Biometric characteristics of the wild population of sea urchin Paracentrotus lividus (Lamarck, 1816) on the Tunisian coast

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Biometric characteristics of the wild population of sea urchin *Paracentrotus lividus* (Lamarck, 1816) on the Tunisian coast

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Abstract
The present study was conducted to provide biometric data of the edible sea urchin *Paracentrotus lividus* along the Tunisian coastline where thirteen marine localities were selected randomly. A total of 653 individuals were collected and their metric and weight measurements were recorded. The size distribution of the different samples was determined and relative growth expressions were deduced. Data analysis showed that all localities' samples of the wild population were dominated by one-size class, except Port Prince and Haouaria. Interestingly, only diameter-height relationships (D-H) were different between the geographical localities. Diameter-weight relationships (D-TW and D-TWTE) revealed a significant negative growth for all the localities, with the exception of Gammarth which showed positive growth for total weight (D-TW). Moreover, the multivariable analysis revealed divergences and/or similarities between metric and weight variables. Altogether, data highlights the inter-population discrimination with respect to geographic localization and clear segregation between the northern and the eastern localities demonstrated the plasticity of the species.

Keywords South Mediterranean · Tunisia · Sea urchin · Biometrics

Introduction

Nowadays, edible species of echinoids have a great economic interest due to the development of fishing activities (Ourens et al. 2015). The purple sea urchin *Paracentrotus lividus* (Lamarck, 1816) is a case study. In the Mediterranean, *P. lividus* is an emblematic species widely distributed along the Mediterranean and the northeastern Atlantic coasts. Species are encountered mainly in rocky shores and seagrass meadows (Tomas et al. 2004). It is present from the intertidal zone up to - 80 m and its density decreases with depth (Lecchini et al. 2002). *P. lividus* is the main herbivore (Sala and Zabala 1996). Through grazing, species have an important ecological role in coastal marine ecosystems and in controlling benthic algal communities (Guidetti et al. 2004; Guidetti and Dulcic 2007; Bulleri 2013). Furthermore, these particular species are also harvested for their gonad by professional fishing, recreational fishing and illegal harvesting (Loi et al. 2017). As a result, some regions display overexploitation. Protective measures have been taken in some EU countries where species are considered as preserved symbols. Since 1996, *P. lividus* have been included in the protocol for the conservation of biodiversity (Annex III of the Barcelona Convention) as a marine species whose exploitation is regulated. A regional decree of fishing is usually practiced in France (Loi et al. 2017) and Italy (Gianguzza et al. 2006). The harvesting of species is being regulated i.e., reconsidered fishing period, catch quotas, and minimum harvestable size.

In this context, many local populations of *P. lividus* along the northern part of the Mediterranean and Atlantic coasts have been investigated (Sala et al. 2012; Jacinto et al. 2013; Vafidis et al. 2019). Biology of the sea urchin *P. lividus* has been the subject of a great deal of research, and studies have mainly focused on the reproductive cycle (Vafidis et al. 2019), growth (Lozano et al. 1995), biometric traits (Regis 1981) and the dynamic of population and stock management (Guinda et al. 2016). On a large geographical scale, the results revealed variability in the biological traits of species. In literature, reproduction does not have the same pattern. Lozano et al. (1995) and Loi et al. (2017) reported a single spawning season

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for *P. lividus* in Spain and Corsica, while Fernandez and Boudouresque (1997) and Guettaf et al. (2000) recorded two periods in France and Algeria. In regard to growth, the individuals reached ten years of age in Spain (Ouréns et al. 2013; Turon et al. 1995). While in other regions, the maximum age was seven to eight years in Ireland, Tunisia and Portugal (Crapp and Willis 1975; Sellem et al. 2000; Gago et al. 2003). Biometric and morphological traits vary according to geographical localities. Changes in the morphological and physiological traits of sea urchin (the weight of the gonad, intestine, lantern, length and body size) were observed during a decrease in food availability (Ebert 1996). The abiotic and biotic environmental factors have an important effect and are often involved in changes. Food availability, fishing and pollution, for example, were factors. Size change tests with sea urchin species, in particular, have been reported by several authors. Fernandez and Boudouresque (1997) have shown that when food resources are limited in lagoon tests, decline in size. Guinda et al. (2016) indicated that 76% of the stock of commercial individuals is composed of smaller average sizes in the coastal region of Cantabria (Spain) where sea urchins are exploited. In Portugal, Bertocci et al. (2013) reveal that the harvest was associated with a significant reduction in the abundance of commercially valuable individuals. Finally, on Ustica Island (Sicily) Gianguzza et al. (2006) underlined the role of regulated fishing in maintaining sea urchin populations at such low densities that no interspecific competition is induced with *Arbacia lixula*.

