Histomophological studies on the stomach of Eurasian Hobby (*Falconinae*: *Falco subbuteo,* Linnaeus 1758) and its relation with its feeding habits

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Abstract: The avian stomach was a muscular organ, located between the esophagus and the intestine and it was consisted of two parts; the proventriculus and the ventriculus as reported in many text books and previous articles. A morphological study of stomach was carried out, grossly and under light microscopy on ten adult normal healthy Eurasian Hobbies. The stomach was constituted by two chambers: proventriculus and gizzard. The proventriculus was elongated fusiform shaped organ and extended from the level of 2nd intercostal space to the level of 4th rib, while the ventricular resembles a biconvex lens and was extended from the level of 4th rib to the level of 7th rib. There is no any proventricular papilla on the gastric epithelium surface. Both, the mucous tunic of the proventriculus and of the ventriculus present folds were lined by simple columnar epithelium. The tunica mucosa of the proventriculus was extensively folded due to the presence of well-developed longitudinal muscle bundles. The Eurasian Hobby stomach ischaracterized by the absence of the isthmus. There are fourventricular muscles that radiating from a powerful fan-shaped tendinous center; two thick and two thin muscles. The luminal surface of the ventriculus have cuticle, which was sloughed and shed small fine area around the pyloric opening and very thin membrane and highly closely adherent to the lining surface of gizzard. The gizzard was separated from the small intestine by a slit-like ventriculo-duodenal opening, which guarded by the very small pyloric sphincter in addition to the pyloric valve which consists of two small folds.

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1. Introduction

The *Falconidae* family was belonged to the order *Falconiformes*. The *Falconidae*is a family of diurnal birds of prey, this family was divided into two subfamilies; *Polyborinae* (includes caracaras and forest falcons), and *Falconinae* (includes falcons, kestrels and falconets). The subfamily *Falconinae* has five genus; *Herpetotheres*, *Spiziapteryx*, *Polihierax*, *Microhierax* and *Falco*(have around 37 species and widely distributed on all continents of the world). The *Eurasian Hobby* was one of 11 species of family Falconidae in Egypt and was belonged to Genus *Falco* (including; true falcons, hobbies and kestrels) and subgenus*Hypotriorchis***(Myers et al., 2009)**. TheEurasian Hobbyhas twosubspecies; *subbuteo* (nominate race is resident in Africa, Europe and Central and East Asia, winters in Central and South Africa and South Asia) and *streichi* (described by Hartert and Neumann in 1907, was smaller in size and was found further east of *subbuteo*'s distribution range) **(Bird Life International, 2013).**

The stomach of birds was divided into three types according to nature of diet as noted by **(Hassouna, 2001)**; first type, soft eating birds as in kestrel and owl in which the main function of the gizzard was the storage of food. Second type, hard diet eating birds as in turkey and sparrow in which the main function of the gizzard was mechanical treatment of the food while the third type, intermediate diet eating birds as in goose, hoopoe and darter in which the role of gizzard was storage and physical digestion.

Many authors related the size and shape of the stomach with the nature of diet **(Taylor, 2000, Denbow, 2000, Klasing, 1999)**; in *carnivorous* and*piscivorous species*, both structures were very distensible and may be difficult to differentiate grossly due to the soft nature of their diet. In birds that eat hard food, the proventriculus was relatively thin-walled and glandular while the ventriculus was muscular, thick-walled and powerful. This gastric arrangement was typical of granivorous, omnivores, insectivores and herbivores**.(Nickel et al., 1977)** in vegetarian fowls, the gizzard was considered as a masticator organ and the best developed in species that ingest hard foods such as *granivorous*, **(Klasing, 1999, Taylor, 2000)** and in *insectivores*, **(Gartrell, 2000).**

In relation to the morphology of the digestive tract of the Eurasian Hobby, we found poor references in the literatures about the stomach of the Eurasian Hobby. This fact awakened our interest to study the anatomical position, morphology of the Eurasian Hobbystomach.

In this study, our aim was to study the histomophological characters of the Eurasian Hobbystomach in addition to compare our findings with the previous literatures. In our literature review, we could not find sufficient information about Eurasian Hobby stomach in birds of the *Falconidae*family.

2. Materials and methods

Samples

The stomachs (proventriculus and ventriculus) for this study were collected from ten adult normal healthy Eurasian Hobbiesweighing approximately 150 g, were captured from Desouk city, kafre El-sheik Governorate, Egypt. Then the birds were kept in individual cages, fed with new-born rats, chow for dogs and water adlibitum during 3 days at circadian time table (12 hours of light and 12 hours of dark).

For gross morphology

All Eurasian Hobbieswere sedated by Rompun (Xylazine hydrochloride 20 mg/ml, then anaesthetized with chloral hydrate. After all the Eurasian Hobbieswere anaesthetized,they were well bled via the common carotid artery(sexes and body weights were not recorded). Seven adult normal healthy Eurasian Hobbiesof both sexes were used to demonstrate; the topographic position of the stomach in the thoraco-abdominal cavity, then to perform the gross morphological studies of the external and the internal features of the stomach. Three Eurasian Hobbieswere used as fresh and four were formalized in a 10% formalin solution. Then the gross morphological features of the stomach were examined in situ by the nacked eyes, next dissected, and photographed by digital camera (Sony)

The anatomical nomenclature used was based on Nomina Anatomica Avium (NAA) **(Baumel et al., 1993)**.

