



External morphology of *Sacculina leptodiae* (Sacculinidae: Rhizocephala) parasitizing the xanthid crab, *Leptodius exaratus* (Xanthidae: Brachyura) from the coasts of the Red Sea, Gulfs of Suez and Aqaba, Egypt

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ABSTRACT

A total of 41 externae (35 single and 3 double) of the parasitic sacculind, *Sacculina leptodiae* (Sacculinidae: Rhizocephala) were investigated during this study. They were obtained from 38 individuals (23 males and 15 females) of the xanthid crab, *Leptodius exaratus* (Xanthidae: Brachyura) collected from the Egyptian coasts of the Red Sea and Gulfs of Suez and Aqaba. The rate of infection represented 5.50% of all populations (691 individuals, 400 males and 291 females) and was slightly higher in males (5.75 %) than in females (5.15 %). The single 35 externae represented 92.11 %, compared with only 3 individuals have double externae represented 7.89 %. The externae of this parasite were extruded on the abdomens of infected crabs, each was attaching with its interna (rootlets) in the internal body cavity of the host via a very short stalk or peduncle. The externae varied in shapes, size and color based on the developmental maturity stages, which comprised immature (1 - ≤ 3.5 mm), early maturing (>3.5- ≤ 5.0 mm), maturing (>5 – 10.4 mm) and spent (flattened shape) stages. The size of externae varied from 1.0 to 10.4 mm in breadth and averaged 5.19± 2.76 mm in males and 5.63± 3.17 mm in females. The externae have dense cover of spaced bundles carrying excrescences composed of hard chitin, varied from 15.6 – 47.0 µm, and averaged 32.74± 8.45 µm. The interna comprised network of rootlets of this parasite invaded ovaries, testes, hepatopancreas and all crab's body cavities.

INTRODUCTION

Certain members of crustaceans have become so modified for parasitism as to be superficially unrecognizable as crustaceans (Schmidt & Roberts, 1977). Members of superorder Rhizocephala, which is among the most familiar order of class Cirripedia (Crustacea), are highly specialized parasites of decapod malacostracans (Highnam and

Hill, 1977; Schmidt & Roberts; 1977; Warner, 1977; Buttler, 1980 and El-Sayed *et al.*, 1997, 1998). This order comprises three specialized parasitic families, of them Sacculinidae is specialized primarily parasites of brachyurans crabs (Guerin-Ganivet 1911; Boschma, 1933a, b, 1936, 1937, 1947, 1948, 1954, 1955a, b). The infective stage is a cypris larva, which settles on the cuticle of the base of a hair and enters the crab as a tiny cellular mass. Inside the host's body, the tiny cellular mass takes its position at the base of the hind gut caecum. After that it develops gradually as a mass of ramifying rootlets which serve a nutritional function and penetrates through the body of the crab, even to the tips of the legs (Hartnoll, 1962, 1967; Schmidt & Roberts, 1977; Warner, 1977; El-Sayed *et al.*, 1997, 1998; Alazaly, 2017).

The internal sacculinid cellular mass doesn't has gut, but obtains its nutrients from the hosts and increases in size by ramifying rootlets throughout the body cavities. It increases with time in size causing pressure on the hypodermis of the crab and finally penetrates the ventral surface of the host's abdomen and extruded on the ventral abdominal surface forms a gonadal mass known as "externa". The externa includes gonads only (testes and ovaries) and remains attached the internal host's body by a stalk (Hartnoll, 1967; Schmidt & Roberts, 1977; Warner, 1977). The externae increase in sizes with maturity and a mantle cavity becomes full of mature eggs and nauplius larvae (Hartnoll, 1967), which metamorphose into the cypris larvae, which represent the infective stage to the crab during or shortly after molting (Hartnoll, 1967; Schmidt & Roberts, 1977).

The xanthid crab, *Leptodius exaratus* is the main host of *Sacculina leptodiae* in the Indo-Pacific regions including Red Sea. It belongs to family Xanthidae, within superfamily Xanthoidea). Males are generally larger than females and characterized morphological in mature individuals by narrow and tapering abdomen, consists of 7 segments of them, 3-5 are fused together. Their abdomens have only two pairs of uniramous pleopods (the first is the longest). In females, the abdomen is broad, with 7 distinct free segments, occupied by 4 pairs of biramous pleopods on segments 2-5. Both of immature males and females have triangular abdomens, characterized with obvious locking mechanisms, remain at maturity in males, but disappeared in females. The genital openings are located on coxae of the 5th legs in males, while are found on the 6th thoracic sternites in females (Barnard, 1950; Serene, 1984; El-Sayed *et al.*, 1997, 1998; El-Sayed, 2004; Ng *et al.*, 2008; Ahmed, 2020).

The xanthid crab, *Leptodius exaratus* is a very common species of crabs occurs along the coasts of the Red Sea, Gulfs of Suez and Gulf of Aqaba. It occurs in the intertidal and shallow subtidal zones of the mixed sandy and rocky areas, constructing its burrows underneath small stones, gravel or rock boulders of different sizes. The reproductive cycle of this species is definite and extends from spring to late summer and early autumn, with a maximum value during June-July. Ovigerous females were detected during the period from April to September and early October (El-Sayed, 2004).

The effects of *Sacculina leptodiae* on the intertidal xanthid crab, *Leptodius exaratus* were investigated by Siddiqui and Ahmed (1993) and Moazzam and Moazzam (2004) along coasts of Pakistan on the Arabian Sea. El-Sayed *et al.* (1997, 1998) studied the effects of *Sacculina* sp. on the individuals of this crab from the Red Sea and its associated gulfs (Suez and Aqaba), while Alazaly (2017) investigated the occurrence of this parasite on *L. exaratus* at Hurghada, Red Sea. The rate of infection and morphological modifications, in addition to histological demonstration were also given and discussed by the previous authors, but there is a lack of information on complete morphology and stages of maturity for this parasite.

Therefore, this study aims at through light on the external morphology and different stages of maturity for this parasite from the Egyptian Red Sea coasts and its associated gulfs (Suez and Aqaba).

MATERIALS AND METHODS

A total of 691 individuals (400 males and 291 females) of the xanthid crab, *Leptodius exaratus* was examined during this study. The majority of these specimens (392) were collected from the northern portions of Gulf of Suez (Ain Sokhna, Adabia, Port Sokhna and Ras Matarma), in addition to 247 specimens collected from the Red Sea proper comprised the northern portion at Hurghada (40 specimens), Ras Mohammed Protected Area (33 specimens) and 174 specimens from 20 sites extending along the Egyptian Red Sea coasts from South Safaga to Shalatein South. Other 52 specimens were also collected from Protected Areas of Gulf of Aqaba (Nabq, Abu Galoum and Taba).

The majority of these specimens were collected from the Suez Gulf during the period from April 2014 to February 2018, while those from Ras Mohammed, Hurghada and Taba (Gulf of Aqaba) were collected during September 2017, February 2018, and June 2015, respectively. However, the specimens of the Red Sea proper and Gulf of Aqaba were collected previously during the period from April 1994- April, 1996 and from July 1994 to May 1995, respectively and were preserved among the Reference Collection of Al-Azhar University.

