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Original article

Morphological studies of the stomach of falcon

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ABSTRACT

A morphological study of the stomach of the falcon was carried out, grossly and under light microscopy. Anatomically, the stomach of the falcon is constituted by two externally distinguishable chambers: a cranial chamber, the proventriculus (*pars glandularis*), which is cranially connected to the esophagus and caudally, to the gizzard (*ventriculus or pars muscularis*). There is no papilla on the gastric epithelium surface of the proventricular. Both, the mucous tunic of the proventriculus and of the gizzard present folds lined by simple columnar epithelium. The tunica mucosa of the proventriculus is extensively folded due to the presence of well-developed longitudinal muscle bundles. There is no intermediate zone (isthmus) between the proventriculus and the gizzard. The luminal surface of the ventriculus have cuticle, which is sloughed and shed small fine area (around the pyloric opening) and very thin membrane and highly closely adherent to the lining surface of gizzard.

1. Introduction

The avian stomach is a muscular organ, located between the esophagus and the intestine and it is consists of two parts; the proventriculus and the ventriculus as reported in many text books as (McLelland 1979) and (Dyce, Sack et al. 2010) and by many authors as (Klasing 1999), (El-Bakary, 1993), (Hassouna, 2001a) and other.

(Hassouna, 2001a) divided the stomach of birds into three types; first type; soft eating birds as in kestrel and owl in which the main function of the gizzard is the storage of food. Second type; hard diet eating birds as in turkey and sparrow in which the main function of the gizzard is 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 is storage and physical digestion. The size and shape of the stomach is based on diet, in *carnivorous* and *piscivorous species* both structures are 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 is relatively thin-walled and glandular while the ventriculus is muscular, thick-walled and powerful. This gastric arrangement is typical of granivorous, omnivores, insectivores and herbivores (Ziswiler and Farner 1972), (Klasing 1999), (Denbow 2000) and (Taylor 2000). (Nickel, Schummer et al. 1977) in vegetarian fowls, the gizzard is 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).

2. Materials and methods

In the present work, we utilized 8 adult falcons weighing approximately 150 g, captured in the country side of desouk, Egypt. 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 h of light and 12 h of dark).

The work was carried out on the stomach (proventricular and gizzard) of these 8 adult clinically healthy falcons of both sexes. All falcons were sedated by Rompun (Xylazine hydrochloride 20 mg/ml, then anaesthetized with chloral hydrate.

After the laparotomy and after uncovering the esternal breastplate, organs were documented “in loco” and later partial evisceration of the alimentary tract was made. The materials destined to the morphologic study were collected and the lengths of the stomach (proventricular and gizzard) were measured. Afterwards, these organs were fixed in a 10% formalin solution. Findings were photographed using an 8 Mega Pixel digital camera with 5× zoom capacity. The anatomical nomenclature used was based on Nomina Anatomica Avium (NAA) (Baumel, King et al. 1993).

For the histological study, the stomach (proventriculus and gizzard) were immediately fixed in Bouins liquid, for 24 hours. After dehydratation with ethylic alcohol in increasing concentrations (70 to 100%) the fragments were embedded in paraffin, sectioned at 5µm and stained by Hematoxylin-eosin, then made two histological sections of 2 micrometers, at proventriculus and ventriculus.

In relation to the morphology of falcon digestive tract, we found poor references in the literature. This fact awakened our interest to study the morphology of the falcon stomach.

3. Results

3.1. Anatomical studies

3.1.1. Position and relation of the stomach

The falcon stomach is muscular organ which divided into two distinct different structures, the first structure is the proventriculus (*Glandular stomach*, *Ventriculus glandularis*) and the second structure is the ventriculus or muscular stomach (*Gizzard, Ventriculus muscularis*), in which the first part is a cranial glandular and muscular part while the second part is a caudal muscular part which are not separated by an isthmus or intermediate zone from each other.

The falcon stomach is located between the esophagus and the intestine, at the left of the median line and it is located dorsal to the liver. The stomach is generally placed at left dorsal and left ventral parts of the thoraco-abdominal cavity, which reach to 3.3 cm in the length.

The proventricular is in contact ventrally from the left side, with the left lobe of the liver which leave an impression on the left lobe of the liver while on the right side the proventricular is related caudodorsally to the spleen. The gizzard also contact the liver and sternum while the more extensive contact to the lower part of the left lateral abdominal wall, in which this is more clear when the sternum and abdominal muscles are removed.

