

Histological studies of some internal organs from the Freshwater Mite, *Unionicola aegyptiaca* collected from the Mussel, *Caelatura aegyptiaca*, Sohag, Egypt.

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Abstract: This study investigates the digestive system of freshwater mite, *Unionicola aegyptiaca* which starts with an anteroventrally mouth opening and ends with a posterodorsally anal opening. This system occupies a major portion of the body cavity and consists of three main parts: the foregut (mouth, muscular pharynx and oesophagus), the midgut (ventriculus with its associated three pairs of gastric caeca) and the hindgut (rectal tube and rectum). A pair of salivary glands is situated ventrolaterally in the anterior end of the body cavity. The main excretory system of the present freshwater mite consists of a pair of elongated Malpighian (excretory) tubules which extends along the length of the body. The nervous system of the present species consists of a central nerve mass (brain) with several nerve trunks that branched to supply nerves to various body parts. The brain is separated into two regions: supraoesophageal and suboesophageal nervous masses.

Keywords: Internal anatomy – Histology – *Unionicola aegyptiaca* – *Caelatura aegyptiaca* – Egypt.

1 Introduction

Internal anatomical and histological studies on some species of mites were done by several authors e.g. [1] for *Tetranychus telarius*; [2] for *Echionlaelaps echidninus*; [3] for *Caloglyphus mycophagus*; [4] for *Dermatophagoides farinae*; [5] for *Lardoglyphus konoi*; [6] for *Archeogozetes longisetosus*; [7] for some species of *Brevipalpus* mites; [8] for *Dermanyssus gallinae* and [9] for *Tetranychus urticae*.

The internal anatomy of some mite species is described depending on the whole mounts and serial histological sections [2,8,9]. Generally, the digestive system of mites is organized into three recognizable parts: the foregut (mouth, muscular pharynx and oesophagus), midgut (ventriculus with its associated gastric caeca) and hindgut (rectal tube and rectum) [2,5,6,7,8,9,10,11].

The excretory system of mites consists of a pair of elongated Malpighian (excretory) tubules which extends along the length of the body [2,9]. The excretory system of *Echionlaelaps echidninus* and *Tetranychus urticae* have been studied in detail [2,9].

The nervous system of mites is a clustered region of nervous tissue known as the synganglion in the anterior section of idiosoma and anterior to the midgut [2,8].

In general, the brain is separated into two regions, the supraoesophageal and the suboesophageal nervous masses as reported by [12] for the mites, *Dermatophagoides pteronyssinus*; [2] for *Echionlaelaps echidninus* and [8] for *Dermanyssus gallinae*. The present work aims to study the internal anatomy and histology of digestive, excretory and nervous systems of unionicolid mite, *Unionicola aegyptiaca* [13] which collected from the freshwater mussel, *Caelatura aegyptiaca*.

2 Literature Review

The specimens of freshwater mussel, *Caelatura aegyptiaca* were collected from the western bank of the River Nile about 1km from Girga city, Sohag Governorate. The mussels were collected about 5m off the shore and at 1.5 to 2m depth during April 2016.

For separating the mites from the mussels, the tissues and mantle cavity of each mussel were searched for adult mites. The soft parts of the mussels were repeatedly washed by a jet of water and the rinsing water was examined under a binocular microscope. The mites were picked up from the soft tissues and mantle cavity using a fine pointed dissecting needle or a fine camel's hair brush. The adults were collected, counted and temporarily preserved in 70% ethanol for 3-5 days.

For the histological study, the specimens of both sexes of freshwater mite, *Unionicola aegyptiaca* from the freshwater mussel, *Caelatura aegyptiaca* were fixed with

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Carnoy's fluid, dehydrated in a graded series of alcohols, embedded in paraffin wax, sectioned at 3- 5 μm and stained with haematoxylin and eosin. The stained sections were examined under a research microscope and then photographed using Zeiss light microscopy.

