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Ecological studies on the hermit crab *Calcinus latens* (Paguroidea: Diogenidae), from Aqaba Gulf, Egypt; Part (II), some morphological aspects of intersexuality phenomenon

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ABSTRACT

The present study aims to shed light on some morphological aspects of intersexuality along with sexual dimorphism in the population of *Calcinus latens* (Randall, 1840). It is based on the same sample and so, the same measurement data of part I of some ecological studies that were performed on *C. latens*. So, the examined specimens were 442 (121 males, 46 intersex individuals, 275 females) collected from the Lagona region in Dahab city, Aqaba gulf, Egypt. The measurements included shield length (Sl), shield width (SW), wet weight (Weg), length (LpL) and height (LpH) of left chelar propodus and right chelar propodus length (RpL). The population was divided into six size classes. Morphological and statistical evidence, suggesting that intersex individuals may function as males, were recorded. Sexual dimorphism was indicated in all the measured dimensions. The overall sex ratio was 1:2.3, in favor of females. Typical males showed higher abundance percentage in the larger size classes than in the smaller ones. Typical females showed the reverse. Intersex individuals were present only in size classes that included typical females. That finding indicates a connection between their role and typical females abundance, suggesting that they may serve as a "backup" for typical males in reproduction. That, in turn, could interpret their higher abundance percentage in *C. latens* population (≈10.4%) than in other hermit crabs populations, assuming a higher males mortality rate in the case of the *C. latens* population.

INTRODUCTION

Hermit crabs include more than 1100 species and around 43 species of them belong to genus *Calcinus* Dana, 1851 (McLaughlin *et al.*, 2010). The hermit crab species *Calcinus latens* (Randall, 1840) is found in various habitats, including; coral reef flats where there is not high surf, rocky platforms, rock pools on lower shore, coral heads in lagoons, rubble and sand (McLaughlin, 2002). It was one of the two most dominant species in the intertidal and the shallow sub-tidal areas along the Red Sea coast of Egypt (Abd El-Wakeil *et al.*, 2009).

In some of the Red Sea *C. latens* specimens, Said (2008) noticed the existence of both female and male genital openings on coxae of 3rd and 5th pereopods respectively in the same individual. The existence of an individual with both male

and female characters in a protandric, protogynic, or normally gonochoristic species is called intersexuality (Sagi *et al.*, 1996). In Crustacea, intersexuality has been recorded mainly in species that show either protandry, in which there is a change of sex from male to female or protogyny, in which opposite change occurs (Sagi *et al.*, 1996). The male and female characters that make an individual be called an intersex individual may be just external morphological characters, or they may also include internal gonadal differentiation (Sagi *et al.*, 1996). For defining such characters, differentiation between males and females should be determined first.

Morphological differentiation between the two sexes may be sometimes obvious, and sometimes, it only can be shown by statistical analyses based on comparative morphometric techniques (Accioly *et al.*, 2013). The group of differences in the secondary sexual characteristics in body size and body shape is called sexual dimorphism and caused by the complex interactions of natural, intra- and intersexual, fecundity and ecological selections (Miličić *et al.*, 2013). Sexual dimorphism is common among plants and animals (Fairbairn, 1997). It characterizes hermit crabs and other decapod crustaceans (Gusev and Zabotin, 2007).

In crustaceans, many aspects of the population structure were widely documented. For example, Wenner (1972) investigated the sex ratio in some marine crustaceans including some hermit crabs. He found that there is a widely spread deviation from the expected 1:1 sex ratio in those crustaceans and the field data examination in some different groups shows that sex ratio is a function of size in all the examined cases. Population studies generally include density descriptions, size distribution, dispersion patterns, sex ratio and reproductive periods that can be compared among different populations (Branco *et al.*, 2002). Such comparisons are important in detecting differences among those populations (Branco *et al.*, 2002). For instance, through studying the population size structure, the abundance pattern and percentage of intersex individuals in different populations could be checked. Then, they could be used in understanding the variability of such individuals among those populations which, according to Turra (2007), is the first step to understand intersexuality in hermit crabs.

In summary, although hermit crabs are considered to be the most morphologically diverse group of decapod crustaceans, intersexuality has been documented and carefully studied for just a few species of them (Fantucci *et al.*, 2008). In those crabs, one can argue if intersexuality may be part of a true hermaphroditism mechanism (Turra, 2004). In the hermit crab *C. latens* (Randall, 1840), although some observations of female gonopores in some male specimens were reported before in literature (McLaughlin, 1986), there was neither rejection nor embrace for a suggestion about sex reversal (Wenner, 1972). Therefore, the present study that represents part II of some ecological studies performed on *C.latens* (Randall, 1840) by Abd El-Wakeil *et al.* (in progress) aims to achieve one major goal.

