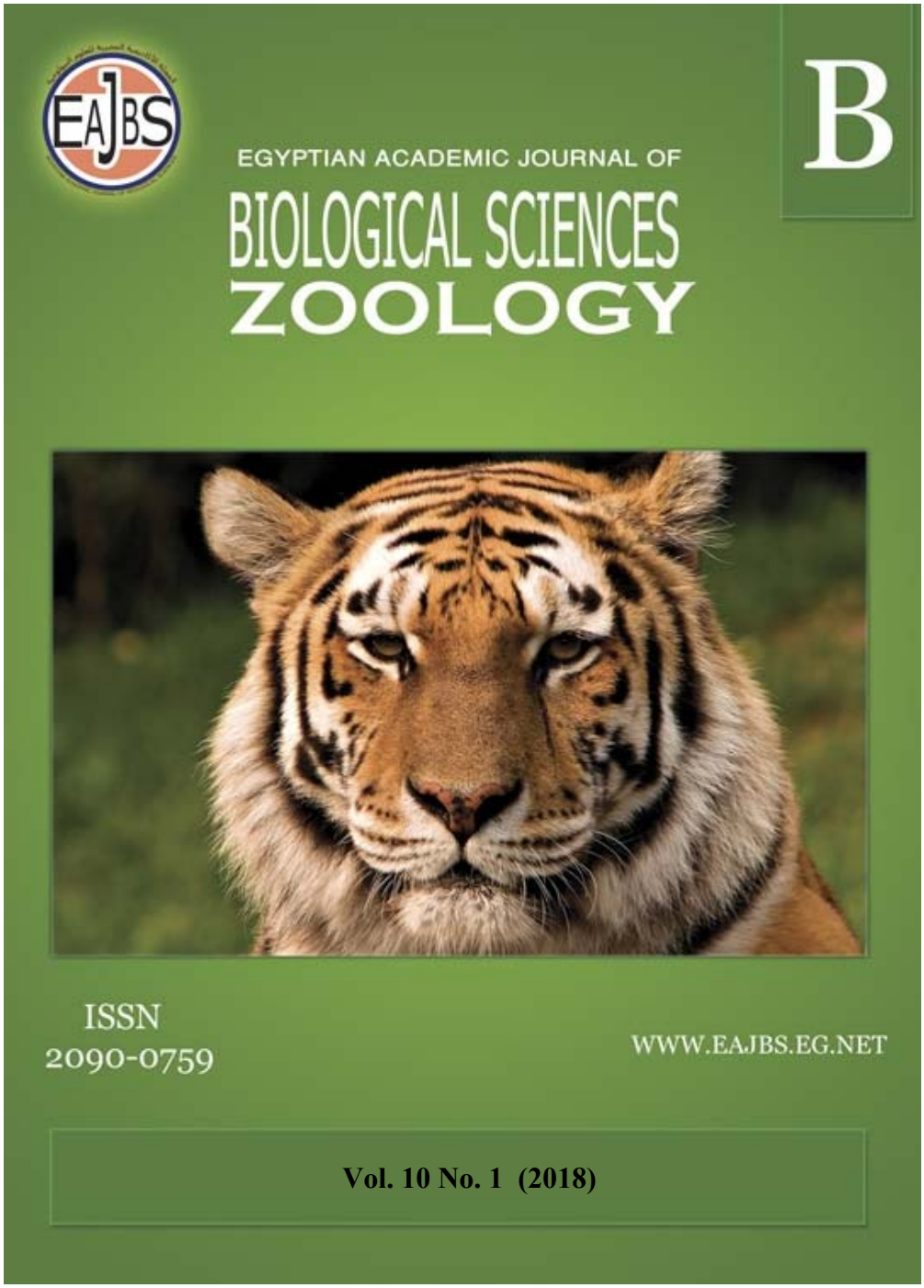

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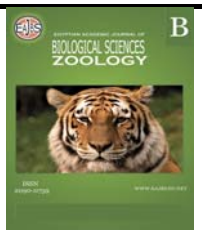

Reproductive Biology of The Solitary Ascidian, *Herdmania momus* (Ascidiacea: Hemichordta) from Hurghada Coasts, Red Sea, Egypt

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ABSTRACT

The reproductive biology of the ascidian *Herdmania momus* (Savigny, 1816) was studied at anthropogenic impacted sites along Hurghada coasts, Red Sea, Egypt, during January - December 2013. The specimens of this species were collected monthly from the shallow subtidal zones, and varied from 1.20 to 7.0 cm in total length and from 1.28 to 50 g in total body weight. The results showed that, *H. momus* is hermaphrodite, carries ovaries and testes at the same individuals, but ovaries are larger in size and shapes than testes. The smallest immature individual has 1.2 cm in length; while the smallest mature individual measured 1.46 cm in length and 1.18 g in weight, with ovaries of 0.041g in weight. The sexually mature individuals of this species have ovaries containing oocytes varied in shapes and sizes, passing through four main stages of maturation reaching stage IV or late vitellogenic stage (ripe ova), with oocytes varied from 100 to 140 µm in diameter, characterized with deep orange color and dense accumulation of yolk granules. It was followed by stage V or spent stage of irregular resorbed eggs. The appearance of ripe ova at stage IV showed spatial and temporal variations. The monthly averages of gonadosomatic indices (GSI) exhibited that, the whole populations of this species at all sites have lengthy breeding season extends nearly all the year around and characterizes with high peaks in gonadal activity during January (6.21), April (6.15), June (6.47), July (6.28), declined slightly in May (5.86), and September (5.15), with remarkably spatial variations at the studied sites. The number of mature eggs or fecundity varied from 1481 to 3724 and averaged of 3082.96±769.96 eggs for all populations. These values exhibited greatly individual variations denoting to partially spawning for each individual. The relationship between total body length (cm) and mean the number of eggs (fecundity) showed an increase in egg number with an increase in animal length.