The individuals of *L. exaratus* crab were collected by hand from the intertidal and shallow subtidal zones during low tide or using snorkeling during high tide. The collected individuals were preserved immediately after collection in 10% seawater formalin solution. All available information on color of life individuals, carapace case and occurrence of parasite on abdomens of infected crab males and females was recorded. At the laboratory, the collected crabs were sorted and sexed into mature and immature individuals and identified according to Serene (1984) and compared with those deposited in the Reference Collection of Al-Azhar University and that described by Ahmed (2020). Measurements of carapace and chelae dimensions and abdominal breadth for all normal

and infected individuals (males and females) were measured by caliper vernier to the nearest 0.1 mm.

A total of 41 externe (35 single and 3 double) were obtained from 38 individuals (23 males and 15 females), then cleaned, and examined under binocular microscope (OPTIKA microscope, SZM-1, SN: 402748, Italy) and identified according to the description given by Guerin-Ganivet (1911) and Boschma (1933a,b, 1936, 1937, 1948, 1955a) and compared with those reported by El-Sayed *et al.* (1997) and Alazaly (2017). The sizes of incubated eggs within mantle cavity and excrescence lengths (cuticle spicules) were measured to the nearest 0.01 mm by withdrawing smears from the mantle cavities and examined small pieces from cuticles under Stereo-binocular microscope Model XSZ-107T, SN: 001787. The number, position and color of externae on crab's abdomen were recorded. The size of externae was measured using vernier caliper with accuracy of 0.01 mm. The externa breadth: Is the maximum distance between the two lateral far points on the sides of the externa. Externa thickness: Is including the maximum distance between the anterior and posterior points on the externa. Eexterna highest: Is the maximum distance between the upper and lower points on the externa.

Based on size and color of the externae as well as the presence or absence of eggs and larvae in mantle cavity, they were classified into main four stages of maturity. The parasitized crabs (males and females) were dissected to follow up the ramifying rootlets of parasites within different organs, particularly between gonads and hepatopancreas branches and compared with those in normal crabs.

- **Scanning electron microscope:**

Externae of *S. leptodiae* were cleaned by (NH₄ OH) using ultrasound cleaner apparatus and fixed in 5% cold glutaraldehyde in buffer for 24 hours. Specimens were washed in phosphate buffer and fixed in 1% osmium tetroxide for 2 hours and washed again in phosphate buffer. Specimens were dehydrated in different grades of ethyl alcohol and then mounted on the metal stamp, coated with gold in vacuum evaporator. The sacculina were examined and photographed by A scanning electron microscopy (JEOL-JSM-T200), at the National Center for Mycology, Al-Azhar University, Cairo, Egypt.

All measurements were treated statistically using Excel statistical program, where the average \pm SD and T-test values were calculated.

RESULTS

1. Taxonomy of *Sacculina leptodiae*

A total of 691 specimens of *Leptodius exaratus* (400 males and 291 females) were collected from the Egyptian Red Sea coasts and Gulfs of Suez and Aqaba. Out of the investigated crabs, 38 individuals (23 males and 15 females) were infected with 41

externae (35 single and 3 double) of the parasitic rhizocephalan sacculind, *Sacculina leptodiae* (Plates I, II, V). The externae of this parasite were detected on the abdomens of the infected individuals, and has the following taxonomic position:

Phylum: Crustacea (Brunnich, 1772)

Class: Maxillopoda (Dahi, 1956)

Subclass: Thecostraca (Gruvel, 1905)

Infraclass: Cirripedia (Burmeister, 1834)

Superorder: Rhizocephala (Muller, 1862)

Order: Kentrogonida (Delage, 1884)

Family: Sacculinidae (Lilljeborg, 1860)

Genus: *Sacculina* (Thompson, 1836)

Sacculina leptodiae Guérin-Ganivet, 1911

2. The host crab, *Leptodius exaratus*:

The xanthid crab, *L. exaratus* is the host for *S. leptodiae* (Plate I). It belongs to family Xanthidae within superfamily Xanthoidea. It is common on the Egyptian coasts of the Red Sea and its associated gulfs (Suez and Aqaba). A total of 691 individuals (400 males and 291 females) of this crab were collected and examined. Of them 38 individuals (23 males and 15 females) were infected with *S. leptodiae*, and carrying 41externae (35 single and 3 double externae). All infected individuals were full mature and have external sexual dimorphism. The overall infection rate recorded 5.50 % between all populations at the different study areas, and was relatively higher in males (5.75%), than in females (5.15%), but no infection was recorded in immature.

The individuals of the xanthid crab, *Leptodius exaratus* have xanthoid-shaped carapace, beings broader in breadth than length. The carapace varied from 4.0 to 19.60 mm with an average of 11.04 ± 3.40 mm in length, and ranged between 5.50 and 30.60 mm and averaged 16.05 ± 5.30 mm in breadth. Males are characterized with more slightly massive chelipeds than females. The propodal length of chelipeds varied from 3.2 to 28.7 mm and averaged 11.1 ± 5.4 mm and from 1.5 to 13.0 mm and averaged 5.2 ± 2.7 mm in height. Males have tapering abdomen, consists of seven segments of them 3-5 segments are fused together into a single unit. Male abdomen has two pairs of uniramous pleopods (Plate V a), the first is the longest and varied from 1.5 to 8.7 and averaged 5.33 ± 2.6 mm in length. Female abdomen consists of 7 free segments, with breadth varied from 0.8 to 6.8 mm and averaged 2.47 ± 1.1 mm. It occupied by 4 pairs of biramous pleopods on the 2nd to 5th segments (Plates IIb & Vh).

3. External morphology of *Sacculina leptodiae*:

The externae of *S. leptodiae* appear as extruded sac-like structures (Plates I, II, V) represent the reproductive organs which contain gonads, ovaries and testes only within mantle cavity. These externae appears as soft body without segmentations and free from any arthropod appendages. Each externa connects with the ventral side of the host abdomen with a muscular short stalk or peduncle (Plates IIb & Vh), beings sunking at full

maturity (Plates IIb & IIIa). It receives nutrients from the host via a nutrient absorbing system called internaes composed of numerous rootles ramifying in the internal body cavities and organs (hepatopancreas, intestine and gonads). It opens to the exterior through a muscular mantle opening or atrial pore occurs on rounded papilla. The mantle opens on the center of rounded papillae in the middle of the anterior region (Plate IIa) and are characterized with well-developed muscular system composed of at least 4 major muscles, in addition to other 4 smaller muscles in-between (Plate IIIa, b).

The shape of externaes of this parasite varied from rounded, semi rounded or oval to panduriform and become flattened or depressed or as elongated sacs of variable dimensions at late stages of maturity and releasing eggs. Their color is varied based on their different maturity stages (Plates I, II, V & VI).

The outer surface of externaes composes of double cuticles, beings extended in the immature, early mature and maturing individuals, but becomes crenulated or wavy-shaped in late stage of maturation or spent stage (Plates IIb, VIg, h). It has dense cover of spaced bundles of excrescences each composes of several spicules of hard chitin origin from common base varied in length from 15.6 – 47.0 μm , and averaged $32.74 \pm 8.45 \mu\text{m}$ each spine has very minute lateral spinules (Plates IIIc & IVc).

