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Monitoring the relationship between alteration in environmental factors and nutritive value of *Rissoides desmaresti* (Crustacea)

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ABSTRACT

Rissoides desmaresti shrimp is a good source of a high nutritional value, which makes it a very healthy food choice for humans. The relationship between the environmental factors (temperature, salinity, pH value, and dissolved oxygen) and the nutritive values of *Rissoides desmaresti* (Crustacean- Stomatopoda) was addressed and the factors were seasonally measured in the current study. Concurrently, the nutritive values (crude protein, lipid, carbohydrate, calorific value, moisture, and ash) in the muscle tissue of *Rissoides desmaresti* were seasonally analyzed. The statistical analysis showed that the values of the correlation coefficient for different biochemical composition parameters with the ecological factors ranged between very strong positive correlation and very strong negative correlation. The relationships were different; the most influential detected factor was salinity, followed by temperature, dissolved oxygen, and pH. Remarkably, these constituents are affected by the alteration in ecological factors, forming an indicative indicator to know how far the organism is affected by those factors, and detect their permanent change associated with the climatic changes.

INTRODUCTION

Marine organisms have been widely investigated, but limited interest has targeted the influence of environmental factors on these organisms, especially after climate change. In this context, **Posey (1986)** found that those factors have a major influence on the distribution and status of marine organisms. **Whiteley (2011)** investigated the physiological and ecological responses of crustaceans to ocean acidification and stated that, the most species at risk are exclusively marine, which have limited physiological capacities to adjust to the environmental change, because these changes could affect species' survival, distribution and abundance. **Akram Ullah *et al.* (2020)** reported that the biochemical composition differs *in Scylla olivacea* although no information was collected about the factors that can affect it. In many parts of the Mediterranean Sea, the physicochemical parameters are unstable, being affected by many factors **(Mohamed, 2006)**. **Lee (2008)** showed that the macrobenthic assemblage is influenced by environmental conditions. Marine organisms are interacted with numerous environmental factors such as water temperature, salinity and wave action **(Underwood, 1981)**.

Environmental factors, especially temperature, exposure to air, salinity, and light may affect physiological tolerance and enzyme systems., Those factors cause dehydration, which may damage the outer membranes and disrupt blood circulation and tissue water content **(Crivelli, 1982; Rico, 1996; Davenport *et al*., 2009)**. Notably, the change in the mean of water temperature reflects the variations predicted by climate scenarios for 50 years **(IPCC, 2007)**. **Bridget *et al.* (2014)** studied the environmental effects on the growth of the fished lobsters and crabs. Water pH is a significant environmental factor which affects the biochemical marine ecosystem and organisms; it's great effect is markedly noted with respect to the photosynthesis activity of aquatic flora, temperature, salinity and some organic constituents **(Hutchinson, 1957; Abd-Elaziz, 2009)**. The salinity in marine ecosystems can fluctuate either seasonally or a seasonally due to the alteration in environmental factors **(Johnson *et al*., 1991)**. **Velasco *et al.* (2019)** reported that, there are changes in salinity and other major abiotic stressors associated with global changes (such as temperature, salinity, pH, pollutants, etc.), the effect of which is detected in the physiological features of aquatic organism and its performance **Zakaria *et al*. (2007) and Aboul Ezz *et al.* (2014)** emphasized that, influences of environmental factors variations have been recorded on marine organisms and ecosystem in southeastern Mediterranean. **Vincent *et al*. (2008)** reported that highly frequency of dissolved oxygen measurements in the Mediterranean coastal lagoon showed different dynamics on different time scales; this variation leads to wind stress that contributes to exceed the oxygen saturation concentration, water temperature, and solar radiation. **Whiteley (2011)** stated that the interactive effects of multiple stressors on the survival of marine crustaceans have been poorly studied, despite the fact that ocean acidification occurres simultaneously with changes in temperature, salinity and oxygen.