INTRODUCTION

Ascidians or “sea squirts” are a group of soft-bodied marine animals belong to Class Ascidiacea, Subphylum Tunicata, within Phylum Urochordata

(Millar, 1970; Vine, 1986; Shenkar, 2012). These are the largest and most diverse class of the sub-phylum Tunicata comprises approximately 3000 described species found in all marine habitats from shallow water downwards to deep water environments (Millar, 1970). Adult ascidians are sessile, inhabiting a wide variety of hard habitats mainly coral reefs and rocky substrates, as well are successfully foul various artificial hard surfaces and natural substrates such as rocks, eelgrass blades, pilings, shells of bivalve mollusks, jetties, ship and boat hulls, floating docks and other man-made structures all over the world to the deep sea (Millar, 1970, 1971; Vine, 1986; Shenkar, 2008, 2012). Ascidians can grow either solitary or in colonies. Solitary sea squirts are typically looking like small cylinders or round balls about the size of grapes. In fact, one common species is called "sea grape". Colonial ascidians, on the other hand, grow in thick, slimy mats that can range from dime-sized to huge colonies as large as sheets of plywood ascidians (Shenkar, *et al.* 2012).

Adult ascidians have little resemblance to typical chordates, while ascidian larvae are known as tadpole larvae because of their shape (Millar, 1970). Most of the short-lived tadpole larvae non-feeding and have the cleared four fundamental characteristics of the phylum represented by: a dorsal tubular nerve cord, notochord, rudimentary pharyngeal gill slits and a post-anal tail, in addition to the presence of the endostyle in the pharynx that would evolve as the thyroid gland in vertebrates (Fujita and Nanba 1971). After short period these larvae settle on the preferable substrate and undergo metamorphosis during which they lose all these characteristics except for the endostyle and the gill slit rudiments in the pharynx, which become functional and multiply to form the branchial sac (Millar 1971).

All ascidians are hermaphrodites, having both male and female organs. They generally avoid self-fertilization by developing only eggs or only sperm at any one time (Newlon *et al*., 2003). Most solitary ascidians release their eggs and sperm into the water for external fertilization, while colonial ascidians usually retain and brood their eggs (Lambert 2005). Under natural conditions, ascidian larvae do not normally disperse very far, often just a few meters or less (Ayre *et al*., 1997).

Adult ascidians are benthic animals and constitute a minor benthic component on exposed surfaces of the natural coral reefs. They are generally found in cryptic environments such as grottos, crevices and the sides or undersides of rocks and corals. Solitary species are frequently protecting themselves in exposed sites better than colonial species from effects of hazardous environmental conditions and predation using their rigid tunic covered by epibionts that provide camouflage and physical protection (Monniot *et al*. 1991). However, both colonial and solitary species successfully foul various artificial substrates such as jetties and other man-made substrate adjacent to the natural coral reef (Oren and Benayahu 1998; Shenkar *et al*., 2012). As ascidians are able to filter even minute particulate matter (Bak *et al*., 1998; Bone *et al*., 2003), any rise in nutrient levels and organic material will have a direct influence on their abundance.

The scientific explorations of the Red Sea fauna and flora began with the Danish "Arabia Felix" expedition to the Red Sea in 1772–1773, with the extremely important works of Peter Forsskäl, continuing with Savigny's studies during Napoleon's campaign in 1779–1801 (Fishelson, 1971, 2000). Several cosmopolitan ascidian species such as *Phallusia nigra* and *Didemnum candidum* were originally described by Savigny from this area (Savigny 1816). However, not many species have been added to the original inventory list since then, and the ascidian fauna of this area remains relatively unknown.

At the present time, there are about, 73 ascidian species belonging to 13 families are recorded from the Red Sea (Vine, 1986; Shenkar, 2012). The majorities of these species are colonial and have the wide distribution in the Indo-Pacific regions, of them eight species have been recorded for the first time from this region by Shenkar (2008, 2012). The Gulf of Aqaba and the Gulf of Suez represent the northern boundary of the natural distribution for the majority of tropical species recorded in this study. However, several species have successfully entered the Mediterranean Sea through the Suez Canal.