For histological studies

Three stomachs of adult normal healthy Eurasian Hobbiesof both sexes were obtained then the stomachs divided into several segments, then each segment were immediately fixed in Bouin's liquid, for 24 hours. After dehydration with ethylic alcohol in increasing concentrations (70 to 100%) the fragments were cleaned in xylene and embedded in soft paraffin, and sectioned at 5µm and were stained by Hematoxylin-eosin (H & E) for general character.

3. Results

A. Anatomical findings:

The Eurasian Hobby stomach was belonged to the carnivorous birds according to the type of food and eating habits.

The Eurasian Hobby stomach was considered as a caudal dilated continuation of the esophagus and was located between the esophagus and the intestine, at the left of the median line and it was located dorsal to the liver. The stomach was generally placed at the left dorsal and left ventral parts of the thoraco-abdominal cavity, which reach to about 3.3 cm in the length.

The Eurasian Hobby stomach was a muscular organ which divided into two distinct different chambers, the cranial chamber was the proventriculus (*Glandular stomach*, *Ventriculusglandularis*) and the caudal chamber was the ventriculus (*Muscular stomach, Gizzard, Ventriculus muscularis*), in which the cranial chamber was a glandular and supported with a muscular bundles while the caudal chamber was a muscular part. The isthmus or intermediate zone which separated the two distinct chambers of the stomach was abscent in the Eurasian Hobby stomach.

A.1. Proventricular (*Glandular stomach*)

The proventriculus was lies in the middle part of the thoraco-abdominal cavity and its long axis was directed from craniodorsally and medially to caudoventrally and laterally, and was extended from the level of the 2nd intercostal space to the level of the 4th rib.

The proventriculus was related to some air sacs; in which the thoracic air sac was separated it from the heart and liver while the abdominal air sacs was separated it from the left abdominal wall. Together with the spleen, it was accommodated in a pocket of the visceral peritoneal sac. It was hardly in touch by the external palpation.

The proventricular stomach was attached to the vertebral column at the entrance of thorax by connective tissue, vessels and fixed in its position; dorsally by the blood vessels especially the celiac artery and ventrally by the presence of the heart and laterally by the lobes of the liver (Fig. 1).

The proventricular was in contact ventrally and laterally, with the left lobe of the liver which produces a deep gastric impression on the visceral surface of the left lobe of the liver while, on the right side, the proventricular was related caudodorsally to the spleen and it was covered with the cranial thoracic air sac dorsally.

The proventriculus was placed in front of the gizzard and it was an elongated fusiform shaped organ which reach to about 1.7 cm in length and 3cm in wide while the ventricular stomach reach to about 1.6 cm in length and 3.8 cm in wide (Fig. 1).

The proventricular stomach was a structure located between the esophagus cranially and the ventricular stomach caudally. Cranially; the proventricular stomach was separated from the esophagus by a clear constriction externally, while internally, it was identified by the color; in which the color of proventricular was dark brown and have well-developed longitudinal muscular folds while the esophagus was whitish and folded. Caudally, the

proventriculus was separated from the ventricular stomach by very weak constriction and there was no clear division internally as there was no demarcation line or space (isthmus) between proventricular and ventricular part of the stomach but differentiated from each other by their structure in which each one have its characteristic structure (Fig.1 and 2).

The proventriculus was not confluent with the esophagus cranially, in which the proventricular has a number of the well-developed longitudinal folds due to presence of well-developed longitudinal muscle bundles, in which this longitudinal folds reach to 5 longitudinal folds which were separated from each other by clear longitudinal grooves while the internal surface of the esophagus was smooth and folded and not have any muscle bundles. There were no macroscopic papillae in the internal (mucosal) surface of the proventricular, in which the mucosal surface of the proventricular was smooth (Fig.2).

The ventral two longitudinal proventricular muscular folds were the large, longer, thicker than the rest of longitudinal proventricular muscular folds, in which reach to about 1.6 cm in the long and 0.5 cm in the thickness near the gizzard while about 0.3 cm in thickness near the esophagus and the rest of the longitudinal proventricular muscular folds were appeared to be branched from this two large longitudinal muscular folds. The two longitudinal proventricular muscular folds behind the large two longitudinal proventricular muscular folds were reached to about 1.4 cm in the length and 0.4 cm in the thickness near the gizzard while about 0.3 cm in thickness near the esophagus while the last longitudinal proventricular muscular fold was the smaller one which reach to about 1.2 cm in the length and 0.4 cm in thickness near the gizzard while 0.2 cm in thickness near the esophagus. These muscular folds were wide near the gizzard while narrow toward the esophagus. The grooves between the muscular folds were clear and reach to about 0.2cm in depth (Fig.1B).

A.2. Gizzard (*Ventricular or pars muscularis gizzard*)

The ventricular stomach was the second chamber of the Eurasian Hobby stomach which was located between the proventriculus cranially and the duodenum caudally (Fig. 2A:1, 4) and was extended from the level of the 4th rib to the level of the 7th rib. The ventricular was filled the lower quadrant of the caudal part of the thoraco-abdominal cavity and extended beyond the midline to the right side and it can be touched immediately caudal to the breast bone, as a firm mass (Fig. 1). The craniocaudal axis of the gizzard was extended ventrally and to the right.