3 Results

3.1. The digestive system

3.1.A. Digestive system organs

In whole mounts, the digestive system of both sexes of the adult freshwater mite, *U. aegyptiaca* starts with an anteroventrally mouth opening and ends with a posterodorsally anal opening. In general, this system occupies a major portion of the body cavity and consists of three main parts: the foregut (mouth, muscular pharynx and oesophagus), the midgut (ventriculus with its associated three pairs of gastric caeca) and the hindgut (rectal tube and rectum) (Fig. 1).

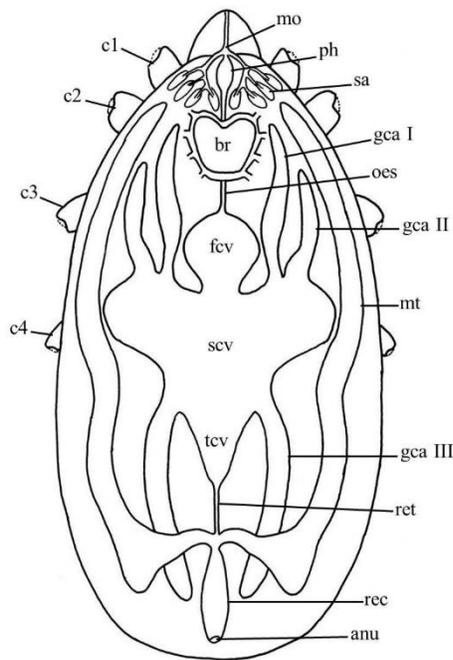


Fig. 1: Diagrammatic drawing of an adult *Unionicola aegyptiaca* showing the digestive, excretory and nervous systems.

The mouth opens into the muscular pharynx, which ends posteriorly in a thin oesophagus. The oesophagus passes posteriorly through the brain mass and then turns sharply upward to enter the ventriculus of the midgut on the posteroventral side of its first median chamber. The midgut is located in the central of the body cavity, proximally between the third pair of legs. The midgut is composed of three central chambers associated with three pairs of gastric caeca. The ventriculus of the midgut has three central chambers (first, second and third). The first median chamber of the ventriculus is small in comparison

to the other parts of the ventriculus and gives rise anteriorly to a thin oesophagus. Posterior to the first median chamber the ventriculus broadens and form the second median chamber which gives rise to three pairs of gastric caeca. The first two pairs and the third one of gastric caeca arise from the anterolateral and posterolateral margins of the second median chamber of ventriculus, respectively. The second median chamber extends posteriorly to form a narrow third median chamber which enters the rectal tube to the rectum (Fig. 1; Pl. 1a, b). It is likely to note that, the midgut of fed mite specimens increased in size and decreased in the unfed mites (Pl. 1c).

Histologically, the muscular pharynx is an oval in cross-section with dark stained walls. The pharynx is surrounded by two sets of muscles (depressors and dilators). The depressor muscles are several in numbers and extend transversely along the entire length of the pharynx. The dilator muscles are five pairs in number with the members of the pair arranged in lateral rows on either side of the median line of the pharynx (Pl. 1e- h).

The oesophagus is oval in cross-section and passes longitudinally and obliquely through the brain (suboesophageal nervous mass), therefore, it appears as a foramen within the brain mass. The oesophageal wall has distinct small round nuclei, though no cell structure that can be seen (Pls 1e, g, h, 2a, b).

In histological sections, the midgut is composed of a single layer of epithelium that surrounds the midgut lumen. The epithelial cells of ventriculus chambers and gastric caeca have different shapes; cuboidal, polygonal and columnar. These cells are characterized by vacuolated cytoplasm and dark distinct nuclei with nucleoli. It is likely to note that, the lumens of the ventriculus and gastric caeca contain groups of cells surrounding the food materials to form large intracellular vacuoles and are known as free cells. These cells are proliferating, small in size and circular in shape with clear cytoplasm and a small distinct nucleus (Pl. 2c- h).