In contrast, the southern shores of the Mediterranean remain insufficiently studied despite the presence and large concern for these species. Along the African coast, species have been considered in some works in Morocco (Bayed et al. 2005), Algeria (Guettaf et al. 2000), Tunisia (Sellem et al. 2000) and Egypt (Elmasry et al. 2015), but information about population traits are scarce. Throughout the Tunisian shallow coastal waters, *P. lividus* is the predominant sea urchin species encountered. Commercial interest in this species is particularly increasing and only a few harvesting conditions have been established temporarily (in 2000). No official regulations are set up and the regulations are applied scientific data known as basic knowledge for halieutic resources. Biometry, reproduction, growth and population dynamic information are needed. Studies about growth and reproduction regarding the *P. lividus* species are limited to the northern coasts (Sellem et al. 2000; Sellem and Guillou 2007). On the other hand, investigations from biometric traits and population structures on the Tunisian coast are rare. Only Deli et al. (2017) have explored some morphological divergence of the species across the African Mediterranean coast. Given the scarcity of information on the *P. lividus* population in Tunisia, this study is devoted to the biometric characterization and structure of the species population along the Tunisian shore. A sampling campaign carried out in thirteen geographical locations allowed the collection of specimen size ranging from 25.2–67.9 mm. Biometric relationships using size and weight data were established and population structure was determined. Finally, results were compared to discern the variations and similarities between samples.

Materials and Methods

Study Area and Sample Collection

This study was carried out on the Tunisian shore, located on the central part of the South Mediterranean coast. Due to its geographical location, Tunisia's climate is essentially influenced by types of winds. The northern coast is exposed to mild and humid sea winds which cause a significant drop in temperatures and an increase in precipitation. Contrastingly, in the south of the country, winds are dry causing a rise in temperatures (Ben Ismail et al. 2012). *P. lividus* is a preponderant sea urchin on the shallow rocky shore (Sellem et al. 2011). To scan the spatial distribution of *P. lividus*, exploration was spread over the four geographical areas of the coast corresponding to the regional divisions (northern coast, gulf of Tunis, gulf of Hammamet and gulf of Gabès), between April and May 2011. The surveys were carried out at random close to the coastline where thirteen samples of sea urchins affiliated with thirteen geographical localities were sampled.

Sea urchins were collected at random in a sampling surface not exceeding 100 m2 in each of the different localities: Tabarka (ta), Ras Angela (ra), Sounine (so), Gammarth (ga), Port Prince (pp), Haouaria (ha), Kelibia (ke), Maamoura (ma), Hergla (he), Monastir (mo), Mahdia (mh), Kerkenah (kr) and Jerba (je) Fig. 1. Samples were gathered on rock substrate covered with algae between 2 and 5 m depth. In total, 653 specimens of *P. lividus* were used for this study.

Data Analysis

In the laboratory, the specimens were drained on absorbent paper for 10 min. The immediately-drained total weight (TW) was measured with an electronic balance (0.01 g). Two metric measurements were made using a digital vernier calliper (0.1 mm). The diameter size (D) perpendicular to the oral-aboral axis) and the height (H by oral-aboral axis) were measured (excluding spines). Subsequently, sea urchins were dissected to remove all the contents of the coelomic cavity and release the skeletal parts, including the test (with spines) and Aristotle's lantern. All the skeletal parts (TWTE) were dried at 70 °C for 48 h and then weighed. The samples of the recorded localities were grouped by size classes and represented by