The ventricular stomach resembles a biconvex lens or may take the kidney shape (Fig. 2A). Its craniocaudal diameter (3.5 cm) was the greater than its dorsoventral one (2.5 cm)

Cranially, the Eurasian Hobby gizzard was related to the proventriculus, the two lobes of the liver and sternum. Laterally, the gizzard was related to the left lobe of the liver while caudally, it was separated from the left abdominal wall by the left ventral hepatic celomic cavity. The dorsal surface was separated from the left testicles in case of male (or from the ovary and oviduct in case of female) by the left abdominal air sac. Medially, the gizzard was related to the spleen cranially and to the various intestinal segments caudally, while dorsally the medial surface was separated from the rectum and ceca by the left abdominal air sac. The ventral border of the gizzard was related to the ascending and descending parts of the duodenum and pancreas. The ventricular was reached the floor of the abdominal cavity and sternum. Caudally, the gizzard was related to the duodenal loop and jejunum and the distal part of the cecum and ileum.

The gastric ventriculus was consisted of; body and two blind sacs (craniodorsal and caudoventral). The body of gizzard was the main part which separated the two tapering ends, the craniodorsal blind sac (*saccuscraniodorsalis*) and caudoventral blind sac (*saccuscaudoventralis*), in which the proventriculus open in the craniodorsal blind sac while the pyloric (*gastroduodeneal*) opening and the origin of the duodenum were present on the right side, adjacent to the craniodorsal blind sac (Fig. 2A). The craniodorsal blind sac (*saccuscraniodorsalis*) was opened into the dorsal part of the body, while the caudoventral blind sac (*saccuscaudoventralis*) was opened into the ventral part of the body, while the proventriculus was opened by a wide opening into a craniodorsal blind sac.

The muscles of the gizzard were divided into four muscles that radiating from a powerful fan-shaped tendinous center; two thick muscles (cranioventral and caudodorsal) (Fig. 2A: b, d) and two thin muscles (craniodorsal and caudoventral) (Fig. 2A: a, c). The two thin muscles were covering the blind sacs (craniodorsal and caudoventral) (Fig. 2A: a, c), while the two thick muscles were covering the body. The gizzard was covered by a peritoneal coat and the tendinous layer was thickest at these central points, each of which was called a tendinousaponeurosis (Fig. 2A:6) and there were no muscles fibres present at the center of the aponeurosis (Fig. 2A:e).

The asymmetrical arrangement of these four muscles provides mixing and grinding actions during contractions. A white and brilliant sheet was observed in the center of gizzard characterized by a tendinous connective tissue (Fig. 2A: e). The caudodorsal thick

muscle was extended transversely over the dorsal contour of the body between the two tendinous centers of both sides, in which its caudal part was thicker than its cranial part. The cranioventral thick muscle was extended transversely over the ventral contour of the body between the two tendinous centers of both sides, in which its cranial part was thicker than its caudal part. The craniodorsal thin muscle was covered the craniodorsal blind sac and extending between the tendinous parts and blended with the caudodorsal thick muscle. The caudoventral thin muscle was covered the caudoventral blind sac and extending between the tendinous parts and blended with the cranioventral thick muscle. The connections between the thick and thin muscles were not marked externally.

The Eurasian Hobby gizzard was lined by low fine folds without any separation from the internal surface of the proventricular (Fig. 2B). The internal musculature of the ventricular stomach was less than those present in the proventricular stomach, in which it was lined by the low gastric folds (Fig. 2B:5, 6). The inner surface of the gizzard was lined by a tough membrane (cuticle), this green soft membrane which called the cuticle (*cuticulagastrica*) was present in the center part of the cavity of the gizzard around the pyloric opening only while the rest of the cavity without this cuticle membrane (Fig. 2B: 3) and its attachment to the lining epithelium was firm.

The Eurasian Hobby gizzard was separated from the small intestine by a slit-like pyloric (*ventriculo-duodenal*) opening (Fig. 2B: 4) which reaches to about 0.2cm in diameter and present in the ventral part of the ventriculus between the thin muscle of the craniodorsal blind sac and the cranioventral thick muscle of the body and at small distance from the proventricular by about 0.4 cm. pyloric opening was guarded by the very small pyloric sphincter in addition to the pyloric valve. The pyloric valve was consisted of two small folds; one long reach to about 0.5 cm in length and 0.1 cm in the thickness while the other was very small in which reach to about 0.2 cm in length and 0.05 cm in thickness. Pyloric opening and its sphincter and its fold regulate the passage of food into the small intestine by slowing the movement of large particles (Fig. 2B).

B. Histological findings:

The analysis of the histological sections, under light microscopy, revealed that the wall of the Eurasian Hobby stomach (proventriculus and gizzard) was constituted by the following four layers: tunicamucosa or the mucous membrane (*tunica mucosa gastris*), tunica submucosa (*telasubmucosagastris*), tunica muscularis (*tunica muscularisgastris*) and tunica serosa (*tunica serosa*).

B.1. Proventricular (*Glandular stomach*)

The tunica mucosa (*tunica mucosa gastris*) of the proventriculus has a well-developed longitudinal muscular folded (*plicae*) and separated by grooves (*sulci*) due to the presence of well-developed inner proventriculus longitudinal layer of the tunica muscularis. This thick tunica muscularis of proventriculus (inner longitudinal and outer circular smooth muscles) makes up the greater part of the thickness of proventricular wall. The folds in the luminal surface were lined by a simple prismatic epithelium (Fig. 3).