4. Maturity stages of *Sacculina leptodiae*:

The careful examination for *S. leptodiae* externaes showed that, these externaes can be classified into four distinct stages comprises:

4.1. Virgin or immature externaes: Externaes appear as rounded or ovoid to slightly globular- shaped body; varied in sizes from 1.0x1.0 x1.0 to $\leq 3.3 \times 2.7 \times 1.1$ mm (breadth x height x thickness). They are compact with solid texture, has whitish color. Abdomens (pelons) of infected males and females are slightly opened and loss their locking mechanisms (Plate Va,b).

4.2. Early mature externaes: Externa at this stage has variable sizes and shapes. Their color varied from pale whitish to yellowish and faint yellow color. The size varies from $>3.3 \times 2.7 \times 1.1$ to $5.0 \times 4.0 \times 2.5$ mm (BxHxTh). They are nearly globular shaped or swollen body, some externaes are elliptically. The mantle cavity does not contain mature eggs, but they contain ovaries at early stages of maturity contain oocytes less than 100 μm . Abdomens of infected males and females are remarkable opened and far from abdominal grooves and sternum (Plate V c & d).

4.3. Maturing externaes: The examined externaes have variable shapes varied from oval or semi oval, to semi spherical or an elongated distended body. They vary in color from bright yellow, to deep yellow or orange. These are extending transversely or perpendicular on the body axis length, and are characterized by prominent rounded shoulders in some specimens with obscure gonopores or mantle opening in-between. Their size is larger than $5.0 \times 4.0 \times 2.5$ mm (BxHxTh) and reached the largest sizes up to $10.4 \times 7.1 \times 4.0$ mm (B x H x T). This stage represents the full mature externaes, with maturing ovaries realize fertilized eggs

into mantle cavity averaged $142.5 \pm 11.91 \mu\text{m}$ (Plate VI, A-F). Abdomens are greatly opened (Plates I, II, V).

4.4. Spent externae: The general outline of spent externae likes semi empty sac, greatly flattened, with posterior (terminal) compressed border at the atrial pore, but is still slightly swollen near the peduncle (anterior border). The outer surface of externae is characterized by several irregular ridges with elongated folds extend facing the abdominal groove on thoracic sternum. The spent externae contain remaining of unreleased eggs and cypris larvae averaged $117.5 \pm 20.53 \mu\text{m}$ (Plate VI a-g) and un hatching eggs; some of them being irregular, partially broken and resorbed. The color of spent externae is brownish or faint yellowish brown or deep pink with few scattered dark pigments. They have the same size (breadth and depth) of maturing stages, but were greatly compressed in thickness at the atrial pore, and slightly swollen at the base attached to the host's body around stalk or peduncle. In some externae, few specimens of parasitic bopyrids (family Bopyridae: Epicaridea) were detected (Plates VI g-i).

5. Size of externae:

The present results in Table (1) exhibited that, the size of *S. leptodiae* externae was varied according to developmental stages of maturity, incidence of double infections and even between sexes. Generally, externae varied in size from 1.0 – 10.4 mm in breadth (B), 1.5- 7.1 mm in height (H) and between 1.0 and 4.0 mm in thickness (Th). The overall breadth averaged 6.06 ± 2.89 mm, and was 5.77 ± 2.65 mm in males and 7.19 ± 2.81 mm in females, without significant difference between sexes ($P > 0.05$, $DF = 34$).

The overall externae height and thickness were also varied, recorded 4.49 ± 1.43 and 5.90 ± 1.39 mm for height and 1.87 ± 0.79 and 2.76 ± 1.14 mm for thickness in males and females, respectively with only significant difference in thickness between males and females ($P < 0.05$).

The smallest single externa was rounded or nearly ovoid shaped and measured 1.4x 1.0x1.0 mm B x H x Th. It was recorded on male of 15.6 x22.9 mm (Cl X Cw) during June 19968 from Ain Sokhna; while the largest externa measured 10.4 x 7.1 x 3.0 mm (B x H x T), recorded on the abdomen of female (16.2x24.3 mm) collected during September 1993 from the same site.

In the three double externae, the smallest ones measured 1.0x 1.0x1.0 and 2.4 x 2.4 x1.5 mm in males and 2.0 x1.5x1.0 mm in females (BxHxTh), while the largest externae measured 3.8 x 2.4x1.5 and 1.6x1.0 x1.0 mm in males, but increased to 9.4 x6.0 x3.0 mm (B x H x T) in female. All were collected from Ain Sokhna during September, 1998.

The breadth of externae showed seasonal variations between sexes. It averaged 7.58 ± 2.11 mm during summer and 3.77 ± 3.30 mm in autumn between males and was statistically significant ($P < 0.05$). In females, externae breadth averaged 5.06 ± 2.56 mm in

autumn and 5.31 ± 3.10 mm in summer at Ain Sokhna without significant differences between seasons ($P > 0.05$).

Table (1): Values of averages (\pm SD) and ranges for breadth, height and thickness of *S. leptodiae* parasitizing *L. exararus* during this study (values in mm).

Extreanae		Breadth (mm)		Height (mm)		Thickness (mm)		
		Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	
Single	Males	1.0-10.0	5.77 \pm 2.65	1.0-6.5	4.49 \pm 1.43	1.0-3.0	1.87 \pm 0.79	
	Females	1.6-10.4	7.19 \pm 2.81	1.5-7.1	5.90 \pm 1.39	1.0-4.0	2.76 \pm 1.14	
Double	♂♂	1 st	1.0-3.8	2.4 \pm 2.97	1.0-2.4	1.7 \pm 0.99	1.0-1.4	1.2 \pm 0.28
		2 nd	1.6-2.4	2.0 \pm 2.05	1.0-2.4	1.7 \pm 1.13	1-1.5	1.25 \pm 1.06
	All males		1.0-6.6	3.45 \pm 2.39	1.0-2.4	2.45 \pm 1.22	1.0-3.0	1.73 \pm 0.88
	♀♀	1 st	2.0	Only one	1.5	-	1.0	-
		2 nd	9.4	Only one	6.0	-	0.3	-
	All males and females		1.0-10.4	6.06 \pm 2.89	1.0-6.5	4.42 \pm 1.82	1.0-3.4	2.13 \pm 0.92

DISCUSSION

During this study, a total of 41 externae (35 single and 3 double) of the rhizocephalan crustacean, *Sacculina leptodiae* were obtained from 38 individuals (23 males and 15 females) of *L. exaratus* which collected from the Red Sea, Gulf of Suez and Gulf of Aqaba. Guerin- Ganivet (1911) described *S. leptodiae* for the first time and described it as a new species on the type specimens of *Chlorodius exatarus* (= *Xantho hydrophilus*) a synonym of *Lebtodius exaratus* from Djibouti, Gulf of Aden and east coast of Africa at Mozambique. After that, Boschma (1933 a,b, 1936, 1947, 1948, 1954, 1955a,b) reported this parasite on the individuals of *Xantho exaratus* (= *Leptodius exaratus*) from Gulf of Suez and Red Sea, Zanzibar and Grand Comoro Island (Indian Ocean).