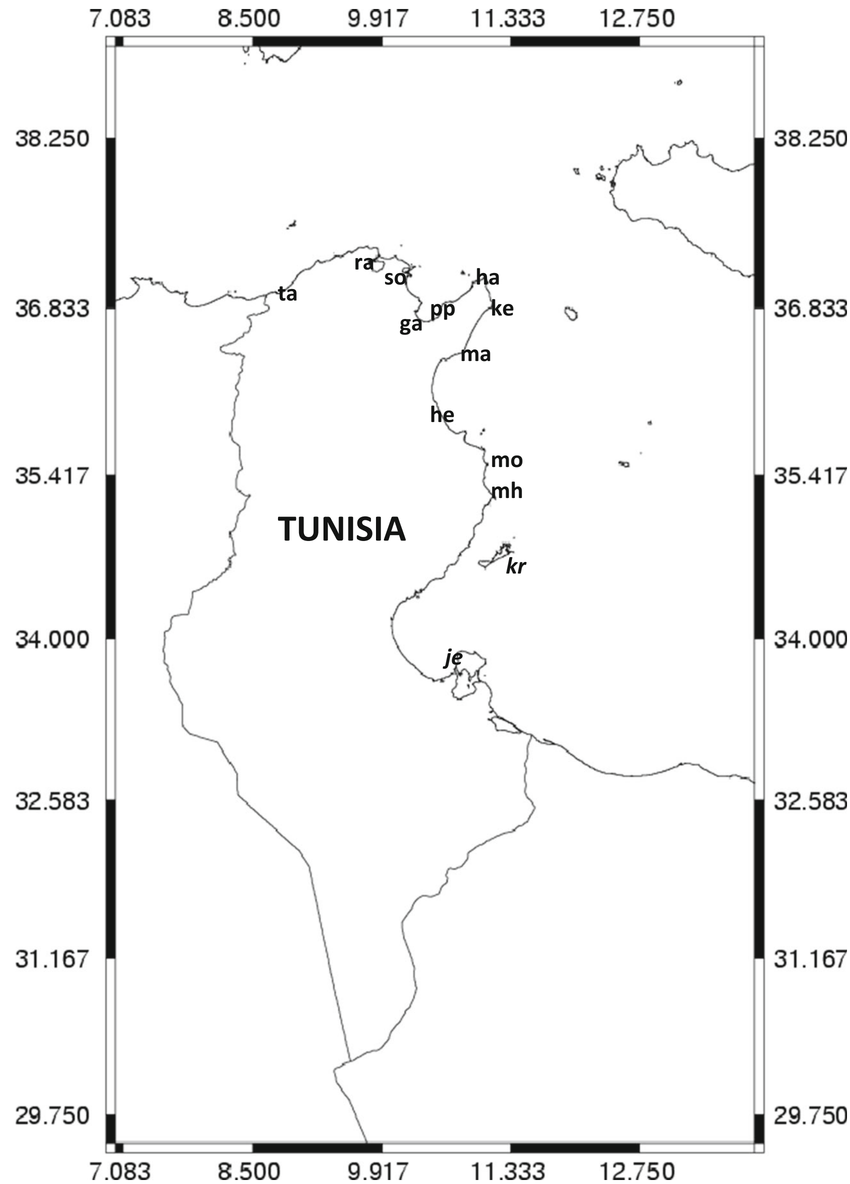


Fig. 1 Sampling localities of the studied sea urchin *Paracentrotus lividus* from Tunisia coasts ta Tabarka, ra Ras Angela, so Sounine, ga Gammarth, pp. Port Prince, ha Haouaria, ke Kelibia, ma Maamoura, he Hergla, mo Monastir, mh Mahdia, kr Kerkena, je Jerba

histograms. Size frequency distributions were compared using a Chi 2 test when necessary. The relative growth was investigated using diameter D as the reference variable. The relationship (D-H, D-TW and D-TWTE) was fitted using linear regression analysis, expressed by the eq. $W = a + b (D)$ where (a) is the intercept of the regression and (b) is the slope which represents the growth coefficient. The b value was tested with the t-test and the differences were considered significant at $P < 0.05$. One-way ANOVA was used to evaluate similarities and differences between sample variables, followed by a Tukey HSD post-hoc test. Prior to the analysis, the normality and homogeneity of variance were tested with Shapiro-Wilk and Levene tests. To discern the heterogeneity of samples within localities, factorial discriminant analysis (FDA) was conducted. All statistical analysis was performed with XLSTAT (Windows 10).

Results

Size Distribution

Thirteen samples of *P. lividus* specimen living in Tunisia's shallow coasts were investigated (Table 1). The diameter size (D) varied from 25.2–67.9 mm. The largest specimen was found at Port Prince and the smallest was found at Sounine. The comparison of the average sizes of the diameter revealed significant differences between the thirteen localities (ANOVA, $F = 28.202$, $P < 0.0001$). Moreover, sea urchin samples from Tabarka, Ras Angela, Sounine, Gammarth, Port Prince, Haouaria, Kelibia, Maamoura and Hergla were specified by specimens with an average diameter $D \geq 41.9$ mm. In contrast, Monastir, Mahdia, Kerkenah and Jerba samples were characterized by a lower mean diameter

Table 1 Biometry of *Paracentrotus lividus* in different geographical locality

Locality	n	D±sd (mm)	H±sd (mm)	TW±sd (g)	TWTE ±sd (g)
Ta	40	48.07 ± 6.45	23.69 ± 3.49	39.04 ± 14.69	14.15 ± 5.23
Ra	60	45.66 ± 2.7	22.43 ± 2.11	34.85 ± 5.81	10.81 ± 1.69
So	42	44.9 ± 5.66	22.36 ± 3.32	37.98 ± 11.92	14.24 ± 4.73
Ga	47	47.68 ± 3.96	24.92 ± 2.46	33.98 ± 10.7	13.18 ± 2.88
Pp	63	50.02 ± 8.8	25.75 ± 5.01	53.49 ± 22.12	15.72 ± 6.09
Ha	75	48.92 ± 6.52	25.57 ± 4	33.96 ± 8.94	14.49 ± 5.19
Ke	40	43.75 ± 3.49	22.14 ± 2.5	33.69 ± 6.49	10.95 ± 2.42
Ma	62	41.95 ± 5.52	21.54 ± 3.41	27.01 ± 6.34	10.01 ± 3.35
He	48	41.93 ± 6.43	20.52 ± 3.62	29.27 ± 11.94	9.97 ± 3.73
Mo	42	39.8 ± 4.82	20.51 ± 2.67	25.61 ± 9.54	8.65 ± 3.26
Mh	44	38.22 ± 3.74	20.97 ± 2.26	20.75 ± 5.08	6.70 ± 1.91
Kr	47	38.64 ± 4.89	19.75 ± 3.08	24.07 ± 8.07	8.56 ± 2.71
Je	43	39.86 ± 3.63	20.15 ± 1.59	25.47 ± 4.98	7.77 ± 1.59

n number, *D* diameter, *H* hight, *TW* total weight, *TWTE* total weight test, *sd* standard deviation

that ranged between 36.5 and 39.9 mm. Nine size classes were defined, according to the test diameter, without spines (means: 32, 37, 42, 47, 52, 57, 62 and 67 mm). It is worth noting that all samples showed a diameter distribution with one mode (42 or 47 mm), whereas only Port Prince and Haouaria samples showed two modes at the level of 42 and 52 mm (Fig.2). Recruits (small sea urchins <20 mm) were not observed during the sampling period in all localities. The juveniles, (20 – 30 mm) corresponding to 22 and 27 classes, were identified at Port Prince, Hergla and Kerkenah with very low frequencies, which did not exceed 7% at Kerkenah, as an example. The individuals from size (30-40 mm) corresponding to classes 32 to 37 were observed in all localities with frequencies ranging from 2.12% - 86.0%. The sized sea urchins (40-50 mm) corresponding to classes 42 to 47 are also represented in all sampled localities with more than 50% of the individuals at the levels of Tabarka, Ras Angela, Sounine, Gammarth, Kelibia, Maamoura and Hergla. Finally, large sea urchins (> 50 mm) corresponding to classes 52, 57, 62 to 67 are only well represented in Port Prince and Haouaria with more than 50% of the specimens. However, in Mahdia, Kerkenah and Jerba large sizes of *P. lividus* were noticeably absent.