The Red Sea constitutes a unique ecosystem with high biological diversity, but at the present time, it faces several threats. The main sources of marine pollution come from land-based activities; over-population and urbanization and coastal dredging and filling operations, power and desalination plants and refineries, recreational and tourism, wastewater treatment facilities, power plants, coastal mining and quarrying activities, oil bunkering and habitat modification like dredging and filling of wetlands (UNEP, 1997). In addition to dredging and disposal of dredging wastes of the major sources of induced environmental damage (UNEP,1996) which affect on shallow water marine fauna particularly filter feeding organisms as ascidians.

The present study aims to study the direct and indirect effects of human impacts and oil pollution on the reproductive activities of the sea squirt *Herdmania momus*(Ascidiacea:Urochordata) from the coasts of Hurghada coasts, Red Sea, Egypt.

MATERIALS AND METHODS

The present study was carried monthly during the period from January to December 2013. It comprised surveying and collecting individuals of *Herdmania momus* from five sites chosen along the Egyptian Red Sea coast, extending from Al-Gona north Hurghada to Mangrove site lies at 17 Km South Safaga (Figure, 1). The position of each site was determined by GPS and all available information on tides, wave action, habitat type, vegetation, types of impacts and status of ascidians were recorded. These sites are called from the north to the south as:

(1) The Site I (AL-Gouna or Abu-Tig Marina): It lies at about 20 km north of Hurghada City (27º 24' 28" N and 33º 40' 30"E). This site suffers from oil pollution due to the effects of petroleum activities at Gemsha area.

(2) Site II (The National Institute of Oceanography and Fisheries, NIOF, Red Sea branch): This site locates at about 5 km away from the center of Hurghada City (27º 17' 08"N and 33º 46' 18" E). It is characterized by a wide and shallow reef flat extends about 150 m seaward, with many sandy depressions and ends seawards with a lagoon of about 5 m depth. It has a jetty of about 60 m length.

(3) Site III (Fishing Port at Hurghada): This site lies at Hurghada City (27 º 13' 43"N and 33º 50' 31"E) and uses daily for repairing, maintaining and constructing fishing ships, in addition to the fishing market. This site is highly affected by the discharge of drainage water of fish washing, and sewage that localizes shipyards.

(4) Site IV (Grand Hotel jetty): It this site lies also at Hurghada City (27º 10' 22" N and 33º 49' 42" E), with small harbor characterizes by the anthropogenic effects that resulted from the tourism activity, in addition to effect desalination plant drainage.

(5) Site V (Mangroves swamps 17 km south Safaga): This site locates at about 17 km south Safaga City at the end of Wadi Safaga (27º 24' 28" N and 33º 40' 30 E), and characterizes with fringed and sheltered mangrove trees. It extends about 2 km along the shoreline and seaward 200m wide thickets of healthy trees and shrubs of monospecific forests of *Avicennia marina*. It has also several scattered rocky bottom areas, with many small sandy pools and lagoons, their bottom covers with a thin layer of sand or intermixed with mud varied in depth from 0 to 0.5 m.

Fig. (1): Sites of *Herdmania momus* collection during the present study

Sampling of specimens:

A total of 297 specimens of *Herdmania momus* were collected monthly during the present study. The specimens of this species were collected by hand from its habitats during snorkeling from the intertidal and shallow subtidal zones at the studied sites from January to December 2013. The collection of most specimens was carried out during daytimes of calm weather and good sea conditions particularly before sunset. This time is good for collection due to increased animal activity and made them easier for collection. However, during the coldest months when seawater temperature is low, the specimens were collected early from the mid-day till sunset. Sharp knives were used for collection ascidians attached to rocks or those occurred among ship fouling or those occurred on the available hard substrate such as dead corals, piers and sometimes among algae.

The collected samples were preserved in 10% neutral formalin solution and kept in plastic containers provided with the label on the date, time and site of collection, status, forms and type of substrates, then transferred to the laboratory for identification.

Laboratory Examinations:

At the laboratory, all collected specimens were identified according to Millar (1970, 1971) and Shenkar (2012). Measurements of length, total weight, gonad

weight, oocyte diameter and the occurrence of symbionts were recorded. At least ten monthly specimens were dissected from each site and gonads were weighed and examined. The gonad index (GI) was calculated according to the following formula:

GI=Weight of gonads / weight of body x 100

The stages of gonad maturation were classified according to Kessel (1983) and Swalla *et al.*(1991). At least three subsamples of known gonadal weight were taken, all eggs were counted, and then the average egg number was calculated and multiplied by the total weight of gonad. The absolute fecundity was calculated and expressed as "the total number of eggs per specimen", and then the total average of egg numbers for all population was estimated.

The spawning season for the studied species was determined from monthly variations in gonad index. Egg diameters were measured using a micrometer (0.01 ml under dissecting microscope. They were classification into different development stages according to Prodon *et al*. (2006). The previous reports on oogenesis in several ascidians species (Kessel, 1983; Swalla *et al.,* 1991) considered that there are basically 3 stages of gonad vitellogenic(GV) -containing oocytes, in addition to late-stage small transparent pre-vitellogenic (stage I), growing vitellogenic oocytes (stage II) and post-vitellogenic, pigmented, full-grown GV-stage oocytes (stage III). They were characterized by the following:

- In early stage II oocytes (50–70 µm in diameter)
- In late stage II vitellogenic oocytes (70–80 µm in diameter and pigmented)
- In full grown pigmented stage III oocytes (about 80-100 µm in diameter)
- Oocytes (stage IV) arrest in meiotic metaphase (about 100-140 µm in diameter).

