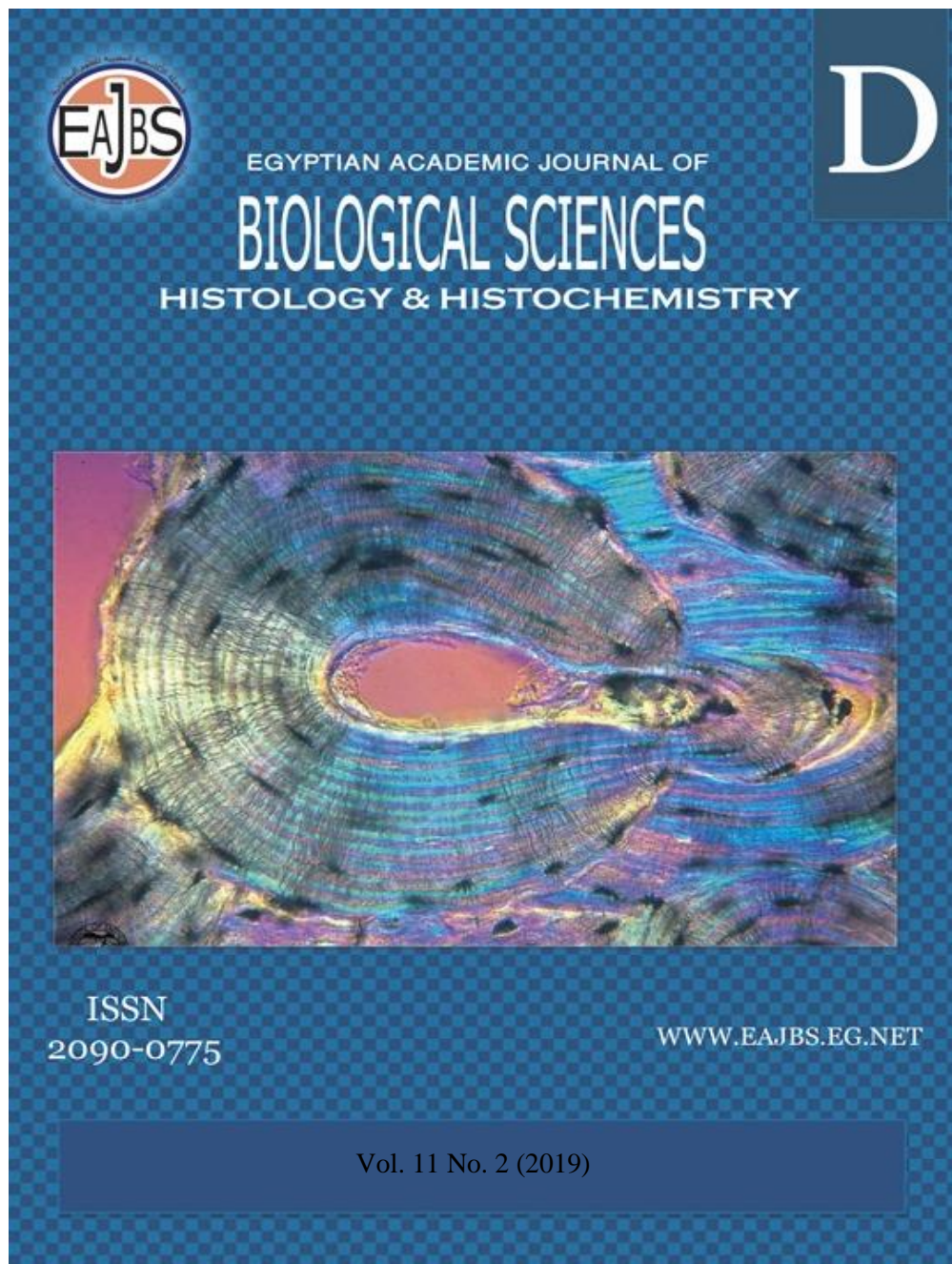


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## Histomorphological and Histochemical Study of the Ovary and the Uterine Tubes of the Adult Guinea Pigs (*Cavica porcellus*)

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### ABSTRACT

This study was carried out to identify the histological structures of the ovary and the related uterine tubes of the adult guinea pig (*Cavica porcellus*). To conduct such project, 14 adult guinea pigs at their diestrous period were collected from the local breeders directly. Animals were euthanized, dissected and subsequently ovaries and specimens from uterine tubes were collected and fixed by 10% neutral buffered formalin and some of specimens were fixed in Bouin's solution for subsequent histochemical staining then subjected to routine processes such as dehydration, clearing, embedding and block preparation. Sections of 6  $\mu$ m were prepared and stained with hematoxylin-eosin, Masson's Trichrome, Alcian blue (pH 2.5) and Periodic acid shift stains.

Gross findings showed two bilateral rounded and slightly elongated ovaries situated in the abdominal cavity suspended by mesovarium ligament. Microscopic findings revealed prominent large follicles and to a lesser extent, the small and medium types in the ovaries of adults studied guinea pigs. The data showed the presence of many pre-ovulatory follicles during the diestrous period in this polyestrous species. Gross findings of the uterine tubes revealed the presence of bilateral uterine tubes. Each tube included short straighten preampulla which was expanded cranially to form infundibulum, coiled long ampulla and finally the isthmus, the shortest and straight part traversed the cranial end of the uterine horn. Microscopically, all of the uterine tube was lined with simple columnar epithelium. Mucosa showed very long and branched mucosal folds in the pre-ampulla, for lesser extent in ampulla but shortest and widest in isthmus. Tunica muscularis was absent at infundibulum, thinnest at pre-ampulla, whereas, the thickest in isthmus. Histochemically, the non ciliated columnar cells (present mainly in the isthmus and few in ampulla) were stained positively with AB and PAS stains.

### INTRODUCTION

Domestic guinea pigs (*Cavia porcellus*) are a descendant of the wild cavy (*Cavia aperea*) which is one of the common rodents who lived in South America. Guinea pig is herbivorous rodent characterised by stocky body, short neck, and limbs and more closely related to porcupines than mice and rats (Kunzl and Sachser, 1999; North, 1999). They are now widely distributed because of its popularity as a pet and a food source.

They were commonly used in biomedical research, for example in studies of the human immune system, since guinea pig immunological genes are more similar to humans than those from mouse so that considered a very important model organism for toxicology and vaccine testing. Guinea pig is known as one of the gold standards for modeling human disease. It is especially important as a molecular and cellular biology model for studying the human immune system, as its immunological genes are more similar to human genes than are those of mice (Guo *et al.*, 2012).

In contrast to the massive number of studies conducted on the reproductive tract of domesticated animals, few studies and paucity of works were focused on the female reproductive organs of the guinea pigs. In domestic animal studies were focused on histomorphology of some organs of the female reproductive tract such as oviduct of golden hamster (Abe and Oikawa, 1989), mice (Stewart and Behriner, 2012), porcupine (Ozdemir *et al.*, 2005), mouse (Lauschova, 2003), bitch (Steinhauer *et al.*, 2004), and does (Al-Saffar and Almayahi, 2019). Similarly, few researches dealt with bird's reproductive organs such as mallards (Abood and Al-Saffar, 2015).

Up to date, there are no available studies in the previous and present literatures investigated the ovaries and the uterine tubes of the female guinea pigs. According to the importance of this animal species as one of the good experimental models, the project was performed. The obtained morphological, histological and histochemical data may be of value in giving basic information on this species for researchers that aim to conduct their researches and the experiments in many medical and veterinary fields such as pathological, physiological and pharmacological aspects.

## MATERIALS AND METHODS

### Animal's Collection and Study

#### Design:

Fourteen adult female Guinea pigs (*Cavica porcellus*) were selected to conduct the present research. Apparent healthy animals were purchased directly from the local breeders. They were left under supervision before their euthanasia and subsequent dissection. Each animal weighed with a sensitive weighing balance and euthanized by intraperitoneal injection of 500 mg/kg sodium Phenobarbital (Eifler *et al.*, 2009). Then each animal was placed on the dorsal recumbency to view its ventral aspect. Thereafter, a midline abdominal incision was performed craniocaudal from the xiphoid cartilage to the pubic symphysis in order to expose the organs in the abdominal cavity. The intra-abdominal ovaries and uterine tubes were exposed and photographed in situ and later dissected out. The organs were weighted by sensitive balance then washed by physiological saline solution and subsequently immersed in fixatives (10% formalin, Bouin's solution). Macromorphometric measurements included the estimation of relative weight and length of the ovaries and uterine tubes.

#### Histological Procedure:

Ovaries as a whole and uterine tubes were washed with normal saline and then immersed in 10% neutral buffered formalin for 48 hrs. For future staining with histochemical stains, some specimens were fixed by Bouin's solution for 16 hr. Next to fixation, specimens were dehydrated through ascending series of ethyl alcohol (70%, 80%, 90%, and 100%) each for 2 hrs, then cleared with xylene for ½ hr. Specimens were infiltrated with paraffin wax (58 – 60 °C ) then embedded with new paraffin wax to obtain blocks of paraffin. Paraffin sections of six microns were prepared

by using rotary microtome. The general histological staining procedure was performed by Hematoxylin and eosin (H&E). Special histochemical procedures were conducted by Masson's trichrome, Alcian blue (AB) (pH 2.5) and periodic acid Schiff (PAS) stains. The two latter stains were conducted to identify secretory cells of acidic and neutral mucopolysaccharides, respectively (Culling *et al.*, 1985). Histological slides were photographed using the colour USB 2.0 digital image system (Scope Image 9.0) which was provided with image processing software. Data of macromorphometric measurements were analyzed by ANOVA using SPSS software (version 14).

## RESULTS

### Gross Findings:

Gross examination of the female genital system of the adult guinea pigs revealed that it comprised of right and left ovaries and two associated uterine tubes (Fig. 1).

### Ovaries:

The ovaries were rounded and slightly elongated in shape with white to slightly yellowish color. They were fixed in situ by the mesovarian which was continuous with mesosalpinx that held the uterine tubes. The ovaries showed rounded cranial and caudal poles and they were situated caudally to their corresponding right and left kidneys. The left one was away for a short distance from the left corresponding kidney, whereas, the right ovary was closer toward the right kidney. The ovarian surfaces appeared not smooth because they possessed large ovarian follicles and so gave signs of follicular bulging which was feature of the pre-ovulation. Ovaries, pre-ampulla, and ampulla with their associated mesovarium, mesosalpinx, respectively were located on both sides

of the midline where the abdominal aorta and caudal vena cava existed. Blood vessels come into the ovaries and left out at their cranial poles (Fig. 1).

Morphometrical measurements such as weight, length, and diameter were listed in table 1. The means of body lengths and weights of the studied guinea pigs were  $225 \pm 2.30$  mm and  $545 \pm 3.09$  gm, respectively. The means of length and weight of the ovary were  $5 \text{ mm} \pm 0.05$ ,  $0.05 \pm 0.001$  gm so that the relative length and weight were 0.022 and 0.00009, respectively. The means diameter of ovary was  $3.5 \pm 0.013$  mm.

### Uterine Tubes:

They were two elongated tubes comprised of three distinct segments that were pre-ampulla, ampulla, and isthmus. The preampulla was expanded cranially to form the infundibulum near the cranial pole of the ovary and then the tubal portion was thin, short and straight invested in mesosalpinx which was continuous with the adjacent mesovarian. The caudal end of pre-ampulla continued as long, coiled tube called the ampulla. The remaining part of the uterine tube was the isthmus which was short, straight and joined the cranial part of the uterine horn. The mesosalpinx which held the uterine tube was continuous with the mesovarium cranially and the mesometrium caudally forming the broad ligament (Fig. 1).