Sacculina leptodiae infects several species of the true crabs in the Indo-Pacific regions. It infects four species of the family Xanthidae: *Xantho exaratus*, *Xantho spec*, *X. gracilis*, and *Pseudozius caystrus*, one Portunid crab, *Thalamita stimpsoni*, and possibly *Camposcia retusa* of family Majidae and *Carupa laeviuscula* of family Portunidae (Boschma, 1948; 1955a). However, the specific identity of the parasites of the various Xanthid crabs and of *Thalamia stimpsoni* is practically certain and the status of the parasites of *Camposcia retusa* and *Carupa laeviuscula* needs further confirmation (Boschma, 1948). *S. leptodiae* has wide distribution in the Indo-Pacific and reported on *L. exaratus* at Pakistan by Siddiqui and Ahmed (1993) (Indian Ocean), and from the Red Sea by El-Sayed *et al.* (1997, 1988) and Alazaly (2017).

The external morphology of the parasitic *Sacculina leptodiae* externae reported during this study is similar to that given by Guerin- Ganivet (1911), Boschma (1933b, 1947, 1948, 1955) in several main characters. However, based on the examination of large numbers of externae during this study at different stages of maturity, they had

several body forms but all are in same outline for those described by the previous authors. During this study, additional characters comprised general occurrence of excrescences bundles, lengths of excrescences and changes in outline morphology during maturity stages were detected and explained than those demonstrated in the previous studies (Guerin- Ganivet, 1911; Boschma, 1933b, 1948, 1955 a&b; Seddiqui and Ahmed, 1993). On the other hand, El-Sayed *et al.* (1997, 1998) and Alazaly (2017) gave very short description for this species from the Red Sea. Hence, this study, gave full description for externae of *S. leptodiae* at different maturity stages.

The outer cuticle of the examined externae showed that, they are covering with dense spaced bundles of excrescences which varied from in length from 15.6 – 47.0 μm , and averaged $32.74 \pm 8.45 \mu\text{m}$. These results are in agreement with that reported by Boschma (1948) and Aalzaly (2017); but the length is slightly shorter than that reported by Boschma (1946) which varied from 50-80 μm in the same species. However, Boschma (1948) indicated that, the external cuticle which are not arranged in groups showed slight differences in few specimens. The spines of the external cuticle may remain isolated, but then they are rather distinctly arranged in groups. The aberrant arrangement of the spines in those specimens, however, may be due to individual variation within the same species and between different hosts based on the different in size of the host. The peculiarity is not striking enough to regard it as of specific value.

The careful investigation of externae of *S. leptodiae* showed that, there are four distinct stages of maturity can be recognized as: virgin or immature, early mature, maturing and spent. The previous studies recognized only three maturity stages for this parasite, comprised immature, mature and maturing stages which were described in very short notes by El-Sayed, *et al.* (1998) and Alazaly (2017). For *Sacculinea polygenea*, parasitizing *Hemigrapsus sanguineus*, three maturity stages comprised virgin, mature and maturing externae were recognized by Lutzen and Takashi (1997). However, during this study, spent stage was added based on the presence of remain of cypris larvae in addition to unreleased fertilized eggs some of them were resorbed in atrial cavity or have irregular outline. The presence of super parasitic crustaceans may be bopyrids (family Bopyridae: Epicaridea) according to Bourdon (1980) were detected within spent externae which agrees with that mentioned by Hartnoll (1967). In addition, there are remarkable changes in general outline and color of exterane accompanied with the appearance of dark brown spots on the external surface after releasing larvae, great antero-posterior flattened and appearance of several wrinkles and wavy ridges on the outer surface.

The color of externae was increased with gradual increasing of the developed oocytes within ovaries due to accumulation of yolk granules. These results are in agreement with the results of Wardle & Tirapak (1991). They explained that, the externae are changed in size by increasing in ovary size during maturity while color is changed from white to brownish or yellowish by the deposition of the formed yolk granules in the mature ova within the ovaries. They also added that, the externae are protected from the

environmental hazard conditions by thick cuticle and tightly closed mantle opening. However, further histological investigations are necessary to follow up the oogenesis and larval development of this parasite to identify it to its specific level.

The size of *S. leptodiae* externae was greatly varied according to different maturity stages, incidence of double externae and even between sexes. During this study, the size of externae varied from 1.0 –10.4 mm in breadth, 1.5-7.1 mm in height and between 1.0 and 4.0 mm in thickness. The overall breadth averaged 5.9 mm, 5.19 ± 2.76 mm in males and 5.63 ± 3.17 mm in females, without significant difference between sexes. These results are very close to those reported for the same species on *L. exrataus* by Guerin-Ganivet (1911) and Boschma (1933b, 1936, 1937, 1947, 1948, 1955).

Boschma (1933b) recorded 8 externae of the similar species, *Sacculina sinensis* on three individuals of *L. exrataus* distributed as 5, 2 and one on the three individuals, respectively. Their sizes reported $6 \times 5.5 \times 2.5$ mm in a single externa, $8.5 \times 6.5 \times 4.5$ mm and $8 \times 6.5 \times 4$ mm in a double and between $4.5-5 \times 4 \times 2-2.4$ mm in 4 externae and 2 mm in all dimensions in last of the five externae.

The size of *S. leptodiae* externae is suitable the host's size. Some species of *Sacculinids* may reach larger size. *Sacculina ignorata* varied from 3.1- 12.5 mm on the xanthid crab, *Actaea hirsutissima* which has similar size with *L. exaratus* (Alazaly, 2017). Other sacculinids may reach larger sizes, of them *Heterosaccus dolifusi* externae which varied from 100 -120 in length, 20-25 mm in diameter, 35-45 g in weight and reached 150 mm. This species parasitizes the portunid crab *Charybdis longicolis* inhabits the Egyptian Mediterranean coasts (Nour Eldeen *et al.*, 2019).

The present results are in agreement with that reported by Siddiqui and Ahmed (1993) from the Indo-Pacific localities including Red Sea and El-Sayed (1997, 1998). They recorded that, the size of *Sacculina sinensis* parasite varied in breadth from 1.9- 10.4 mm, but being lower than that reported by Alazaly (2017) which varied from 3.5- 12.5 mm for those recorded from Hurghada, Red Sea. In double externae, the size (breadth) averaged 7.58 ± 2.11 mm during summer and declined to 3.77 ± 3.30 mm in autumn between males at Ain Sokhna, compared with seasonal averages of 5.31 ± 3.10 mm in summer and 5.06 ± 2.56 mm in autumn for females indicating to maximum of breeding for this species during summer season in both sexes.

It is obvious that, this parasite obtains its nutrients via the rootlets system of its interna, which are widely penetrated and scattered within the host particularly around the hepatopancreas and intestine and within ovaries, testes, as well as in all spaces of body cavities. The structure of these rootlets is adapted for their function which agree well with that reported by Hartnoll (1962, 1967), Schmidt & Roberts (1977), and Warner (1977). These results are in agreement with the results of Wardle & Tirapak (1991). In spite of the obtained results, further studies are necessary to give more information on this parasite and its life cycle at the studied areas and on its phylogeny.