That major goal is to shed light on some morphological aspects of intersexuality in *C.latens* (Randall, 1840). For achieving that, two secondary goals were pursued. The first one of those secondary goals was to study the differences and similarities in some body and chelae dimensions that intersex individuals showed in comparison to both sexes along with sexual dimorphism to determine whether those individuals function as males or as females. The second one was to study the population size structure as a mean to determine intersex individuals role in the population.

MATERIALS AND METHODS

The present study represents part II of the ecological studies on the hermit crab *Calcinus latens* (Randall, 1840), from Aqaba Gulf, Egypt. So, the following used material and measurements are the personal data that were used in part I by Abd El-Wakeil *et al.* (in progress). A sample of *Calcinus latens* (Randall, 1840) was randomly hand-collected from the intertidal area in parallel to the shore line during an hour from the Lagona region in Dahab city, beside Dahab Village Lagona hotel (28° 28' 23N, 034° 29' 58E), Aqaba Gulf, Egypt, on 29-08-2014. Then, specimens were preserved in 70% Ethyl Alcohol. The crabs were pulled out of their shells after smashing those shells carefully, using a hammer when needed. Specimens which had any damage, that was assumed to affect measurements, were excluded. Then, for 442 specimens, six dimensions were measured. Those dimensions included shield length (Sl), shield width (SW), wet weight (Weg), left chelar propodus length (LpL), left chelar propodus height (LpH) and right chelar propodus length (RpL). Shield length (Sl) as an indication of the crab size was measured from the rostrum tip to the midpoint of the shield posterior margin (McLaughlin, 2002). The measured dimensions were according to the diagram represented by Bertini & Fransozo (1999). Lengths were measured in millimeters, using a binocular stereomicroscope equipped with an ocular micrometer placed in one of its eyepieces and with the aid of a ruler and caliper. Wet weight was measured in grams, using a digital scale. Gender was determined as stated by Turra (2004) as follows: female specimen/s (F) has the genital openings on coxae of 3rd perepods and male specimen/s (M) has the genital openings on coxae of 5th pereopods while intersex individual/s (Ins) has both female and male genital openings on coxae of 3rd and 5th pereopods respectively. Ovigerous females (Ovf) were separated from non-ovigerous females (Nf). So, there were 121 males (M), 46 intersex individuals (Ins) and 275 females (F); 63 non-ovigerous (Nf) and 212 ovigerous (Ovf) included in the total sample. As applied by Mantelatto *et al.* (2005), the morphological sexual maturity size was considered the size of the smallest ovigerous female. Since the smallest specimen (Sl=2.6mm) in the total sample was an ovigerous female, all of the specimens were considered matured sexually (Abd El-Wakeil *et al*., in progress).

In the present study, the pleopods of intersex individuals were examined and compared to the pleopods of some typical males and some typical females. The posterior branchial region just under the carapace on both sides of each intersex individual was checked for the presence of parasites. The population was divided into 6 size-classes (A, B, C, D, E & F) according to the commonly used rule $6 \leq k \leq 15$ (k= classes number), with a 0.7 mm width of each class.

Checking the normality of the data and the standardization of the measured chelar propodi dimensions (LpL, LpH and RpL) were done to study relative growth and heterochely during carrying out the above mentioned part I by Abd El-Wakeil *et al.* (in progress). That standardization was done using the equation applied by Anagnostou & Schubart (2014). Data checking for normality was done using Shapiro-Wilk tests through the SPSS program (PASW Statistics 18). Non-normality was found in the Data.

So, in the present study, non-parametric tests were used through the SPSS program (PASW Statistics 18) for the statistical analysis. For determining the differences in the six measured dimensions between males and females and between each of them and intersex individuals, the Mann-Whitney test was used. Regarding chelar propodi dimensions (LpL, LpH and RpL), two series of that test were applied

using their absolute values in one series and their standardized values in the other. Regarding the measured body dimensions (Sl, SW and Weg), one series of that test was applied using their absolute values. Males represented the larger sex while females represented the smaller one. Thus, the compressed size dimorphism index (SDI) and the degree of size dimorphism (SD [%]) were calculated by the same formulae applied by Anagnostou & Schubart (2014) as follows. The SDI was calculated by the formula, –[(mean size of males/ mean size of females) – 1]. The degree of size dimorphism was calculated as SD [%]= the absolute value of (SDI)*100. For testing the sex ratio significance, Chi-square test was used as applied by Lins & Costa (2010) only in size classes that included both sexes.

