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Morphological and Anatomical Structure of *Aplysia fasciata*, (Poiret, 1789) Mollusca: Gastropoda: Aplysiidae in the Western Coast of Libya

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ABSTRACT

Aplysia fasciata is a peculiar marine gastropod that is a one of the Aplysiidae family. It is frequently seen in the eastern Atlantic Ocean and the Mediterranean Sea's coastal waters. This study investigated structure of morphological and anatomical of *A. fasciata*. Thirteen specimens of *A. fasciata* were obtained on 16th of June, 2022 during spawning season that were available significantly and abundantly. Specimens were kept in the laboratory in filtered seawater with a salinity of 37 ppt, pH 7± 0.5, room temperature 25°C, and water temperature 20°C. Until the samples are study the external form and then to study dissected internal organs, anatomical investigations. Morphological features usually coloured extremely dark brown. It has soft body is coated in a thick substance that resembles mucus and has two tentacle pairs, the largest pair being utilized for sensory awareness and react defensively to touch by retracting their gills into their protective mantle cavity. Had for thirteen *A. fasciata* their external measurements obtained in order to examine their physical attributes than dissected it was found the digestive tract is mostly composed of the foregut, midgut, and hindgut. The oesophagus and a buccal mass made up the foregut. A sizable crop, grinding plates, and a real stomach made up the midgut (digestive pouch). An intestine and a rectum comprise the hindgut. Reproductive system had both male and female reproductive organs. The reproductive system consists of ovotestis, small hermaphroditic duct, accessory genital masses, large hermaphroditic duct, seminal receptacle, spermatheca, genital aperture. The tiny and big hermaphroditic ducts are attached to this mass. The survival of *A. fasciata* depends on its intricate reproductive system. The inside shell in *A. fasciata* possesses a simple, It has a saucer like form, and a recurved, pointed umbo and rostrum that dangle over the concave interior. The shell is imbedded in the mantle. The exterior is coloured yollesh and features a sculpture of a few faint radiating lines, close-set concentric striae, and growth lines. Particularly *A. fasciata* are amazing animals with unusual behaviours and adaptations and their study offers insightful knowledge about marine life.

التركيب المورفولوجي والتشريحي لـ *Aplysia fasciata* (Poiret, 1789)، من الرخويات Gastropoda: Aplysiidae في الساحل الغربي لليبيا

نجلاء محمد أبو شعلة[1]*، محمد الشارف[2]، إدريس محمد منصور[3] وعبد الفتاح محمد الفيتوري[2]

Aplysia fasciata هو نوع غريب من بطنيات القدم البحرية وهو أحد فصيلة Aplysiidae يُرى بشكل متكرر في شرق المحيط الأطلسي والمياه الساحلية للبحر الأبيض المتوسط. بحثت هذه الدراسة في البنية المورفولوجية والتشريحية لـ *A. fasciata*. تم الحصول على ثلاثة عشر عينة من *A. fasciata* في 16 يونيو 2022 خلال موسم التزاوج والتي كانت متوفرة بشكل كبير ووفير. تم حفظ العينات في المختبر في مياه البحر المفلترة بملوحة 37 جزء في الألف ودرجة حموضة 7 ± 0.5 ودرجة حرارة الغرفة 25 درجة مئوية

ودرجة حرارة الماء 20 درجة مئوية. حتى تتم دراسة العينات الشكل الخارجي ثم دراسة الأعضاء الداخلية المشرحة. السمات المورفولوجية عادة ما تكون ملونة باللون البني الداكن للغاية. جسمها ناعم ومغطى بمادة سميكة تشبه المخاط ولها زوجان من المجسات، يستخدم الزوج الأكبر للوعي الحسي والرد دفاعيًا عند اللمس عن طريق سحب خياشيمها إلى تجويف الرداء الواقي. تم الحصول على قياسات خارجية لثلاثة عشر نوعًا من *A. fasciata* لفحص سماتها الجسدية ثم تشريحها ووجد أن الجهاز الهضمي يتكون في الغالب من الأمعاء الأمامية والأمعاء الوسطى والأمعاء الخلفية. يتكون المريء وكتلة خدية من الأمعاء الأمامية. يتكون الأمعاء الوسطى (الحقيبة الهضمية) من ألواح طحن ومعدة حقيقية. يتكون الأمعاء الخلفية من أمعاء ومستقيم. يحتوي الجهاز التناسلي على أعضاء تناسلية ذكورية وأنثوية. يتكون الجهاز التناسلي من خصية بيضوية وقناة خنثى صغيرة وكتل تناسلية إضافية وقناة خنثى كبيرة ووعاء منوي وحيوان منوي وفتحة تناسلية. ترتبط القنوات الخنثوية الصغيرة والكبيرة بهذه الكتلة. يعتمد بقاء *A. fasciata* على نظامها التناسلي المعقد. تمتلك القشرة الداخلية شكلًا بسيطًا، ولها شكل يشبه الصحن، وقبة منحنية مدببة ومنقار يتدلى فوق الجزء الداخلي المقعر. القشرة مدفونة في الوشاح. الجزء الخارجي ملون باللون الأصفر ويتميز بنحت لبضعة خطوط شعاعية خافتة وخطوط متحدة المركز وخطوط نمو. تعد *A. fasciata* بشكل خاص حيوانات مذهلة ذات سلوكيات وتكيفات غير عادية وتقدم دراستها معرفة ثاقبة عن الحياة البحرية.