3.2. The proventricular (glandular stomach)

3.2.1. Position, relation and fixation of the proventricular

The proventriculus is lies in the middle part of the body cavity and its long axis is directed from craniodorsally and medially to caudoventrally and laterally, extended from the level of the 2nd intercostal space to the level of 4th rib. It is related to the left abdominal air sac and the caudal thoracic air sac of the same side. Together with the spleen, it is accommodated in a pocket of the visceral peritoneal sac. It is hardly in touch by the external palpation (Fig. 1). The proventricular stomach was attached to 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.

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

The proventricular stomach is a structure located between the esophagus and the ventricular stomach, rostrally; the proventricular stomach separated from the esophagus by a weak constriction externally, which not clear internally but internally identify by the color; in which the color of proventricular is dark brown and have well-developed muscular folds while the esophagus is whitish and folded, but in the caudal portion of gizzard, externally, the proventriculus separates from the ventricular stomach by very weak constriction dorsally and abscent ventrally and there is no clear division internally as there is no demarcation line or space (isthmus) between proventricular and ventricular stomach but differentiated from each other by their structure in which each one have its characteristic structure (Fig.1 and 2).

The proventriculus is 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, in which this longitudinal folds reach to 5 longitudinal folds which are separated from each other by clear longitudinal grooves while the internal surface of the esophagus is smooth and folded and not have any muscle bundles. There are no macroscopic papillae in the internal surface of the proventricular, in which the internal surface of the proventricular is smooth (Fig.2).

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

3.3. The gizzard (ventricular or muscular stomach)

3.3.1. Position, relation and fixation of the gizzard

The ventricular is the second chamber of the stomach which located between the proventriculus and the duodenum (Fig. 2A:1, 4), lying in the left dorsal and ventral regions of the thoraco-abdominal cavity, to the left of the median line and it can be touched immediately caudal to the breast bone, as a firm mass (Fig. 1). The ventricular stomach resembles a biconvex lens or may take the kidney shape (Fig. 2A).

The internal musculature of the ventricular stomach is less than the proventricular part of stomach, in which it is lined by the low gastric folds (Fig. 2B:1, 5) while externally, it is formed by two thick masses of muscle that inserts on glistening tendinous centers, one on each surface (dorsolateral and ventrolateral muscles) (Fig. 2A: b, d) and there are two thin muscles that cover the blind sacs (craniodorsal and caudoventral) (Fig. 2A: a, c). The gizzard is covered by a peritoneal coat and the tendinous layer is thickest at these central points, each of which is called a tendinous aponeurosis (Fig. 2A:6) and there are no muscles fibres present at the center of the aponeurosis (Fig. 2A:6).

In relation to the gastric ventriculus, the body of gizzard is the main which separates the two tapering ends, the saccus craniodorsalis and saccus caudoventralis, in which the proventriculus open in the craniodorsal blind sac while the pylorus and the origin of the duodenum are on the right side, adjacent to the craniodorsal blind sac (Fig. 2A).