RESULTS

During sex determination, female genital openings on one or both coxae of 3rd pereopods and male genital openings on one or both coxae of 5th peropods were found in the same individual in 46 out of a total 442 examined specimens and accordingly such individuals were called intersex (Figure 1; A, B & C). Also, two males were, each, found with only a single genital opening located on coxa of left 5th pereopod (Figure 1D). Three types of intersex individuals were observed. Almost all intersex individuals belonged to the first type in which two relatively small female gonopores on coxae of 3rd pereopods and two bigger male gonopores on coxae of 5th pereopods found (Figure 1A). In the second type, there was only one female gonopore on coxa of right 3rd peropod and two male gonopores on coxae of 5th pereopods (Figure 1B). One intersex individual belonged to the third type with only a single male gonopore on coxa of left 5th pereopod and two female gonopores on coxae of 3rd peropods (Figure 1C).

When two female gonopores were found in intersex individual, they were either almost equal or varied in size. Either one or both of those female gonopores was relatively big and obvious, small, very small or even minute. In all patterns of intersex individuals, the size of female gonopore(s) was observed to be generally less than the sizes of typical female gonopores. In intersex individuals, female gonopores were sometimes with partial or almost complete calcification (Figure 1; E, F & G). Male gonopores in intersex individuals were almost equal in size, but they were always and generally almost the same size as those of typical males. Both tended to be bigger and more obvious than female gonopores of intersex individuals. Either one or both of them were, sometimes, partially calcified (Figure 1; F & H).

Pleopods of both intersex individuals and the examined typical males were 4 biramous, unpaired, short (The two rami of each pleopod usually short; one clearly shorter than the other), poorly-developed and provided with relatively non-dense short setae. Pleopods of the examined typical females were also, 4 biramous, unpaired, but they were relatively long (The two rami of each pleopod usually long and subequal in length), well-developed and provided with relatively dense long setae. Not a single case in intersex individuals was observed to be ovigerous. The presence of an isopod parasite was recorded in one case of intersex individuals (Figure 1; I). Except observing more broadening in carapace, no abnormalities in the morphology of chelipeds, pereopods, pleopods or carapace were observed in intersex individuals. It was observed that left chela shape usually tended to be almost rectangular in typical males and intersex individuals and almost ovate or sub-quadrate in typical females.

The series of the Mann-Whitney test using the absolute values of the measured body dimensions (shield length (Sl), shield width (SW) and wet weight (Weg)) revealed the following results. Males and intersex individuals showed no significant difference than each other in those body dimensions (Table 1). However, intersex individuals were significantly larger than females in those body dimensions (Table 1). Males were also significantly larger than females in the measured body dimensions (Table 1), indicating the existence of sexual dimorphism regarding those dimensions. The compressed size dimorphism index (SDI) values were -0.14, -0.16% and -1.38 in the case of Sl, SW and Weg respectively. The degree of size dimorphism was 14%, 16% and 138% in the case of Sl, SW and Weg respectively.

Table 1: Results of the series of the Mann-Whitney test using the absolute values of body and chelar propodi dimensions of *C. latens* specimens