INTRODUCTION

A.fasciata is a peculiar marine gastropod that is a one of the Aplysiidae family (Sethi et al., 2019). It is frequently seen in the eastern Atlantic Ocean and the Mediterranean Sea's coastal waters (Derby, 2007; Cunha and Simone, 2019; Ibrahim et al., 2020). The elongated body of the sea hare, which resembles the shape of a hare or rabbit, gives it its name. This strange animal has a delicate body coated in a viscous material that resembles mucus. Furthermore, it possesses two pairs of tentacles, the bigger of which is employed for sensory perception. As herbivores, sea hares consume algae and other marine vegetation for sustenance and their meat is inedible, and they are considered one of preserving the ecological equilibrium in their environments (Miller, 2020; Ibrahim et al., 2020 and Mehrotra et al., 2021). Some researchers believe that A. fasciata and A. brasiliana, which are both found along the Atlantic coast of the Americas, are the same species with only a differing regional colour pattern. A. fasciata has been reported in earlier research to reach lengths of up to 40cm. Usually, coloured black or extremely dark brown, the parapodia, foot, and tentacles may occasionally have a tiny red border around them. Moreover, a lot of them have body wide mottled patches. Like most sea slugs, A. fasciata has two oral tentacles and two additional, smaller rhinopores on its neck that are located in front. The rhinopores are in front of the eyes. They are small, circular tails are attached to their rear. It is internal organs and gills are covered in a mantle. There is a thin, fragile inner shell inside the mantle. The shell is concave, yellowish in colour, and has a slightly hooked apex. Its thin shell offers little protection. The ink gland resides inside the mantle and when threatened; they can release a purple ink like substance as a defence mechanism (Gonzalez et al., 2022).

Additionally, sea hares have a remarkable ability to regenerate lost body parts, such as their tails. Researchers continue to explore the biology and ecology of sea hares to gain a better understanding of these intriguing marine gastropods. Sea hares have developed a variety of survival techniques to help them live in their surroundings, despite their seeming vulnerability. They can move and travel through the water thanks to their powerful, muscular feet. They can also anchor themselves to rocks or other surfaces with the aid of this foot (Sethi et al., 2019 and Mehrotra et al., 2021).

Sea hares have both the male and female reproductive organs, making them may be sexually separated or may be hermaphrodite. If there are two couples, you can they participate in intricate mating rituals, sea hares are recognized for their unusual reproductive practices. They engage in elaborate mating rituals, where they exchange sperm packets. After fertilization, the sea hare lays thousands of eggs, which hatch into larvae and eventually develop into adult sea hares (Taïeb, 2001; Sethi et al., 2019; Nimbs and Wilson, 2021 and Elfituri and Abushaala, 2023).

They can find mates, evade predators, and look for food thanks to their effective swimming style. Apart from its anatomical modifications, A. fasciata display intriguing conduct. When handled or disturbed, they have been known to react apprehensively, retracting their gills and withdrawing inside their protective mantle cavity. They can stay safe and avoid possible threats thanks, to this defensive reaction. Though it's thought to be non-toxic, the ink is said to be secreted as a result of the sea hare being physically attacked. A. fasciata is known to consume seaweed and algae that are adhered to rocks and other surfaces. Sea hares exude a substance similar to ink. Eating red algae causes the ink to turn purple (Susswein et al., 1984). This research is concerned with studying external features of A. fasciata and internal anatomy, for samples collected from the western coast of Libya from the Northeast of the Tripoli city, Tajoura beach (Figure 1).