The luminal surface of the proventriculus was lined with simple columnar epithelium, and the transverse sections of the surface epithelium were folded to form finger-like projections. The mucosa of the proventriculus contains the simple superficial tubular glands (*Gll. Proventricularis superficialis*) lined throughout their length by a columnar epithelium. The tunica submucosa was constituted by connective tissue, containing blood vessels and contains a high number of the lobules of the large deep compound tubular proventricular glands (*Gll. Proventricularis profundus*), in which these large deep compound tubular proventricular glands were lined by the same surface epithelium and with adjacent lobules separated by fine strands of connective tissue. Each gland lobule contains a central cavity with straight secretory tubules radiating to the interlobular connective tissue. A thick lamina propria was constituted by connective tissue with blood vessels and this thick lamina propria was located around the glandular layer. Under the lamina propria, there was a well-developed tunica muscularis (*tunica muscularisgastris*), thetunica muscularis are the major structural component of the proventricular wall and have been located to various areas of the organ. There is no lamina muscularis mucosa. (Fig. 3)

The muscle tunic (*tunica muscularisgastris*), presents an inner layer of longitudinal disposed smooth muscular fibers (*stratum longitudinale*) and another outer, of circulary disposed fibers (*stratum circulare*). The inner longitudinal layer was more developed than the outer circular layer. This thick muscular layer occupies the greater part of the thickness of the wall of the proventriculus. In between these two layers (inner longitudinal and outer circular layer), the elongated ganglia of the myenteric plexus were observed. The tunica serosa of the proventriculus (tunica serosa) was constituted by loose connective tissue (Fig. 3).

B.2. proventricular-ventricular junction

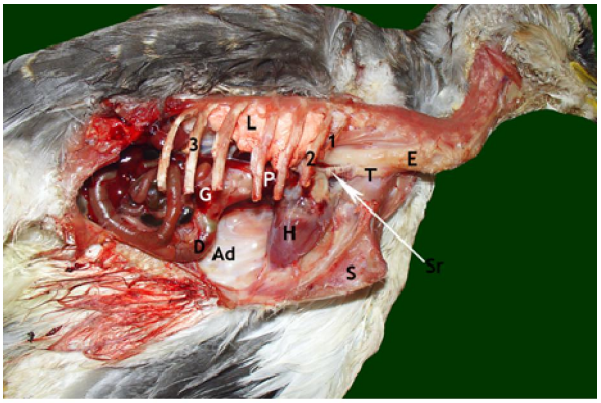
There was no intermediate zone (isthmus) between the proventriculus and the gizzard but the differenation between them macroscopic by the internal structure of them: proventriculus was

characterized by the extensive longitudinal folds while the ventriculus by the presence of low gastric folds. The proventricular-ventricular junction was characterized bynon-folded mucosa that lined with simple columnar epithelium. The submucosa was constituted by connective tissue, containing blood vessels and lacked for the proventricular glands. There is a thin lamina propria, constituted by connective tissue with blood vessels and was separated the gastric epithelium from the glandular layer which consisted of high number of simple tubular branched glands (*Gll. Proventricularis*) and take its characteristic shape, in which this glands were lined by the same surface epithelium and with adjacent lobules separated by fine strands of connective tissue. The glandular layer is the major structural component of the proventricular wall. Each gland lobule contains a central cavity with straight secretory tubules radiating to the interlobular connective tissue. The tunica muscularis (*tunica muscularisgastris*) was thinner than this present in the proventricular and consists of two layers; inner circular and outer longitudinal. (Fig. 4)

B.3. Gizzard (*Ventricular or Muscular stomach*)

The mucous membrane of gizzard (*tunica mucosa gastris*) presents low folds (*plicae*), which were lined by simple columnar epithelium. Over the small area of the mucous membrane of ventriculus, exactly, at the area around the pyloric opening (*ventriculo-duodenal*) only was lined with secretory product of mucosal glands, which solidifies at the surface to form a small weak cuticle layer (*cuticulagastrica*) while the rest of luminal surface not have cuticle layer, in which the cuticle was sloughed and shed small fine area and very thin membrane and highly closely adherent to the lining surface of this area of the gizzard and it was often green, brown or yellow in color because of reflux of bile pigments from the small intestine (Fig. 5).

The surface lining of the tunica mucosa was consisted of low columnar cells. A submucosa was present, containing the well-developed glandular layer, was consisted of the compound tubular glands (gizzard glands or *Gll. Ventricularis*), in which these large compound tubular ventricular glands were lined by the same surface epithelium and with adjacent lobules separated by fine strands of connective tissue. Each gland lobule contains a central cavity with straight secretory tubules radiating to the interlobular connective tissue(Fig. 6).These large compound tubular ventricular glands were located under the tunica mucosa followed by lamina propria (*lamina mucosa gastris*), which was constituted by a dense connective tissue. The lamina muscular mucosa was present under the lamina propria. The tunica serosa was constituted by connective tissue (Fig. 5).