Dimension in M & Ins	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Sl	M	121	167	83.97	10160.0	2779.0	10160.0	-.014	.989
	Ins	46		84.09	3868.0				
SW	M	121	167	82.93	10034.0	2653.0	10034.0	-.467	.641
	Ins	46		86.83	3994.0				
Weg	M	121	167	84.14	10180.5	2766.5	3847.5	-.059	.953
	Ins	46		83.64	3847.5				
LpL	M	121	167	83.46	10099.0	2718.0	10099.0	-.233	.816
	Ins	46		85.41	3929.0				
LpH	M	121	167	82.86	10026.5	2645.5	10026.5	-.494	.622
	Ins	46		86.99	4001.5				
RpL	M	121	167	83.09	10053.5	2672.5	10053.5	-.397	.692
	Ins	46		86.40	3974.5				
Dimension in Ins & F	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Sl	Ins	46	321	220.47	10141.5	3589.5	41539.5	-4.712	.000
	F	275		151.05	41539.5				
SW	Ins	46	321	228.21	10497.5	3233.5	41183.5	-5.328	.000
	F	275		149.76	41183.5				
Weg	Ins	46	321	247.76	11397.0	2334.0	40284.0	-6.851	.000
	F	275		146.49	40284.0				
LpL	Ins	46	321	266.35	12252.0	1479.0	39429.0	-8.346	.000
	F	275		143.38	39429.0				
LpH	Ins	46	321	245.26	11282.0	2449.0	40399.0	-6.681	.000
	F	275		146.91	40399.0				
RpL	Ins	46	321	246.26	11328.0	2403.0	40353.0	-6.774	.000
	F	275		146.74	40353.0				
Dimension in M & F	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Sl	M	121	396	261.65	31659.5	8996.5	46946.5	-7.306	.000
	F	275		170.71	46946.5				
SW	M	121	396	265.44	32118.5	8537.5	46487.5	-7.750	.000
	F	275		169.05	46487.5				
Weg	M	121	396	293.02	35456.0	5200.0	43150.0	-10.902	.000
	F	275		156.91	43150.0				
LpL	M	121	396	310.54	37575.5	3080.5	41030.5	-12.952	.000
	F	275		149.20	41030.5				
LpH	M	121	396	285.73	34573.0	6083.0	44033.0	-10.097	.000
	F	275		160.12	44033.0				
RpL	M	121	396	285.74	34575.0	6081.0	44031.0	-10.110	.000
	F	275		160.11	44031.0				

F, females; **Gr**, group; **Ins**, intersex individuals; **LpH**, left chelar propodus height; **LpL**, left chelar propodus length; **M**, males; **N**, number of individuals; **RpL**, right chelar propodus length; **Sl**, shield length; **SW**, shield width; **Weg**, wet weight.

The main results of the two series of Mann-Whitney test applied on the absolute and the standardized values of measured chelar propodi dimensions; left

chelar propodus length (LpL) and height (LpH) and right chelar propodus length (RpL), were the same as each other (Tables 1 & 2). Males and intersex individuals did not show any significant difference than each other in neither the absolute values (Table 1) nor the standardized values (Table 2) of any of the chelar propodi dimensions. Intersex individuals were significantly larger than females in both the absolute (Table 1) and the standardized values (Table 2) of all the measured chelar propodi dimensions. Significantly, males were larger than females in the absolute values of all the measured chelar propodi dimensions (Table 1). They were also significantly larger than females in the standardized values of all the measured chelar propodi dimensions (Table 2), indicating the existence of sexual dimorphism regarding the chelar propodi dimensions.

Table 2. Results of the series of the Mann-Whitney test using the standardized values of chelar propodi dimensions of *C.latens* specimens

Dimension in M & Ins	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Stand. LpL	M	121	167	82.25	9952.50	2571.5	9952.5	-.758	.449
	Ins	46		88.60	4075.50				
Stand. LpH	M	121	167	83.82	10142.00	2761.0	10142.0	-.079	.937
	Ins	46		84.48	3886.00				
Stand. RpL	M	121	167	82.98	10040.50	2659.5	10040.5	-.443	.658
	Ins	46		86.68	3987.50				
Dimension in Ins & F	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Stand. LpL	Ins	46	321	295.45	13590.50	140.5	38090.5	-10.617	.000
	F	275		138.51	38090.50				
Stand. LpH	Ins	46	321	284.95	13107.50	623.5	38573.5	-9.788	.000
	F	275		140.27	38573.50				
Stand. RpL	Ins	46	321	284.77	13099.50	631.5	38581.5	-9.775	.000
	F	275		140.30	38581.50				
Dimension in M & F	**Gr**	**N**	**Total Number**	**Mean Rank**	**Sum of Ranks**	**Test Statistics**			
						U	**W**	**Z**	**P**
Stand. LpL	M	121	396	331.51	40113.00	543.0	38493.0	-15.341	.000
	F	275		139.97	38493.00				
Stand. LpH	M	121	396	319.17	38619.00	2037.0	39987.0	-13.917	.000
	F	275		145.41	39987.00				
Stand. RpL	M	121	396	318.81	38575.50	2080.5	40030.5	-13.876	.000
	F	275		145.57	40030.50				

F, females; **Gr**, group; **Ins**, intersex individuals; **LpH**, left chelar propodus height; **LpL**, left chelar propodus length; **M**, males; **N**, number of individuals; **RpL**, right chelar propodus length; **Stand.**, standardized.