Morphometrical measurements such as lengths and weights were listed in table 1. The means of lengths and weights of the uterine tubes were  $14 \pm 0.002$  mm and  $0.09 \pm 0.0012$  mg so that the relative length and weight were 0.062 and 0.00016, respectively. The means diameter of uterine tube was 1.0 mm.

**Table 1.** Macromorphometric measurements of the ovary and uterine tubes of adult guinea pigs

Organs	Diameter (mm)	Length (mm)	Relative length	Weight (gm)	Relative weight
Ovary	3.5± 0.013	5.0± 0.05	0.022	0.05± 0.001	0.00009
Uterine tube	1.0	14	0.062	0.09	0.00016
Body weight (mean ± SE)	545 gm ± 3.09				
Body length (mean ± SE)	225 mm ± 2.03				

**Microscopic Findings:****Ovaries:**

Microscopic examination revealed similar microscopic structures for both right and left ovaries. They were covered by simple cuboidal epithelium forming the germinal epithelium. This epithelial layer was missing at the hilus of the ovary, where the blood vessels were entered or left the organ. Beneath this germinal epithelium, a layer of dense irregular collagenous connective tissue fibers represented the tunica albuginea (Fig. 2, 3).

Ovaries showed distinctly two regions that were an outer one called the cortex and an inner called the medulla. The cortex region showed different types of follicles. They were distributed between tunica albuginea and the interior of the organ, with many thin interfollicular connective tissue septae. The interior of the medulla of the ovary was constructed of irregular dense collagenous connective tissue stroma. It was prominently filled with blood vessels. Arbitraries of the blood vessels were obviously localized around the large follicular types which could play their role in subsequent stages of follicular maturation and ovulation (Fig. 4).

Obviously, the ovaries showed a cortical zone filled with different types of follicles. According to the classification of Pederson and Peters (1968) they were small, medium and large follicles. The small follicles primarily present were type 1, 2 and 3a. They were numerous types of present follicles. The 1<sup>st</sup> type of follicles was the primordial oocyte characterized by large nucleus and nucleolus. No cells were attached to

the surfaces of these cells which were invested in the surrounding connective tissue. Type 2 follicles were numerous in number as in case of type 1. They were characterized by the presence of incomplete ring of squamous follicular cells attached to the surface of each oocyte. Similar to the above types, follicles of type 3a were numerous in number. They were characterized by the presence of complete ring of cuboidal follicular cells attached to their surfaces. The number of follicular cells in such rings was lesser than 20 (Fig. 5, 6, 7).

Lesser number of medium-sized follicles recorded compared to those of the small follicles. These follicles were type 3b, 4 and 5a. Type 3b follicles characterized by an oocyte surrounded completely by one layer of cuboidal follicular cells with a number more than 20 cells, whereas, type 4 showed two layers of follicular cells surrounding the oocyte (Fig. 6, 7). The type 5a showed three layers of follicular cells surrounding the oocyte (Fig. 8).

Noticeably many large follicles were identified during the diestrous stage in the ovaries of adults studied guinea pigs. These were follicles type 5b, 6<sup>th</sup>, 7<sup>th</sup> and 8<sup>th</sup> (Graafian follicle). Ovarian follicle 5<sup>th</sup> type (b) showed granulosa cells more than three layers, theca interna and theca externa around each oocyte (Fig. 9). In follicles type 6, starting the presence of small spaces or cavities in the granulosa called antral cavities (Fig. 10, 11). The 7<sup>th</sup> type of follicles identified by its fully developed antrum and the formation of corona radiata cells around the oocyte (Fig. 3). Four or more of this type and the subsequent type 8<sup>th</sup> were usually



observed in the ovaries of the studied guinea pigs (Fig. 12). Type 8<sup>th</sup> or called the Graafian follicles were characterized by well-developed cumulus oophorus as well as corona radiata and the fully developed antrum. Prominently, rich blood supply was observed around the large follicles.

The medulla formed of dense connective tissue bundles filling the core of the ovary. Numerous blood vessels were distributed in the medullary stroma. The blood vessels were passed through hilus into the medulla where many branches intervene with connective tissue running between follicles. The blood supply was distinctly distributed around large follicles (Fig. 4).

#### **Uterine Tubes:**

The uterine tubes showed three regions by reference to their characteristic histological features. They were distinguished according to their wall morphological differences into pre-ampulla, ampulla, and isthmus. Distinctly, the mucosa of the whole uterine tube was lined with simple columnar epithelium with only ciliated at pre-ampulla, whereas, in the ampulla, most of epithelium covered with ciliated and for a lesser extent non-ciliated. In the isthmus, mostly of non-ciliated cells with fewer number of ciliated present in between.

Microscopically the wall of uterine tubes was constructed of three different tunicae that were mucosa, muscularis and serosa at its free part or adventitia at its attached part to mesosalpinx. The thicknesses of these tunicae were different in the three different regions.

#### **A. Pre-ampulla:**

The beginning portion of this tube was expanded forming the infundibulum. The mucosa was highly folded. The primary folds were very long with many secondary small folds lined with simple columnar ciliated epithelium (Fig. 13, 14). The epithelium was rested on lamina propria of loose connective tissue well

supplied by blood vessels. Post the expanded infundibulum, the tube portion of the pre-ampulla showed shorter mucosal folds. The mucosa still lined with the same epithelium and rested on lamina propria connective tissue rich with blood vessels. Next to this, a thin muscular layer of smooth muscle fibers (1 to 3 circularly arranged layers) identified in the wall of the tube. The free border was covered with serosa, whereas, the attached border to the mesosalpinx showed adventitial connective tissue filled with large number of blood vessels with the presence of adipose tissue. Histochemical staining showed post staining with Masson's trichrome, thin layer of loose connective tissue lamina propria underneath lining epithelium and in the cores of mucosal folds. The stain gave green color to the present collagenous fibers and red-brown color to the smooth muscle fibers of tunica muscularis (Fig. 15). Sections of pre-ampulla were negatively reacted toward both PAS and AB (pH 2.5) stains due to absence of mucous secretory cells in its lining epithelium (Fig. 16).

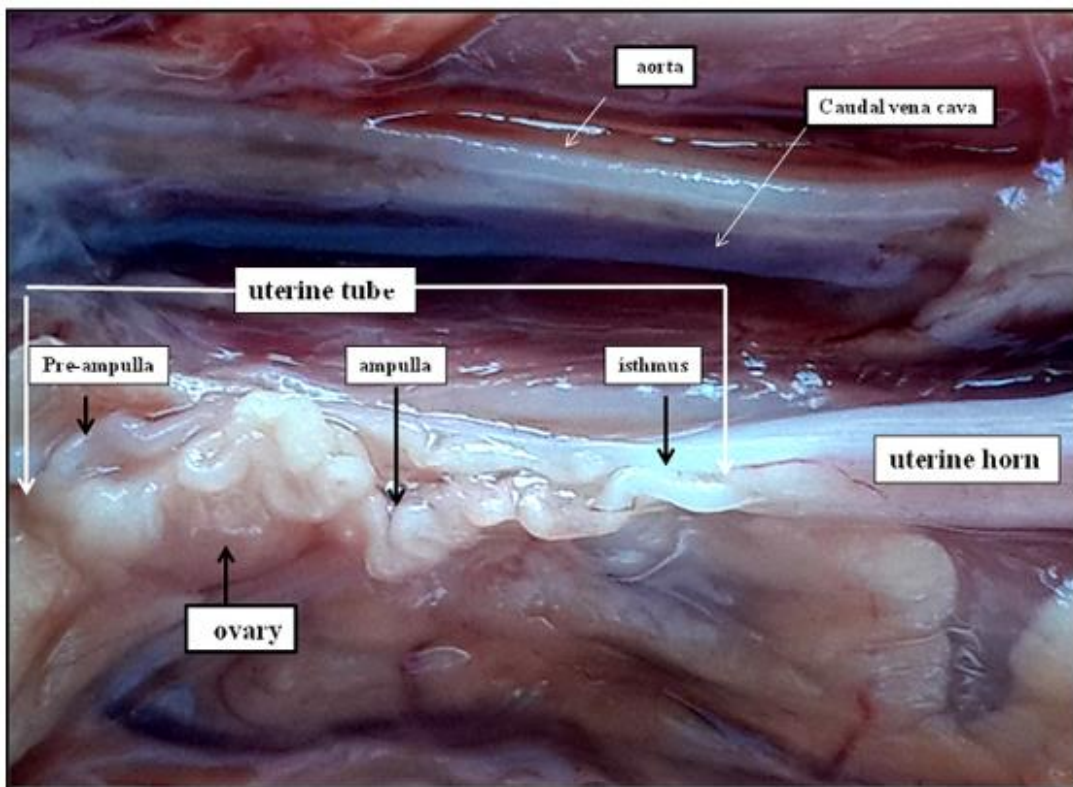
#### **B. Ampulla:**

Similarly to the pre-ampulla, the epithelium of the ampulla was simple columnar mostly ciliated with the few non-ciliated cells were present in between. The tunica mucosa showed little number of mucosal folds (4 to 6 folds). It showed primary folds with or without a number of small secondary folds. The tunica muscularis was thicker relatively to what was found in the last part of pre-ampulla. It composed of 5 to 8 circularly arranged smooth muscle fibers (Fig. 17). Post staining with Masson's trichrome showed thin layer of loose connective tissue lamina propria underneath lining epithelium and in the cores of mucosal folds (Fig. 18). Weak reactions were obtained toward both PAS and AB stains in few cells of the lining epithelium.

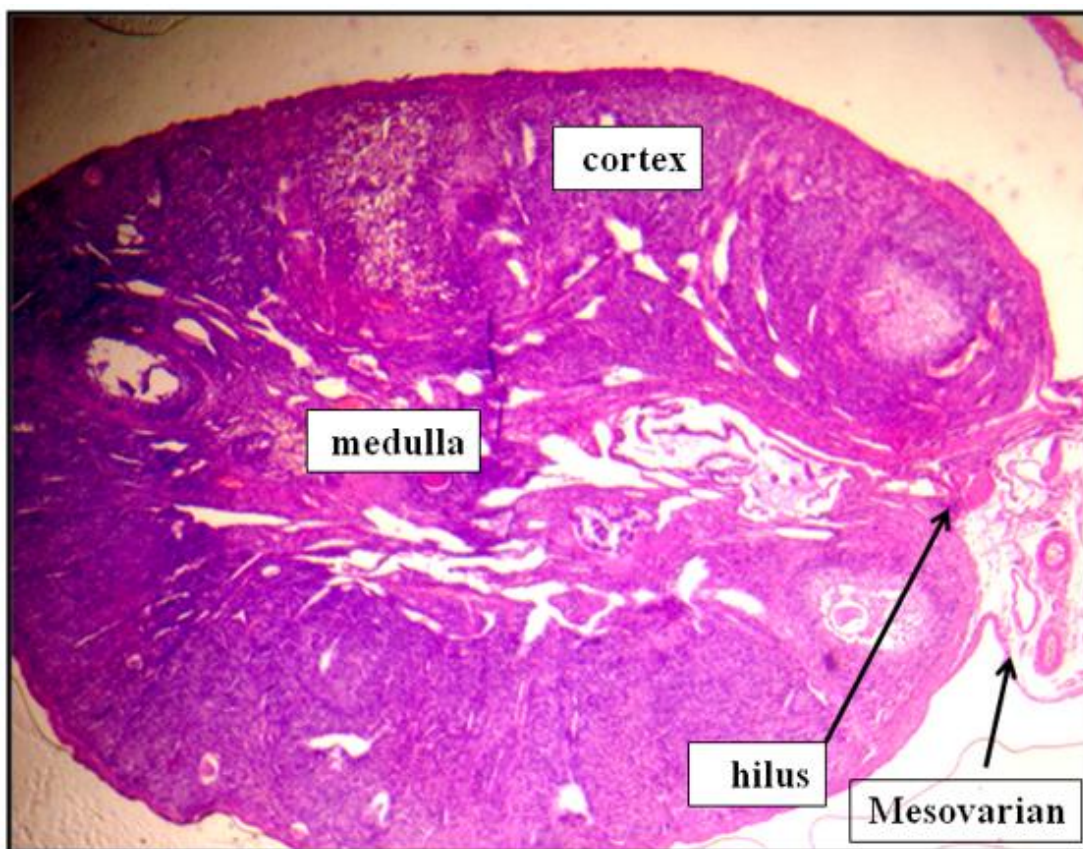
**C. Isthmus:**

It showed non-ciliated simple columnar epithelium and lesser number of primary mucosal folds which were wider and shorter in length compared to those observed in ampulla. Distinctly, the muscularis was thickest than those of ampulla and pre-ampulla (Fig. 19, 20).