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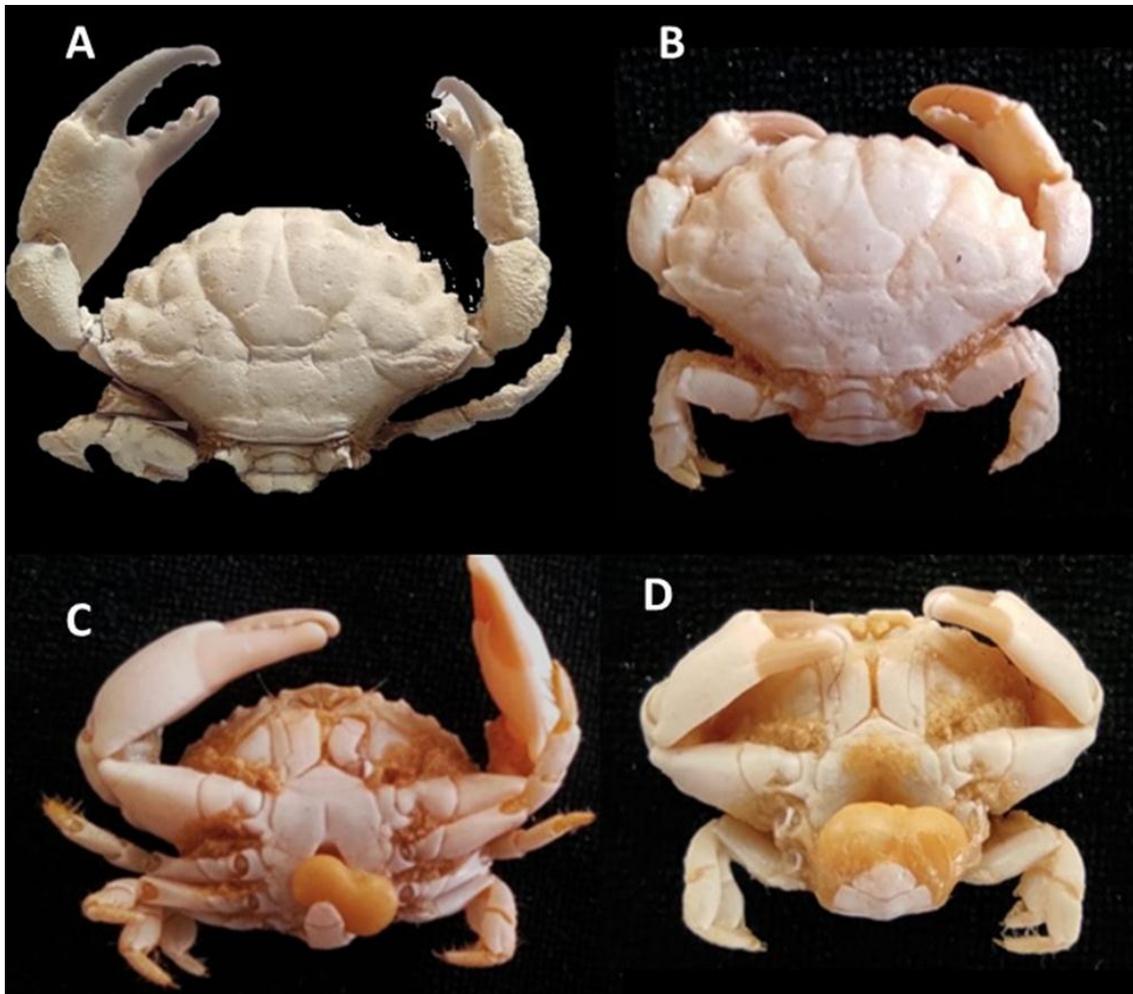


Plate I: Dorsal surface of *Leptodius exaratus* male (A), and female (B), ventral view of infected male (C) and infected female (D) carrying single externae of *Sacculina leptodiae*.

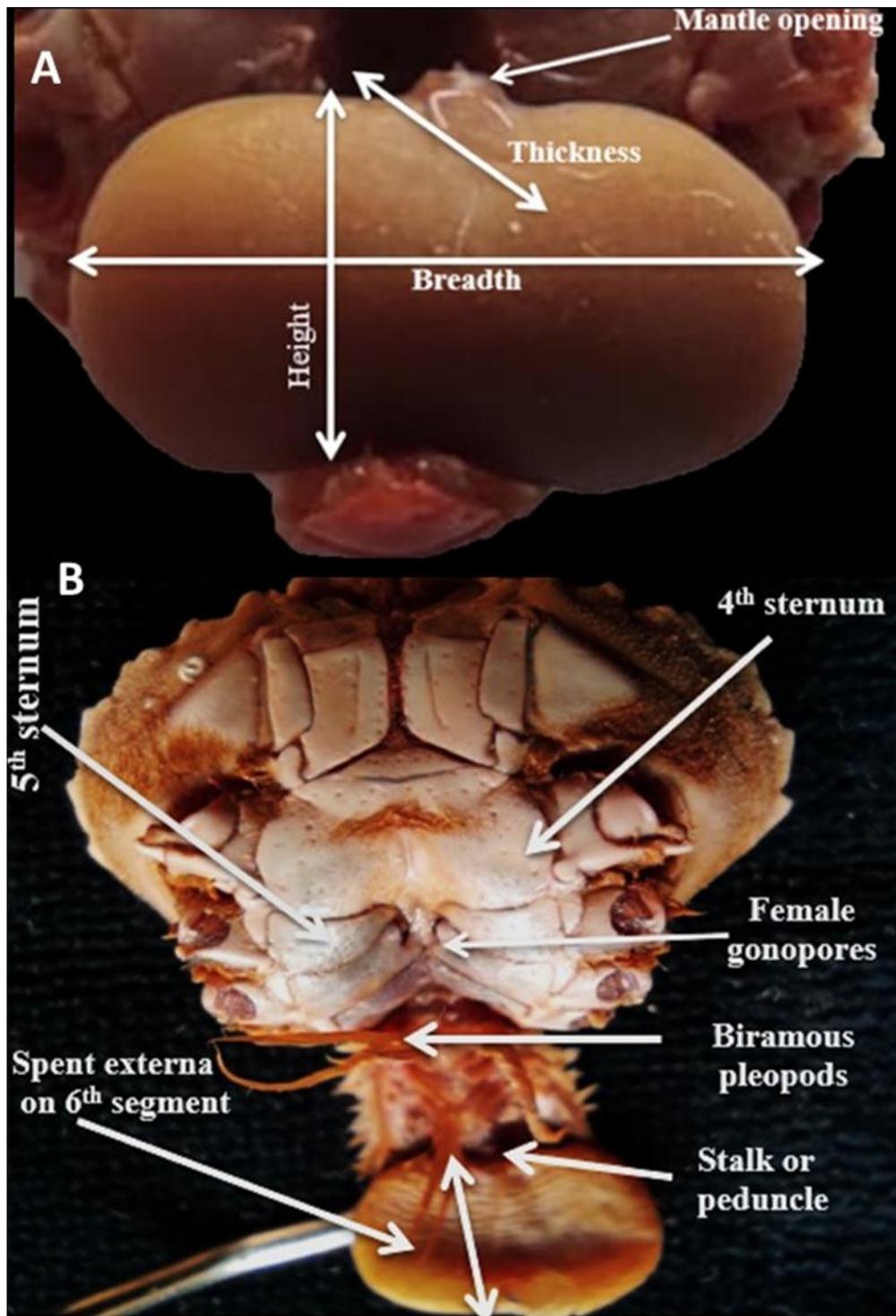


Plate II: General morphology of *Sacculina leptodiae* infected *Leptodius exaratus* (A) Dimensions comprised breadth, height and thickness of maturing extern (0.5x0.4x0.26 cm BHT) and B) Ventral view of infected female host with spent showing height (arrow) and external morphology after egg releasing.