The fecundity (the number of ripe eggs) was determined for each specimen by counting ripe eggs in three subsamples of the known weight of ovary and calculated b multiplying the average number in the ovary weight according to Bagenal and Tesch(1978).

All statistical analyses were carried out using SPSS 22. Averages, and standard deviations regression analyses, t-test, and Chi-square were used for data analyses. Results are presented as averages ± standard errors throughout the text unless denoted otherwise.

RESULTS

A- Collected Specimens:

A total of 297 specimens of the solitary ascidian *Herdmania momus* (Savigny, 1816) were collected from the shallow subtidal zones at sites 1, 3 and 4. In contrast, only one individual was photographed at site 2 below 3 m depth, but no specimens were obtained from site 5 during the course of this study. The smallest individuals measured 2.0, 1.46 and 1.20 cm in length and 2.0, 1.28 and 1.50 g in total body weight collected from the previous sites, respectively. While the largest individuals measured 6.0, 5.0 and 7.0 cm in length and 12.2, 18.8 and 36.5 g in total body weight at the same sites, respectively.

B-General Morphology:

The field observations showed that, the solitary ascidian *Herdmania momus* is considered a polymorphic animal, and has variable morphological forms between its populations and even between individuals of the same population. All the obtained specimens have an inflated spherical body that is slightly longer along the antero-posterior (head-butt) axis. It has two short, diverging, trumpet-shaped siphons at its anterior free end. Its color is also variables, with reddish siphons, being slightly darker

than the body in most specimens. The whole body of this species is enveloped, as in all other ascidians, within a complex external tunic or a test, from which the term tunicate is derived. This tunic varies in consistency from soft, thin and delicate to a leathery, thick and robust.

C- Reproductive System:

The present results showed that, *Herdmania momus* is hermaphrodite and carries both ovaries and testes at the same individuals. It was found that, there is a single long gonad lies in the connective tissues on each side of the body wall (Figure 3). Gonads contain both ovaries and testes together. It was noticed that, testes are being attached to the ovary side, while gut loop beings enclose the left gonad at the posterior end. Ovaries are varied according to maturity stages from thread-like at the early stage to lobulated long structure at late stages and in all are longer than testes. They are characterized by deep orange color particularly at late stages of egg maturity, compared with lighter orange or faint testes. The thin and delicate oviducts and sperm ducts are separate, run parallel to the intestine and open into the atrium near the anus. They carry matured eggs and sperm travel to the cloaca.

D- Size of the First Maturity:

The laboratory examination of the present study showed that, the smallest immature individuals have 1.2 cm in length. It was collected from site 4 (Grand Hotel) during November 2013, and has no signs of gonads. While the smallest mature individuals measured 1.46 cm in length and 1.18 g in weight, and was collected during August 2013 from site 3 (Fishing Port). It has ovary of 0.041 g in weight, compared with the larges immature individuals of 2.0 cm length and 2.0 g body weight collected in July 2013 from site1 (Al Gona).

E- Stages of Oocyte Maturation:

The laboratory examination showed that the sexually mature individuals of *H. momus* have ovaries containing different stages of oocytes varied shapes and sizes (Table 1). Those are passed through four main stages of maturation, to reach final maturity before ovulation. These stages can be differentiated as follows:

Stage I (early): Oocytes are very abundant, with the obvious nucleus, have faint color, being entire oval, varied from 30 to 59 µm and averaged 50 µm in diameter.

Stage II (Pre-vitellogenesis): Oocytes are also abundant, with the obvious clear nucleus, have opaque color, semi-oval and varied from 50 to 80µm in diameter.

Stage III (Early vitellogenic stage): The oocytes increased in size, and varied from 80 to100µm in diameter, with faint or light orange color, being slightly oblong or elliptical in shapes surrounded with thin follicle cells.

Stage IV (Late vitellogenic stage): Oocytes increased to vary from 100 to 140 µm and were characterized with deep orange color due to the dense accumulation of yolk granules, appearance clear test, surrounded with follicle cells and the vitelline space.

Monthly Variations in Oocyte Maturation at the Study Sites:

The results in Tables (1) show variations in frequencies percentages of different stages of oocyte maturation of *H. momus* collected from the sites of this study. It was found that, oocytes of stage II were occurred with relatively high percentages at all sites except only during November at site 3 (Fishing Port). On the other hand, the appearance of ripe ova or oocytes at stage IV were recorded from April to October at site 1(Al Gona), from February to June and during December at

site 4 (Grand Hotel), and in January, March-April, July-October and in December at site 3 (Fishing Port).

On the other hand, oocytes of stage III were recorded from February to October at Al Gona (site 1), and all year round except only November at site 3 (Fishing Port), and during January and June at site 4 (Grand Hotel).

Table (1): Monthly percentages in developmental stages of oocytes *Herdmania momus* at the study sites from Hurghada coasts, Red Sea, Egypt (St. = stages).