Post staining with PAS stain, the non-ciliated cells showed apical pinkish coloration indicated a positive reaction toward this stain (Fig. 21). Staining the sections with AB stain, bluish coloration was observed in the non-ciliated secretory cells (Fig. 22).

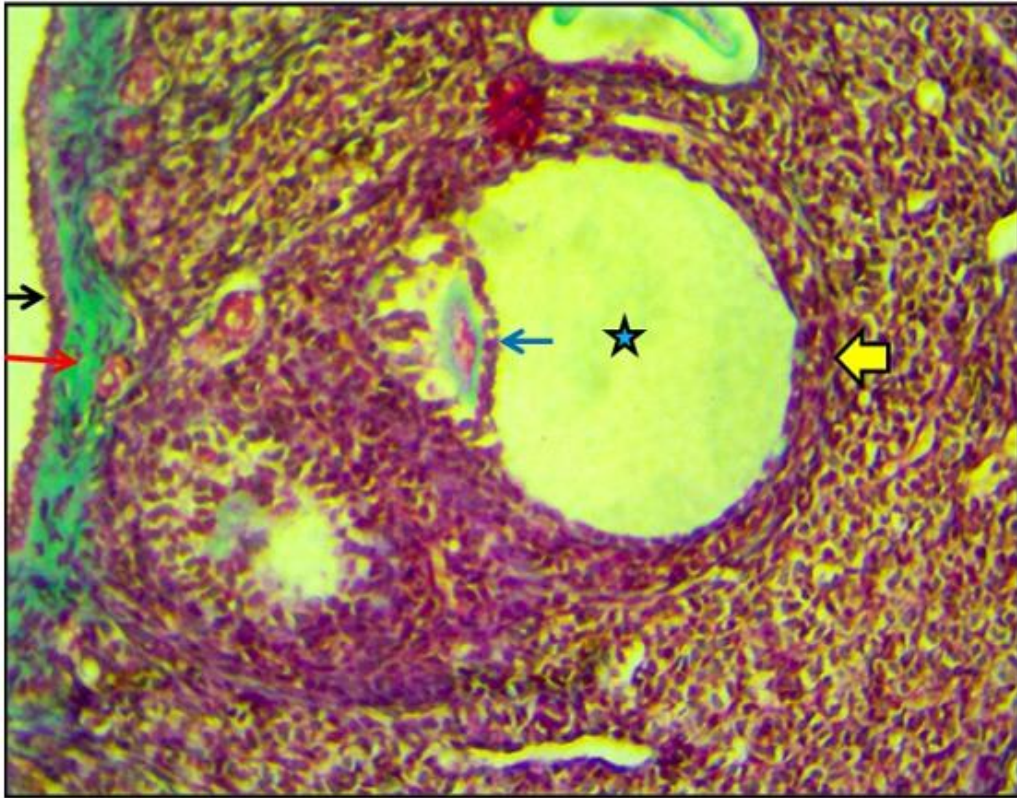


**Fig.1.** ovary, uterine tube and uterine horn in situ

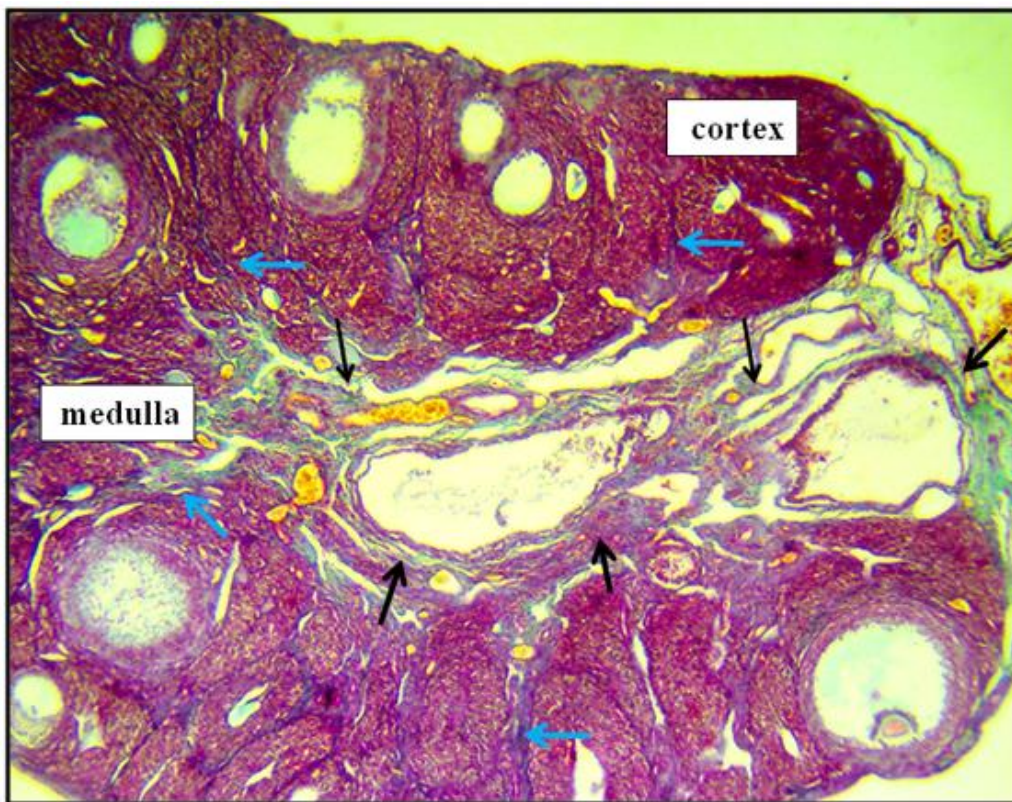


**Fig. 2.** Ovary showed cortex and medulla, hilus and mesovarium. X4, H&E



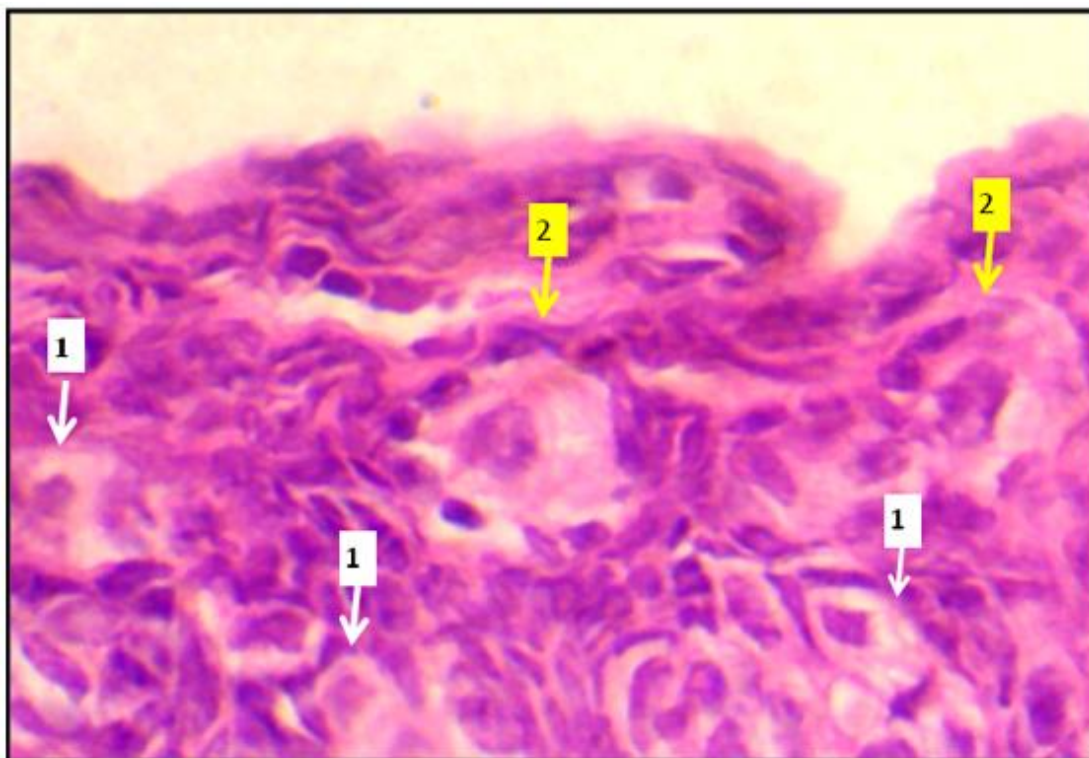


**Fig. 3.** Ovarian capsule showed germinal epithelium (black arrow), tunica albuginea (red arrow), sub-germinal 7<sup>th</sup> type of follicle (yellow arrow) characterized by antrum (blue star) and corona radiata (blue arrow). X20, Masson's trichrome

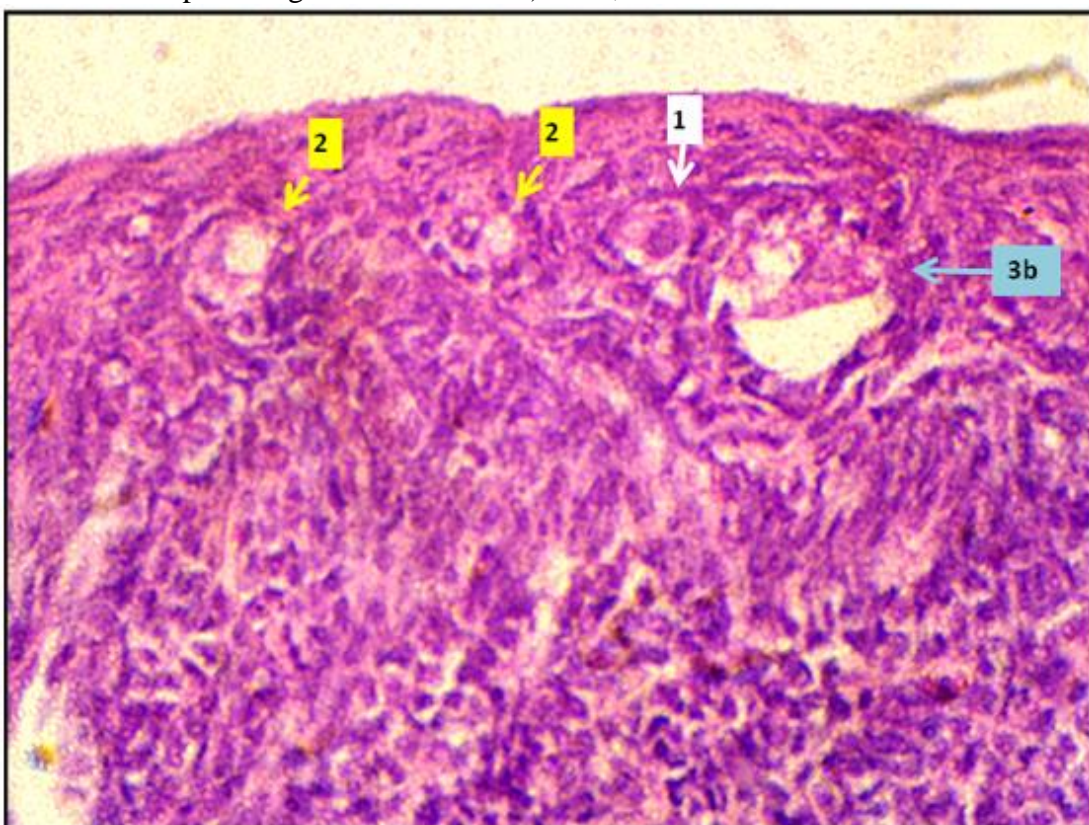


**Fig. 4.** Ovarian stroma showed distribution of the connective tissue stroma in the medulla (black arrows) and between cortical follicles (blue arrows). X4, Masson's trichrome stain