The rectal tube of the hindgut leaves the posteroventral wall of the ventriculus and passes medially to the rectum. In histological sections, the epithelial cells of the rectal tube are dark stained and irregular in shape with large circular nuclei and distinct nucleoli (Pl. 3a). The rectum is the posterior part of the digestive system is often distended greatly with accumulating waste materials from the rectal tube or excretory tubules (Malpighian tubules). The epithelial cells of the rectum are irregular, compact and stained more deeply than those of the rectal tube. The rectum empties the faeces dorsally into the anus of the body (Pl. 3b).

3.1.B. Salivary glands

A pair of salivary glands is situated ventrolaterally in the anterior end of the body cavity (Fig. 1; Pl. 3c, e). The anterior end of each gland is tapering narrower than the posterior one and reaches up to the base of the chelicera.

While the posterior one of each gland is directed into the body cavity and reaches up to the point of the anterior gastric caeca. In transverse sections, the gland proper consists of large cells which are highly vacuolated, granulated and contain prominent deeply staining nuclei.

Because of the vacuolation, the cytoplasm is very sparse within the cells (Pl. 3d).

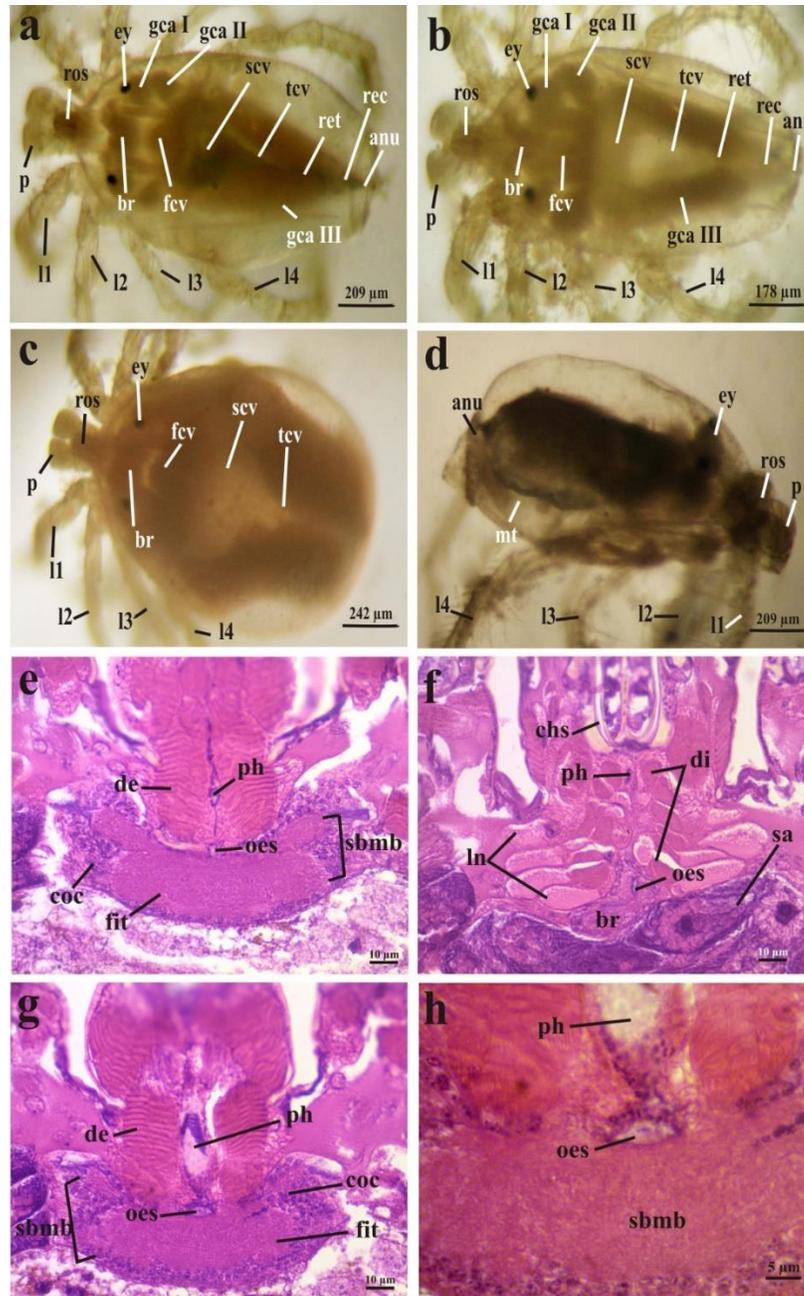


Plate 1a-h. Photomicrographs of adults (a-d) and histological sections through the foregut and brain of adult female *Unionicola aegyptiaca* (e-h). (a) The digestive and nervous systems of unfed female. (b) The digestive and nervous systems of unfed male. (c) The digestive system in fed female. (d) The Malpighian (excretory) tubules of an adult female. (e) Wall and depressor muscles of the pharynx and the beginning position of the oesophagus. (f) Dilator muscles of pharynx. (g) The opened pharynx. (h) An enlarged part from (Pl. 1g) showing the epithelial cells of the oesophageal and pharynx walls.

3.II. The excretory system:

The main excretory system of the present freshwater mite, *U. aegyptiaca* consists of a pair of elongated Malpighian (excretory) tubules which extends along the length of the body (Fig. 1; Pls 1d, 3c, e). These tubules extend anteriorly to reach the coxae of leg I and salivary glands. The excretory tubules extend back inwardly and slightly ventral

to the posterior gastric caeca and pass under the ventriculus. Posteriorly, these tubules extend to empty into the beginning of the rectum to the anus.

The cells of excretory tubules are large in size, compact and irregular in shape with distinct dark stained nuclei and nucleoli. The circumference of the tubule varies from three to five cells (Pl. 3f).