In the studied population, males, intersex individuals and females constituted almost 27.4%, 10.4% and 62.2%, respectively. Mean of size (Sl) was ≈3.7±.6mm, ≈4.0±.8mm, ≈4.0±0.6mm and ≈3.5±0.4mm in the total sample, males, intersex individuals and females respectively. Minimum of Sl was 2.6, 3.0, 2.9, 2.6 millimeters in the total sample, males, intersex individuals and females respectively. Maximum of Sl was 7.2, 7.2, 5.3, 5.5 millimeters in the total sample, males, intersex individuals and females respectively. Minimum, maximum and mean of size (Sl) were respectively, 2.9, 4.4 and ≈3.6±.3mm in non-ovigerous females. However, they were respectively, 2.6, 5.5 and ≈3.5±.4mm in ovigerous females.

In size classes, size (Sl) ranged between 2.5 and 3.2 mm in class A, 3.3 and 4.0 mm in class B, 4.1 and 4.8 mm in class C, 4.9 and 5.6 mm in class D, 5.7 and 6.4 mm in class E and 6.5 and 7.2 mm in class F. Typical males formed 10.1%, 23.5 %, 55.9%, 58.8%, 100% and 100% of size classes A, B, C, D, E and F respectively.

Typical females formed 81%, 69.5% , 18.6% and 17.6% while intersex individuals formed 9%, 7%, 25.4% and 23.5% of size classes A, B, C and D respectively (Figure 2).

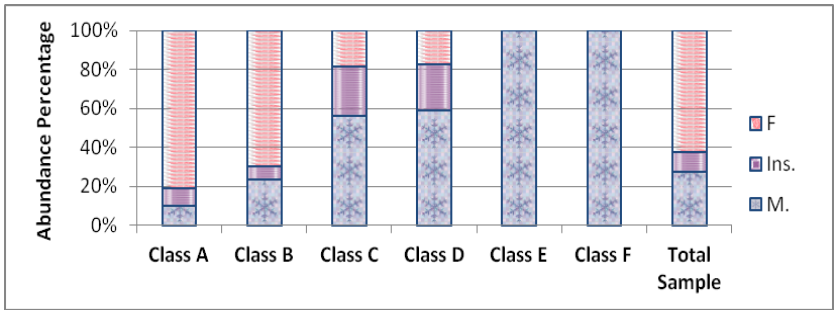

Fig. 2. Abundance percentages of males (M), intersex individuals (Ins) and females (F) in each size class and in the total sample of *C. latens*.

In the three smallest size classes; A, B and C, the sex ratio (M:F) was significantly varied from the expected, 1:1, but it showed the reverse in the fourth size class, D. In size classes; A and B, it was in favor of females while in the size class, C, it was in favor of males. The overall sex ratio (M:F) was 1:2.3, in favor of females and significantly varied from the expected, 1:1.(Table 3).

Table 3. Sex ratio in the population of *C. latens* and Chi-square test results

Size Class	N of M	N of F	N of Ins	Total	Sex Ratio (M/F)	Chi-square test		
						χ2	df	P
Class A	9	72	8	89	1:8	49.000	1	.000
Class B	64	189	19	272	1:3	61.759	1	.000
Class C	33	11	15	59	3:1	11.000	1	.001
Class D	10	3	4	17	3.3:1	3.769	1	.052
Total	121	275	46	442	1:2.3	59.889	1	.000

F, females; **Ins**, intersex individuals; **M**, males; **N**, number of individuals.

DISCUSSION

In the present study, female gonopores on coxae of 3rd peropods, which were sometimes obvious and relatively big, were recorded in the same individuals of *C. latens* that have male gonopores on coxae of 5th peropods. In literature, only minute female gonopores were reported in males of *C. latens* (Wenner, 1972). The two presently observed types of *C. latens* intersex individuals that were with either one (right) or two female gonopore(s); in addition to, two male gonopores, were also, recorded in the hermit crab, *Isocheles sawayai* (Fantucci *et al.*, 2008). There was another type of intersex individuals recorded in hermit crabs with only a left female gonopore; besides, two males gonopores (Gusev and Zabotin, 2007 & Fantucci *et al.*, 2008). In the present study, there was a third type of intersex individual with two female gonopores and only a left male gonopore. That type was not generally deviated than typical males as, in two of those males, also, only a left gonopore was recorded. Besides, that type was represented by only one intersex individual. So, the almost persistent existence of two male gonopores with the variability of female gonopores number, in *C. latens* intersex individuals, could be interpreted as an indication that those individuals may function as males as in the case of *Isocheles sawayai* (Fantucci *et al.*, 2008).