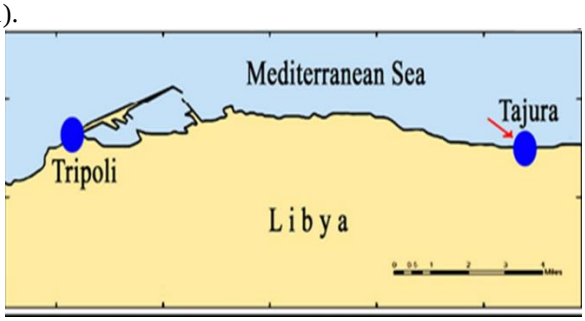

Figure (1): Map of the Mediterranean Sea showing the location of specimen' collection from Tripoli coast - Tajura beach

Materials and Methods

On June 2022, during spawning season, thirteen individuals of A. fasciata that were abundantly available. Were collected during a routine collection trip from the western coast of Libya, northeast of Tripoli city, by scuba diving sampling at a depth of 1–1.5meters 13°20' 59" E, 32°53' 46" N (Figure 1). The samples were examined for their morphological and anatomical. Individuals were maintained in the laboratory in filtered seawater at 37 ppt salinity, pH 7±0.5, room temperature 25°C, and water temperature 20°C (Figure 2). Were measure externally and whole body weight in mg, total body breadth in cm, and total length in cm. and measured the length of the tentacles in centimetres and the total length of the head in centimetres (Table 1). Then, anatomical studies were performed on specimens weighing more than 200g in order to examine dissected interior organs. Mettler PM600 was used to measure the total weight. An Olympus TG4 camera was used to take pictures of the specimens, and it has an automatic stacking mode. Excel 2016 was used to calculate the samples measurements' mean and standard deviation (Abushaala et al., 2022).

Results and discussion

Morphological features

All the individuals coloured extremely dark brown. The morphological features and external characteristics of A. fasciata has cephalic tentacles, two oral tentacles and two additional, smaller rhinopores on its neck that are located in front. The head contains the sensory organs, including the eyes and tentacles. There are two different kinds of tentacles as conical rhiophores that protrude dorsally from the surface of the neck and cephalic tentacles that resemble folds in the body wall. Furthermore, it possesses two pairs of tentacles, the bigger of which is employed for sensory perception. It has wide feet that help it move and stabilize itself on the substrate; also there is genital aperture, and genital groove. In addition, there is grinding plates; and the internal shell which gives suppport to her body; as for parapodia it is wide and flutters like a butterfly; the mantle and mantle cavity are housed in the two symmetrical parapodia that are separated posteriorly. Siphon and anus it is located in the back of it is a body. And for her small and circular tails are attached to their rear. A. fasciata exude a substance similar to ink turn purple. The ink gland resides inside the mantle and when threatened; they can release a purple ink-like substance as a defence mechanism (Figure. 2).

Thirteen A. fasciata specimens were measured externally. Total length/cm ranged from 11 to 19 cm, total body width/cm was 9.5 to 15.5 cm, and whole body weight was 444.7 to 75.14 mg. The dimensions of the head were as follows: the length of the tentacles was 0.6 to 1.8 cm, and the head measured between 3 and 7.5 cm (Table 1).

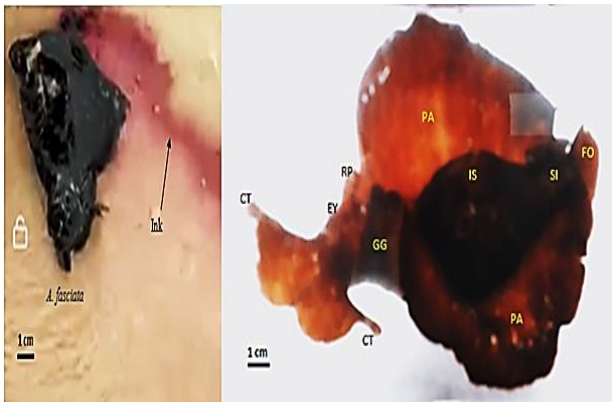

Figure (2): External features of A. fasciata CT, cephalic tentacles; EY, eye; FO, foot; GG, genital groove; PA, parapodia and SI, siphon.

Table (1): External Measurements of A. fasciata specimens.