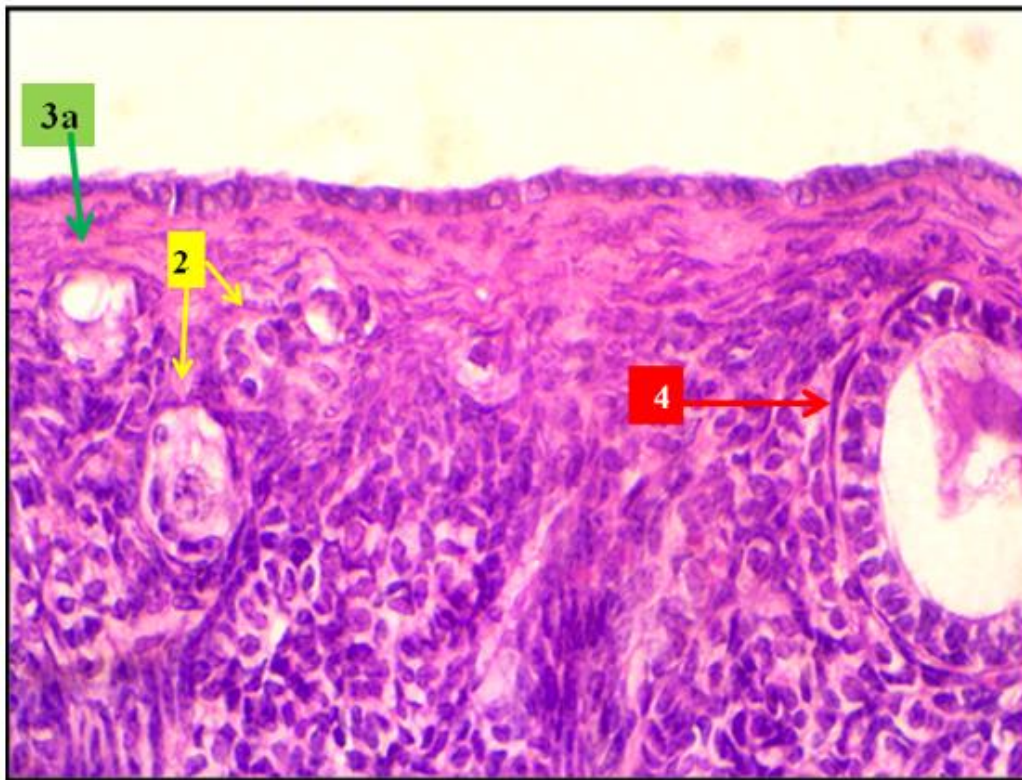


**Fig. 5.** Ovarian follicles showed 1<sup>st</sup> type (oocyte) and the 2<sup>nd</sup> type (oocyte with incomplete ring of follicular cells). X40, H&E

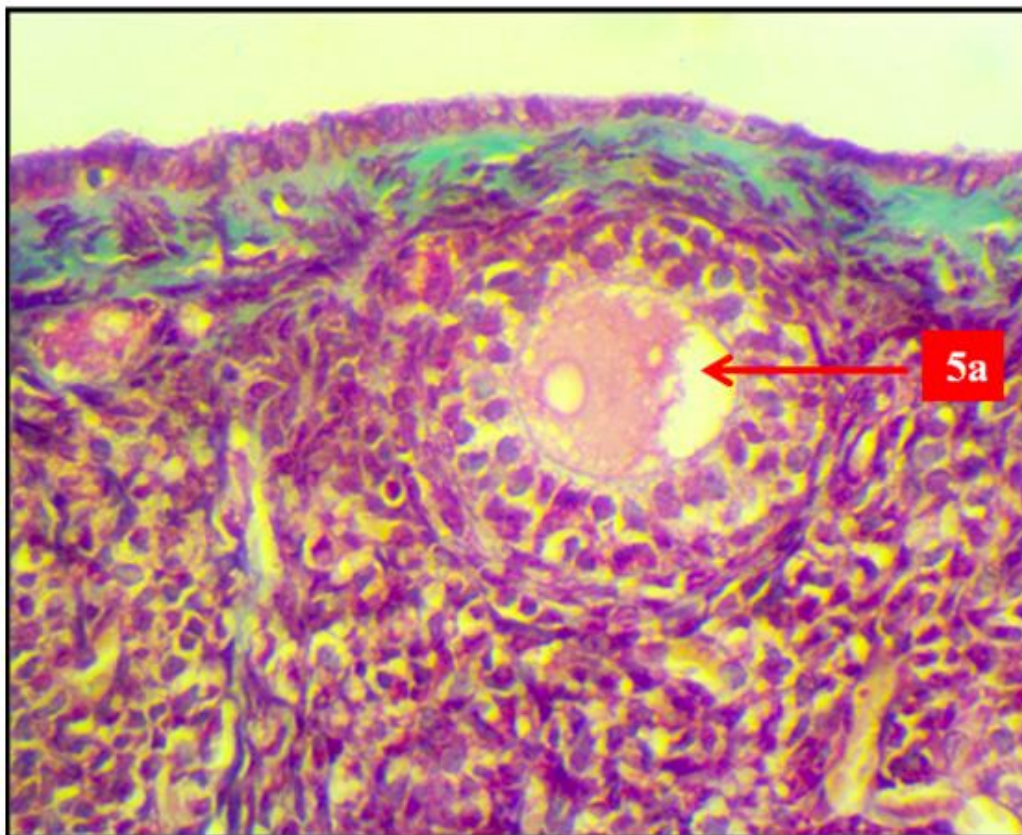


**Fig. 6.** Ovarian follicles showed 1<sup>st</sup> type (oocyte), 2<sup>nd</sup> type (oocyte with incomplete ring of follicular cells) and 3<sup>rd</sup> type b (oocyte with complete ring of follicular cells more than 20). X40, H&E



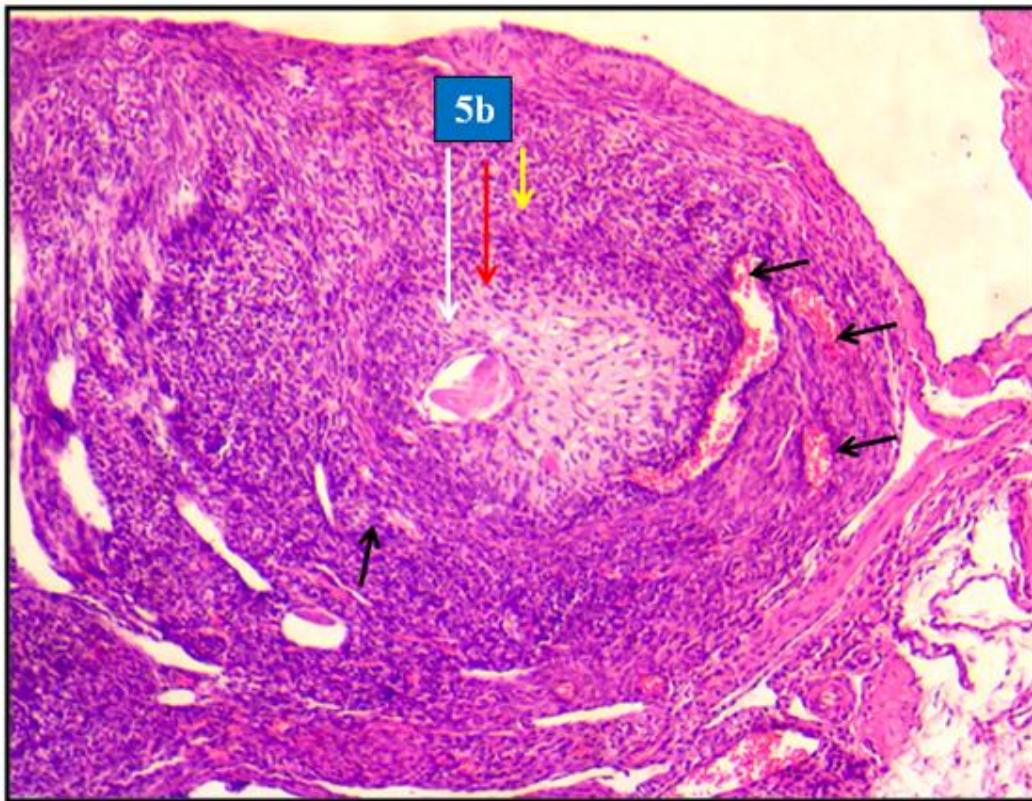


**Fig. 7.** Ovarian follicles showed 2<sup>nd</sup> type (oocyte with incomplete ring of follicular cells, 3<sup>rd</sup> type a (oocyte with complete ring of follicular cells less than 20) and 4<sup>th</sup> type (oocyte with complete ring of double layers follicular cells). X40, H&E

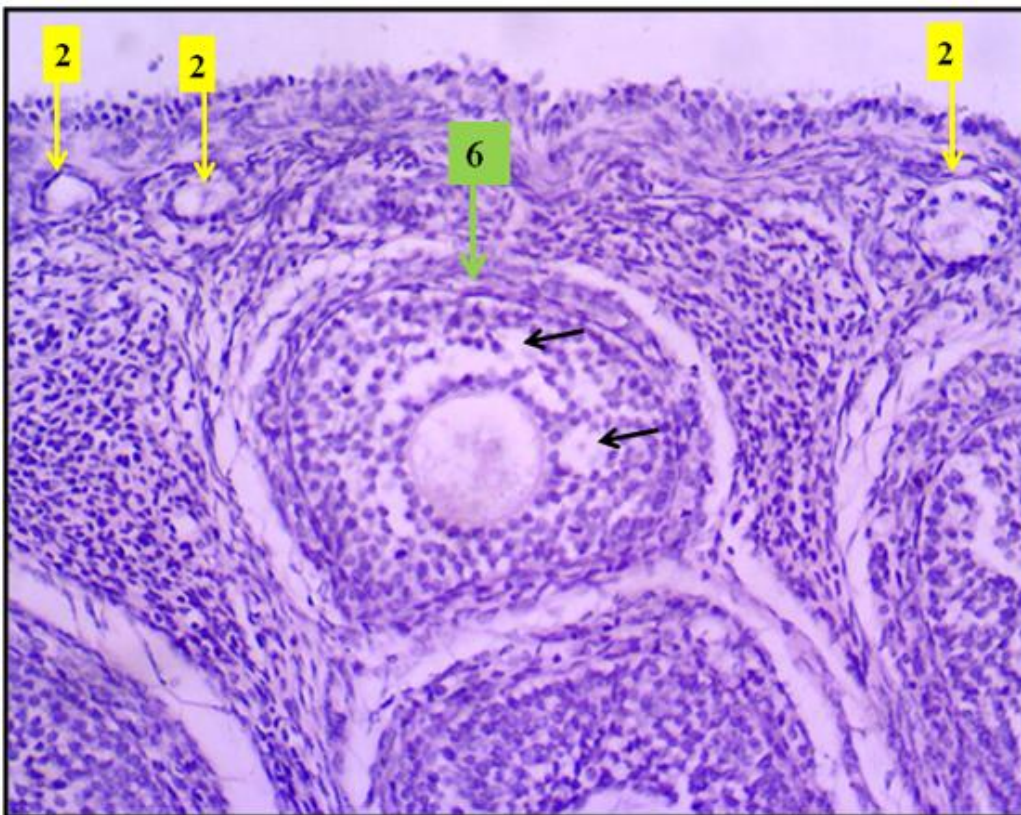


**Fig. 8.** Ovarian follicles showed 5<sup>th</sup> type (a) showed oocyte with complete ring of three layers follicular cells. X40, Masson's trichrome stain