Furthermore, it is interesting to compare the population structure in Ras Angela and Sounine where sea urchin fishing has been carried out for ten years (Sellem et al. 2011). The analysis of temporal changes showed a significant difference in Ras Angela's and Sounine's locality structures (between May 2000 and May 2011, Chi 2 test respectively $P < 0.0001$ and $P < 0.0005$). As a rational explanation, these later differences occurred due to the high dominance of specimens in the 52 mm size-class in May 2000 (the beginning of the fishing activity), and which were not highly significant in May 2011 (the present study). Furthermore, we noted that in 2001, the two localities presented respectively 40% and 33.89% of specimens with $D > 55$ mm while in 2011, proportions declined to 5% and 7.31%, respectively. Likewise, both localities recorded a reduction in the mean size, reporting 45.66 and 45.38 mm as opposed to 49.06 and 49.32 mm, respectively. Moreover, as noticed in the previous class, the 42 mm size class shows significant correlations (Chi 2 tests, $P < 0.0001$). Contrarily, the 47 mm size class did not reveal significant differences in the size structure of these two localities during the two periods of investigation (Chi2 test; $P > 0.05$).

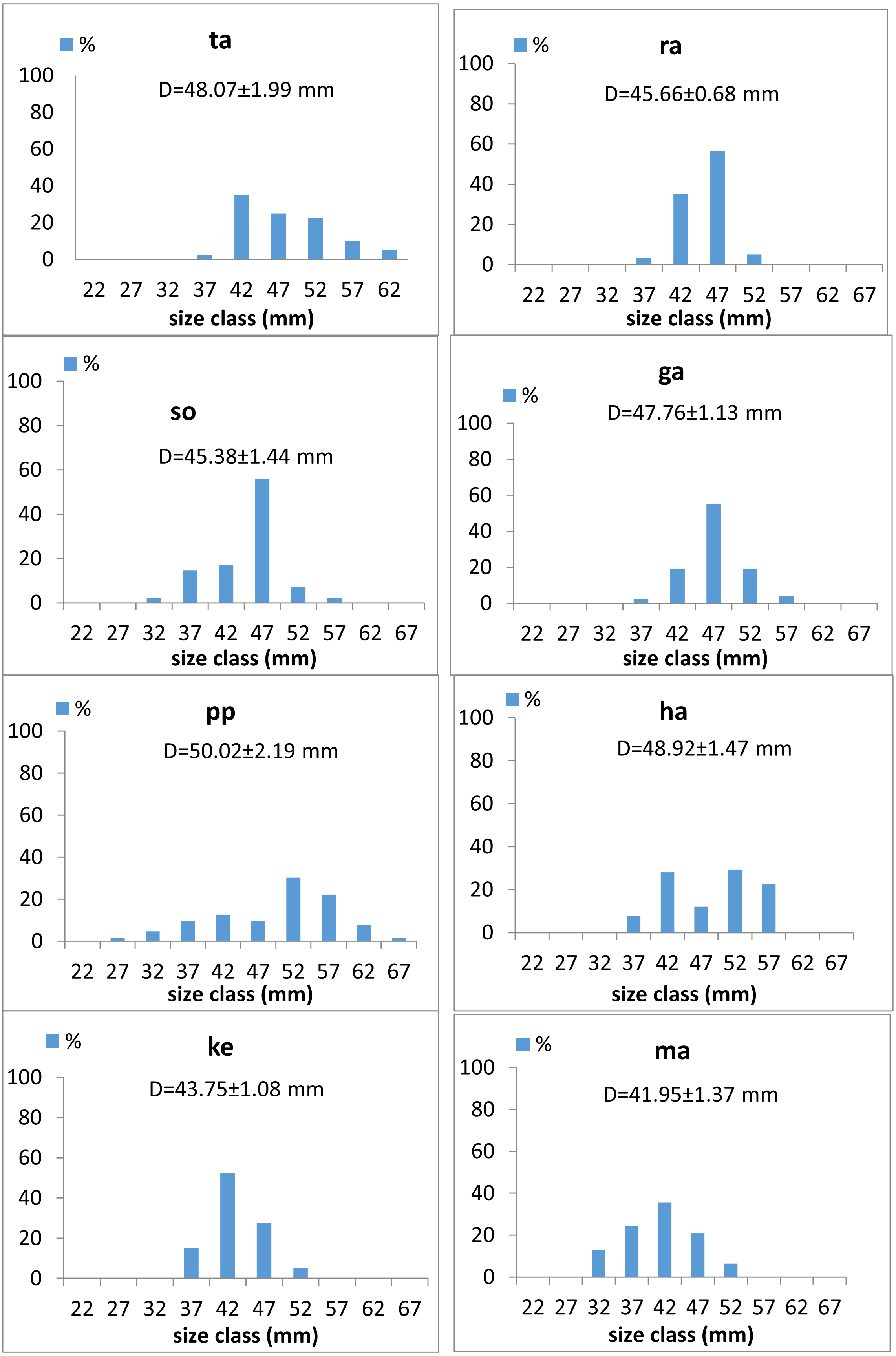
Metric and Weight Relationships