No	Total length/cm	Total width/cm	Total weight/mg	Head length/cm	Length of tentacles/cm
1	15	13.5	135.1	5	1
2	12	10	98.6	3.5	0.6
3	19	14	316.3	6	1.3
4	19	13.3	444.7	7	1.3
5	17	15.5	264.1	5	1.4
6	17	12.5	285.6	7.5	0.9
7	11.7	11.7	125.2	5.2	0.9
8	11	9.5	75.14	3	0.8
9	18.5	15.5	257.6	3.5	1.8
10	13.6	12.2	126.7	5.2	1.2
11	17.4	15.2	263.1	6.3	1.4
12	14	15	220.2	5.5	1.2
13	13.3	11	85.3	4.5	0.9
Mean	**15.27**	**12.9**	**207.5**	**5.16**	**1.13**
Std.Deviation	**2.87**	**2.05**	**110.3**	**1.34**	**0.32**

The species of gastropods belonging to the subclass Opistobranchia, the most of A. fasciata, is a fascinating marine gastropod that is a member of the Aplysiidae family. It is found in the eastern Atlantic Ocean and the Mediterranean Sea's coastal waters (Derby, 2007; Dirrigl et al., 2018; Ibrahim et al., 2020). The soft body of the sea hare is coated in a thick substance that resembles mucus, giving it a peculiar body shape. It has two tentacle pairs; the largest pair being utilized for sensory awareness. As herbivores that consume algae and other marine plants, sea hares are essential to preserving the ecological balance of their environments (Lee et al., 2015). Their beautiful motions and effective swimming behaviour can be attributed to their bilateral symmetry and streamlined body structure. In addition, A. fasciata react defensively to touch by retracting their gills and siphoning into their protective mantle cavity (Gonzalez et al., 2022).

Morphological features A. fasciata is squat in appearance and has an extended, very thin shell, but the fleshy mantle that creates two broad flaps like extensions on the rear

completely covers the shell. The foot extends backwards and is incredibly wide. The head has two pairs of tentacle like extensions and is somewhat elongated. The two rear tentacles are fairly extended and near to one another; this may be a reference to the shape and placement of a hare's ears, which is where the popular name sea hare originated. The colour is a dark brown that is nearly consistent. The form of the mouth can vary greatly, being either semicircular or circular (Nimbs and Wilson, 2021). The name of the subclass Opisthobranchs, which means gill placed behind, originates from the special gill that sea hares use to breathe, which is located inside the pallium cavity behind the heart. The lone gill is also covered. Because of this, this mollusc is assigned to the order of the Tectibranchs (Tettibranchia), just like the other Aplysia species (Ibrahim et al., 2020).

Anatomy

It is internal organs and gills are covered in a mantle. The digestive gland occupies the majority of A. fasciata's body cavity and is essential for breaking down food and drawing nutrients out of it. This organ is a reflection of the herbivorous diet algae that the sea hare consumes. Within the body cavity of A. fasciata, the digestive tract is mostly composed of the foregut, midgut, and hindgut. The oesophagus, two salivary glands, and a buccal mass made up the foregut. A sizable crop, grinding plates, and a real stomach made up the midgut (digestive pouch). An intestine and a rectum comprise the hindgut. There is a ganglion on top of the oesophagus posterior to the huge, dark red buccal mass. The broad, dark gray in colour, the thin-walled crop makes contact with the oesophagus. It is full of algae and serves as a storage area. Large pyramidal teeth line the inner wall of the anterior gizzard. The actual stomach, which is a tiny digestive pouch, is the opening for the posterior gizzard. The abdomen empties into a huge gray brown digestive gland that is lodged in a gray brown gut with thin walls. After coiling multiple times via the digestive gland, the intestine contracts into the anus (Figure. 3).

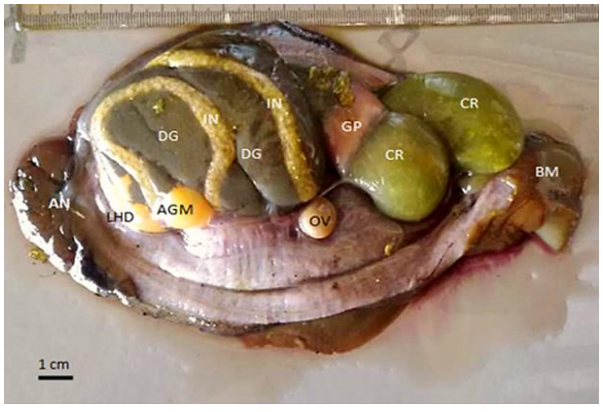

Figure (3): The anatomy of A. fasciata is shown in the anatomical feature of the digestive system. BM, buccal mass; CR, crop; GP, grinding plates; IN, intestine; DG, the digestive gland; AN, anus; and part of the reproductive system (OV, ovotestis; AGM, accessory genital mass; LHD, the large hermaphroditic duct).