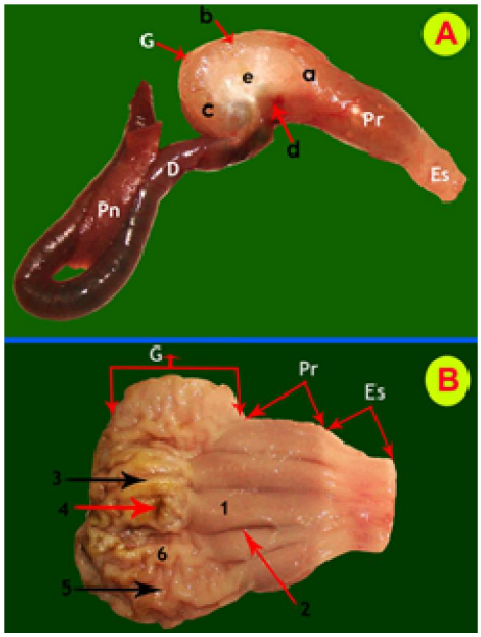
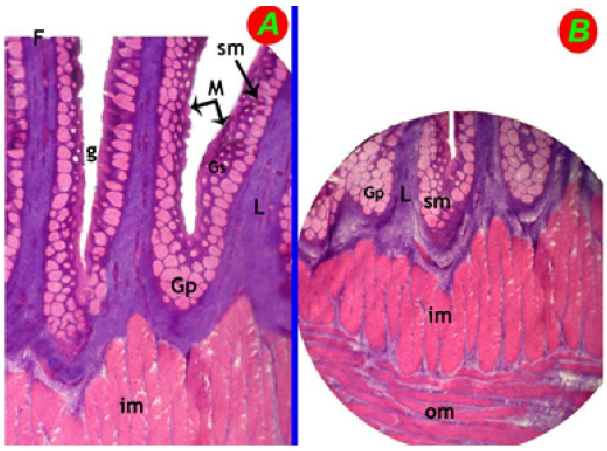


Figure 2: A- Anatomical appearance of the of stomach of the Eurasian Hobby; B- Anatomical appearance of the interior of stomach of Eurasian Hobby

Es- Esophagus, Pr- proventricular, G- gizzard, D- duodenum, Pn- pancreas, a- thin craniodorsal muscle (lined cranial blind sac), b- thick caudodorsal muscle, c- thin caudoventral muscle (lined caudal blind sac), d- thick cranioventral muscle, e- central tendinous part, 1- Proventricular fold lined with mucous membrane, 2- longitudinal groove, 3- cuticle layer, 4- pyloric opening, 5 and 6- low and high ventriculus folds.



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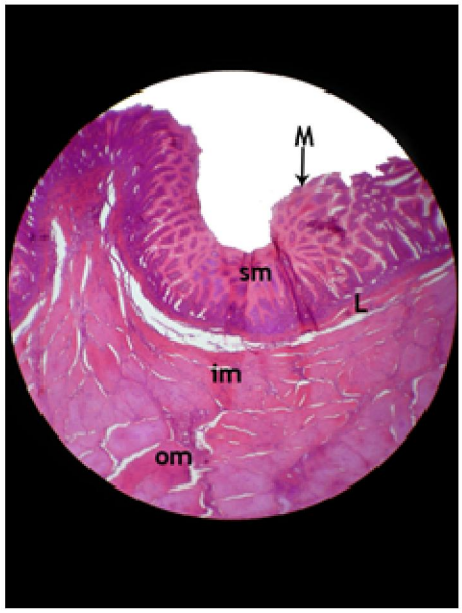

cross section of the proventriculus-ventricular of the Eurasian Hobby:
M- tunica mucosa, sm- subtunica mucosa, L- lamina propria, im- Inner longitudinal layer of tunica muscularis 5- Outer circular layer of tunica muscularis.

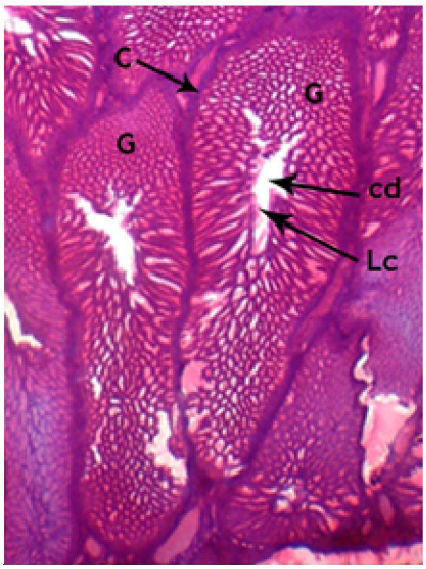

Figure 6: Light microscopic appearance of the ventricular glands of the Eurasian Hobby:
G- Ventricular glands, cd- Central cavity, c- capsule of gland, Lc- luminal of gland.

4. Discussion

From the background of available published data; **(Calhoun, 1954)** in chicken**, (Nickel et al., 1977, Bailey et al., 1997, McLelland, 1979, Klasing, 1999, Bacha and Bacha, 2000, Whittow, 2000,**

Elizabeth and Fredric, 2001, Dursun, 2002) in domestic birds, **(Catroxo et al., 1997)** in red-capped cardinal, **(Nazan et al., 2010)** in sea gulls and **(Rocha and De Lima, 1998)** in owl, the our study in the Eurasian Hobbystomach as in all birds was a muscular organ which divided into two distinct different chambers; the proventriculus and the ventriculus. While **(Hodges, 1974)**, noted that, the stomach of birds was consisted of three compartments; proventricular, ventricular and pyloric part, but this third part was reduced in the domestic birds.