In the present work, when two female gonopores found in an intersex individual, they were either almost equal or varied in size. In intersex individuals, the sizes of the female gonopores were generally less than those of the regular female gonopores. However, the male gonopores were generally almost equal in size to typical males gonopores, supporting the suggestion that those individuals may function as males. In *Coenobita rugosus* intersex individuals, there was either only a single female gonopore that was almost similar in size to the gonorpores of a regular female or two female gonopores that were different in size and form (Gusev and Zabotin, 2007). In *C.latens*, sometimes, either one or both female gonopores in intersex individuals were partially calcified. The same was recorded in two out of three *Clibanarius* hermit crab species; however, in contradictory with the present study, no partial calcification was recorded in male gonopores in intersex individuals of any of those three species (Turra, 2004).

In this work, there was a similarity between intersex individuals pleopods and typical males pleopods on the one hand and a difference between both than those of typical females on the other. In hermit crabs, males pleopods are completely different from those of females (Lancaster, 1988) and so their pleopods morphology could be used in some cases to determine sex as used by Wada *et al.* (2014). Therefore, this present finding also, strongly suggests that *C. latens* intersex individuals may function as males. The same was reported in *Isocheles sawayai*, but no parasites were found in its case (Fantucci *et al.*, 2008). In the present work, an isopod parasite was recorded in only one out of 46 intersex individuals. Besides, except the observed more broadened carapace, *C. latens* intersex individuals as those of *Isocheles sawayai* which were studied by Fantucci *et al.* (2008), showed no abnormalities in the morphology of chelipeds, pereopods, pleopods or carapace. Thus, the possibility that such infection caused the present recorded morphological aspects of intersexuality could be almost rejected, especially with the detection of statistical evidence indicating that the intersex individuals may function as males.

Regarding all the 6 measured dimensions in *C. latens*, typical males were not significantly different from intersex individuals while both were significantly larger than typical females. Sant'Anna *et al.* (2009) found the same regarding the size of males, females and intersex individuals of the hermit crab, *Clibanarius vittatus*. Those findings indicate sexual dimorphism in size (Sl), shield width, wet weight, left chela size (represented by LpL and LpH) and right chelar propodus length in *C. latens*. Sexual dimorphism was recorded in chela size and in cephalic shield length, weight and cheliped size in the hermit crabs, *Calcinus tibicen* and *Birgus latro* respectively, with males being larger than females in those dimensions (Fransozo *et al.*, 2003 & Anagnostou and Schubart, 2014). The degree of sexual dimorphism regarding the crab weight was higher than that regarding the other measured body dimensions in the present study. The same was reported by Anagnostou & Schubart, (2014) in *Birgus latro*. There is evidence suggesting that sexual size dimorphism reflects males and females adaptation to their different reproductive roles (Fairbairn, 1997). Therefore and because intersex individuals showed no differences from typical males and shared them the same differences from typical females, those findings also strongly suggest that such individuals play the same reproductive role of typical males.

In the present study, the overall sex ratio was in favor of females and significantly different from the expected ratio, 1:1. Turra & Leite (2000) recorded the same results for sex ratio in three co-existing *Clibanarius* species, but with values that were different among those species and different from the value reported herein.

Sex ratio in *C. latens* differed from 1:1 and from that of two other sympatric species (Wenner, 1972). In hermit crabs, the sex ratio, in the field, was in favor of females but it was 1:1 in the laboratory (Asakura, 1995).

In size classes, ordered from the smallest size class (A) to the two largest size classes (E and F), abundance percentage ranked in ascending order in typical males and in descending order in typical females till there were only typical males in the two largest-size classes. So, the sex ratio was in favor of females in the smaller size classes; A and B, while in the larger size class; C, it was in favor of males. On consistency with that, Turra & Leite (2000) found that in three *Clibanarius* populations, the sex ratio was a function of size as males were less in abundance than females in smaller size classes. Females of hermit crabs tend to be very abundant in the smaller and the intermediate size classes while the larger classes constituted only of males (Sant'Anna *et al.*, 2009). Persistently, *C. latens* intersex individuals were present only in size classes that included typical females. That finding indicates a connection between their role and typical females abundance and so, it suggests that they may serve as a "backup" for typical males in reproduction. For explaining males absence in the smallest size classes in the hermit crab, *Clibanarius zebra* and females complete absence in the largest classes Wenner (1972) suggested the hypothesis of protogyny in hermit crabs (Turra, 2007).

