohydrates are required as the primary source of energy during oogenesis, it presents some extra high levels in spring and autumn, according to the theory that glu-

cose is the first source of energy to be used during the gonadal period of development (Ansel, 1974). Patrick et al. (2006) has demonstrated the inverse relationship between gonadal mass and carbohydrate levels in the oyster *Magallana gigas* (Thunberg, 1793) (Mollusca Bivalvia).

It should be noted that there is an inverse relationship between glucose content and total protein in *P. lividus* gonads, which seems to be a clear indication of the use of carbohydrate stores to obtain the energy needed to the synthesis of proteins, which is fundamental in the formation of gametes (Fenaux et al., 1977). Similar situations have been observed in *Strongylocentrotus purpuratus* (Giese, 1966), *Abatus shackletoni* (McClintock & Pearse, 1987), *Arbacia lixula* (Fenaux et al., 1977; Tavares, 2004), *Echinometra lucunter* (Linnaeus, 1758) (Tavares, 2004).) and *P. lividus* (Fernández, 1998, Montero-Torreiro & Garcia-Martinez, 2003) (see also Table 2).

Total lipids in *P. lividus* are affected by the season, lipids suggest nutrient accumulation during gonadal development, values dropped significantly during spawning, which would indicate that deposits observed towards the end of gametogenesis would correspond to storage in gametes. *Psammechinus miliaris* (P.L.S. Müller, 1771) (Echinoidea Parechinidae) showed differences in lipid composition before spawning, whereas the composition was paired after this event, indicating that

these components were deposited in the gametes during the last stage of gametogenesis (Hughes et al., 2006).

The total lipids in the digestive tract, unlike the gonadal, do not have a seasonal variation profile. Therefore, it seems clear the direct relationship between total lipids in the gut and the bioavailability of favorable food for algal production, which is the basis of the diet of *P. lividus*. The same conclusion, had already been exposed by Oudejans & van der Sluis (1979), who established that one of the main causes of variation in total lipid levels in the pyloric caeca of the starfish, *Asterias rubens* is the ability of the organ to digest and to accumulate the lipids contained in food.

During periods of gametogenesis, a positive correlation was found between gonadal lipid percentages and gut in sea urchin populations at S1 ($R^2 = 0.62$), S2 ($R^2 = 0.76$) and S3 ($R^2 = 0.93$). For proteins, only S2 and S3 were positively correlated with ($R^2 = 0.96$) and ($R^2 = 0.95$) respectively. Concerning carbohydrate, a positive correlation was recorded at S1 with ($R^2 = 0.94$) and S2 ($R^2 = 0.69$).

It has been possible to demonstrate through our results, a transfer of the components, from the gut to the gonads in the populations of sea urchins *P.*

lividus, and their use as a source for the biosynthesis of the gametic tissues, which confirms that the gonads and the digestive system are probably dependent organs from the point of view of nutritive and energetic needs in order to properly conduct gametogenesis.

CONCLUSIONS

The evolution of the GI fluctuates monthly with a decrease in spring and autumn, indicating the presence of a double spawning within the different *P. lividus* populations frequenting the west Algerian coastal fringe. The biochemical cycle is directly related to the reproductive cycle, with a higher proportion of proteins, followed by lipids and carbohydrates. The quality of the gonads has been affected by their biochemical composition that change according to their reproductive stages, from the storage of nutrients in the somatic cells provided by the gut to an increase in the number and / or size of gonadal cells.

In *P. lividus*, energy requirements during gametogenesis would be provided by food intake and nutrient transfer observed from intestines to gonads.

Species	Organ	% P	% C	% L	References
<i>Strongylocentrotus purpuratus</i> (Stimpson, 1857)	G	32 - 41	3.3 - 7	21 - 27	Lawrence et al., 1966
	Int	41.0 - 49.0	18.0 - 20.0	3.1 - 4.6	
<i>Abatus shackletoni</i> Koehler, 1911	G	24.0 - 36.9	2.0 - 7.3	14.2 - 27.9	Giese, 1966
	Int	28.3 - 41.7	3.10	20.3 - 30.0	
<i>Arbacia lixula</i> (Linnaeus, 1758)	G	56.2	4.6	27.0	McClintock et Pearse, 1987
	Int	34.5	1.6	3.7	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	38.1	5.2	15.7	Fenaux et al., 1975
	Int	48.2	5.8	18.8	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	30.2 - 51.5	4.2 - 7.0	9.8 - 15.5	Fenaux et al., 1977
	Int	29.9 - 40.5	3.4 - 10.2	13.4 - 18	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	39.1	9.7	15.6	Fernandez, 1996
	Int	38.1	20.1	8.8	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	30 - 40	5.15	12 - 18	Fernandez, 1998
	Int	33 - 45	3.4 - 12.6	10.6 - 27.2	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	36 - 60	7.1 - 14.0	12.8 - 16.1	Montero Torreiro et al., 1998
	Int	24.1 - 42.0	28.6 - 31.1	6.4 - 9.9	
<i>Paracentrotus lividus</i> (Lamarck, 1816)	G	25.8 - 45.2	3.4 - 7.0	9.2 - 14.4	present study
	Int	21.9 - 34.6	2.1 - 4.9	9.6 - 12.7	

Table 2. Comparative table of the biochemical composition of the gonads and intestines expressed as a percentage: Protein (P), Carbohydrate (C) and Lipid (L) in different Echinid Species. G: Gonads, Int: Intestine.

This further confirms that echinoid gonads behave as an organ that tends to provide two functions: gamete production and energy storage.

Variations in the availability and quality of food in different habitats did not significantly affect the physiology of sea urchin populations, which is possible due to the high phenotypic plasticity of adaptation of *P. lividus* to the environment, conditions and way of life as well as a decrease in metabolic demand and / or a decrease in growth when individuals are important in their size, so the need for food is less important, while the reproductive power is maintained (Fernandez, 1996). Confirmed by some echinoids that feed at a low rate and the gonads are fully developed, similarly, a positive correlation is found between the gonadal and repletion index and this did not affect the development of the sea urchin as the gonads were not voluminous.

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