The relationships between the variables (D-H, D-TW and D-TWTE) are consigned in Table 2 and presented in Fig.3. Diameter-height (D-H) relationships from the different localities were found to be significant, and the b values varied from 0.61 to 1.20. A negative allometric growth ($P < 0.001$) was found in Monastir, Mahdia and Djerba. A significant positive relationship ($P < 0.001$) was observed in Kelibia, Maamoura and Kerkenah and finally a significant isometry ($P < 0.001$) was found in Tabarka, Ras Angela, Sounine, Gammarth, Port Prince, Haouaria and Hergla. Diameter-weight relationships (D-TW and D-TWTE) revealed a significant negative growth for all the localities, with the exception of Gammarth which showed positive growth for total weight.

Comparison of Localities

Considering the thirteen localities, both normality ($P > 0.05$) and homogeneity of variance ($P > 0.05$)

Fig. 2 *Paracentrotus lividus*: size class distribution analysis at each locality during April to May 2011 ta Tabarka, ra Ras Angela, so Sounine, ga Gammarth, pp. Port Prince, ha Haouaria, ke Kelibia, ma Maamoura, he Hergla, mo Monastir, mh Mahdia, kr Kerkena, je Jerba.



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size class (mm)
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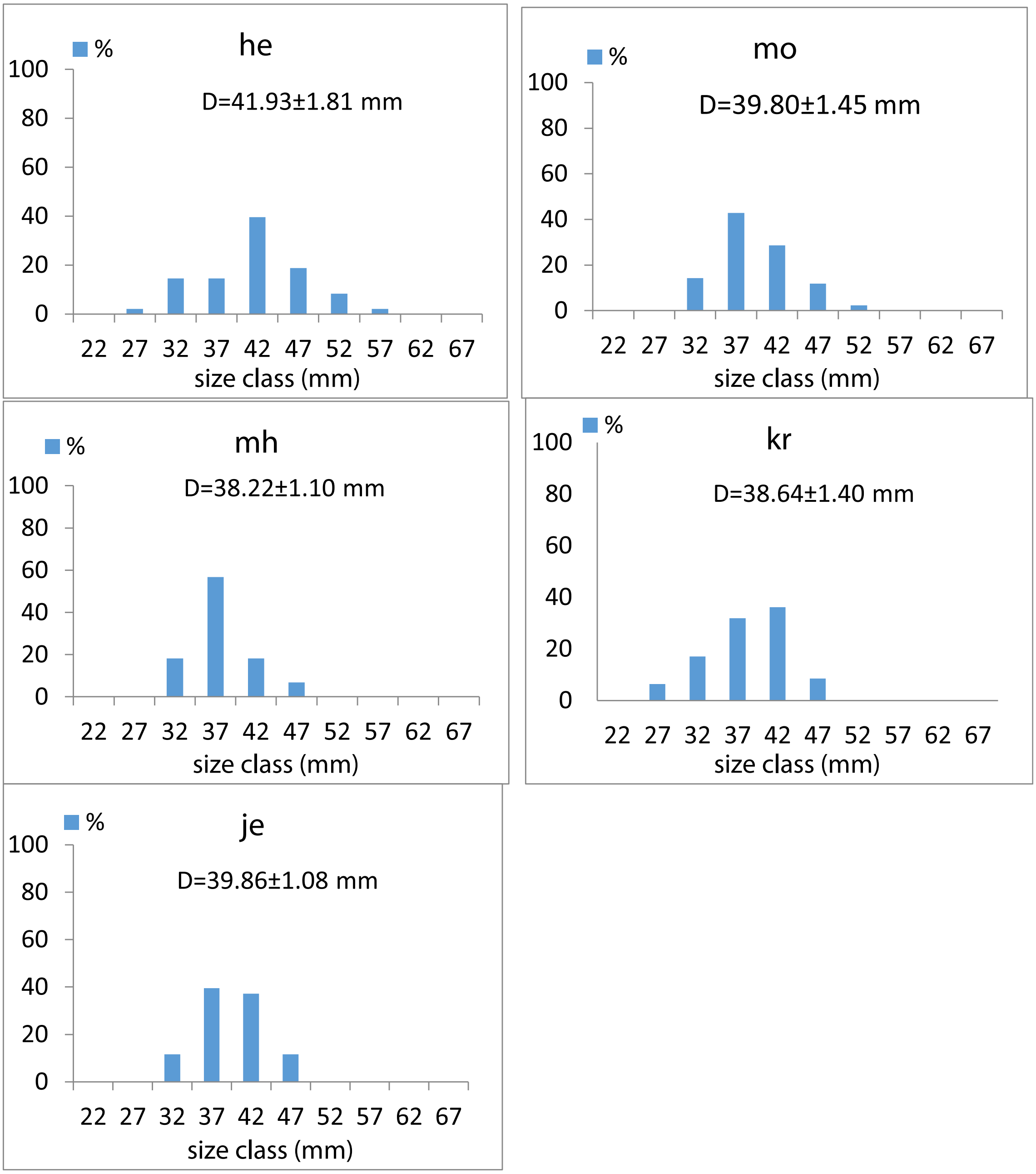

Fig. 2 (continued).