The variation in frequency of the intersex individuals in the populations of the different Decapoda groups is still unexplained (Gusev and Zabotin, 2007). However, the above suggested "backup" assumption may interpret such variation among hermit crab species as follows. The possession of a large cheliped by the congener species *Calcinus laevimanus* (Randall, 1840) make it have a restricted range of shell species choice in the field as only shells with large apertures suit it (Reddy and Biseswar, 1993). The species *C. latens* also has an appreciably larger left cheliped while *Clibanarius* species have sub-equal chelipeds (McLaughlin *et al.*, 2007). So, it may have more difficulty than that *Clibanarius* species have in finding the suitable shells in the field. Accordingly, both of the higher stress of shells scarcity on males than females and the consequent higher mortality rate in males than in females in the field (Asakura, 1995) become more pronounced in *C. latens* than in *Clibanarius* species. That matter, in turn, causes much need to "backup" for typical males for reproduction in the case of *C. latens* population, expressed in the present study in a higher abundance percentage of intersex individuals (≈10.4%) than in *Clibanarius* populations (~2-7%) (Turra and Leite, 2000).

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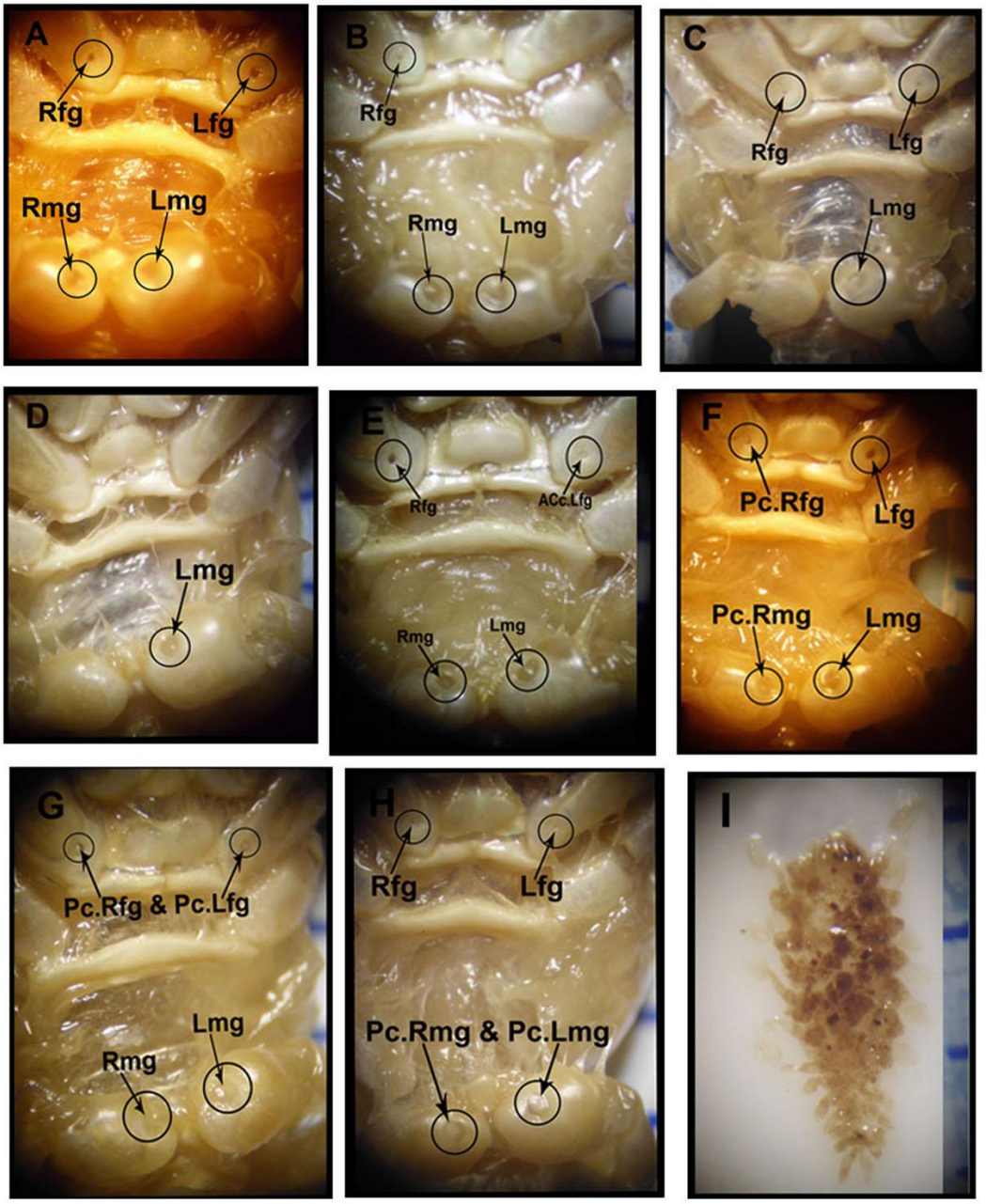