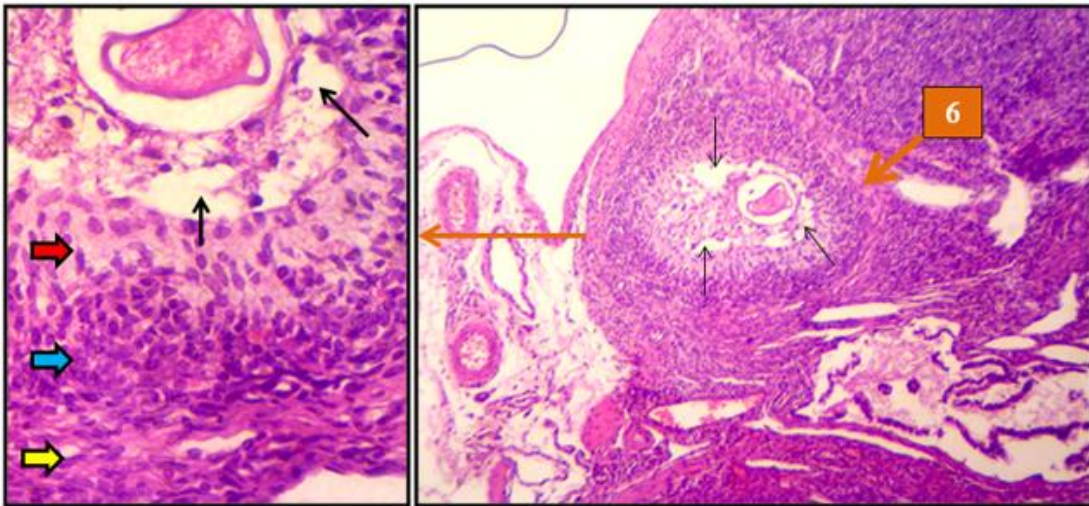


**Fig. 9.** Ovarian follicle showed 5<sup>th</sup> type (b) with appearance of granulosa of more than three layers (white arrow), theca interna (red arrow), theca externa (yellow arrow) with rich blood vessels X10, H&E

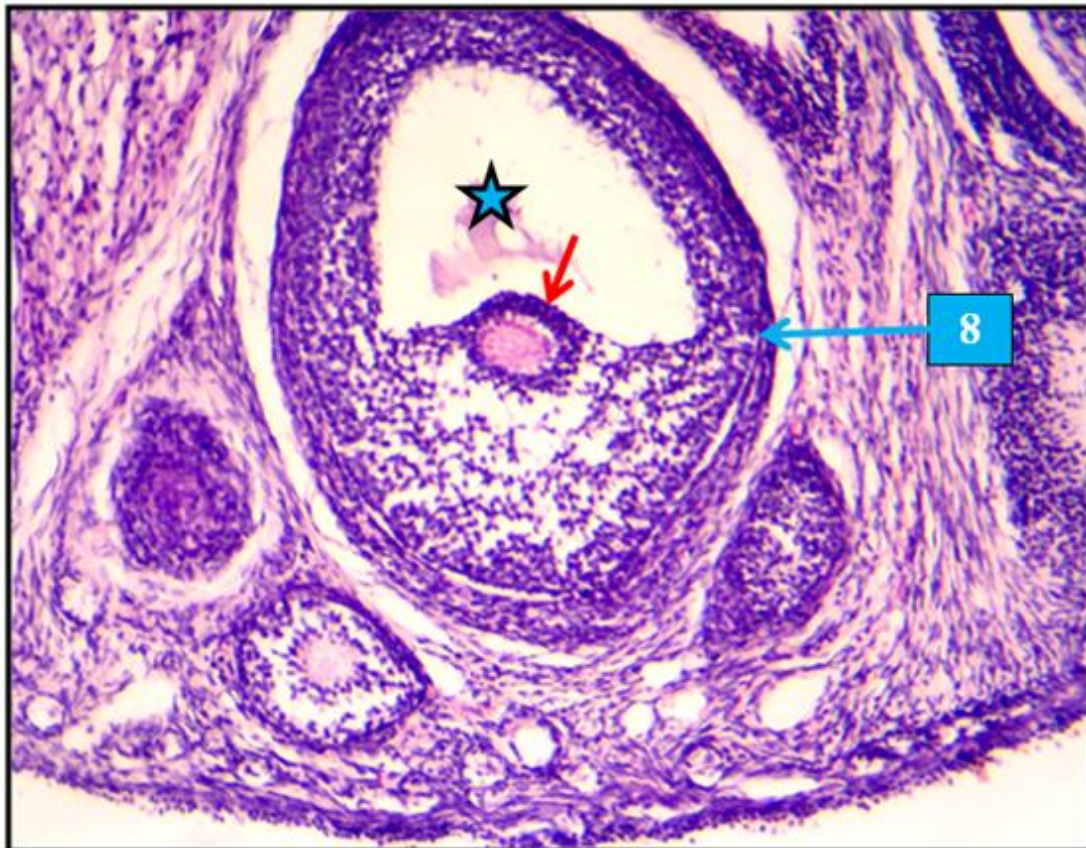


**Fig. 10.** Ovarian follicle showed the 2<sup>nd</sup> type and the 6<sup>th</sup> type (appearance of antral spaces within granulosa cell indicated by black arrows). X20, H&E



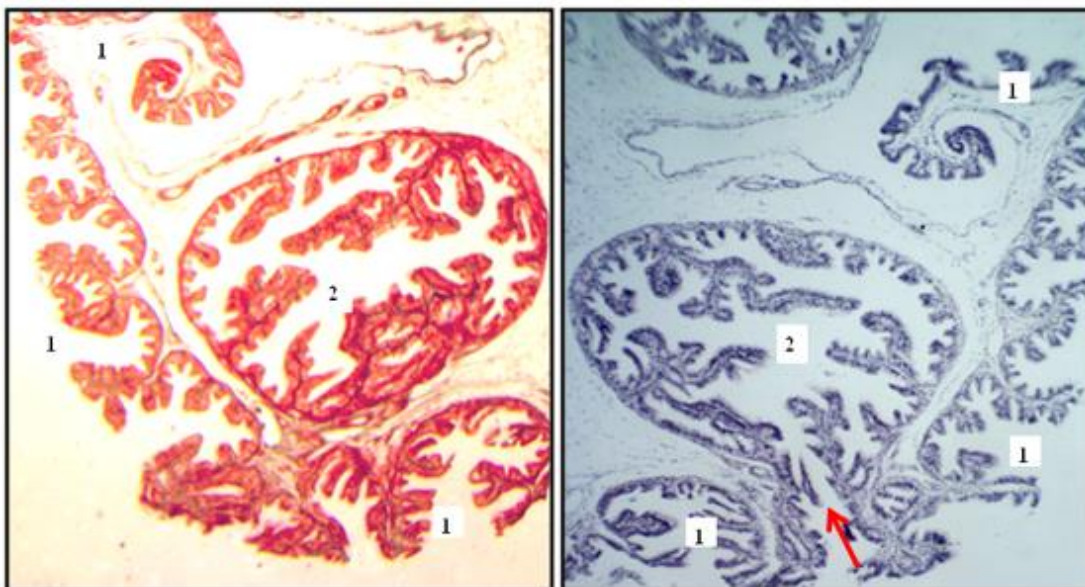


**Fig. 11.** Ovarian follicle 6<sup>th</sup> type characterized by the appearance of antral spaces within granulosa cells (black arrows), granulosa cells (red arrow), theca interna (blue arrow) and theca externa (yellow arrow). X40 (left), X20 (right), H&E

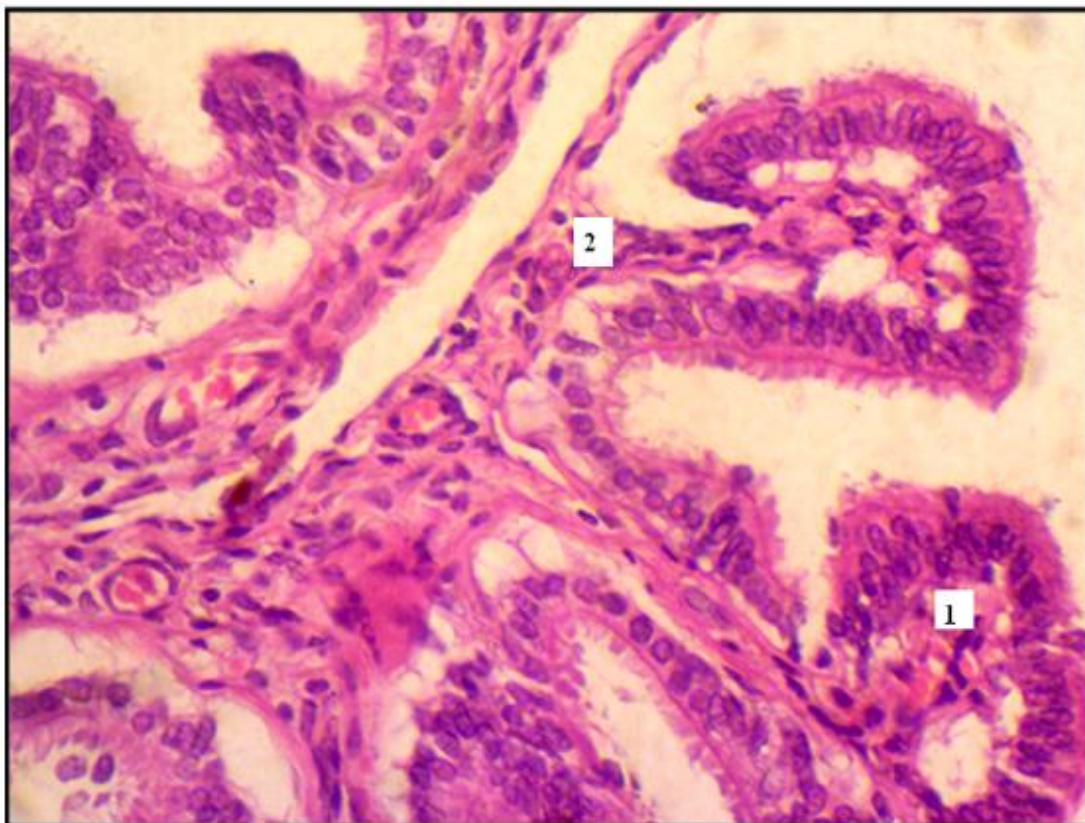


**Fig. 12.** The 8<sup>th</sup> type of ovarian follicles showed cumulus oophorus (blue arrow), antrum (blue star) and corona radiata (red arrow). X10, H&E