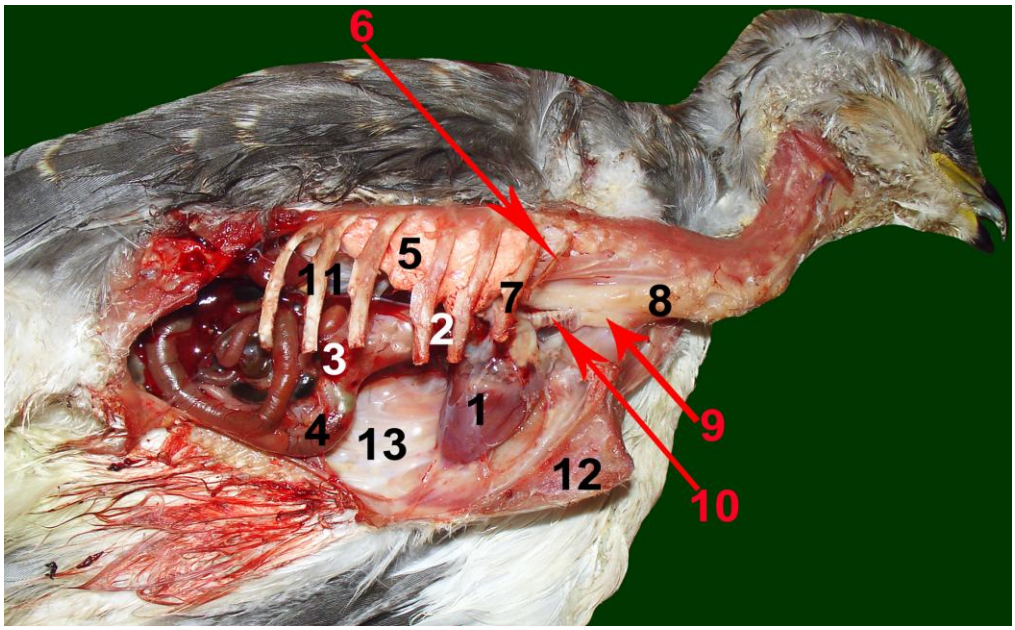

Fig. 1. Left view of the topography of the body cavity of the falcon.

1-heart, 2-proventricular, 3-gizzard, 4-duodenum, 5-right lung, 6-1st floating rib, 7-2nd floating rib, 8-esophagus, 9-trachea, 10-syrinx, 11-6th rib, 12- sternum (keel bone), 13- abdominal wall.

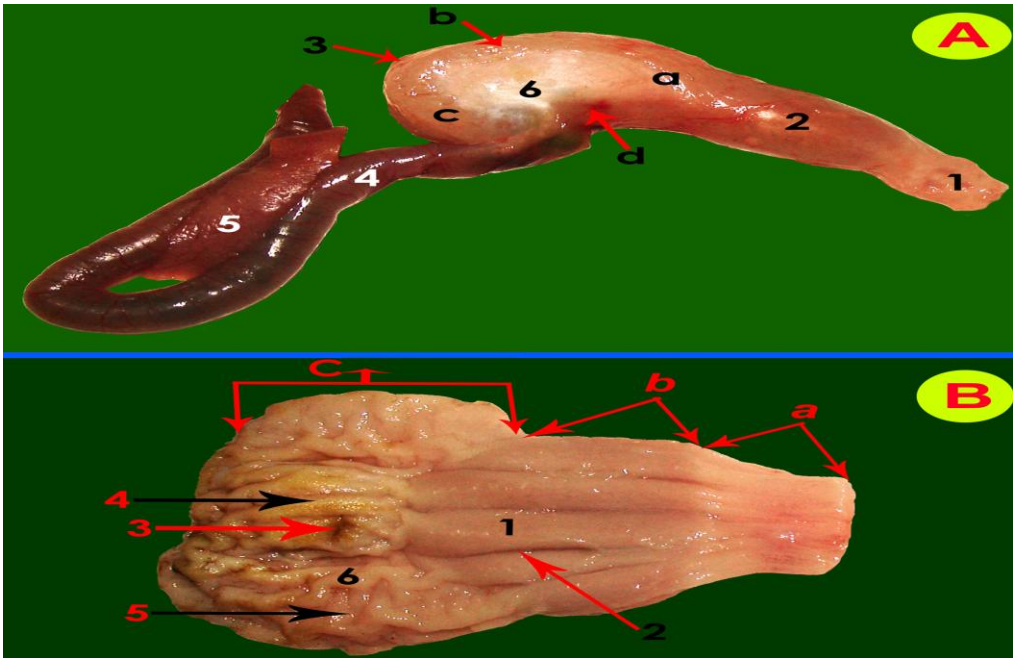

Fig. 2A,B. Exterior of stomach of falcon. Lateral aspect, right side.

1- Esophagus, 2- proventricular, 3- gizzard, 4- duodenum, 5- pancrease, 6- central tendinous part, a- thin craniodorsal muscle (lined cranial blind sac), b- thick caudodorsal muscle, c- thin caudoventral muscle (lined caudal blind sac), d- thick cranioventral muscle.

Interior of stomach of falcon.

1- Proventricular fold lined with mucous membrane, 2- longitudinal groove, 3-pyloric opening, 4-cuticle layer, 5-low ventriculus folds, a- esophagus, b-proventricular, c-gizzard.

Internally, the gizzard is lined by low fine folds without any separation from the internal surface of the proventricular (Fig. 2B). The green soft membrane which called the cuticula gastrica is 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: 4).