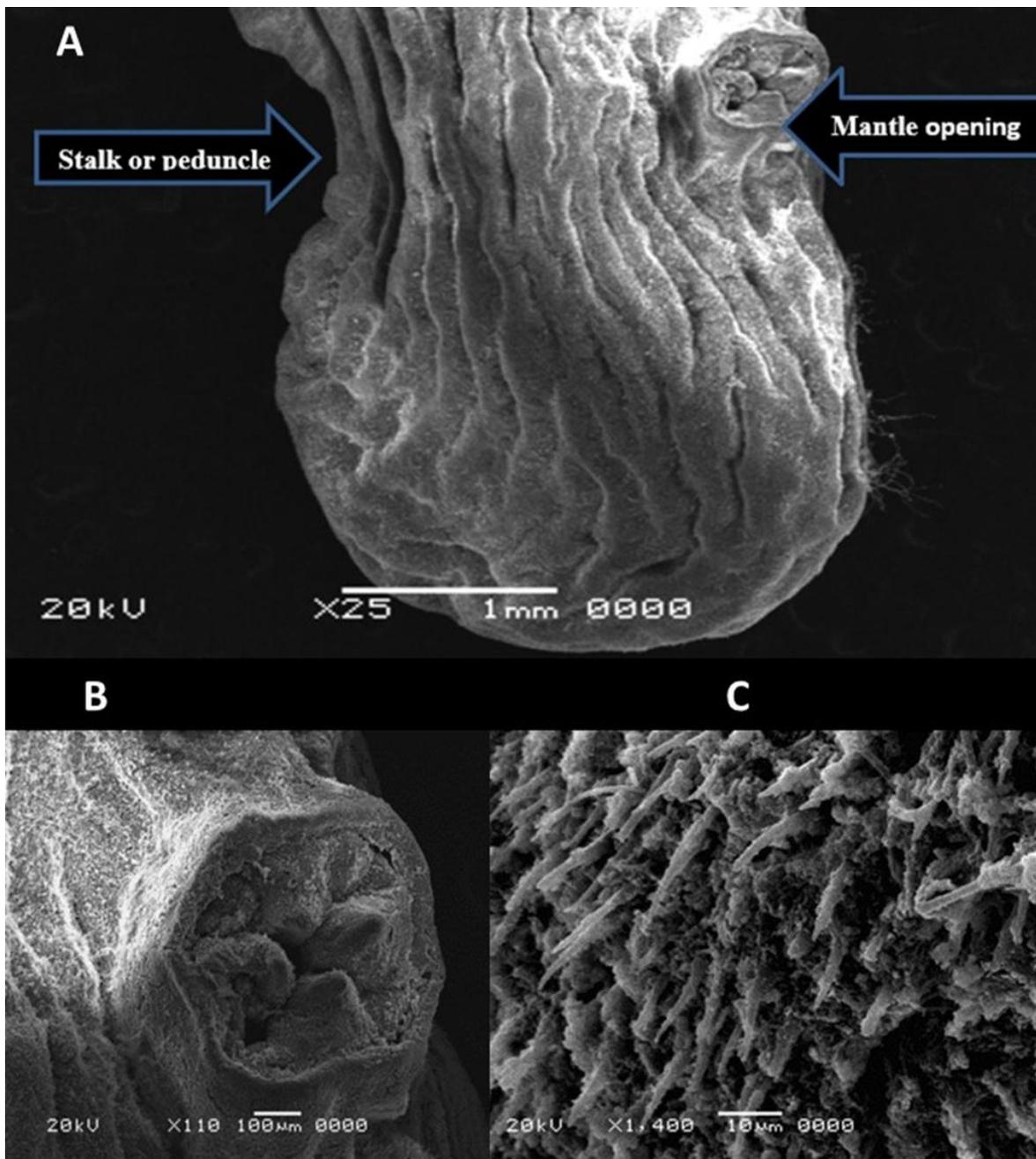


Plate III: Scanning electron photographs showing external feature of extrena of *S. leptodiae* (A), enlarged externa showing mantle opening (B), and excrescences on externa surface (C). Scales are indicating on photos.