assumption of variables D, H, TW, and TWTE were satisfied. The mean values of the estimated metric and weight variables (i.e., D, H, TW, and TWTE) were presented in Table 1. The analysis of variance showed a highly significant locality effect for all parameters ($P < 0.0001$). Multiple comparisons of averages of D, H, TW and TWTE showed a divergence between the analysed samples, and Tukey HSD clearly discriminated against the locality samples (Table 3). Additionally, Port Prince and Mahdia showed a highly significant difference in values of diameter and height, while the localities of Tabarka, Ras Angela, Sounine, Gammarth, Haouaria and Kelibia indicate significantly proximate means. This is also the case in the localities of Jerba, Kerkena, Monastir, Hergla, Maamoura and Kelibia which constitute a second collection with close significant values. For the total weight, Port Prince and Haouaria data reveals significantly equal means. Furthermore, Mahdia shows a mean total weight that is significantly different from all the localities. Finally, for the total weight test, Port Prince, Gammarth and Haouria constitute one homogenous group as their values are equal. Kerkenah also displays an average significantly different from all the localities.

Table 2 Parameters of the relationship between (D-H), (D-TW) and (D –TWTE) for *Paracentrotus lividus* along Tunisia coasts

Relationship	D-H			D-TW			D-TWT		
Locality/parameters	a	b	R^2	a	b	R^2	a	b	R^2
Tabarka (ta)	0.31813	1.0059	0.8403	2.76955	2.5809	0.8875	3.04576	2.4909	0.8244
Ras Angela (ra)	0.45606	1.0882	0.4424	2.92082	2.6825	0.832	2.67778	2.2325	0.7103
Sounine (so)	0.39416	1.0547	0.7726	2.79588	2.6312	0.9625	3.39794	2.771	0.9076
Gammarth (ga)	0.29303	1.0076	0.7384	4.04576	3.3122	0.6664	2.79588	2.3309	0.78
Port Prince (pp)	0.38174	1.0542	0.8841	2.82391	2.6658	0.9672	2.88606	2.3917	0.9492
Haouria (ha)	0.41117	1.076	0.8409	1.54363	1.8148	0.8536	3.39794	2.6725	0.9267
Kelibia (ke)	0.63227	1.2045	0.7525	1.92445	2.1	0.8247	2.76955	2.3126	0.7833
Maamoura (ma)	0.47782	1.1152	0.8122	0.0161	0.8873	0.2677	2.95861	2.4254	0.8357
Hergla (he)	0.38248	1.0437	0.8374	2.95861	2.7076	0.9647	3.1549	2.55	0.9595
Monastir (mo)	0,10,403	0.8845	0.6432	3.09691	2.813	0.833	3.22185	2.6053	0.7966
Mahdia (mh)	0,22,651	0.978	0.7286	1.12378	1.5364	0.359	1.80967	1.6577	0.3091
Kerkenah (kr)	0.45942	1105	0.815	3.1549	2.852	0.9656	3.22185	2.613	0.9255
Jerba (je)	0.22999	0.6712	0.6065	1.17457	1.6093	0.652	1.6216	1.5667	0.551

a b parameter of the allometric equations, R^2 coefficient of determination

The application of AFD clearly revealed the existence of significant differences between individuals from different samples. Interestingly, three main localities (Port Prince, Haouaria and Mahdia) showed the greatest gap from the origin of the axes (Fig.4). Samples from Port Prince were situated on the negative side of axe 1, while samples of Mahdia and Haouaria were located on both sides and positioned at the positive side of this axe. The arrangement revealed two groups: the first group enclosed Gammarth, Tabarka, Sounine, Ras Angela and Kelibia which overlaps with Port Prince and Haouria. The second, comprised Hergla, Monastir, Kerkena and Jerba which overlaps with Mahdia.

Discussion

In the Mediterranean *P. lividus* occupy divers habitats (Guidetti et al. 2004), but species favors boulders which provide mainly protection against waves and predation (Sala and Zabala 1996). On rock substrates, scattered with photophilic algae, *P. lividus* is frequently collected by amateur and professional. Morphometric relationships and somatic growth are the first steps which has used to establish and develop sustainable fishery of the species (Pancucci and Panayotis 1994; Gianguzza et al. 2006; Guinda et al. 2016).

The present survey is the first report on biometric characteristics of the *P. lividus* population from the coasts of Tunisia. Results revealed that linear and weight parameters, diameter (D), height (H), total weight (TW) and total weight test (TWTE) were not homogenous among the different localities' samples. Significant and insignificant differences were observed between the thirteen selected localities.

Throughout the period of investigation, the samples' size distribution from the thirteen localities were not similar and diameter means were significantly different. Port Prince and Haouaria showed bimodal distribution, while a unimodal size frequency distribution was observed within all the other localities. Classical studies have documented that the different size classes of *P. lividus* could be associated to many characteristics such as: habitat (i.e., depth and substrate) (Guidetti et al. 2004), environmental conditions (i.e., water temperature, salinity, currents and pollution) (Fernandez et al. 2006) and biology and physiology of the species (Vafidis et al. 2019). The lack of some sea urchin size classes as well as the decreases in some frequencies may be associated with harvesting (Farina et al. 2018), which is specifically the case of the Ras Angela and Sounine localities where collection has been done. In this study, these localities displayed substantial changes within the population structure. However, harvesting pressure was also associated with the significant reduction in density and abundance of specimens (Guidetti et al. 2004; Bertocci et al. 2013; Ourens et al. 2014). In the absence of field data and since no major difference in species' abundance between the localities was observed during the sampling period, it is noteworthy to suggest that distribution size changes are likely mostly attributed to the fishing intensity, at least for the two locations of Ras Angela and Sounine.