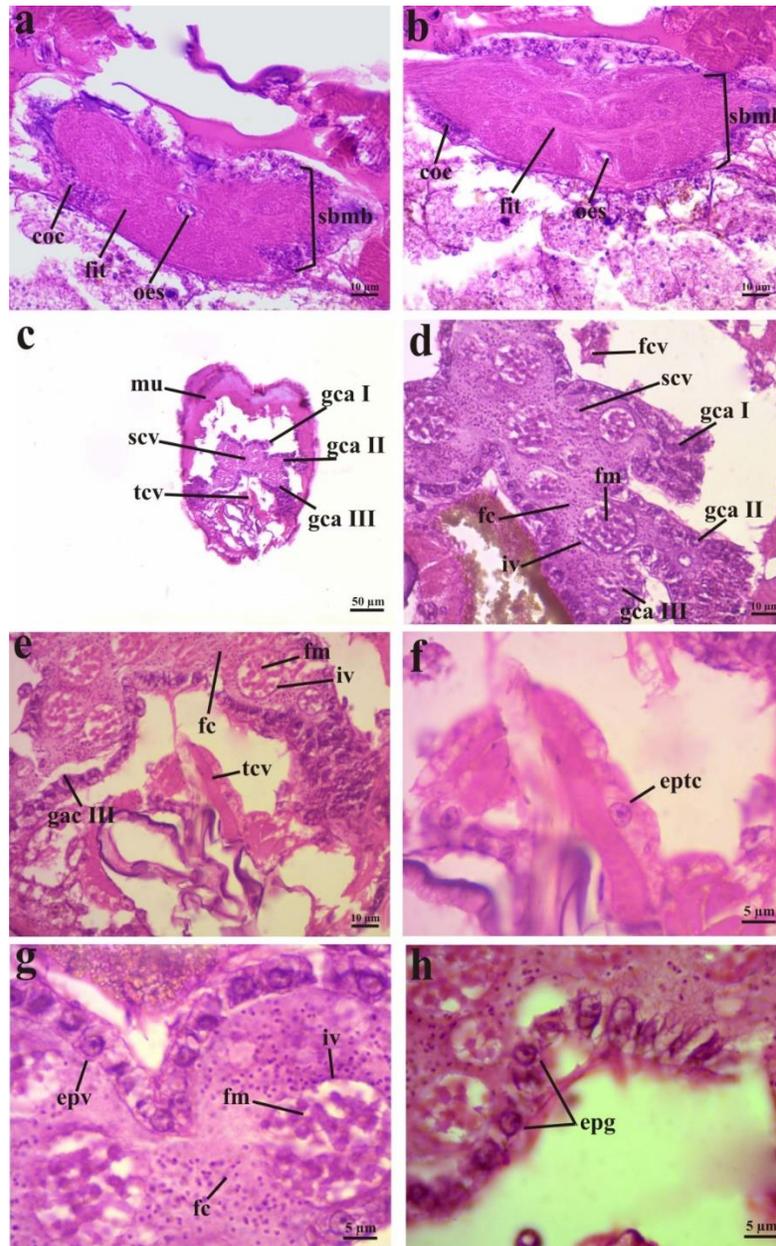


Plate 2a-h. Photomicrographs of histological sections through the suboesophageal mass of brain of adult female (a-b), midgut and ventriculus of adult male *Unionicola aegyptiaca* (c-h). (a) The middle position of the oesophagus. (b) The end position of the oesophagus. (c) The second and third ventricular chambers. (d) An enlarged part from (Pl. 2c) showing free cells and intracellular vacuoles within the ventriculus. (e) An enlarged part from (Pl. 2c) showing the third median chamber of ventriculus. (f) An enlarged part from (Pl. 2e) showing the epithelial cells of the third median chamber wall. (g) The epithelial cells of the ventriculus wall. (h) The epithelial cells of gastric caeca.

3.III. The nervous system

Histologically, the nervous system of the present freshwater mite, *U. aegyptiaca* consists of a central nerve mass (brain) with several nerve trunks that branched to supply nerves to various body parts. The brain is located anteroventrally in the body cavity and surrounded by a neurolemmal sheath. It is separated into two regions, supraoesophageal and suboesophageal nervous masses (Fig. 1). There are four pairs of pedal ganglia extending distally from the supraoesophageal nervous mass and an additional pair of gnathosomal ganglia (Pl. 3g, h).

The suboesophageal nervous mass is bisected longitudinally by the oesophagus (Pls 1e, g, h, 2a, b). The brain mass has two layers; external and internal layers. The external layer is characterized by small rounded deeply staining cortical cells, while the internal layer is lightly staining fibrous tissue (Pls 1e, g, h, 2a, b, 3g, h). The nerves are classified into two groups according to their origin. The first group is originated from the supraoesophageal nervous mass and includes the nerves of gnathosoma and ventriculus. While the second group is originated from the suboesophageal nervous mass and includes the nerves of the legs and opisthosoma (Pl. 1f).