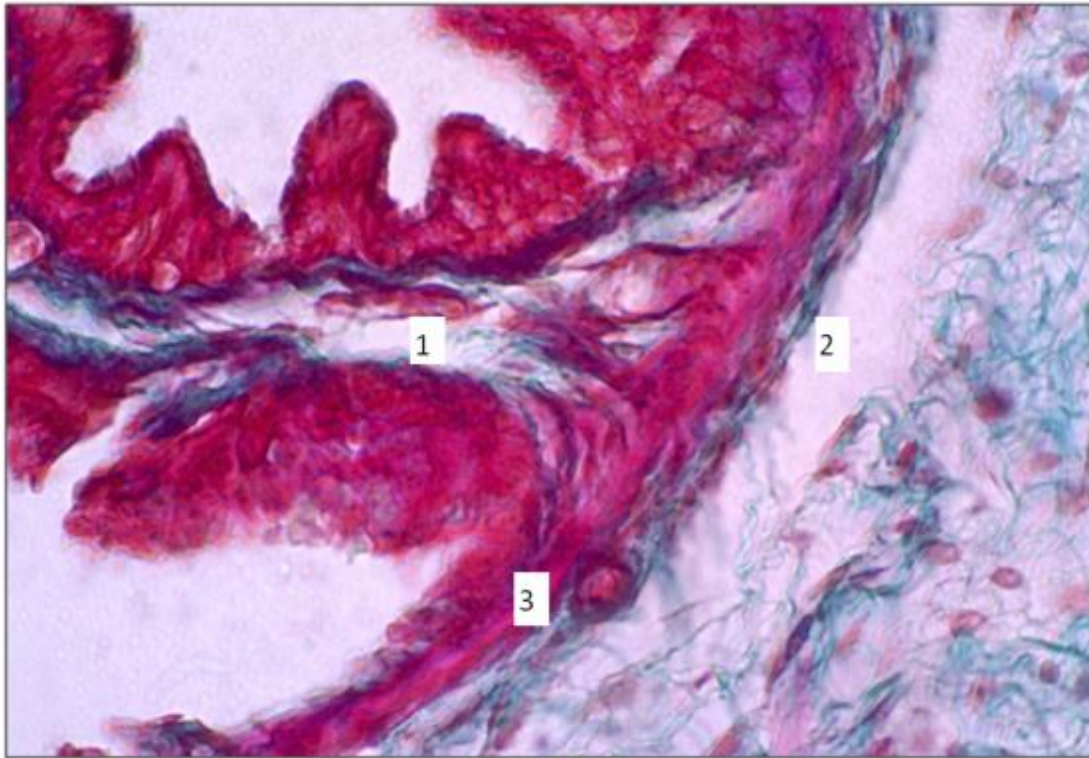


**Fig. 13.** Pre-ampulla showed its expanded infundibulum (1) changed into the tubal parts (2). Red arrow showed the continuity between both portions. X4, Masson's trichrome (left) and X4, H&E (right).

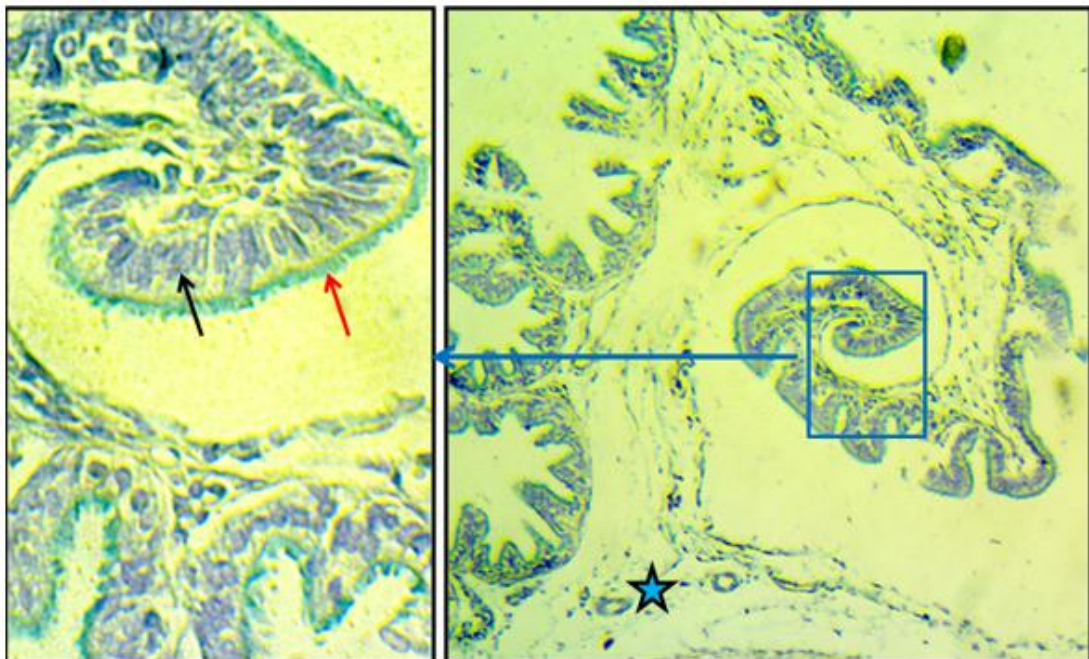


**Fig. 14.** Infundibulum showed mucosa of simple columnar epithelium ciliated (1) and subepithelial connective tissue lamina propria (2). X40, H&E

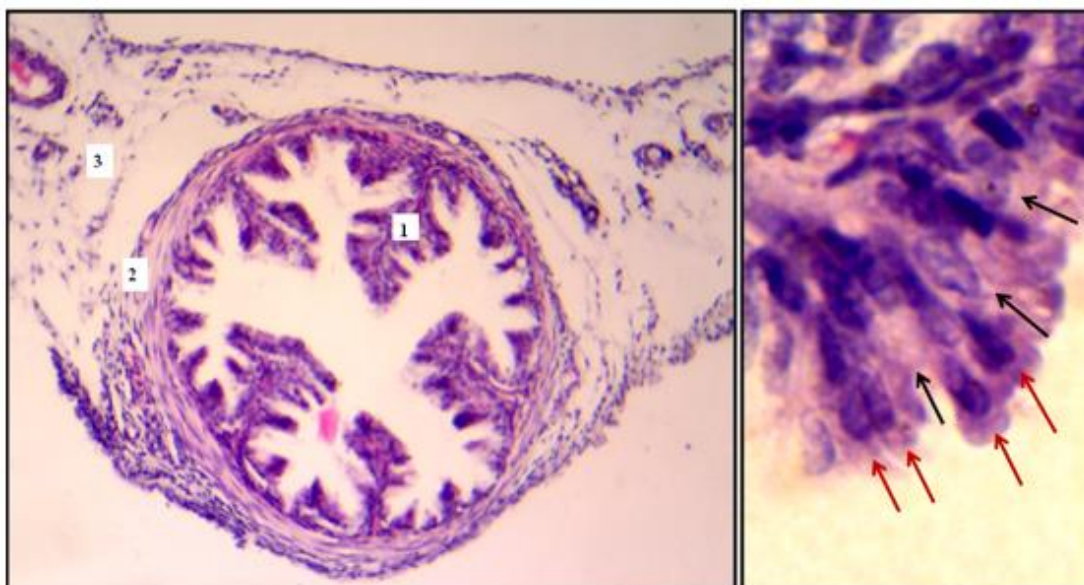




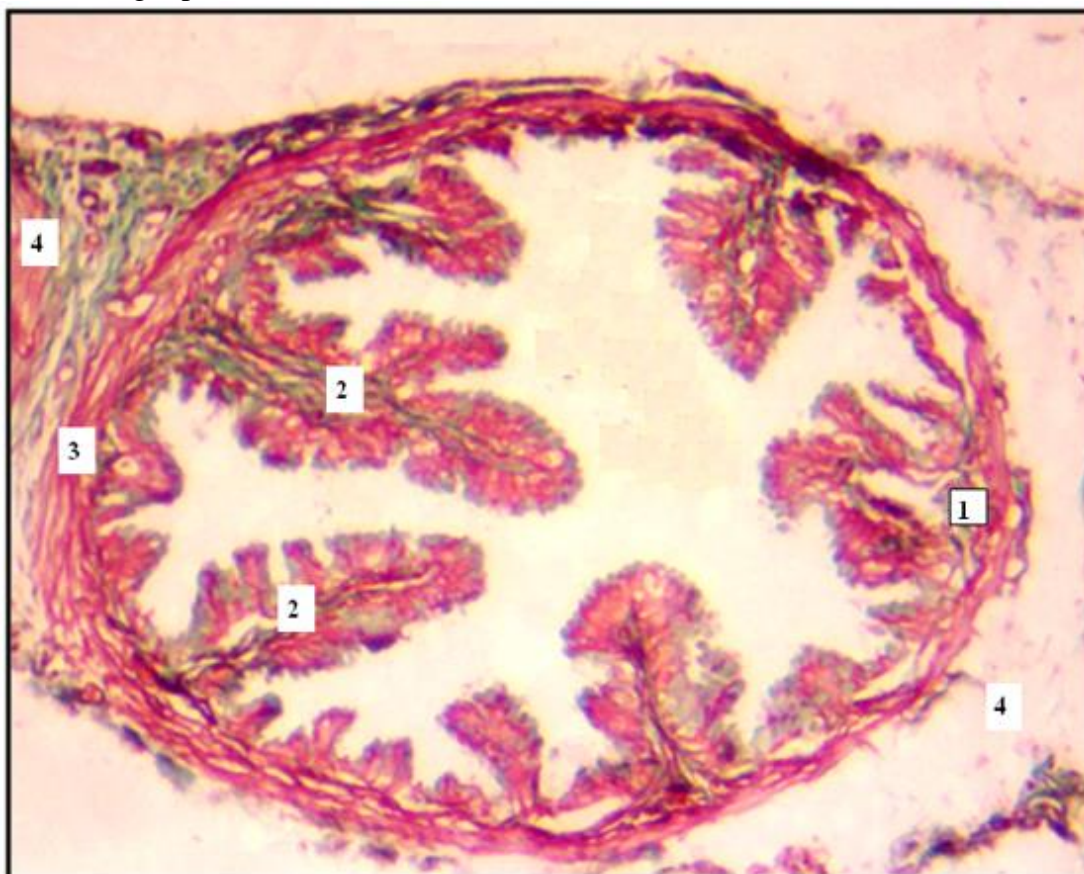
**Fig. 15.** Pre-ampulla tube showed core of fold (1) and mesosalpinx (2) loose connective tissue stained with Masson's trichrome stain, delicate muscular layer of smooth muscle fibers (3). X40, Masson's trichrome stain



**Fig. 16.** Pre-ampulla at infundibulum showed ciliated (red arrow) columnar epithelium (black arrow) which was non secretory and negative toward to AB stain. X40 (left), X10 (right), AB