To face the global change, understanding and predicting the effects of multiple stressors is one of the most pressing challenges in conservation and applied ecology **(Coˆte´ *et al*. 2016; Scha & Piggott, 2018)**. These changes in organism are the primary and most sensitive responses to stress **(Crain, 2008).** In addition, they may ultimately alter community composition **(Folt & Chen, 1999)**, and interfere in ecosystem processes and services, which sustain human welfare **(Gutie, 2019)**. In recent years, several meta analyses have synthesized the results of studies that have tested joined effects of multiple stressors in marine ecosystems **(Harvey *et al*., 2013; Przeslawski *et al*., 2015; Berger *et al*., 2019)**. Effects exceeded to include freshwater ecosystems **(Jackson *et al*., 2016)** at different organizational levels, from organisms to communities showing contrasting results. While an overall synergistic effect of multiple stressors has been found in marine systems. However, no study has specifically provided a comprehensive review of organism responses of inland aquatic species or populations to the combined effects of salinity changes with other global change stressors. Thus, the aim of this work was to identify the changes induced by environmental factors (temperature, salinity, pH value, and dissolved oxygen) in *Rissoides desmaresti* nutritive value (crude protein, lipid, carbohydrate, calorific value, moisture and ash) as an indicator of the effect of alteration in environmental factors on marine organism by measuring and identifying these variables, and evaluating statistically the relationships among them.

MATERIALS AND METHODS

Sampling

For the present work, seasonally sampling was collected for *Rissoides desmaresti* (108 specimens) during a period of one year, extending from January 2015 to January 2016, along the southwestern coast of the Mediterranean Sea (Port Said Governorate). Specimens stated as XL size were collected fresh from the study area. The collected specimens were transported to the laboratory to be studied.

Identification of species

For identification, this study followed the descriptions of **Anone (1973**).

Physicochemical parameters

The four environmental factors [water temperature, dissolved oxygen, hydrogen ion concentration (pH), and salinity] were monthly measured at the collection area.

1- **Water temperature**: It was measured using a mercury thermometer graduated to 100˚C.

2- **Salinity**: the seawater salinity was estimated using the drying method of **Apha (1985)**.

3- **Dissolved oxygen**: It was determined according to Winkler's method, modified in the study of **Parsons *et al*. (1984)**.

4- **Hydrogen ion concentration (pH)**: It was measured with pH meter (pH ep^3 pocket-sized microprocessor pH meter).

Measurements of nutritive value

Determination of total protein:

The total protein was determined using the Folin phenol reagent, which was described in **Lowry *et al*. (1951)**, with a modification provided in the study of **Ansell and Lander (1967)**.

Determination of total lipid:

Lipids determination was performed according to the method of **Knight *et al.* (1972)**.

Determination of carbohydrate content:

Glycogen was measured according to the method of **Carrol *et al.* (1956)**.

Calculation of calorific value:

The calorific content for each sample (stage) has been calculated in each case for the biochemical composition by multiplying each component by the appropriate calorific equivalents (4.2 kcal for carbohydrates; 9.45 kcal for lipids, and 5.7 kcal for protein). The results were expressed as kcal per gram **(Phillips, 1969)**.

Water Content:

Weight loss was performed at 105ºC until the determination of constant weight according to the method of **Ruiz-Roso *et al.* (1998)**.

Ash content:

It was performed by incineration in a muffle furnace at 450 – 500 degree to constant weight following the methods of **AOAC (1990)**.

Statistical analysis:

Statistical tests were carried out using the statistic software SPSS (2008) for determination of mean: ẋ, standard deviation: б x and Pearson's correlation coefficient, where the correlation values were explained after calculating them as shown in Table (1).

Table 1. Explanation values of Correlation factor

Value of Correlation factor	Meaning	Abbreviation
+1	Perfect positive correlation	P. P. C.
From 0.9 to 0.99	Very strong positive correlation	V. S. P. C.
From 0.7 to 0.89	Strong positive correlation	S. P. C.
From 0.5 to 0.69	Medium positive correlation	M. P. C.
From 0.3 to 0.49	Weak positive correlation	W. P. C.
From 0.01 to 0.29	Very weak positive correlation	V. W. P. C.
0	No correlation	NO C.
From -0.01 to -0.29	Very weak negative correlation	V. W. N. C.
From -0.3 to -0.49	Weak negative correlation	W. N. C.
From -0.5 to -0.69	Medium negative correlation	M. N. C.
From -0.7 to -0.89	Strong negative correlation	S. N. C.
From -0.9 to -0.99	Very strong negative correlation	V. S. N. C

RESULTS AND DISCUSSION

Fluctuation of ecological factors:

Table (2) shows the general values of dissolved oxygen during this study. The minimum value was (4.2 mg/l) recorded during winter, while the maximum was (5.5 mg/l) measured during spring, with an annual mean of 4.6 ± 0.5. While, the seasons of summer and autumn recorded means of 4.3 and 4.5 mg/l, respectively. Regarding temperature (°C) values, the minimum value was (16.8°C) recorded during winter, whereas the maximum was (27.9 °C) was detected during summer, with an annual mean of 22 ± 4.1. In addition, spring and autumn recorded means of 20.5 and 24°C, respectively. At the same time, general salinity values (S ‰) showed that the minimum value during autumn was 25.2 ‰ , but its maximum was ٣٤.5 ‰ during summer, with an annual mean of 29.9 ± 3.9 ; while spring and winter recorded means of 33 and 27.2 ‰, respectively. On the other hand, the minimum recorded value of pH was 7.0 during spring, whereas winter recorded the maximum value of 8.5, with an annual mean of 7.6 ± 0.5. While, summer and autumn seasons recorded means of 7.6 and 7.5, respectively.

One of the basic goals of the marine ecologists is to identify factors, which affect marine organisms. This goal is difficult to achieve due to the complexity of natural marine environmental factors and their interactions **(Lee, 2008)**. Those changes, with respect to the organism, are the primary and most sensitive responses to stress **(Crain, 2008).** They may ultimately alter community composition **(Folt & Chen, 1999)** and interfere in ecosystem processes and services, which sustain human welfare **(Gutie, 2019)**. In recent years, several meta analyses have synthesized the results of studies that have tested joined effects of multiple stressors in marine ecosystems **(Harvey *et al*., 2013; Przeslawski *et al*., 2015; Berger *et al*., 2019)** and freshwater ecosystems **(Jackson *et al*., 2016)** at different organizational levels, from organisms to communities, and have shown contrasting results. While, an overall synergistic effect of multiple stressors has been found in marine systems; however, no study has specifically provided a comprehensive review on organism responses of inland aquatic species or populations to the combined effects of salinity changes with other global change stressors.

The knowledge about ***Rissoides desmaresti*** (Stomatopoda – Squillidae) is very important from the scientific point of view because this animal, like most marine crustaceans, plays an important role in the food chain, food web, marine ecosystem, as well as the diet and health of the population. The alterations in the environmental condition of marine habitat influence the biochemical composition of marine animals (**Snyder, 2004; Mohamed, 2006; Abd-Elaziz, 2009)**. For the environmental factors, the fluctuations in the crustaceans might be related not only to water temperature, but also to its indirect influences on their food items **(Rico, 1996)**. It was noticed that the proximate composition in the studied species changed seasonally. This finding agrees with that of Farina *et al*. **(2003)** who reported that, the feeding of some species can pose strong effects on the ecosystem process. These changes in proximate composition are due to the fluctuation of temperature or salinity **(Sumpton & Greenwood, 1990)**. The changes in food composition of the studied species may reflect the changes in the availability of food type **(Choy, 1986)**, which is affected by the alteration in the environmental factors.

Nutritive Composition

Table (2) demonstrates the protein, lipid, and carbohydrate contents (g/100 g tissue) of *Rissoides desmaresti*. The data showed that the protein contents differed seasonally. The highest value (14.5 g /100 g) was observed in summer , while the lowest was recorded in winter and autumn, with value of 13g/100 g. The protein contents recorded 14 g/100 g in spring. With respect to the lipid content, the highest value was calculated in summer (1.3 g/100 g), while the lowest was measured in winter (0.9 g/100 g). Whereas, in spring and autumn, values recorded were 1.2 and 1 g/100 g, respectively. On the other hand, the highest value of carbohydrate was recorded in the summer season (5.3 g/100 g), but its lowest was calculated in winter (4 g/100 g). In spring and autumn, values determined were 5 and 4.5 g/100 g, respectively. Simultaneously, the data of calorific value (K.cal /100g) showed that the values differed from season to the other. The highest value was 117.21 K.cal /100g in the summer season, but the lowest one was calculated in winter season, with value of

99.4 K.cal /100g. On the other hand, spring and autumn registered values of 112.14 and 102.45 K.cal/100g, respectively.

Table (2) presents the water and ash contents (g /100 g) of *Rissoides desmaresti*. For water content, the highest value was calculated in winter (78.9 g/100 g), while the lowest was in summer (77.5 g/100 g); it recorded 78 and 77.8 g/100 g for spring and autumn, respectively. On the other hand, the highest value of ash was recorded in summer (1 .7 g/100 g), but the lowest was calculated in the seasons of winter and autumn (1.5 g/100 g), while ash recorded a value of 1.6 g/100 g in spring.