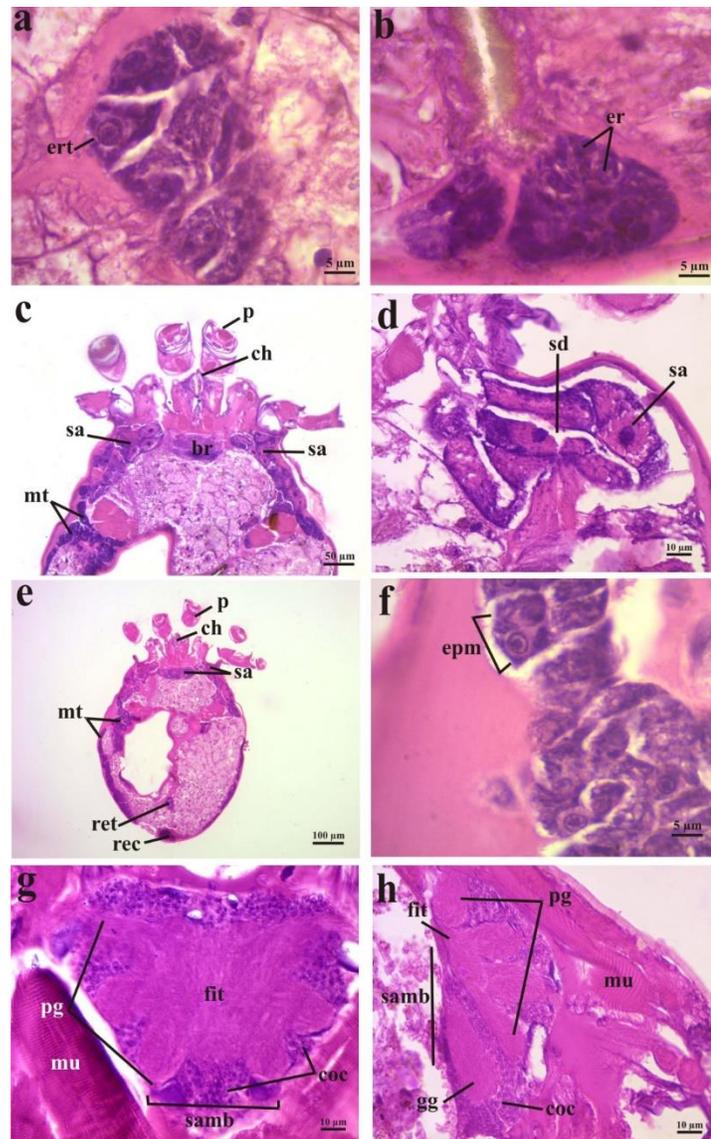


Plate 3a-h. Photomicrographs of histological sections through the body (a-f) and the supraoesophageal mass of brain of adult female *Unionicola aegyptiaca* (g-h). (a) The epithelial cells of rectal tube. (b) The epithelial cells of the rectum. (c) Salivary glands and Malpighian (excretory) tubules. (d) An enlarged part from (Pl. 3c) showing the salivary gland and its duct. (e) The Malpighian (excretory) tubules. (f) An enlarged part from (Pl. 3e) showing the epithelial cells of Malpighian tubules. (g) The pedal ganglia. (h) Lateral view of gnathosomal and pedal ganglia.

4 Discussion

4.I. The digestive system

4.I.A. Digestive system organs

The present investigation revealed that the digestive system of both sexes of adult freshwater mite, *Unionicola aegyptiaca* occupied a major portion of the body cavity

and consisted of three main parts: the foregut (mouth, muscular pharynx and oesophagus), the midgut (ventriculus with its associated three pairs of gastric caeca) and the hindgut (rectal tube and rectum). The same results were recorded by [2] for mite, *Echionlaelaps echidninus*. The nomenclature was proposed by some authors for divisions of the digestive systems of several mites (Table 1).

Table 1: The nomenclature of the digestive system divisions of the present species and the other published mites.

Mite species	Digestive system			Source