From the published data noted that there were anatomical variation in the position of the stomach between the different birds; our observation noted that, the Eurasian Hobbystomach was located at the left of median line; agree with that observed by **(Baumel et al., 1993)**. From the previous article, there are species variations in the position of the proventricular stomach, our study in the Eurasian Hobby, observed that the proventricular stomach was extended from the level of the 2nd intercostal space to the level of the 4th rib, which agree with **(Hassouna, 2001)** in kestrel while in goose from the 2nd intercostal space to the 5th rib, in turkey from the 3rd intercostal space to the 5th rib, in sparrow and hoopoe from the 4th intercostal space to the last rib but in owl and darter from the 2nd or 3rd intercostal space to the 6th rib, moreover **(El-Ghazali, 2008)** reported that in duck from the 4th rib to the 6th intercostal space but in goose from the 5th rib to the level of the 7th intercostal space, in pigeon the proventriculus was extended from the level of the 3rd to 5th rib and in hoopoe was extended from the level of the 3rd intercostal space to 6th rib, but in ibis from the level of the 6th rib to the level of the synsacrum.

From the previous articles, there are species variations in the shape of bird stomach as noted by **(King and Mclelland, 1975)**, the proventricular was highly distensible in some species which swallow large masses of food, e.g. albatrosses, cormorants, storks and gulls. The gizzard was extremely variable in its form and muscularity, dependent on the type of diet, in which the muscle and tunica cuticula tend to be best developed in graminivorous and herbivorous species, e.g. the domestic fowl, pigeons, ducks and geese. In carnivorous birds such as hawks and owls the gizzard tends to be a thin walled bag. In a small number of an aquatic species, including grebes, penguins, pelicans and some ducks and geese, there is a third compartment (pyloric part) between the gizzard and duodenum. Our study in the Eurasian Hobbyagrees with the result noted in the carnivorous birds.

As demonstrated in recent studies, our observation in the Eurasian Hobbystomach agree with **(El-Ghazali, 2008)** in duck that, the proventricular was a fusiform shaped organ, while **(El-Ghazali, 2008, Rossi et al., 2005)** differ in that, was dorsoventrally flattened oval shaped in goose and cylindrical shaped in pigeon and small elongated pear shape in hoopoe and large elongated pear in ibis. **(Hodges, 1974)** noted that the proventricular was a short, thick-walled, spindle-shaped organ. **(Bailey et al., 1997)** the proventriculus of bustards was cone-shaped. **(Salem and Yousria, 2000)** reported that the proventriculus was spindle-shaped in chicken, pigeon and duck but lens-shaped in cattle egret.**(Whittow, 2000)** added that there were different in size among species, in which it was a small in granivorous species while large and distensible in aquatic carnivores. The proventricular of three species of Australian Passerines were small, elliptical, or cone shaped with relatively thin wall **(Ogunkoya and Cook, 2009)**.

Our observation in the Eurasian Hobbystomach agree with **(Rossi et al., 2005)** and **(El-Ghazali, 2008)** in duck, goose and pigeon that theventricular stomach resembles a biconvex lens, while**(El-Ghazali, 2008)** noted that it was oval circumference in hoopoe and rounded sac-like structure in ibis. **(Hassouna, 2001)** in kestrel and owl reported that the ventricular shape was oval sac-like. **(Hodges, 1974)** noted that the gizzard was flattened sphere in shape. **(Bailey et al., 1997)** the gizzard was oval-shaped. **(Chikilian and DE Speroni, 1996)** noted that the gizzard of Nothuramaculosa and Nothoproctacinerascens have round format, and in Crypturellustataupa it presents an oval format.

In most species **(Bailey et al., 1997, King and Mclelland, 1975, Bacha and Bacha, 2000, Nickel et al., 1977)** noted a series of papillae were projected into the lumen of proventriculus, moreover **(Dyce et al., 2002, Rossi et al., 2005, Bailey et al., 1997)** noted that these papillae were low and wide.**(El-Ghazali, 2008)** noted that in grain eating birds as pigeon, the proventricular have round papillae with round opening on its center, while in worm and insect eating birds as hoopoe and ibis, it lack the papillae but containing the round opening only but in mixed eating birds; differ from the duck that containing an oval opening only without papillae to the goose which containing a well-developed papillae. **(Mina et al., 2011)** in ostrich reported that the proventriculus has papillary and no papillary region. In our observation in the Eurasian Hobby stomach, there were no any macroscopic papillae in the internal surface of the proventricular.

In the present investigation, the anatomical pattern of the glandular stomach continued directly from esophagus as a dilatation which separated from the esophagus by a constriction externally, while internally, identify by the color; the color of proventricular was dark brown and have well-developed longitudinal muscular folds while the

esophagus was whitish and folded. Our resultswere differ from that recorded by; **(Baumel et al., 1993, Nickel et al., 1977)** in fowl, **(Bailey et al., 1997)** in bustards and**(Rossi et al., 2005)** in partridge that there was no a clear division between the glandular stomach and the esophagus, while **(El-Ghazali, 2008)** noted that in the duck and goose, there was no line of demarcation while in pigeon, hoopoe and ibis, there was a constriction between the proventriculus and the gizzard.

It is well known in many published articles in different birds that, the proventriculus and gizzard was separated from each other by a constriction (isthmus) **(Rossi et al., 2005, Hassouna, 2001, Dyce et al., 2002, King and Mclelland, 1975, Nickel et al., 1977)**, while our observation agree with **(Salem and Yousria, 2000, El-Ghazali, 2008)** in cattle egret and ibisthat, the proventriculus and gizzard were not separated by intermediate zone (isthmus) from each other and the stomach appear as one chamber, in which **(Salem and Yousria, 2000)** in cattle egret added that, there was a ridge-like elevation present between the two part of the stomach replacing the isthmus. **(Baumel et al., 1993)** noted that in carnivorous and piscivorous fowls that swallow big victuals very little distinction exists between the glandular and the muscular stomach.