The relationship between ecological factors and biochemical composition of *Rissoides desmaresti*

The present study shows that there is a differentiation in biochemical composition of *Rissoides desmaresti* edible portion, which differed seasonally.

Table 2. Seasonal variation of Biochemical composition of *Rissoides desmaresti* edible Portion (g / 100g tissue)

Measurements	seasons	Winter	Spring	Summer	Autumn	A. Mean ± SD
Ecological factor	ºC	16.8	20.5	27.9	24	22.3 ± 4.1
	‰S	27.2	33	34.5	25. 2	29.9± 3.9
	PH	8. 5	7.0	7. 6	7. 5	7.6 ± 0.5
	O2 mg/l	4.2	5. 5	4. 3	4.5	4.6 ± 0.5
Proximate Composition	Protein (g/100g)	13	14	14.٥	13	13.6 ± 0.6
	Lipid (g/100g)	0.9	1.2	1.3	1	1.1 ± 0.2
	Carbohydrate (g/100g)	4	5	5.3	4.5	4.7 ± 0.5
	Cal. Value (K.cal / 100g)	99.4	112.14	117.21	102.45	107.8 ± 7.2
	W. content (g/100g)	78.9	78	77.5	77.8	78 ± 0.5
	ASH (g/100g)	1.5	1.6	1.٧	1.5	1.5 ± 0.1

In the current study, the total protein ratio of *Rissoides desmaresti* was high compared to the total lipid and carbohydrates. This result concurs with those of **Amer *et al*. (1991)**, **Hashem (1992)**, **Abd-Elaziz (2009)** and **Nasef (2016)**. The data of the biochemical composition of *Rissoides desmaresti* showed that the protein contents differ seasonally; the highest value was observed in summer**,** but the lowest was recorded in winter. The recorded decrease in protein levels was detected in winter, perhaps owing to molting, reproduction activity, regeneration for the lost limbs and deposition of protein in chitin, which performs the carapace. This agrees with the results of **Highnam and Hill (1979)** and **Subramoniam (1982)**. The comparison between the total protein and the total lipid levels of *Rissoides desmaresti* showed that the latter levels were the lowest. This finding coincides with those of Hashem **(1992)** and **Venugopal and Shahidi (1998)** who postulated that the total lipid is low in crustaceans. For the lipid content, the highest value was calculated in summer, while the lowest was defined in winter. The changes of lipid levels may be attributed to the morphological and physiological changes of the studied species, such as molting, losing limbs, and performance of the carapace, This result agrees with those of **Akpan (1997)** and **Abd-Elaziz (2009)**.

On the other hand, the highest value of carbohydrate was recorded in summer , while the lowest value was calculated in winter. This result is similar to that of **Schmitt and Santos (1993)**. The increase of the carbohydrate levels may be due to the high activity (glycogenolysis) and accumulation of carbohydrates in the new tissues of molted and post-molted crabs. This concept coincides with the viewpoints of both **Siu-Ming chan *et al*. (1988)** and **Abd-Elaziz (2009)**. At the same time, the data of calorific value (K.cal /100g tissue) showed that the values differed seasonally. The highest calorific value was observed in summer, while the lowest was recorded in winter.

With regard to the water content of *Rissoides desmaresti,* the highest value was (83.5 g/100 g) calculated in winter, while the lowest was measured in summer; this may be the direct reason for the increase in the protein, carbohydrates and lipids in summer, since the water content decrease in animals.

On the other hand, the highest value of ash was recorded in summer, but the lowest one was calculated in winter. This finding concurs with results in other reports, which emphasized that these differences are apparently associated with variations between species, nutrient composition of the diet, the surrounding medium and other environmental factors, e.g., season, location, substrate, depth, water salinity, temperature and anthropogenic influence **(King *et al*., 1990; Aidos *et al*., 2002; Naczk *et al*., 2004; Fabris *et al*., 2006; Kádár *et al*., 2006; Nasef, 2016)**. The changes in the biochemical composition of the body (moisture, protein, fat, and ash) depend on the type of food, composition, density of fish and physiological processes **(Jassim *et al*., 2014)**, which are affected by variation in environmental factors such as temperature and salinity. The effect of season on the nutrient compositions have been studied with respect to some marine animals **(Aidos *et al*., 2002; Hamre *et al*., 2003)**, but the interpretation is difficult and depends on numerous factors **(Özyurt *et al*., 2005)**. Similar to the present results, the fluctuations in biochemical composition is related mainly to the food composition of marine organisms, which are greatly influenced by the changes in environmental factors, particularly temperature, where food intake is lower during colder months **(Suzuki & Shibrata, 1990; Amer *et al*., 1991)**. **Fouda (2000)** reported that the chemical composition differs slightly because of the differences in the size, age and the season of sampling. However, seasonal changes in food items were greatly noticed in temperate **(Amer *et al*., 1991)**, and they affect human impacts, pollution and severe physical conditions **(Fouda, 2000; Soundarapandian, 2013)**.