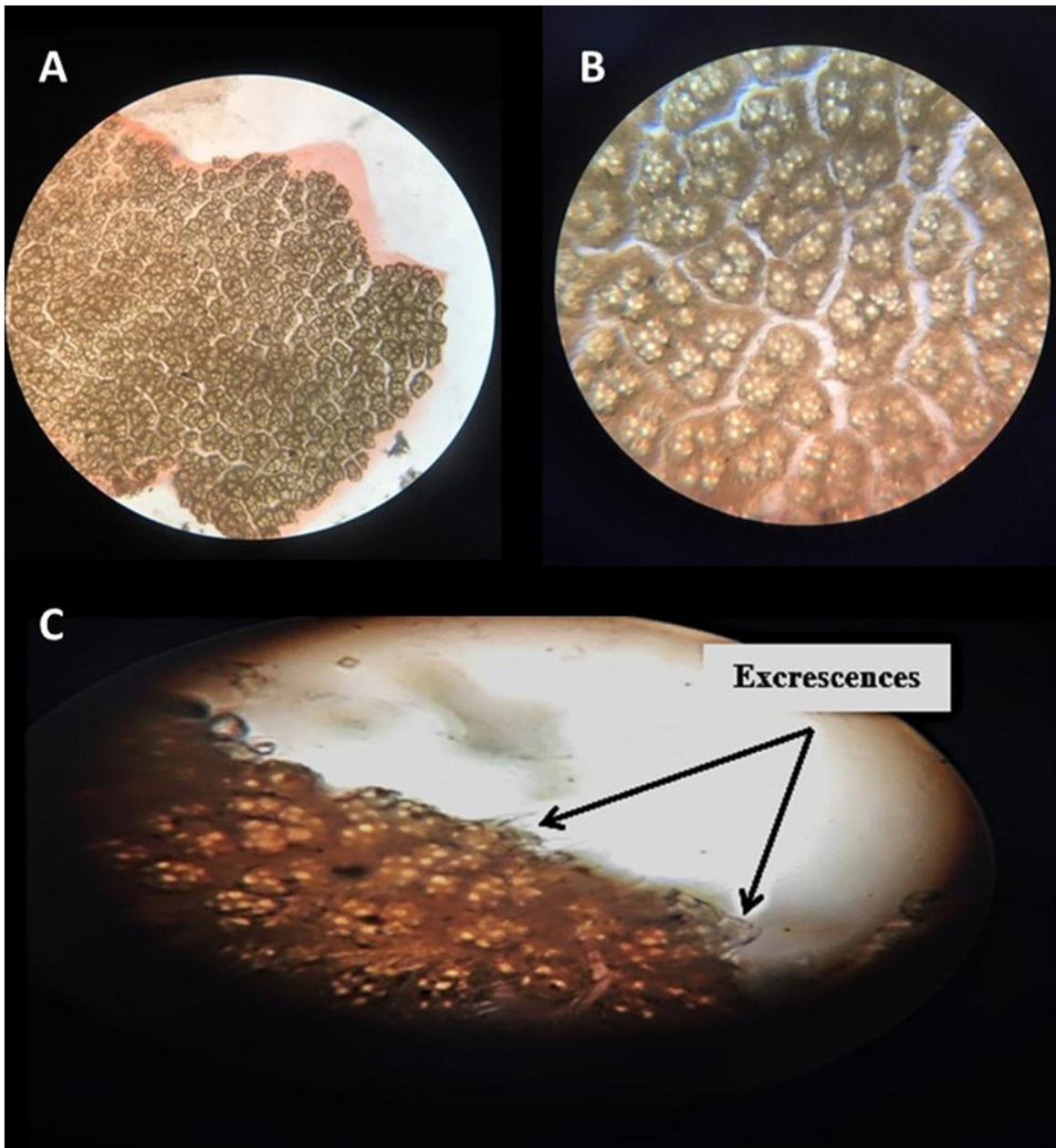


Plate IV: Photos by light microscope showing: A) Top view for bundles of excrescences on epi-cuticle (X 10) and B (X40), C) enlarged bundles showing spinules of excrescences (X100).

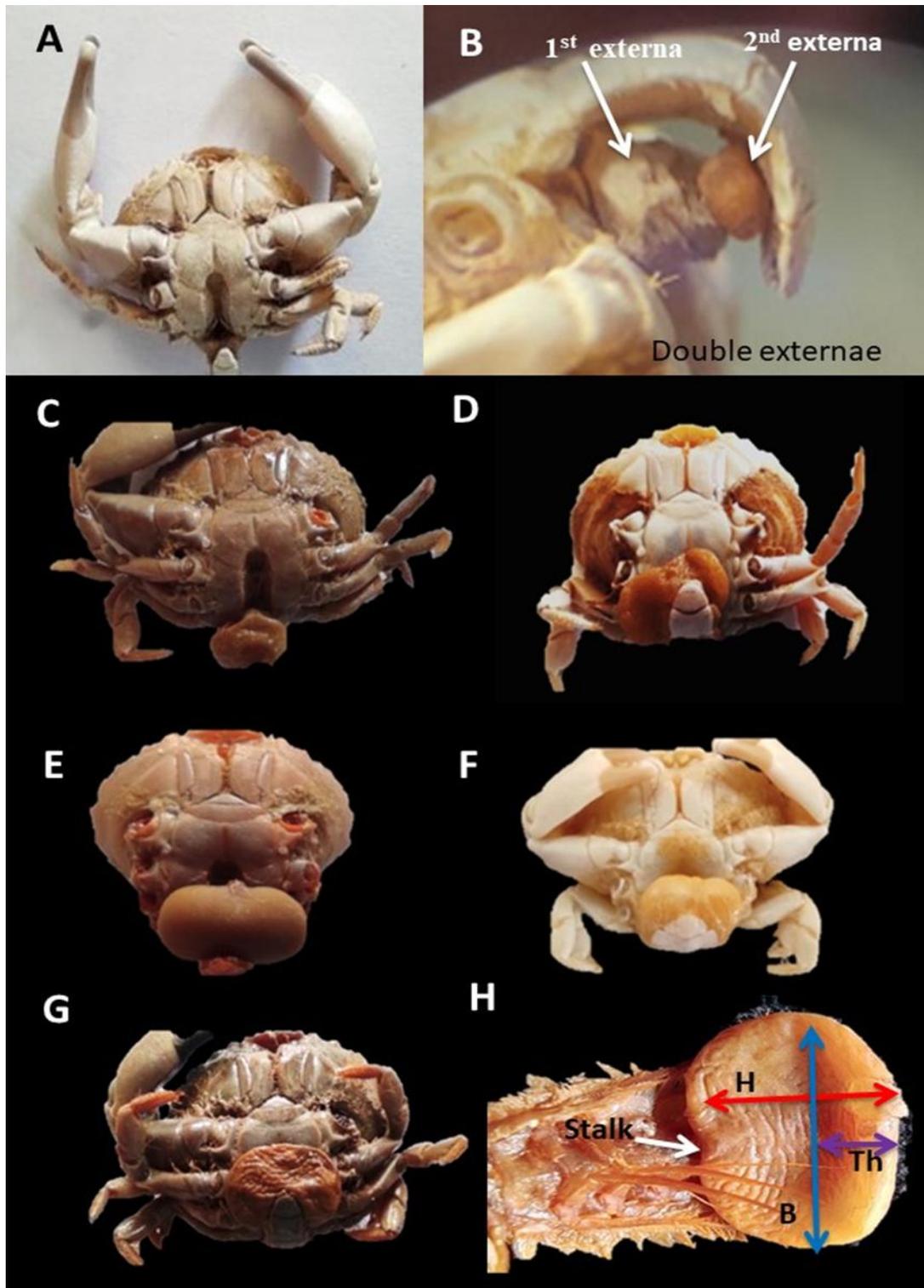


Plate V: Shows changes in size and external morphology during stages of maturity in *Sacculina leptodiae*, A) Virgin or immature, B) double externae at immature stages, C&D) early mature, E&F) maturing, and G&H) spent externa. Arrows denote to Breadth, height and thickness.