All the diameter-weight relationships studied (D -TW) and (D -TWTE) followed a negative allometry in all the localities, with the exception of Gammarth who showed a positive somatic growth for the diameter total fresh weight relationship

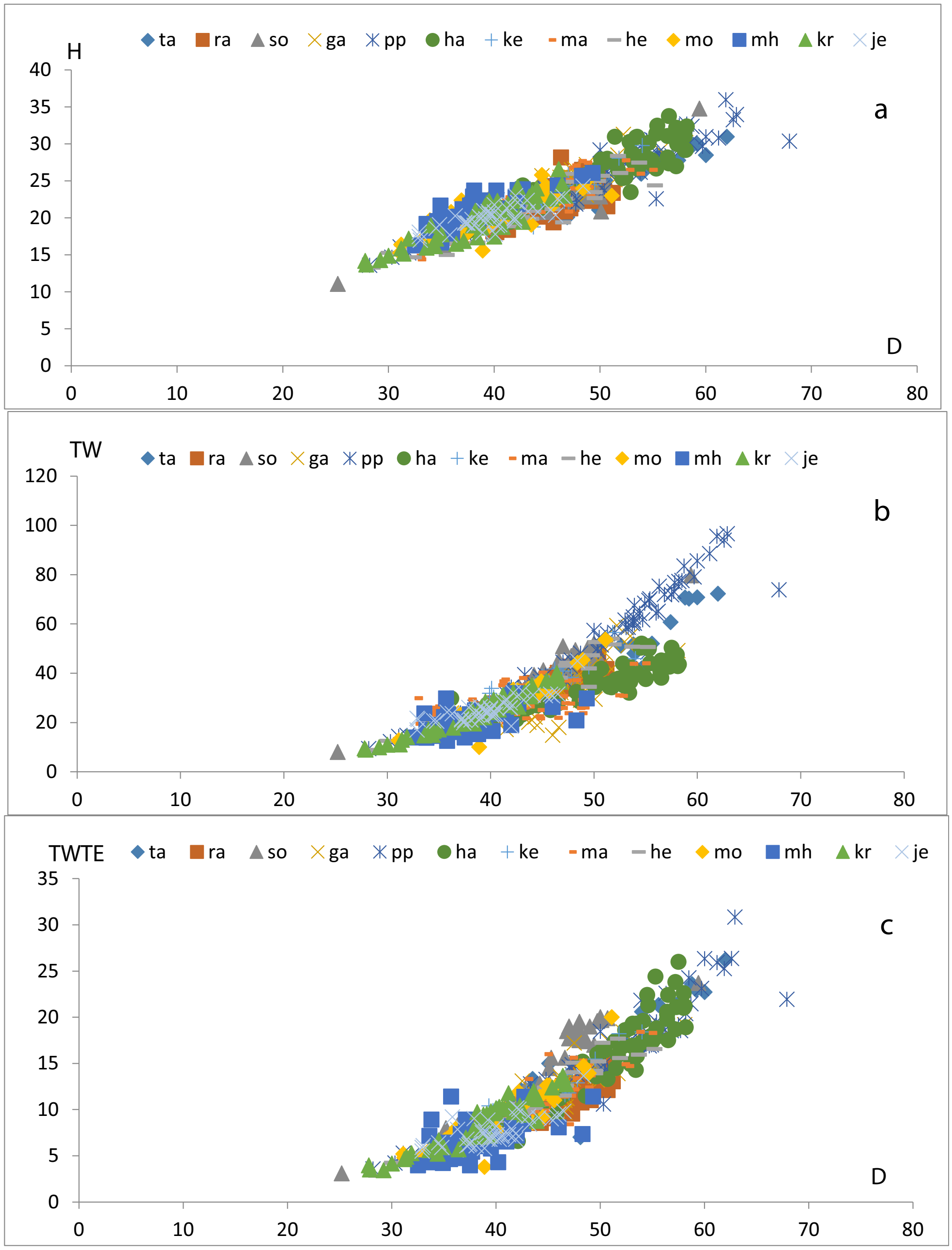

Fig. 3 Graphic representation of the different relationships a Height (H)-diameter (D), b total weight (TW) – (D) and c total weight test (TWTE) - (D) of *Paracentrotus lividus* from Tunisia coast

(D- TW). Such a negative growth pattern has also been reported in populations of *P. lividus* from other areas of the Mediterranean (Regis 1981). Likewise, in Sardinia Pais et al. (2006) and in Greece Antoniadou and Vafidis (2009), reported negative somatic growth similar to that encountered on the Tunisian coast.

However, the relationships D-H showed a spatial variation. This relationship, known as a flattening, is linked to somatic growth, which depends on environmental factors and particularly the food consumption (Guillou and Michel 1994; Fernandez and Boudouresque 1997; Sellem et al. 2000; Ourens et al. 2014). In the different localities examined growth rate shows values between 0.671 and 1.204 close to the values estimated for other Mediterranean regions (Regis 1981). In Greece, for example, growth coefficient of species has value of 0.87 (Antoniadou and Vafidis 2009), who is close to the locality of Monastir, while in Italy it is 1.035, who is borders to the locality of Hergla. Finally, in Turkey Küçükdermenci and Lök (2014) report a growth coefficient of 0.526 adjacent to the locality of Jerba.