Banu *et al.* (2016) investigated the nutritional status of penaeid prawns through proximate composition studies. The previous authors emphasized that all the penaeid prawns are supposed to be a source of food for human consumption. Moreover, the variation in biochemical composition due to enzyme activity during catching shellfish is generally low **(Venugopal & Shahidi, 1998)**. The factors are many and overlapping, therefore, this study was an attempt to find out the extent of the impact of these factors and determine which are more influential.

The relationship between environmental factors and biochemical composition of *Rissoides desmaresti* during this study:

Table (2) shows that the occurrence of this species is affected by water temperature, pH value, salinity and dissolved oxygen, where the maximum values of protein, lipid, carbohydrate and calorific were recorded during summer with the highest water temperature and salinity. However, their minimum values were recorded in winter, with the lowest water temperature, salinity and dissolved oxygen as well as with the highest pH value.

Table 3. The relationship between ecological factors and biochemical composition of *Rissoides desmaresti* with statistical analyses

Prox. Comp., / Eco. Factor	Pearson's correlation coefficient											
	Protein		Lipid		Carbohydrate		Calorific value		Water content		Ash	
	Correlation value	Correlation degree	C. value	C. degree	C. value	C. degree	C. value	C. degree	C. value	C. degree	C. value	C. degree
ºC	**0.61**	m. p. c.	**0.71**	s. p. c.	**0.77**	s. p. c.	**0.69**	m. p. c.	**-0.94**	V. s. n. c	**0.68**	m. p. c.
S	**0.97**	V. s. p. c.	**0.91**	V. s. p. c.	**0.84**	s. p. c.	**0.93**	V. s. p. c.	**-0.47**	w. n. c.	**0.93**	V. s. p. c.
PH	**-051**	m. n. c.	**-0.67**	m. n. c.	**-0.73**	s. n. c	**-0.61**	m. n. c.	**0.72**	s. p. c.	**-0.41**	w. n. c.
O2	**0.28**	V. w. p. c.	**0.36**	w. p. c.	**0.38**	w. p. c.	**0.33**	w. p. c.	**-0.18**	V. w. n. c.	**0.13**	V. w. p. c.

The results in Table (3) exhibit the values of correlation coefficient of different biochemical composition parameters, where the relationships were very far to unity. It was noticed that, temperature showed moderate positive correlation with protein, calorific value and ash, while temperature was strong positively correlated with lipid and carbohydrate. On the other hand, temperature was strong negatively correlated with water content.

On the other hand, salinity showed a very strong correlation with protein, lipid, calorific value and ash, while correlation was strong positive with carbohydrate. At the same time, the value of correlation coefficient for water content was weak negatively correlated with salinity. Dissolved oxygen showed weak positive correlation with lipid, carbohydrate and calorific value, while it showed a very weak positive correlation with protein and ash. Concurrently, the dissolved oxygen was very weak negatively correlated with water content. Additionally, pH showed a moderate negative correlation with protein, lipid and calorific value. The values of correlation coefficient for carbohydrate and ash were of moderate negative and weak negative, respectively. In spite of this correlation, coefficient was strong positive with water content.