Internal anatomy thirteen A. fasciata individuals had their external measurements obtained in order to examine their physical attributes. The digestive gland occupies the majority of A. fasciata's body cavity and is essential for breaking down food and drawing nutrients out of it. This organ is a reflection of the herbivorous diet algae that the sea hare consumes. The significance of the digestive gland in the physiology of the sea hare is shown by its massive size and central location within the body (Sethi et al., 2019; Nimbs and Wilson, 2021 and (Lombardo and Marletta, 2022). Knowing this organ's shape and function helps we better understand A. fasciata's ecological role in marine ecosystems (Sethi et al., 2017 and Lombardo and Marletta, 2022). Within the body cavity of A. fasciata, the digestive tract is mostly composed of the foregut, midgut, and hindgut. The oesophagus, two salivary glands, and a buccal mass made up the foregut. A sizable crop, grinding plates, and a real stomach made up the midgut (digestive pouch). An intestine and a rectum comprise the hindgut. There is a ganglion on top of the oesophagus posterior to the huge, dark red buccal mass. The wide, thin walled crop that makes contact with the oesophagus has a grayish black colour. It is full of algae and serves as a storage area. Large pyramidal teeth line the inner wall of the anterior gizzard, also referred to as the stomach made of red muscular fibres, or the triturative stomach. The actual stomach, which is a tiny digestive pouch, is the opening of the posterior gizzard. The stomach empties into huge gray brown digestive gland that is embedded in a gray brown intestine with thin walls. After coiling multiple times via the digestive gland, the intestine contracts into the anus (Sethi et al., 2019, Lombardo and Marletta, 2022).

Reproductive system

A. fasciata is a hermaphrodite creature that reproduces. It reproduces via self-fertilization solely in the absence of a mate because it possesses both masculine and feminine sexual organs. The ampulla, accessory genital mass, ovotestis, small hermaphroditic duct, and large hermaphroditic duct make up A. fasciata's reproductive system. The small hermaphroditic duct transports eggs from the posterior ovotestis to the accessory genital mass following ovulation. The extra genital mass is connected to the great hermaphroditic duct (Figure 4).

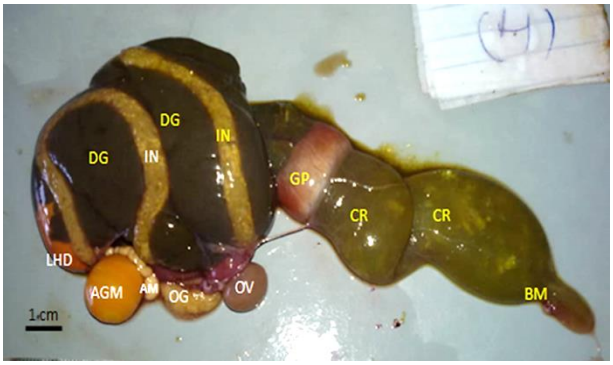

Figure (4): The reproductive system of A. fasciata, anatomical features. OV, ovotestis; OG, the opaline gland; AM, ampulla; AGM, accessory genital mass; LHD, the large hermaphroditic duct.

Reproductive system sea hares A. fasciata have both male and female reproductive organs, making them may be sexually separated or may be hermaphrodite (Sethi et al., 2019). If there are two couples, you can they participate in intricate mating rituals, sea hares are recognized for their unusual reproductive practices. They engage in elaborate mating rituals, where they exchange sperm packets. After fertilization, the sea hare lays thousands of eggs, which hatch into larvae and eventually develop into adult sea hares (Elfituri and Abushaala, 2023). The ovotestis, small hermaphroditic duct, accessory genital masses, large hermaphroditic duct, seminal receptacle, spermatheca, genital aperture, and genital groove make up the opisthobranch reproductive system (Lee, 2008). Ovotestis single unpaired gonad of A. fasciata, is coloured orange yellow. It is typically deeply ingrained in the digestive gland. Which is brownish the ovotestis, which is made up of several follicles, divides the tiny hermaphroditic duct at its opening (Figure 3). The same follicles produce both the oocytes and spermatozoa, which gather into the little hermaphroditic duct's division. Small hermaphroditic duct when it emerges from the ovotestis, the little hermaphroditic duct is comparatively thin and straight; as it gets closer to the supplementary genital mass, it gradually widens and becomes more twisted. The ampulla, a broad section of the tiny duct hermaphrodite, serves as a storage organ for oviduct and endogenous sperm. Accessory genital mass the auxiliary genital mass, a huge hemispherical organ with an orange yellow tint, is situated on the hemocoelom's floor. Three glands make up the accessory genital mass: the mucus gland, the membrane (winding) gland, and the albumen gland (Taïeb, 2001; Nimbs and Wilson, 2021). The tiny and big hermaphroditic ducts are attached to this mass. The survival of A. fasciata depends on its intricate reproductive system. It starts with the large scale generation of eggs, which are followed by the development of swimming larvae (Elfituri and Abushaala, 2023). Moreover, to ensuring the species' survival, this reproductive technique supports coastal environments' biological balance and biodiversity.