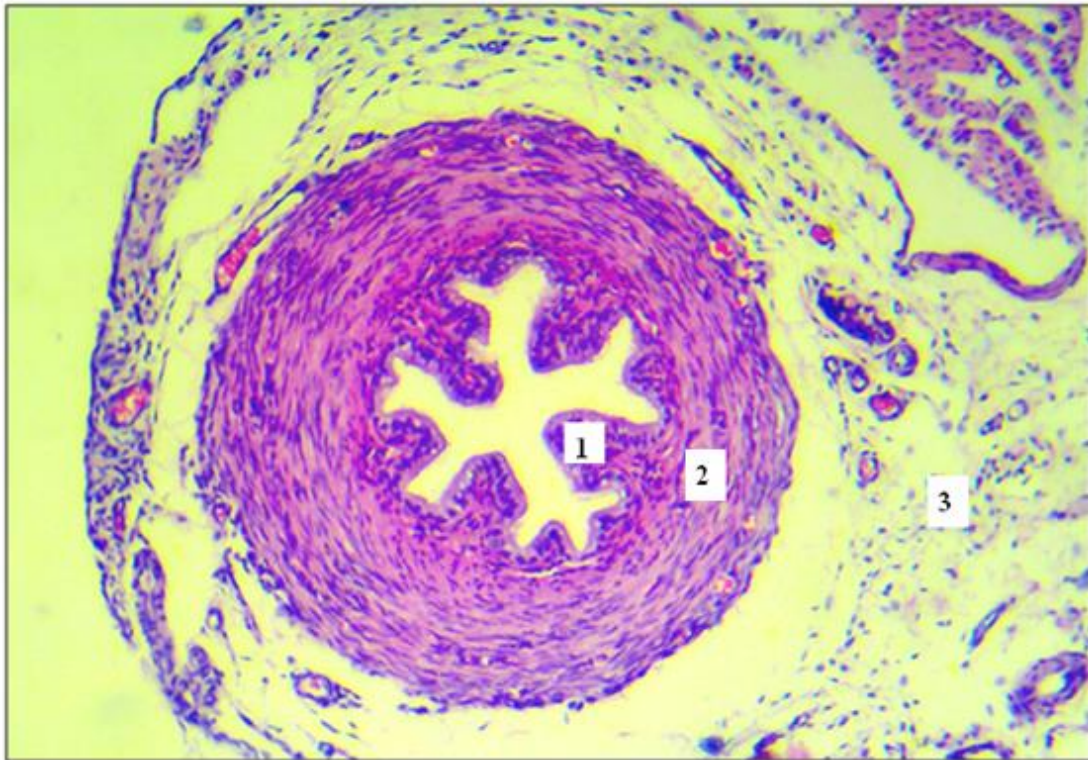


**Fig. 17.** Ampulla showed in left panel:1-mucosa of simple columnar epithelium with mucosal folds. 2- tunica muscularis of smooth muscle fibers .mesosalpinx of loose connective tissue. X10, H&E  
 Right panel: ciliated (red arrows) and non ciliated (black arrows). X40, H&E

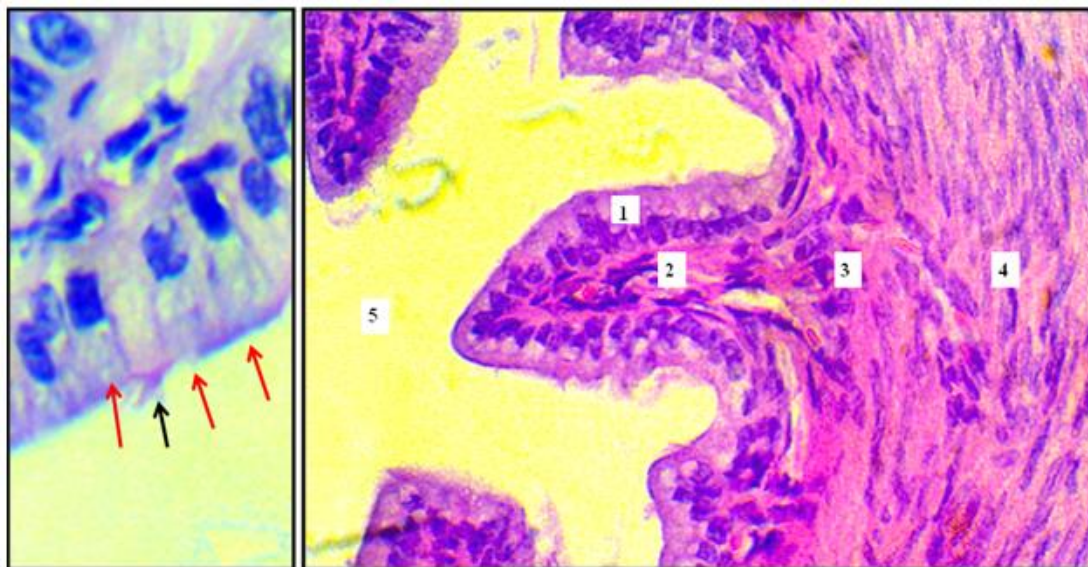


**Fig. 18.** Ampulla showed loose connective tissue in the lamina propria (1) and within the cores of folds (2), thin tunica muscularis of smooth muscle fibers (3) and mesosalpinx (4). X10, Masson's trichrome stain





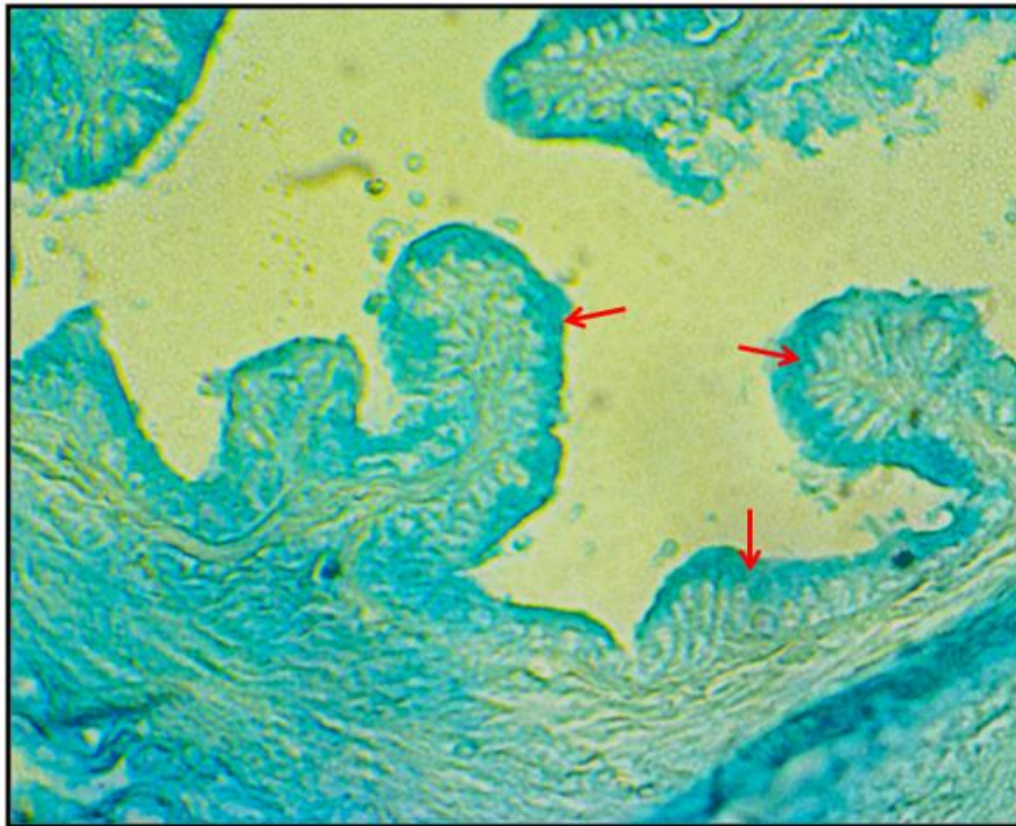
**Fig. 19.** Isthmus showed short and wide folds (1), thick tunica muscularis of smooth muscle fibers (2) and mesosalpinx (3). X10, H&E



**Fig. 20.** Isthmus showed short and wide folds lined with simple columnar epithelium (1), lamina propria (2), core of fold (3), thick tunica muscularis of smooth muscle fibers(4) and lumen (5). Epithelium showed few ciliated (black arrow) and abundant non ciliated cells (red arrows). X40, H&E



**Fig. 21.** Isthmus lining epithelium and mucosal folds showed positive reaction of columnar non ciliated secretory cells toward PAS (red arrows). X40, PAS



**Fig. 22.** Isthmus lining epithelium and mucosal folds showed positive reaction of columnar non ciliated secretory cells toward AB (pH 2.5) (red arrows). AB, X40



## DISCUSSION

### Grossly – Ovaries:

Gross data showed that non-smooth ovarian surfaces because they possessed large ovarian follicles and so gave signs of follicular bulging which is feature of the pre-ovulation. The ovaries of the studied guinea pigs were rounded and slightly elongated in shape with white to slightly yellowish color and such findings were different from the previous records in the ovaries of porcupine which were bean-shaped (Ozdemir et al., 2005). In addition to that current findings were different from other animal species such as African giant rats, in which the ovaries were pinkish in colour and kidney-shaped. But similarly to that in rats, the ovaries in guinea pigs were situated caudally to the kidneys, with the right ovary being located more cranially than the left (Ali *et al.*, 2010).

Ovaries of the studied guinea pigs were found suspended in the abdominal cavity by the mesovarian ligament to the sublumbar muscles and such remarks were similar to those in rats (Ali *et al.*, 2010) but not parallel with those recorded in women because ovaries present with different shapes such as rod shape, “S” shape, oval shape and almond shape in the fetal, prenatal and postnatal ages, respectively and these ovaries were located entirely in the pelvic cavity.

Grossly the ovaries in the guinea pigs were not located in a true ovarian bursa as described in some carnivores and rodent species but were usually surrounded by a mass of adipose tissue accumulated in the mesovarium and the beginning region of the mesosalpinx (Popesko *et al.*, 1990; Capello, 2005).

Ovaries of the current guinea pigs were paired similar to other small-sized mammalian species such as female agouti (*Dasyprocta leporina*) which were related to guinea pigs (Singh *et al.*, 2014). Differently, ovaries in the hamster found ovoid in

shape and completely enclosed in a bursa (Chanut and Williams, 2016).

The paired ovaries in guinea pigs appeared similar to local does not enclose in a true bursa and they were also suspended in the abdominal cavity by the mesovarian ligament to the sublumbar muscles, but differently, the ovaries were triangular in shape. In addition to those ovaries of the guinea pigs were located differently than those of the locals does. They were located caudolateral to the right kidney and the left ovary located cranialateral to the left kidney, whereas, in does, ovaries were both caudally located to the corresponding kidneys (AL-Saffar and Almyahi, 2018 a).

### Grossly - Uterine Tubes:

The gross findings of the uterine tubes in guinea pigs showed two bilateral long tubular organs. The tubes caudally joined the cranial ends of the corresponding uterine horns abruptly into the cavities of horns which were similar to other animal species as for instance in bovine species (Pollard *et al.*, 1991) but in contrary dissimilarly in other species such as African giant rats (Ali *et al.*, 2010) and local domestic does (AL-Saffar and Almyahi, 2019) where it gradually joined as uterine intramural portion.

Currently, the uterine tube showed three different regions that were pre-ampulla (expanded cranially to form infundibulum), ampulla and isthmus, whereas, in other species, Hunter (1984) and Suárez (1987) divided the mammalian uterine tube into three different anatomical regions that were infundibulum, ampulla, and isthmus. This reference considered the rostral portion of the infundibulum as fimbriae which appeared responsible for oocyte transport into the uterine tube after ovulation. However, Abe (1996) gave different names to the different regions of the oviduct in the mammalian species as fimbriae, ampulla, isthmus, and utero-tubal junction.

Current findings revealed that the ampulla was the longest region, whereas the pre-ampulla was shorter and the isthmus region was the shortest and such findings were parallel to those in local does (AL-Saffar and Almyahi, 2019). In fact, the longest length of the ampulla gave a larger chance for events of fertilization and completion of the second meiosis (Bosch and Wright, 2005).

Currently, the means of lengths of the uterine tubes were  $14 \pm 00$  mm which appeared very short compared to those in laboratory rat (2.4 cm) (Hebel and Stromberg, 1976) African giant rat ( $4.44 \pm 0.06$  cm) (Ali *et al.*, 2010), mixed breed rabbit ( $6.00 \pm 0.794$  cm) (Bitto *et al.*, 2006) and in local domestic does (7 cm) (AL-Saffar and Almyahi, 2019). Ovaries of the guinea pigs were covered by the germinal epithelium of simple cuboidal epithelium. Beneath this germinal epithelium, a thick layer of dense irregular collagenous connective tissue fibers represented the tunica albuginea and such findings were in agreement with those recorded in the female porcupine (Ozdemir *et al.*, 2005) and in the local does (AL-Saffar and Almayahi, 2018a).