Sites& Stages / Months	Al- Gona				Fishing Port				Grand Hotel			
	St. I	St. II	St. III	St. IV	St. I	St. II	St. III	St. IV	St. I	St. II	St. III	St. IV
January	57	43			43	21	19	17	35	65		
February	57	22	49		56	27	17		5	52	18	25
March		68	32			55	32	25	13	54	29	1
April	4	51	36	9		37	32	18	17	19	41	2
May	16	28	46	19	36	43	19			58	26	15
June		47	46	7	20	41	39		25	55		18
July	15	37	33	15	22	25	26	29	27	52	19	
August		17	42	4		2	42	33	22	3	48	
September	10	25	26	3	55	19	36	38	28	32	38	
October	12	29	33	35		27	40	33		61	39	
November	70	30			41	59				16	31	
December	46	54			12	22	21	7	15	24	8	10

F- Gonadosomatic Index (GSI):

The results of monthly averages of gonadosomatic indices (GSI) of *Herdmania momus* collected from the studied areas at Hurghada coasts are given in Table (2) and represented in Figure (2). These results exhibit that, the whole populations of this species along the studied areas have lengthy breeding season extends nearly all the year around and characterizes with high peaks in gonadal activity during January (6.21), April (6.15), June (6.47), July (6.28), declined slightly in May (5.86), and September (5.15). These values were declined slightly in February, March, August, and December, and averaged 4.32, 4.83, 4.34 and 4.78, respectively, and reached the minimum values in October (3.73), and November (3.42). However, these data were varied and showed remarkably spatial variations in gonadal activities at the studied sites as follows:

At Al Gona, GSI took the same pattern of the whole population, showing high values of GSI during January (11.95), March (7.30), April (8.03), June (8.01) and July (8.10), but declined in February (3.97), August (3.93), October (3.01) and December (4.74) and reached the minimum average of 2.70 in November and showed moderate values of 5.73, 5.10 and 4.74 in May, September and December, respectively (Table 2 and Figure 2). With exception January, the high values of GI were greatly associated with the appearance of oocytes at stage IV during the period from April to October (Table, 1), indicating to the occurrence of breeding during that period.

In contrast, at Fishing Port, the values of GSI were represented by the lowest values compared with those recorded at Al- Gona and Grand Hotel. These values were varied from 2.65 to 6.77 (Table 2 and Figure 2). With the exception the value of GSI in November, the present results exhibited remarkable lengthy breeding season extends from March to December, with high peaks in gonadal activity in April (6.77) and December (6.70). However, the lowest values were recorded in November (2.63), January (2.72) and February (2.96) only. These results have also coincided with the appearance of mature eggs at stage IV as illustrated Table (1).

At Grand Hotel, the values of GSI were also relatively higher than those of the whole population and increased from 2.90 to 8.07. However, the values of GSI were increased from 6.02 in February and reached the highest value of 8.07 in May, but also has high values during June (7.75) and July (6.75), and declined slightly during August, September, October, and November to 5.08, 5.38, 4.66, and 4.90, respectively and reached the minimum value of 2.90 in December, but increased again to 3.90 in January (Table 2 and Figure 2). These values were coinciding with the appearance of mature oocytes at stage IV from February to June, but disappeared during the period from July to November and January and were associated with high percentages of oocytes at stage III during August –November (Table, 2).

Table (2): Monthly values in gonadosomatic index of *Herdmaina momus* from Hurghada coasts, Red Sea, during the period of this study.

Sites and indices / Months	Grand Hotel		Fishing Port		Al-Gona		All sites	
	Range	GSI	Range	GSI	Range	GSI	Range	GSI
January	0.23- 6.21	3.97	0.10- 4.90	2.72	7.94- 17.23	11.95	0.10-17.23	6.21
February	0.90-7.60	6.02	1.20-5.50	2.96	1.20- 6.70	3.97	0.90-7.60	4.32
March	0.20-6.50	3.42	2.30-6.00	3.76	3.8- 22.00	7.30	0.22- 22.00	4.83
April	0.90-5.70	3.64	1.6011.40	6.77	0.80- 11.50	8.03	0.80-11.50	6.15
May	0.90-6.90	8.07	0.20-6.50	3.79	1.30-11.50	5.73	0.20- 11.50	5.86
June	3.3010.20	7.75	0.20-8.40	3.70	3.20-15.00	8.01	0.20-15.00	6.47
July	2.20-7.30	6.75	1.20-7.80	4.09	4.10-12.00	8.10	1.20-12.00	6.28
August	3.0-8.07	5.08	1.90-6.80	4.00	2.60- 5.10	3.93	1.90-8.07	4.34
September	2.10-7.30	5.38	3.20-8.60	4.96	1.30-12.20	5.10	1.30-12.20	5.15
October	2.80-6.20	4.66	1.03- 6.10	3.53	1.49- 5.50	3.01	1.03-6.20	3.73
November	3.30-6.20	4.90	1.03- 4.40	2.65	0.09- 6.0	2.70	0.9- 6.20	3.42
December	0.70- 5.40	2.90	1.80-8.90	6.70	1.50-7.80	4.74	0.70- 8.90	4.78