	Foregut	Midgut	Hindgut	
<i>Unionicola aegyptiaca</i>	mouth, pharynx oesophagus	ventriculus with three pairs of gastric caeca	rectal tube, rectum	present work
<i>Glycyphagus platygaster</i>	pharynx, oesophagus	ventriculus, colon	rectum, anus	[14]
Acaridei	pharynx, oesophagus	midgut, intestine	colon, rectum, anus	[15]
all mites	pharynx, oesophagus	stomach or ventriculus, intestine	rectum, anus	[16]
<i>Echionlaelaps echidninus</i>	mouth, pharynx oesophagus	ventriculus with three pairs of gastric caeca	rectal tube, rectum	[2]
<i>Caloglyphus berlesei</i>	pharynx, oesophagus	ventriculus, colon	post-colon, rectum, anus	[17]
<i>Caloglyphus mycophagus</i>	pharynx, oesophagus	stomach, colon	rectum, anus	[18]
<i>Dermatophagoides farinae</i>	pharynx, oesophagus	anterior midgut with two gastric caeca, posterior midgut	anterior hindgut, posterior hindgut	[4]
<i>Lardoglyphus konoii</i>	mouth, pharynx oesophagus	stomach with a pair of caeca	colon, rectum anal opening	[5]
Archezogetes longisetosus and Brevipalpus mites	preoral cavity, mouth, pharynx oesophagus	anterior midgut (ventriculus, paired caeca); postventricular midgut (colon, postcolon)	anal atrium, anus (anal opening)	[6,7]
<i>Dermanyssus gallinae</i>	mouth, pharynx oesophagus	ventriculus with three pairs of gastric caeca	hindgut	[8]
<i>Tetranychus urticae</i>	mouth, pharynx oesophagus	ventriculus, caeca, posterior midgut	hindgut	[9]