Overall, investigations discerned a dissimilarity of the thirteen samples within localities. The population of *P. lividus* seems heterogeneous, a clear discrimination is detected between the different samples and two groups of localities are highlighted. Similar observations were identified with FDA assemblages, which also indicated two sub-population groups

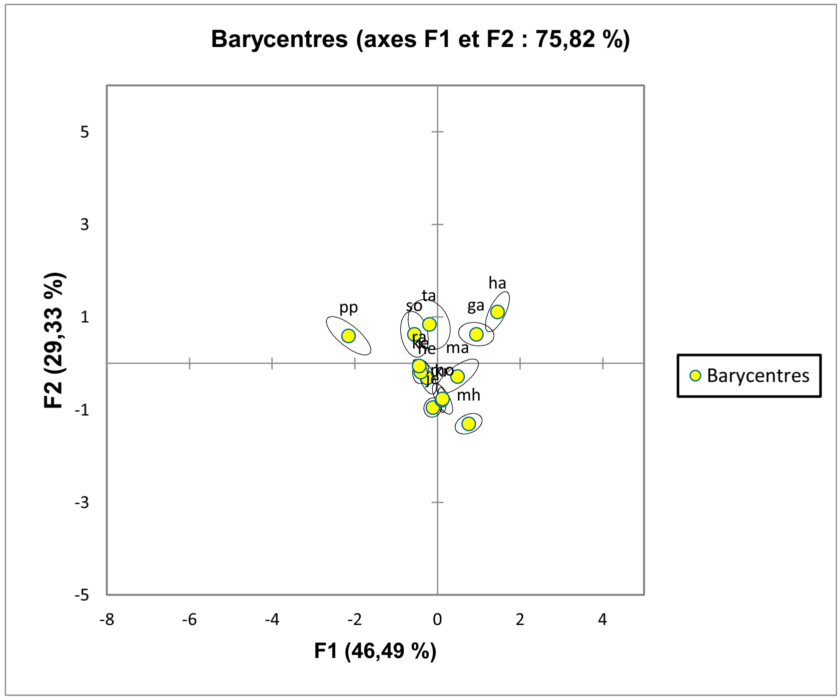

Fig. 4 Factorial Discriminant Analysis (FDA): Barycentric representation of *Paracentrotus lividus* populations of *ta* Tabarka, *ra* Ras Angela, *so* Sounine, *ga* Gammarth, *pp* Port Prince, *ha* Haouaria, *ke* Kelibia, *ma* Maamoura, *he* Hergla, *mo* Monastir, *mh* Mahdia, *kr* Kerkena, *je* Jerba

and which were matched to the geographical separation of the thirteen samples. In fact, subpopulation 1 included localities from the northern part of Tunisia (Tabarka, Ras Angela, Sounine, Gammarth, Port Prince and Haouaria) and sub-population 2, contained localities situated from the eastern coast (Kelibia, Maamoura, Hergla, Monastir, Mahdia, Kerkena and Jerba). Finally, this investigation about biometric characteristics of the wild population of *P. lividus* allowed us to discern a metric and weight variation between populations from Tunisia shore and to describe two divergent groups assigned to two parts of the Mediterranean basin. This finding is in accordance with a previous study which reported a phenotypic divergence of *Paracentrotus lividus* across the Siculo-Tunisian Strait and a significant genetic differentiation between populations from the eastern and western Mediterranean (Deli et al. 2017).

The average values of linear and weight measurements showed significant differences between the northern and eastern localities of Tunisia. This is due to the different levels of the physical and chemical parameters of the waters as well as the physiology of the species. There are few sudies that underline size or weight variability of *P. lividus* in its habitat related to environmental factors but most studies, have shown an important relationship between somatic growth and the availability of food (Guillou and Michel 1994). Fernandez and Boudouresque (1997) revealed in Urbinu lagoon a morphometric variability of species related on the food quantity. In contrast, under eutrophication conditions Pancucci and Panayotis (1994) observed a smaller population of size in the Gulf of Amvrakikos.

In conclusion this preliminary study is the first one that investigated some morphological characteristics of *P. lividus* populations from Tunisia shore. Results shows that species has a plastic response in front of environnemental conditions. The biometric approch should be completed by further investigations especially availability of food consumption a key

Table 3 Statistical metric and weight comparison of *Paracentrotus lividus* with localities. The localities presenting the same letters form a group with significantly similar averages

locality	mh	kr	mo	je	he	ma	Ke	so	ra	ga	ta	ha	pp
variable													
diameter (D)	a	ab	abc	abc	abc	bcd	cde	def	ef	efg	fg	g	g
height (H)	abc	a	abc	ab	abc	abcd	bcd	bcd	cd	e	de	e	e
total weight (TW)	a	ab	ab	ab	bcd	abc	cde	e	de	cde	e	cde	f
total weight test (TWTE)	a	abc	abc	ab	bc	bc	cd	ef	cd	de	ef	ef	f

a, b, c, d, e, f, g statistical significances, *ta* Tabarka, *ra* Ras Angela, *so* Sounine, *ga* Gammarth, *pp* Port Prince, *ha* Haouaria, *ke* Kelibia, *ma* Maamoura, *he* Hergla, *mo* Monastir, *mh* Mahdia, *kr* Kerkena, *je* Jerba factor controlling somatic growth and whose levels would change with physiology of the species.

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