The present investigation agree with **(Hodges, 1974, McLelland, 1975, Nickel et al., 1977)** that, the muscles of the gizzard were divided into four muscles that radiating from a powerful fan-shaped tendinous center; two thick muscles (*cranioventral and caudodorsal*) and two thin muscles (*craniodorsal and caudoventral*). The two thin muscles were covering the two blind sacs (craniodorsal and caudoventral), while the two thick muscles were covering the body. Our study in the Eurasian Hobby confirmed that, the two pairs of opposing muscles; two thick and two thin muscles were responsible for the powerful grinding contractions, as noted by **(Whittow, 2000, Bailey et al., 1997).**

Our result noted the first record of the pyloric valve in which the gizzard was separated from the small intestine by a pyloric opening which was guarded by very small pyloric sphincter in addition to the pyloric valve which consists of two small folds.

Our histological results in the Eurasian Hobbystomach were disclosed that the structure of the proventricular and gizzard were nearly shares the same characteristics with other birds; in which the proventricular and the gizzard had all the four tunics namely, tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa; **(Calhoun, 1954, Selvan et al., 2008, King and Mclelland, 1975, Bacha and Bacha, 2000, McLelland, 1979)**. But our results recorded some variation, which depend on the habits of birds and types of food as noted by **(King and Mclelland, 1975).**

From the previous articles **(Hodges, 1974, King and Mclelland, 1975, Banks, 1993, Catroxo et al., 1997, Rocha and De Lima, 1998)**, the mucosa of the proventriculus has a more developed folds (*plicae*) and grooves (*sulci*), our result in the Eurasian Hobbynoted that, the tunica mucosa (*tunica mucosa gastris*) of the proventriculus has a well-developed longitudinal muscular folds (*plicae*) and separated by grooves (*sulci*) due to the presence of well-developed inner proventriculus longitudinal layer of the tunica muscularis, in addition to the proventriculus was lined with simple columnar epithelium. But **(El-Ghazali, 2008)** noted that no evidence for the presence of well-developed mucous membrane in pigeon. **(Hodges, 1974)**agrees with that **(Banks, 1993)** reported that the tunica mucosa of proventriculus was extensively folded into flattened ridges separated by grooves.

In the Eurasian Hobby, the lining epithelium of the folds of mucous membrane of the proventricular was of simple columnar type, which coincides with the observations of most of the authors **(Calhoun, 1954, Rocha and De Lima, 1998, Selander, 1963)**. The lining epithelium of the folds of gizzard was of simple prismatic type in the Eurasian Hobby, Similar to previous observations by**(Rossi et al., 2005)** in partrigde, **(Glerean and Katchburian, 1964)** describe a high prismatic type epithelium of Gallus. **(Elizabeth and Fredric, 2001, Hodges, 1974)** noted that the gastric epithelium of proventriculus was simple columnar. **(Bacha and Bacha, 2000)** agree with that except that at the base of the sulci, where it is cuboidal. **(Mina et al., 2011)** in ostrich noted that it was simple columnar.

In the gizzard, among several kinds of birds, the folds of the mucosa were described as; longitudinal **(Jain, 1976)** in P. krameri; **(Menin et al., 1990)** in Coragypsatratusfoetens, and high **(Lima, 1979)** in Columba livia but in our study in the Eurasian Hobby, the folds of gizzard in form of low fold without characteristic shape. **(Klem et al., 1983)** described the mucous membrane of the gizzard of Passer domesticus and Turdusmigratorius as constituted by dual viliform folds, whereas**(Vittoria and Richetti, 1974)** noted that the gizzard of carnivorous and granivorous birds, as composed by circular crypts which unfolds. **(Akester, 1986)** stated that in Gallus the elliptical crypts may reach the shape of large and narrow fissures. In our study the mucous membrane of the Eurasian Hobbygizzard was clear developed low folds.

Our result in the Eurasian Hobby agree with **(El-Ghazali, 2008, Rocha and De Lima, 1998)** that, the lamina propria was located under the glandular layer to separate it from the tunica muscularis, this

glandular layer was consisted of high number of the lobules of the tubular proventricular glands (*Gll. Proventricularis*), while **(El-Ghazali, 2008)** noted that this gland was abscent in hoopoe and ibis. The absence of the lamina muscularis mucosa of the proventricular in our study in the Eurasian Hobbyagree with**(El-Ghazali, 2008)** in pigeon and hoopoeand **(Rocha and De Lima, 1998)** in burrowing owl.