In the present work, the oesophagus of the present species, *U. aegyptiaca* passed posteriorly through the brain mass and then turned to enter the ventriculus of the midgut. Similar results were illustrated for some species of mites such as *Echionlaelaps echidninus* [2]; *Lardoglyphus konoii* [5]; *Archezogetes longisetosus* [6]; *Brevipalpus* mites [7]; *Dermanyssus gallinae* [8] and *Tetranychus urticae* [9].

The midgut of the present species, *U. aegyptiaca* is located in the central part of the body cavity proximally between the third pair of legs. In addition, the midgut of fed mite specimens increased in size and decreased in the unfed mites. These investigations are in accordance to that illustrated by [2] for mite, *Echionlaelaps echidninus* and [8] for mite, *Dermanyssus gallinae*. The ventriculus of the present species is composed of three central chambers. These findings are agreed with [2] for *Echionlaelaps echidninus*. Table (1) illustrates the number of midgut chambers and their caeca for some species of mites.

Histologically, the pharynx of the present species, *U. aegyptiaca* is oval in shaped with dark stained walls. Similar data reported by [9] for mite, *Tetranychus urticae*. However, the pharynx had different shapes in some mites e.g. It was triangular-shaped in *Echionlaelaps echidninus* [2], crescent-shaped in *Caloglyphus mycophagus* [3], *Lardoglyphus konoii* [5] and *Archezogetes longisetosus* [6]

and inverted T-shaped in *Brevipalpus* mites [7].

The pharynx of *U. aegyptiaca* is surrounded by depressor and dilator muscles. These results are in accordance with the pharyngeal muscles of mites, *Echionlaelaps echidninus* [2], *Dermatophagoides farinae* [4], *Lardoglyphus konoii* [5] and *Archezogetes longisetosus* [6], but, the pharynx of some species of *Brevipalpus* mites was surrounded by dilator muscles only, while the depressor muscles were lacking [7]. The present investigation showed that the depressor muscles of pharynx of the present species, *U. aegyptiaca* were several in numbers and the dilator muscles are five pairs in number. Similar observations were mentioned for mites, *Dermatophagoides farinae* [4] and *Lardoglyphus konoii* [5]. The present results showed that the oesophagus of the present species, *U. aegyptiaca* passed through the brain mass and its oesophageal wall has distinct small round nuclei. Similar data was recorded for mites, *Echionlaelaps echidninus* [2] and *Lardoglyphus konoii* [5].

Histologically, the wall of the ventriculus chambers and gastric caeca of the present species, *U. aegyptiaca* composes of a single layer of epithelial cells which has different shapes; cuboidal, polygonal and columnar. These cells are characterized by vacuolated cytoplasm and dark distinct nuclei with nucleoli. However, the epithelial cells showed different shapes in other mites such as columnar and

globular for, *Lardoglyphus konoii* [5]; columnar and cuboidal for *Archezogozetes longisetosus* [6] and cuboidal, squamous, rounded and flat for *Tetranychus urticae* [9]. On the other hand, it was reported that the wall of the ventriculus chambers and gastric caeca of mite, *Echionlaelaps echidninus* had two layers; outer and inner epithelial cell which were small flattened and large irregularly columnar in the two layers, respectively [2]. The same author also recorded that the epithelial cells of both layers had small round nuclei and vacuolated cytoplasm in an inner layer only.

The lumen free cells of the ventriculus and gastric caeca of the present species, *U. aegyptiaca* are proliferating, small in size, circular in shape with clear cytoplasm and a small distinct nucleus. The present study suggested that these cells are able to supply the digestive juices, engulf the ingested food materials and form large vacuoles for intracellular digestion. The same results were mentioned by [2] for *Echionlaelaps echidninus*; [8] for *Dermanyssus gallinae* and [9] for *Tetranychus urticae*. [8] suggested that the free cells detached from the gut mucosa and were able to engulf ingested materials within the gut lumen becoming swollen and highly vacuolated.