Description of the inside shell

A. fasciata possesses a simple, vestigial shell. Its height, which makes up around 30% of the animal's length, can reach up to 40% at times. It has a saucer like form, and a recurved, pointed umbo and rostrum that dangle over the concave interior. It has asymmetrical ears on either side of the rostrum. The shell is imbedded in the mantle, which forms the visceral mass's dorsal body wall. There has one big, folding gill beneath the shell. The exterior is colored amber and features a sculpture of a few faint radiating lines, close set concentric striae, and growth lines. A living animal's mantle conceals the shell, with the exception of the absence of a circular foramen operculum (Figure 5).

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The shell's dorsal and exterior faces are depicted, along with the umbo (rostrum), embayment periostracum layer that forms a broad, flexible border, and the inner shell layer, which is a thin, fragile, but is held in place by periostracum and faint radiating lines. The shell endowed of thin shell that provides minimal protection (Karachle et al., 2016).

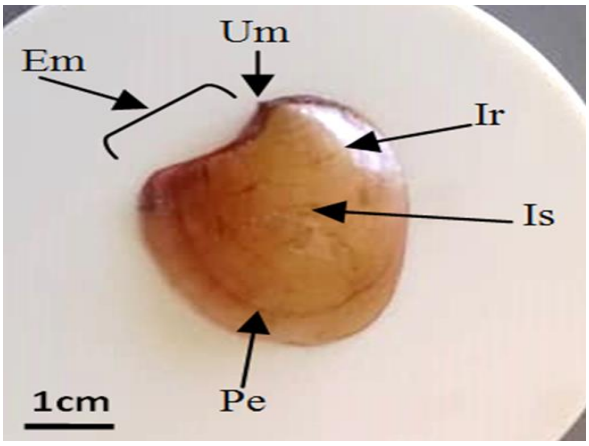

Figure (5): Dorsal and exterior face for shell. Um, Umbo (rostrum); Em, Embayment; Pe, Periostracum layer extends to form broad flexible border; Is, Inner shell layer is a thin, fragile, semi calcareous layer, fractured into pieces but held in place by periostracum. Ir, Indistinct radiating lines.

CONCLUSION

Morphological features usually coloured extremely dark brown. A. fasciata has soft a body is coated in a thick substance that resembles mucus. It possesses two pairs of tentacles; the larger pair is used for sensory awareness and retracts its gills into its protective mantle cavity in a defensive manner in response to touch. Internal anatomy thirteen A. fasciata had their external measurements obtained in order to examine their physical attributes than dissected it was found the digestive tract is mostly composed of the foregut, midgut, and hindgut. The oesophagus and a buccal mass made up the foregut. The midgut consisted of a large crop, grinding plates, and a true stomach (digestive pouch). An intestine and a rectum comprise the hindgut. The reproductive system had both male and female reproductive organs, making them may be sexually separated or may be hermaphrodite. The seminal receptacle, spermatheca, genital aperture, small hermaphroditic duct, accessory genital masses, and large hermaphroditic duct make up the reproductive system. The tiny and big hermaphroditic ducts are attached to this mass. The survival of A. fasciata depends on its intricate reproductive system. It starts with the large scale

generation of eggs to ensuring the species survival, this reproductive technique supports coastal environments' biological balance and biodiversity. The inside shell in A. fasciata possesses a simple, its shape resembles a saucer, and its pointed umbo and rostrum dangle over the interior's concave shape. The shell is imbedded in the mantle. The exterior is coloured yollesh and features a sculpture of a few faint radiating lines, close set concentric striae, and growth lines. Particularly A. fasciata are amazing animals with unusual behaviours and adaptations. Sea hares are capable of growing enormous amounts of eggs and the regeneration of lost body parts and exude a purple ink as a protection mechanism and their study offers insightful knowledge about marine life.

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