This statisticalanalysis clarified the extent of the relationship between the change in the environmental factors and the values of the biochemical composition of the marine organism. It was noticed that, the most influential factor was salinity, followed by temperature, dissolved oxygen and finally pH. Remarkably, those factors are affected by environmental pollution and the resulting climatic changes. This result concurswith that of **Abul-Ezz *et al*. (2014)** who reported that, the environmental factors, especially salinity and temperature, were among the most important factors that affected the rotifers in the marine environment. Their impact on the food web, growth, and diversity of the marine ecosystem is well known. **Zakaria *et al*. (2007)** illustrated the influence of salinity variations on the abundance and community structure of zooplankton in marine environment. **Vicenç *et al*. (2021**) stated that the global environmental change has measurable effects on the epipelagic realm of marine systems. Documented impacts included increases in sea surface temperature, changes in water mass circulation and mixed layer depths, altered primary productivity or ocean acidification. It is worthy to mention that, the effects of the climatic change are posing an increase in the frequency and intensity of marine heat waves **(Frölicher *et al*., 2018; Oliver *et al*., 2018)**. Fröliche Those effects, either directly or through trophic interactions, impact the species inhabiting the epipelagic environment, including those that support high commercial value fisheries. Physiological changes have recently been used to inform about the ecological effects of ocean acidification **(Fabry *et al*., 2008; Guinotte & Fabry, 2008; Widdicombe & Spicer, 2008; Dupont *et al*., 2010)**.

Subsequently, crustaceans occupy a range of aquatic habitats that experience different degrees of environmental variability. Those occupying deep oceans and high latitudes come from relatively stable environments, where physical factors show little variation over temporal and spatial scales. Other environments, such as the intertidal zone and estuaries, can experience wide and rapidly changing fluctuations in physical factors in response to diurnal changes in tidal height. In estuarine environments, seasonal changes in physical variables are affected by changes in the inputs of freshwater and nutrients. Consequently, crustaceans are unusual when compared with other marine taxa because they show a wide variety of responses to salinity change, compared to those that can regulate against external changes and those that simply conform. Studies on crustaceans can therefore provide researchers with an ideal opportunity to examine the relationship between environmental variability and the capacity to tolerate ocean acidification, which has recently been debated in the literature **(Fabry *et al*., 2008; Widdicombe & Spicer, 2008)**.

. Although the results of the current study provided detailed information about the biochemical composition of *Rissoides desmaresti*, the most common in the Mediterranean Sea, in addition to the reflection of seasonal variation on the biochemical composition of one marine benthic crustacean, still more study is needed. There is a large body of work on the environmental influences on crustaceans using single or double variable experiments, and those works are generally conducted for understanding biological processes. Nevertheless, a broader approach is recommended to study the environmental fluctuations and their effects on marine organisms using large-scale. Furthermore, long-term datasets on recruitment coupled with fine-scale oceanographic, biophysical and environmental modeling could hence be studied and tested.

CONCLUSION

The results showed that the values of the correlation coefficient between environmental factors and nutritional variables differed, and the most influential factor was salinity, whereas the least influential factor was pH. It is clear that the effect of changing environmental and climatic factors on *Rissoides desmaresti* represents an example of the extent of the impact on marine organisms.

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الملخص العربي

رصد العلاقة بين التغير في العوامل البيئية والقيمة الغذائية في *Rissoides desmaresti* (القشريات)

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يعتبر الجمبري (***Rissoides desmaresti***) مصدرًا جيدًا ذو قيمة غذائية عالية مما يجعله خيارًا صحيًا للغاية للطعام البشري. لذلك كان الهدف من هذا البحث هو دراسة العلاقة بين العوامل البيئية والقيم الغذائية للجمبري (***Rissoides desmaresti***: رتبة فمية الأرجل - القشريات)، وتحديد مدي ارتباط هذه القيم، ومعرفة أي العوامل أكثر تأثيرا. ولذلك، تم قياس العوامل البيئية (درجة الحرارة، الملوحة، قيمة الأس الهيدروجيني، والأكسجين المذاب) موسمياً. وفي نفس الوقت تم تحليل القيمة الغذائية موسمياً في الأنسجة العضلية للجمبري حيث تم قياس كمية البروتين الخام والدهون والكربوهيدرات والقيمة الحرارية والرطوبة والرماد. وأظهرت التحاليل الإحصائية أن قيم معامل الارتباط لمختلف معاملات التركيب البيوكيميائي والعوامل البيئية تراوحت بين ارتباط إيجابي قوي جدا وارتباط سلبي قوي جدا. وكانت العلاقات متباينة، وكان العامل الأكثر تأثيرا هو الملوحة، تليها درجة الحرارة، يليها الأكسجين المذاب ثم الرقم الهيدروجيني. وقد اتضح من هذه الدراسة أن هذه المكونات تتأثر بالتغير في العوامل البيئية، ويمكن اعتبار ذلك مؤشرا استدلاليا لمعرفة مدى تأثر الكائن بهذه العوامل، وتغيرها الدائم المصاحب لتغير المناخ وعوامله البيئية.