The present investigation showed that the epithelial cells of the rectal tube and rectum of the hindgut of the present species, *U. aegyptiaca* are irregular in shape and dark stained. Similar results were recorded for mite, *Echionlaelaps echidninus* [2]. The epithelial cells of the colon and rectum of the hindgut of mite, *Lardoglyphus konoii* were pavement-like, flattened, squamous and tall, wedge-shaped, respectively [5].

4.I.B. Salivary glands

In *U. aegyptiaca* the salivary gland proper was composed of highly vacuolated and granulated large cells. These cells had sparse cytoplasm and prominent deeply staining nuclei. Similar results were reported by [5] for the fish mite, *Lardoglyphus konoii*.

4.II. The excretory system

The present results showed that the excretory system *U. aegyptiaca* was composed of a pair of elongated Malpighian (excretory) tubules which extended along the length of the body. The cells of excretory tubules were large in size, compact and irregular in shape with distinct dark stained nuclei and nucleoli. The circumference of the tubule varied from three to five cells. Similar results were recorded by [2] for mite, *Echionlaelaps echidninus*. [14] and [15] recorded that several mite species without apparent excretory tubules. The Malpighian (excretory) tubules of mites, *Dermatophagoides farinae* [4] and *Lardoglyphus konoii* [5] were absent.

III- The nervous system

Histological sections revealed that the nervous system of the present mite, *U. aegyptiaca* was composed of brain with several nerve trunks and separated into two regions,

supraoesophageal and suboesophageal nervous masses. Four pairs of pedal ganglia extend distally from the supraoesophageal nervous mass and the suboesophageal nervous mass were bisected longitudinally by the oesophagus. Similar results were mentioned by [2] for mite, *Echionlaelaps echidninus* and [8] for *Dermanyssus gallinae*. Here, the brain mass involved an external layer of small rounded deeply staining cortical cells and an internal layer of lightly staining fibrous tissue. In addition, the nerves were classified into two groups according to their origin. These results are similar to those of mite, *Echionlaelaps echidninus* [2].

5 Conclusion

The present freshwater mite, *Unionicola aegyptiaca* is parasitized on the mussel, *Caelatura aegyptiaca*. The anatomy and histology of internal systems of this mite such as digestive, excretory, and nervous systems were studied. The digestive system consists of three main parts: the foregut (mouth, muscular pharynx and oesophagus), the midgut (ventriculus with its associated three pairs of gastric caeca), and the hindgut (rectal tube and rectum) and a pair of salivary glands. The main excretory system consists of a pair of elongated Malpighian (excretory) tubules which extends along the length of the body. The nervous system consists of a central nerve mass (brain) with several nerve trunks. The brain is separated into two regions; supraoesophageal and suboesophageal nervous masses.

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Appindx A - (Abbreviations)

anu	anus	gg	gnathosomal gangalia
br	brain	iv	intracellular vacuoles
c1- c4	coxae I- IV	l1- l4	legs of adult
ch	chelicera	ln	leg nerves
chs	cheliceral sheath	mo	mouth opening
coc	cortical cells of brain	mt	malpighian tubules
de	depressor muscles of pharynx	mu	muscles
di	dilator muscles of pharynx	oes	oesophagus
epg	epithelial cells of gastric caeca	p	palp
epm	epithelial cells of Malpighian tubules	pg	pedal gangalia
eptc	epithelial cells of third median chamber of ventriculus	ph	pharynx
epv	epithelial cells of ventriculus	rec	Rectum
er	epithelial cells of rectum	ret	rectal tube
ert	epithelial cells of rectal tube	ros	Rostrum
ey	eye	sa	salivary glands
fc	free cells	samb	supraoesophageal mass of brain
fcv	first median chamber of ventriculus	sbmb	suboesophageal mass of brain
fit	fibrous tissue of brain	scv	second median chamber of ventriculus
fm	food materials	sd	salivary duct
gca I- gca III	gastric caeca I- III	tcv	third median chamber of ventriculus