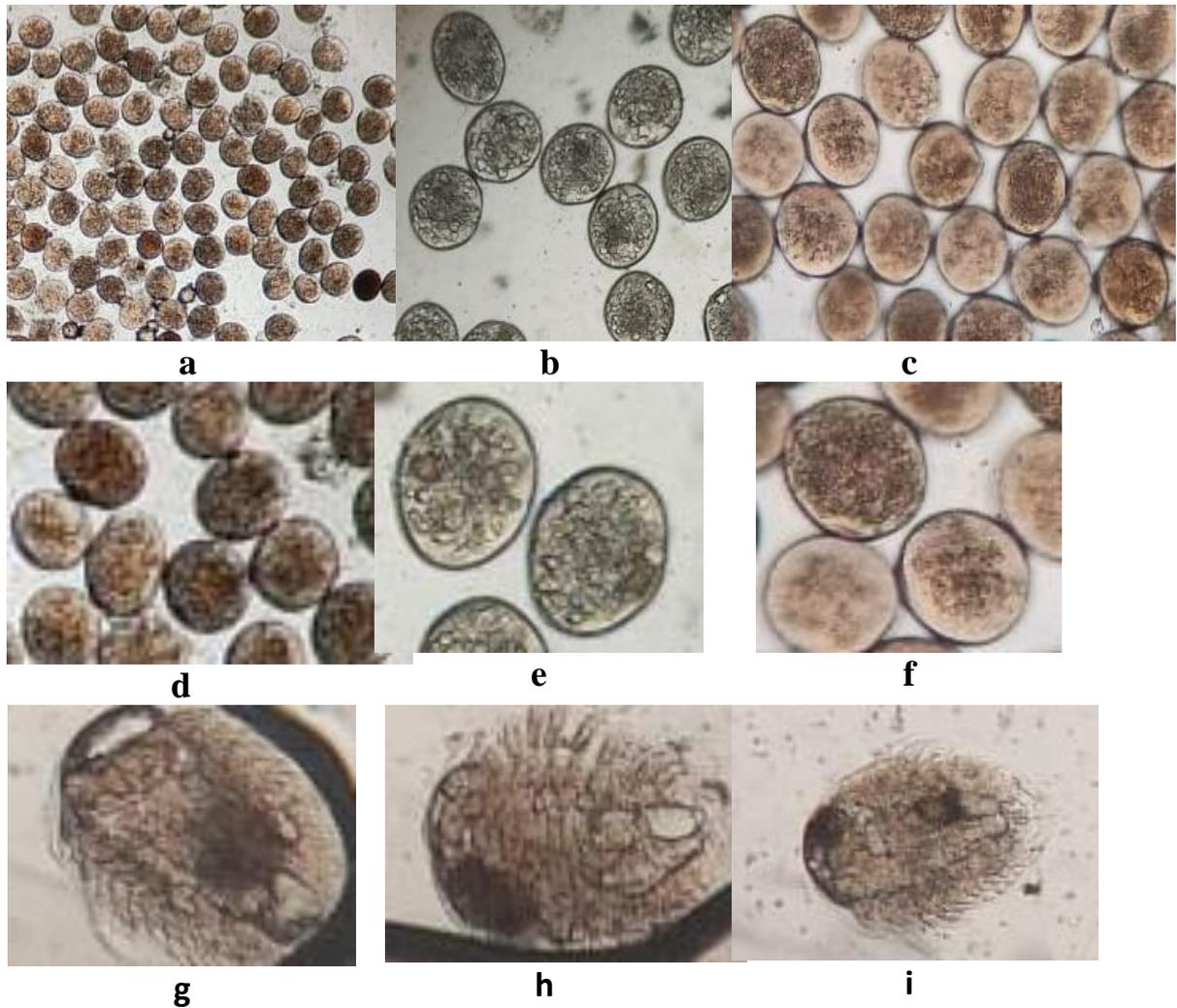


Plate (VI): (a-c) Eggs within ovaries of maturing externae of *Sacculina leptodiae*, (d-f) enlarged eggs and (g-i) enlarged parasitic bopyrids within partially spent externae, with magnifications of X10, x40 and X100, respectively. Notice density of yolk granules and variations in sizes of maturing egg.

الملخص العربي

الصفات المورفولوجية لطفيل *Sacculina leptodiae* (Sacculinidae: Rhizocephala) المتطفل على

سرطان *Leptodius exaratus* من الشواطئ المصرية للبحر الأحمر وخليجي السويس والعقبة

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الملخص العربي

يعتبر طفيل الساكوليونا *Sacculina leptodiae* من عائلة Sacculinidae رتبة Rhizocephala أحد الطفيليات التي تصيب سرطان *Leptodius exaratus* الذي يتبع عائلة Xanthidae من السرطانات الأصلية (Brachyura) واسع الانتشار في المناطق بين المدية بسواحل البحر الأحمر المصرية وخليجي السويس والعقبة. ولقد تم تجميع وفحص 691 فردا من أفراد هذا العائل شملت 400 فردا من الذكور و291 فردا من الإناث، حيث تبين إصابة 38 فردا منها بهذا الطفيل شملت 23 ذكراً و 15 من الإناث، وتحمل الأفراد المصابة على بطونها 41 كيسا تعرف بالاكسترونا (Externae) شملت 35 كيسا منفردا على بطون 35 فردا من السرطان و3 أزواج تشتمل على أكياسا متباينة الحجم على ثلاثة أفراد من هذا السرطان. وتمثل نسبة الإصابة 5.5% من المجموع الكلي لجميع السرطانات بالمناطق المختلفة لتواجدها، وتبدو أعلى في الذكور (5.75%) عنها في الإناث (5.15%) و يعد هذا الفارق غير جوهري من الناحية الاحصائية. كما تمثل أكياس الساكوليونا (*Sacculina*) المنفردة 92.11% مقابل 7.89% للأكياس المزوجة. وتبرز إكسترونا الطفيل كامتداد لحمي متكيس على بطون الأفراد المصابة من السرطان، وتتصل ببطن العائل بواسطة عميد قصير يمتد داخل العائل ليكون شبكة من الجذيريات الخيطية المنتشرة داخل جسم العائل تخترق المناسل والكبد البنكرياسية وتمتد في كل تجاويف الجسم حتى الأطراف والزوائد، وظيفتها تثبيت الاكسترونا المحتوي على المناسل (المبايض والخصى فقط) و امتصاص الغذاء من العائل وامداد الكيس الخارجي به. كما تفتح الاكسترونا للخارج بفتحة طرفية تقع على الطرف الحر تعرف بفتحة البهو يتحكم في قفلها وفتحها عدد من الكتل العضلية البارزة وظيفتها خروج اليرقات بعد فقس البويضات داخل بهو الاكسترونا. ويختلف حجم ولون الاكسترونا حسب مراحل النضج الأربع والتي تشمل المرحلة غير الناضجة أو البكر (1-3.5 مم) ، ثم مرحلة بداية النضج (أكبر من 3.5 – 5 مم)، فالمرحلة كاملة النضج (أكبر من 5-10.4 مم) ثم مرحلة إفراغ اليرقات أو مرحلة الأكياس (اكسترونا) الفارغة التي تتميز بالتفطح والانضغاط من الأمام إلى الخلف. ولقد وجد أن حجم الساكوليونا يتراوح من 1 مم إلى 10.4 مم في العرض بمتوسط 5.19 ± 2.76 مم فيحالة تواجدها على ذكور العائل و 5.63 ± 3.17 مم في الإناث، كما يتدرج اللون من الباهت المبيض في المراحل غير الناضجة إلى الأصفر الشاحب ثم الأصفر الداكن فاللون البني المصحوب ببعض البقع الداكنة في المراحل المبكرة للنضج فالناضجة ثم مرحلة إفراغ اليرقات على التوالي. ويعد طفيل الساكوليونا من الأنواع التي تسبب ظهور تغيرات شكلية وداخلية في العائل المصاب حسب درجة الإصابة. ويتميز السطح الخارجي لأكياس الساكوليونا بتواجد حزم متراسة بشكل متباعد عن بعضها البعض وتحمل شويكات كيتينية صلبة تتراوح من 15.6 - 47.0 ميكرون بمتوسط 32.74 ± 8.45 ميكرون.