#### **Microscopically – Ovaries:**

The current data showed that the cortex and medulla were not easily identified in the ovaries of adult guinea pigs because of the formation and development of many ovarian follicles that were occupied more spaces of the cortical and medullary regions. These caused indistinct separation of these two regions and such structural features were also recognized in ovaries of other species such as does (AL-Saffar and Almayahi, 2018a), rats (Lalithamma *et al.*, 2016), female agouti (Singh *et al.*, 2014) and female Wistar rats (Akpantah *et al.*, 2010).

The cortex in ovaries of guinea pigs was filled with small follicles that were numerous and predominant, whereas, the medium types were scanty. Large follicles were more than

medium types and at least four or more Graafian follicles were detected in the ovary. The development of many Graafian follicles at the diestrous stage reflects their demand in the subsequent stages as the animal is polyestrous. These features were similar to those recorded in the ovaries of wild sand rats in which graafian follicles occupied a large part of the ovarian cortex and were adjacent to the free surface of the gonad. Graafian follicles were also characterized by the presence of secondary oocyte (Boubekri *et al.*, 2007).

The medulla in the ovaries of guinea pigs were formed of irregular dense connective tissue bundles filling the core of the ovary which passed through hilus into the medullary stroma where many blood vessels branches intervene with connective tissue running between follicles, distinctly distributed around large follicles. These findings came in agreement with those recorded in does (AL-Saffar and Almayahi, 2018a), rat (Lalithamma *et al.*, 2016), hamster (Chunt and Williams, 2016) and female agouti (Singh *et al.*, 2014).

#### **Microscopically - Uterine Tubes:**

The beginning portion of this tube was expanded in the guinea pigs forming the infundibulum and such observation was not found in the pre-ampulla of local does, but in both species, the mucosa of this organ was lined with simple columnar cells, mucosa very folded and branched (AL-Saffar and Almayahi, 2019).

The mucosal folds in pre-ampulla of guinea pigs was different to that in Bakerwali goat where the infundibulum and ampulla were lined by pseudostratified ciliated columnar epithelium, in addition to that other difference was the lining of isthmus by non-ciliated pseudostratified columnar epithelium in goat whereas simple columnar in guinea pigs (Saleem *et al.*, 2016).

Similar to guinea pigs, the female agouti showed mucosal membrane of



uterine tubes lined with simple columnar cells with complicated folds which gave many branches (Singh *et al.*, 2014).

Similarly, the acidic mucin that recorded in the isthmus of the guinea pigs was also recorded in the female goat's uterine tubes (Natarajan *et al.*, 2003). In fact, the presence of neutral and acidic secretory cells in the isthmus mucosa indicated its importance to the survival of stores sperms in its lumen. In fact, previous references postulated the importance of this part of the uterine tube in the maturation, transportation, nutrition and capacitating of the coming sperms post-coitus or mating (Suárez, 1987; Pollard *et al.*, 1991; Abe, 1996).

The presence in general different types of epithelial cells in the mucosa of the uterine tubes of the studied guinea pigs (ciliated and secretory cells) was in agreement with the previous research of Cheng and Bostwick (2006).

The presence of mucin secretory cell positive for AB and PAS stains in the mucosa of the uterine tubes of the studied guinea pigs was also recorded in other species such as Angora rabbit (Özen *et al.*, 2010), local does (Al-Saffar and Almayahi, 2019), Bakerwali goat (Saleem *et al.*, 2016).

In conclusion, the ovarian surfaces in the diestrous guinea pig were not smooth because of the ovarian follicles bulging indicated feature of the pre-ovulation. Parallel to this feature, the histology aspect showed many large follicles that were ready for subsequent ovulation. Distinctly, a unique feature to guinea pigs uterine tube was the expansion cranially to form infundibulum, whereas, caudally it forms an abrupt utero-tubal junction and not gradual as identified in other species.

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#### REFERENCES

- Abe, H. (1996). The mammalian oviductal epithelium: regional variations in cytological and functional aspects of the oviductal secretory cells. *Histol. Histopathol.*, 11: 743-768
- Abe, H. and Oikawa, T. (1989). Differentiation of the golden hamster oviduct epithelial cells during postnatal development: an electron microscopic study. *J. Exp. Zool.*, 252: 43-52
- Abood, D. A. and Al-Saffar, F. J. (2015). The post hatching development of the female genital system in Indigenous Mallard Duck (*Anas platyrhynchos*). *The Iraqi Journal of Veterinary Medicine*, 39(2): 17-25
- Akpantah, A. O., Ekong, M. B., Uruakpa, K. C., Akpaso, M. K., Eluwa, M. A. and Ekanem, T. B. (2010). Gonadal histomorphologies and serum hormonal milieu in female rats treated with *azadirachta indica* leaf extract. *Iranian J. Rep. Med.*, 8(4): 185-190
- Ali, M. N., Onyeanusi, B. I., Ojo, S. A., Ayo, J. O., Maidawa, S. M. and Imam, J. (2010). Biometric and morphologic studies of the female reproductive organs of the African giant rat (*Cricetomys gambianus*: Waterhouse). *Folia Morphol.* 69(4): 213-215
- Al-Saffar, F. J. and Almayahi, M. S. (2018a). Histomorphological

- postnatal developmental study of the ovaries of the local rabbits (*Oryctolagus cuniculus*). *Bas. J. Vet. Res.*, 17(2): 124-146
- Al-Saffar, F. J. and Almayahi, M. S. (2019). Structural study of uterine tubes of the rabbit (*Oryctolagus cuniculus*) at different postnatal periods. *Iraqi J. Vet. Sci.*, 33( 2): 277-288
- Bitto, I. I., Arubi, J. A., Gumel, A. A. (2006) Reproductive tract morphometry and some haematological characteristics of female rabbits fed pawpaw peel meal based diets. *Afr. J. Biomed. Res.*, 9: 199–204
- Bosch, P. and Wright, Jr. R. W. (2005). The oviductal sperm reservoir in domestic mammals. *Arch. Med. Vet.*, 37(2): 95-104
- Boubekri, A., Spychalowicz, T. G., Khammar, F. and Exbrayat, J. M. (2007). Histological and immunohistological aspects of the ovarian cycle of the Algerian wild sand rat, *Psammomys obesus* Cretzschmar, 1828. *Folia Histochemica et Cytobiologica*, Supp. 1, 45: 41-49
- Capello V. (2005). Surgical techniques for neutering the female pet rabbit. *ExoticDVM.*, 7(5):15–21.
- Chanut, F. J. A. and Williams, A. M. (2016). The syrian golden hamster estrous cycle: unique characteristics, visual guide to staging, and comparison with the rat. *Toxicologic Pathology*, 44(1): 43-50
- Cheng, L. and Bostwick, D. G. (2006). *Essentials of anatomic pathology*, Springer. pp. 1093-. ISBN 978-1-58829-461-6. Retrieved 18 November 2010.
- Culling, C.F.A., Allison, R.T., Barr, W.T. (1985). *Cellular Pathology Technique*. 4th edn., Butterworth, Wellington
- Eifler, A. C., Lewandowski, R. J., Virmani, S., Chung, J. C., Wang, D., Tang, R., Szolc-Kowalska, B., Woloschak, G. E., Mulcahy, M. F., Ryu, R. K., Salem, R., Larson, A. C., Cheon, E., Strouch, M., Zarlengo, D., Bentrem, D. and Omary, R. A. (2009). Development of the VX2 Pancreatic Cancer Model in Rabbits: A Platform to Test Future Interventional Radiology Therapies. *Society of Interventional Radiology 34<sup>th</sup> Annual Sci. Meeting*
- Guo, Y.; Bao, Y.; Meng, Q.; Hu, X; Meng, Q.; Ren, L.; Li, N. and Zhao, Y. (2012). Immunoglobulin genomics in the guinea pig (*Cavia porcellus*). *PLoS ONE* 7(6): e39298
- Hebel, R., Stromberg, M. W. (1976). *Anatomy of laboratory rats*. Williams and Wilkins Company, Baltimore, pp. 76–80
- Hunter, R. H. F. (1984). Pre-ovulatory arrest and peri-ovulatory distribution of competent spermatozoa in the isthmus of the pig oviduct. *J. Reprod. Fertil.*, 72: 203-211
- Kunzl, C. and Sachser, N. (1999). The behavioural endocrinology of domestication: a comparison between the domestic guinea pig (*Cavia aperea f. porcellus*) and its wild ancestor, the cavy (*Cavia aperea*). *Horm. Behav.*, 35: 28-37
- Lalithamma, A., Naik, A. G. and Changamma, C. (2016). Cytoarchitectural variations in selected rat tissues following the administration of estradiol valerate in aged female rats. *Asian Pacific J. Reprod.*, 5(1): 36–41
- Lauschova, I. (2003). Secretory cells and morphological manifestation of secretion in the mouse oviduct. *Scripta Medica*, 76(4): 203-214
- Natarajan, T., Prasad, R.V., Karade, K. and Jamuna, K.V. (2003).

- Histological and histochemical studies on the oviduct of the buffalo (*Bubalus bubalis*) at different reproductive stages. Indian J. Anim. Sci., **73**: 484-487
- North, D. (1999). The guinea pig. seventh ed. Pool, T. The UFAW Handbook on the Care and Management of Laboratory Animals, 1. Blackwell Science, Ltd., London, pp. 367-388
- Ozdemir, D., Aydin, A., Yilmaz, S., Dinc, G. and Atalar, O. (2005). Observations on the morphology of the ovaries of the porcupine (*Hystrix cristata*). Veterinarski Arciv, **75**(2): 129-135
- Özen, A., Ergun, E. and Kurum, A. (2010). Histomorphology of the oviduct epithelium in the Angora rabbit. Turk. J. Vet. Anim. Sci., **34**(3): 219-226
- Pedersen, T. and Peters, H. (1968). Proposal for a classification of oocytes and follicles in the mouse ovary. J. Reprod. Fert., **17**: 555-557
- Pollard, J.W., Plante, C., King, W.A., Hansen, P. J., Betteridge, K. J. and Suarez, S. S. (1991). Fertilizing capacity of bovine sperm may be maintained by binding of oviductal epithelial cells. Biol. Reprod., **44**: 102-107
- Popesko P, Rajtovà V. And Horak J. (1990). A Color Atlas of Anatomy of Small Laboratory Animals. Vol. 1, Rabbit, Guinea Pig, Vol. 2: Rat, Mouse, Hamster. London, UK: Wolfe Publishing Ltd; 1990
- Saleem, R., Suri, S., Sarma, K. and Sasan. J. S. (2016). Histology and histochemistry of oviduct of adult Bakerwali goat in different phases of oestrus cycle. J. Anim. Res., **6**(5): 897-903
- Singh, M. D., Adogwa, A. O., Mollineau, W. M. and Garcia, G. W. (2014). Gross and microscopic anatomy of the reproductive tract of the female agouti (*Dasyprocta leporina*): A neotropical rodent with potential for food production. Trop. Agric. (Trinidad), **91**(1): 38-46
- Steinhauer, N., Boos, A., A.R, Günzel-Apel, A-R. (2004). Morphological changes and proliferative activity in the oviductal epithelium during hormonally defined stages of the oestrous cycle in the bitch. Reprod. Domest. Anim., **39**(2):110-9
- Stewart, C. A. and Behriner, R. R. (2012). Mouse oviduct development. Results Probl. Cell Differ., **55**: 247-262
- Suárez, S. S. (1987). Sperm transport and motility in the mouse oviduct: Observations *In situ*. Biol. Reprod., **36**: 203-210