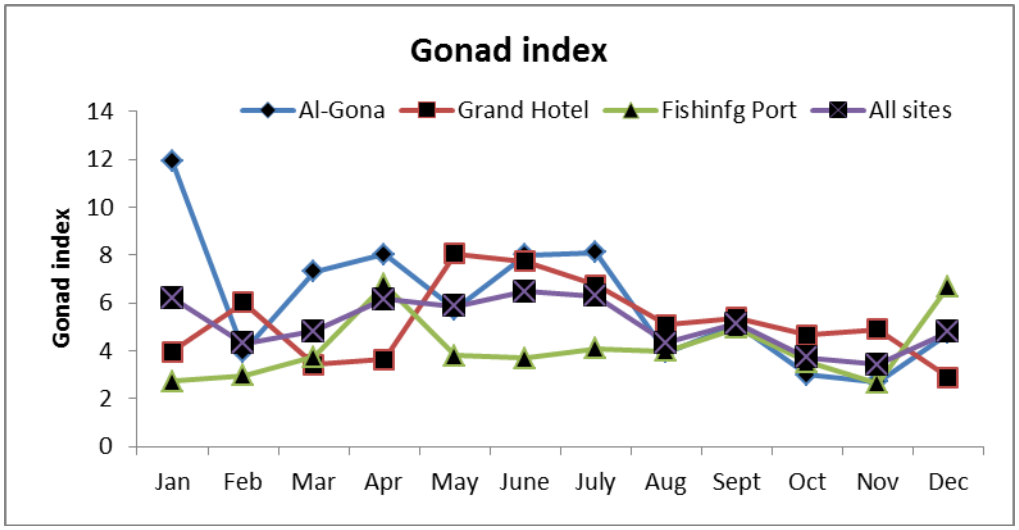

Figure (2): Monthly variations in gonad index of *Herdmania momus* from Hurghada, Red Sea, Egypt, during January- December, 2013.

G -Fecundity:

The number of mature eggs or fecundity within examined mature ovaries of *Herdamina momus* was calculated. The egg number showed remarkable spatial variations between sites and was varied from 1371 to 5976 eggs at Al-Gona, 1548 to 5884 eggs at Fishing Port and 932 to 5197 eggs at Grand Hotel, with averages of 2953.5±1532.47, 3042±1649.72 and 3253.38±1331.96 eggs, at the three sites,

respectively. For all sites, the number of eggs was varied from 1481 to 3724 and averaged of 3082.96±769.96 for all sites (Table, 3). These values exhibit greatly individual variations denoting to partially spawning for each individual.
The relationship between total body length (cm) and mean the number of eggs for each size interval showed an increase in egg number with an increase in the animal length. Therefore, the number of eggs or fecundity (F) exhibited positive correlation with total body length (L). The logarithmic relationships for the whole populations at the three sites and for each population at its specific site were calculated. These relations are represented by the following formulae:

Y= -2.981+0.7799 log X, r= 0.701(All sites)
Y= 3.023+0.657 log X, r= 0.4995 (Al Gona)
Y= 2.988 +0.886 log X, r= 0.836 (Fishing Port)
Y= 2.516+1.555 log X, r= 0.932 (Grand Hotel)

Where: Y= Egg number or fecundity, X= Total length.

These relations are statistically significant, showing curvilinear linear relationship indicating to decline in egg numbers with an increase in total body length. The regression coefficients "b' being lower than "1" at Al Gona and Fishing Port in addition to the whole population, but increased to 1.555 at Grand Hotel. Also, these relations have positive correlation coefficients ‘r’ showing highly significant values at Grand Hotel, but declined gradually throughout fishing port and all sites and reached the lowest of 0.4995 at Al Gona.

Table (3): Increasing number of ripe eggs with an increase in body length of *Herdamonia momus* from Hurghada coasts during the present study.

Body length (cm)	Average egg number at study sites			
	Al- Gona	Fishing Port	Grand Hotel	All sites
2.0	1962	1548	932	1481 ±518.29
2.5	1371	3109	1057	1846±1105.29
3.0	2694	2950	1815	2486±595.32
3.5	1496	2429	2749	2225±651.01
4.0	3985	2612	3985	3527±792.70
4.5	3164	3262	4059	3495±490.89
5.0	3190	4090	3367	3549±476.81
5.5	5976	Did not detected	5197	5586.5±550.83
6.0	1752	5884	3798	2066.03
Averages	2953.5±1532.47	3042±1649.72	3253.375±1331.96	3082.96±769.96

DISCUSSION

The solitary ascidian *Herdimania momus* belongs to family Pyuridae, and order Stolidobranchia, within class Ascidiacea (Vine, 1986; Gosliner *et al*. 1996; Shenkar, 2012). It lives between or under rocks and at the basis of death and live corals from very shallow to 15 m depth in the Red Sea and its associated gulfs (Suez and Aqaba) but can extend downwards to 100 m depth (Gosliner *et al*., 1996). This species is almost spherical, or cylindrical or globular in its general shape, characterized by short trumpet-shaped siphons. The margin of the oral siphon is conspicuously flared. The color of this species varied from tan molted with red and bluish –white. Its external surface contains small epizoides encrustations (Gosliner *et al*., 1996; Nishikawa, 2002. This species has the wide distribution in the western Atlantic and Indo- Pacific regions including Red Sea. It invaded the Mediterranean Sea through Suez Canal and become widely distributed in the eastern Mediterranean

(Por 1978; Galil, 2000; Shenkar, 2008, 2012).