As noted in many previous articles **(El-Ghazali, 2008, Oliveira et al., 2008, Ogunkoya and Cook, 2009, Baumel et al., 1993, King and Mclelland, 1975, McLelland, 1979, Catroxo et al., 1997, Rocha and De Lima, 1998),** there are two layers of proventricular glands; the superficial and deep layer. According to previous articles, the authors differ greatly in the position of the proventricular glands according to bird species, bird habits and type of food; the position of the superficial proventricular glands have some variation; our study in the Eurasian Hobbyagree with **(Aitken, 1958),** that the mucosa of the proventriculus contains the superficial simple tubular glands, while **(Ogunkoya and Cook, 2009, Rocha and De Lima, 1998)** reported that the surface epithelium of proventricular was invaginated into the lamina propria to form the superficial, simple tubular glands. The position of the deep proventricular glands have some variation; our study in the Eurasian Hobbyagree with **(Aitken, 1958, Rocha and De Lima, 1998),** that the presence of the deep tubular proventricular glands in the tunica submucosa, while **(Hodges, 1974)** in fowl noted that the deep tubular proventricular glands were located between the inner and outer layers of the muscularis mucosa.**(Brock, 1925)** reported that the deep proventricular glands present in the lamina propria of domestic fowl and ostrich respectively, whereas **(Bezuidenhout and van Aswergen, 1990)** observed the glands within the lamina muscularis mucosae of the organ in domestic chicken and ostrich respectively. The deep proventricular glands have been observed to divide the lamina muscularis mucosae into superficial and deep layers interconnected by muscle fibres and connective tissue **(Ziswiler, 1967)**.

Our result in the Eurasian Hobby, found well-developed tunica muscularisgastris of proventricular, arranged in two layers; an inner layer of longitudinal muscular fibers and outer layer of circular fibers, this arrangement of the two layer of muscles agree with **El-Ghazali, 2008** in goose, hoopoe and pigeon. While, Most of the authors**(Calhoun, 1954, Hodges, 1974)** have noted, the proventriculus of birds in general, the muscle tunic as constituted by external layer of longitudinal muscle fibers and a circular inner layer, moreover **(Rossi et al., 2005, Elizabeth and Fredric, 2001, Turk, 1982)**, noted that a well-developed tunica muscularis was arranged as inner circular and outer longitudinal layers of smooth muscle. **(Denbow, 2000)** added that the outer longitudinal layer was poorly developed or absent in parrots, waterfowl and some passerines. While **(El-Ghazali, 2008, Nickel et al., 1977, Catroxo et al., 1997)** in duck and ibisnoted that, the musculature of proventriculus has three layers; inner and outer layers of longitudinal and middle circular layer.

Our result in the Eurasian Hobby noted that, a well-developedtunica muscularis are the major structural component of the proventricular wall and have been located to various areas of the organ. While **(Ogunkoya and Cook, 2009)** in three species of australianpasserines reported that, the deep proventricular glands are the major structural component of the proventricular wall. Our result in the Eurasian Hobby agree with **(El-Ghazali, 2008)** in pigeon and hoopoe and **(Rocha and De Lima, 1998)** in owl, that, there is no lamina muscularis mucosa in the proventricular. This results in contrast with **(El-Ghazali, 2008)** in goose, duck and pigeon, but the lamina muscularis mucosa present in our study as noted in all previous articles.

From the available literature, it is well known that the cuticle which differ according the bird species, bird habits and food consumed, in which **(Akester, 1986, Catroxo et al., 1997, Dyce et al., 2002, Landolt, 1985, McLelland, 1979, Rocha and De Lima, 1998),** described as a thick covering plate, lining the mucous membrane of the gizzard, agree with. **(Hodges, 1974)** reported that there is a thick, horny layer lining the lumen of organ as noted in many articles; **(Bailey et al., 1997)** in bustards, **(King and Mclelland, 1975), (Banks, 1993)**and**(Rocha and De Lima, 1998)** in owl. In our observation in the Eurasian Hobby, we found that, over the small area of the mucous membrane of gizzard, which was situated at the area around the pyloric opening only was a small weak cuticle layer while the rest of the luminal surface not have cuticle membrane, in which this cuticle was sloughed and shed small fine area and very thin membrane and highly closely adherent to the lining surface of gizzard and it was often green or yellow in color. **(Gionfriddo and Best, 1996)** refer to that the thickness of the cuticle was highly correlated with food consumed; thick in granivorous, thin in frugivorous and nectarivorous and it was often green, brown or yellow in color. The inner aspect of the gizzard of partridge was lined by a fine cuticulagastrica, with yellowish color **(Rossi et al., 2005)**. **(Taylor, 2000)** the cuticle layer was thick in species with well-developed, muscular stomachs, but in our study in the Eurasian Hobby, it may occasionally be sloughed and shed, which may be green, brown or yellow in color. **(El-Ghazali, 2008)**

the cuticle layer was formed from two layers in hoopoe but had a spongy appearance in ibis.

In our research, the muscle tunic of gizzard in the Eurasian Hobbywas constituted by an inner circular layer and longitudinal arranged external layer. Regarding the arrangement of its layers, our results agreed to some authors; **(Jain, 1976)** in P. krameri and in A. tristis, **(Fieri, 1984)** in Nothuramaculosa (insectivorous and granivorous bird), **(McLelland, 1979, Turk, 1982)** in birds in general, **(El-Ghazali, 2008)** in goose, pigeon, while in hoopoe the muscular layer was arranged as inner oblique layer and outer circular one, but in ibis it was arranged as inner oblique, middle thick circular and outer patches of longitudinal muscle bundles, but in the duck the muscular mass was formed from a single thick layer of smooth muscle fibers. Those same researchers also related that the circular layer was more developed if compared to the longitudinal one which agrees with my observation. Some observations in Literature refer to the presence of three layers in the muscle tunic; **(Espinola and Galliussi, 1990)** in Fulicaarmillata (granivorous bird) and **(Imaizumi and Hama, 1969)** in Urolonchadomestica.

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