Fig. 1. Ventral views show coxae of 3rd and 5th pereopods of specimens of *C. latens*: **A**, **B** & **C**, the three patterns of intersex individuals; **D**, a male with only one gonopore oncoxa of left 5th pereopod; **E**, almost complete calcification in left female gonopore in an intersex individual; **F**, partial calcification in right female and right male gonopores in an intersex individual; **G** & **H**, partial calcification in the two female and the two male gonopores respectively in intersex individuals; **I**, the recorded isopod parasite. Abbreviations: A**Cc.**, almost complete calcification; **Lfg**, Left female gonopore; **Lmg**, Left male gonopore; **Pc.**, Partial calcification; **Rfg**, Right female gonopore; **Rmg**, Right male gonopore. The shown scale is 1.0 mm.

ARABIC SUMMARY

دراسات بيئية عن السرطان الناسك *Calcinus latens* (Paguroidea: Diogenidae) القاطن بخليج العقبة بمصر، الجزء الثانى : بعض الملامح المورفولوجية لظاهرة ثنائية الجنس

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أجريت الدراسة الحالية بهدف إلقاء الضوء على بعض الملامح المورفولوجية لظاهرة ثنائية الجنس (الخنوثة) مع دراسة التباين الجنسى بين الإناث و الذكور فى مجتمع السرطان الناسك كالسينس لاتنس (راندال، ١٨٤٠). بنيت هذه الدراسة على نفس العينة و بالتالى نفس القياسات التى استخدمت فى الجزء الأول من بعض الدراسات البيئية التى أجريت على هذا النوع ، لهذا فإن العينة المستخدمة فى هذه الدراسة هى عينة تم تجميعها من منطقة دهب بخليج العقبة بمصر ، و تتكون هذه العينة من ٤٤٢ فرداً من ذلك النوع ينقسمون إلى عدد ١٢١ ذكراً و ٤٦ فرداً ثنائى الجنس و ٢٧٥ أنثى ، و قد كانت القياسات التى تم قياسها فى تلك الأفراد عبارة عن ستة قياسات هى طول الدرع و عرضه و الوزن الرطب و كذلك طول و عرض المخلب الأيسر و طول المخلب الأيمن ، و قد تم تقسيم المجتمع إلى ستة فئات حجمية ، و قد أظهرت الدراسة أدلة مورفولوجية و إحصائية على أن الأفراد ثنائى الجنس ربما يقومون بنفس دور الذكور فى مجتمع هذا السرطان ، كما وجد هناك تباين جنسى بين الإناث و الذكور فى جميع الأبعاد المقاسة ، و من ناحية أخرى كانت النسبة بين الذكور و الإناث فى ذلك المجتمع هى ١:٢.٣ لصالح الإناث ، كما أظهرت الدراسة أن الذكور تتواجد بدرجة أكبر فى الفئات الحجمية الكبيرة عما تتواجد به فى الفئات الحجمية الصغيرة أما الإناث فقد أبدت النقيض ، و قد تواجدت الأفراد ثنائية الجنس فقط فى الفئات الحجمية التى تتواجد بها الإناث مما يشير إلى احتمالية وجود علاقة بين الدور الذى تلعبه هذه الأفراد و نسبة تواجد الإناث ، الأمر الذى بدوره يقترح أن هذه الأفراد ربما تعمل "كاحتياطى أو دعم" للذكور فى عملية التكاثر ، و ذلك ربما يفسر سبب زيادة نسبة هؤلاء الأفراد فى مجتمع ذلك السرطان الناسك عما هى عليه فى مجتمعات أنواع السرطانات الناسكة الأخرى بافتراض أن نسبة وفيات الذكور فى مجتمع هذا النوع أعلى مما هى عليه فى مجتمعات تلك الأنواع الأخرى.