During the present study, out of the five surveyed sites, the majority specimens of *H. momus* were collected only from three sites at Hurghada comprised Al Gona (20 km north of Hurghada), Fishing Port and from Grand Hotel jetty (at Hurghada City), while very few individuals were collected below 5 m depth at National Institute of Oceanography and Fisheries, and evidence on the occurrence of this species was recorded at mangrove swamps of south Safaga. These results indicated that, the occurrence of this species being correlated with increasing pollution and increasing organic wastes particularly oil pollution resulting from tourist ships at the three mentioned sites and this was confirmed by the complete absence of this species at mangroves of south Safaga and coast of NIOF. These results are in agreement with that mentioned by Shenkar(2008).

The laboratory investigations showed that, all examined individuals of *Herdmania momus* were hermaphrodites, with reproductive system has ovaries and testes at the same individuals. This gonad contains both ovaries and testes. The testes are observed attached on the ovary side. It was noticed that, the gut loop beings encloses the left gonad at the posterior end. These results agree with Newlon *et al.* (2003) and Shenkar (2012). However, there were remarkable differences in maturity stages of both organs in the same individuals, but ovaries were obviously clear and showed obscure ovarian maturation with oocytes at variable developmental maturity stages. These results are in full agreements with that reported by Lambert (2002) and Dijkstra *et al.* (2007 a,b). These authors mentioned that, in solitary ascidians fertilization and larval development usually occur in the water column but colonial species are brooders. Therefore, the solitary ascidians may be having a higher potential for dispersal to more distant locations. Nevertheless, it has been suggested that several colonial species have been introduced worldwide by hull fouling and aquaculture.

The present study exhibited that, oocytes of *H. momus* pass through four stages of egg maturation through which it increases in size due to deposition of yolk granules. These results are in accordance with that demonstrated by earlier studies such as Kessel (1983) Jeffery and Capco (1978) and Swalla *et al*. (1991). They distinguished 3 main stages of oogenesis based on the size, yolk content and pigmentation of oocytes: smaller pre-vitellogenic oocytes (stage I), vitellogenic oocytes (stage II) and larger postvitellogenic oocytes (stage III) which are those able to undergo maturation when released in sea water. The mature egg that is ready for fertilization could logically be called a mature stage IV oocyte. However, size of incubated eggs of *Herdmania momus* beings relatively smaller and ranged between 50 μm and 140 μm in diameter according to maturity stages.

The slight changes in numbers of this species may be attributed to its breeding behavior and occurrence. This species is benthic and lives at the rocky and hard substrates in the shallow subtidal zone. It also characterizes by lengthy breeding season accompanied by releasing larvae all the year around. Therefore, the number of juvenile settlement may equal the number of dead or eliminated old or aging individuals leading to semi-steady population density. However, its breeding was nearly continuous at Fishing Port, and to some extent at El- Gona due to continuous pollution increasing organic matter suitable for ascidian settlement. In contrast, at Grand Hotel only human impacts were related to increasing tourist activities, therefore, the breeding season was interrupted and last egg stages were disappeared in several months.

The current study revealed marked differences in reproductive efforts due to the spatial distribution of *H. momus*. At the study sites, *H momus* was found on settlement plates from shallow (< 1m) to 15m depth. The previous studies have demonstrated that ascidians can show differences in life history traits between subpopulations in different seas (Millar 1954; Davis 1989). Rocha *et al*. (1999) compared the body size of the solitary ascidian *Phallusia nigra* at São Sebastião, Brazil in a subtropical environment with a population studied in a Caribbean coral reef at Jamaica (Goodbody,1961,1962) and Gulf of Mexican (Brown and Swearingen, 1998).

In the present study, the smallest immature individuals have 1.2 cm in length, collected from Grand Hotel during November 2013, without any signs of gonads. While the smallest mature individuals were 1.46 cm in length and 1.18 g in weight and have ovary of 0.041 g in weight collected during August 2013 from site 3, compared with the largest immature individuals of 2.0 cm length and 2.0 g body weight collected in July 2013 from site 1.These results indicated that, all individuals larger than 2 cm are maturing and have gonads at variable maturity stages. Therefore, the monthly averages of gonadosomatic indices (GSI) of *H. momus* exhibited that, the whole populations of this species along the studied areas have lengthy breeding season extends nearly all the year around and characterizes with high peaks in gonadal activity during January, April, June, July, but declined slightly in May, February, March, August and December, and reached the minimum values in October and November. The values of GSI were correlated with increasing ratios of mature oocytes at stage IV and consider a good indicator for breeding season of this species. These results are to some extent in agreement with that recorded by Shenkar (2012) on population from the northern limit of Gulf of Aqaba which recorded high values in gonad indices (above 2%) of *H. momus* throughout the year (excluding April 2005, January and June 2006) with a strong peak (5.7 %) was measured during February, but no significant differences were detected between these values. In contrast to the Mediterranean populations which had low GSI during summer and winter months. This suggests that in the northern Red Sea this species reproduces year round.

The sexual reproduction of ascidians is regulating by several factors. The temperature may be the main factor as mentioned by Millar (1971), but other factors as food availability (Yamaguchi 1975, Sahade *et al*. 2004), turbidity (Millar 1974) and depth (Svane 1984) may also influence gametogenesis. The results of the present study showed that, *H. momus* reproduces all the year-round but with several peaks which reflect the optimum conditions at the selected sites which agree with Goodbody (1961), van Duyl *et al*. (1981) and Shenkar (2012).

On the other hand, the number of mature eggs of *H. momus* showed remarkable spatial variations between sites and averaged of 2953.5±1532.47, 3042±1649.72 and 3253.38±1331.96, at Al-Gona, Fishing, Port and Grand Hotel, respectively which may be attributed to favorite available environmental conditions and availability of food resources. The relationship between total body length (cm) and mean number of eggs for each size interval are statistically significant, showing linear relationship with relatively positive correlation coefficients for whole populations which agree well with that reported by Bagenal and Tesch (1978) on fishes and those reported by El- Sayed *et al*.(1998, 2014) on invertebrates.

In spite of these results, however, other studies are needed to give the complete picture on the other aspects of biology and ecology of this species and other ascidians in the Egyptian Red Sea waters.

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ARABIC SUMMERY

بيولوجية التكاثر في الأسيديا "هيردمانيا موماس" (الأسيديات: شعبة الذيلحبليات) من شواطيء الغردقة، البحر الأحمر، مصر

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تم دراسة بيولوجيا التناسل لنوع الأسيديا "هيردمانيا موماس" المنتشر بالبحر الأحمر في ثلاثة مواقع معرضة لأنواع مختلفة من الأنشطة البشرية الممتدة على سواحل الغردقة (البحر الأحمر) خلال الفترة من يناير إلى ديسمبر ٢٠١٣. ولقد جمعت عينات الدراسة بصفة شهرية من المنطقة الضحلة تحت المدية حيث تم تنظيفها وقياس أطوالها وتسجيل أوزانها. وأظهرت النتائج أن أفراد هذا النوع خناث تحمل الخصى والمبايض على نفس الحيوان الواحد وتتباين أطوالها فيما بين ١,٢ سم إلى ٧,٠ سم وأوزانها من ١,٢٨ جم إلى ٥٠و٠٠ جم، كما تم تسجيل أصغر حجم للأفراد الناضجة التي تحمل المناسل عند ١,٤٦ سم و ١,١٨ جم في الوزن الكلي مع احتوائها على مبايض وصل وزنها ٠.٠٤١ جم. ولقد ظهرت الدراسة الأفراد الناضجة جنسيا لهذا النوع تحمل المناسل وتحتوي المبايض على بويضات مختلفة الأحجام والألوان وتمر بأربع مراحل حتى تصل إلى تكوين البويضة الناضجة المعدة للتبويض التي تتميز باحتوائها على كثافة عالية من حبيبات المح ويتراوح قطرها فيما بين ١٠٠ ميكرون و١٤٠ ميكرون. وتظهر البويضات المتبقية التبويض متآكلة وتمثل المرحلة الخامسة أو فترة الراحة فيما بين المراحل الأربع الأخر في تطور البويضات داخل المبيض. وأظهر التكرار النسبي للبويضات الناضجة كبيرة الحجم والمتوسطات الشهرية لمؤشرات العلاقة بين وزن المناسل والوزن الكلي لجسم الحيوان وجود متوسم تكاثر يمتد طوال العام لجميع العشائر في مناطق الدراسة المختلفة يتميز بذروة في يناير(٦,٢١)، أبريل(٦,١٥)، يونية(٦.٤٩)، ويوليه(٦.٥٨)، إلا أنه يقل نسبيا في مايو(٥,٨٦) وسبتمبر(٥,١٥)، ويصل إلى إلى أدنى مستوياته في شهري أكتوبر(٣,٤٢) ونوفمبر(٣,٧٣) مع وجود اختلافات مكانية بين المواقع المختلفة وإن كانت تسير على نفس النمط إلا أنها تظهر أعلى القيم في عينات الجونة ولكنها تنخفض نسبيا في تجمعات جراند أوتيل وتصل إلى أقل قيمها في ميناء الصيادين. ولقد تم حساب الإخصابية لأفراد هذا النوع حيث تراوح عدد البويضات الناضجة من ١٤٨١ إلى ٣٧٢٤ بويضة بمتوسط عام ٣٠٨٢,٩٦ ± ٧٦٩.٩٦ بويضة لكل العشائر في مناطق الدراسة المختلفة مع وجود علاقات ارتباط بين عدد الويضات والطول الكلي للحيوان في كل المناطق، ويشير التفاوت الكبير في عدد البويضات إلى التبويض المتكرر للحيوان الواحد خلال نفس موسم التكاثر.