The ventriculus consists of two pairs of opposing muscles. The caudoventral and craniodorsal thin muscles (Fig. 2A: a, c) line the craniodorsal and caudoventral of gizzard respectively. The cranioventral and caudodorsal thick muscles (Fig. 2A: b, d) are responsible for the powerful grinding contractions. The asymmetrical arrangement of these four muscles provides mixing and grinding actions during contractions. A white and brilliant sheet is observed in the center of gizzard characterized by a tendinous connective tissue (Fig. 2A: 6).

The gizzard is separated from the small intestine by a pyloric opening (Fig. 2B: 3) which reaches to 0.2cm in diameter and present in the ventral part of the ventriculus and at small distance from the proventricular by about 0.4cm. pyloric opening is guarded by the very small pyloric sphincter in addition to the two small pyloric folds; one long reach to 0.5cm in length and 0.1cm in the thickness while the other is very small in which reach to 0.2cm in length and 0.05cm 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).

3.4. Histological studies

The analysis of the histological sections, under light microscopy, revealed that the wall of the stomach (proventriculus and gizzard) is constituted by the following layers: mucous membrane (tunica mucosa gastris), submucosa (tela submucosa gastris), muscular (tunica muscularis gastris) and serosa (tunica serosa).

3.4.1. The proventricular (glandular stomach)

The tunica mucosa of the proventriculus is extensively folded (plicae) separated by grooves (sulci) due to the presence of well-developed inner 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).

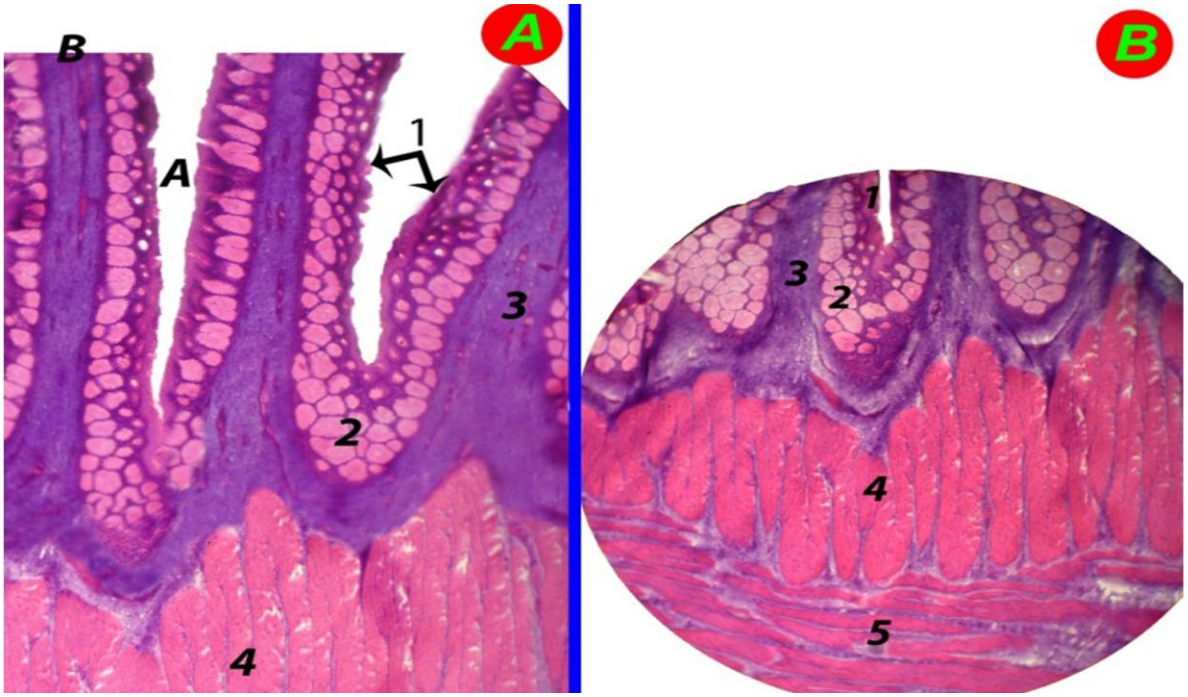

Fig. 3A,B: Photomicrography of the cross section of the proventriculus.
1- Linning epithelium 2-proventricular glands 3-thick lamina propria 4-longitidinal layer of tunica muscularis 5-circular layer of tunica muscularis A- longitudinal fold B- longitudinal grooves.

The luminal surface of the proventriculus is lined with simple columnar epithelium. A thick lamina propria is constituted by connective tissue with blood vessels and it separates the gastric epithelium from the lobules of the submucosal glands, in which this glands form an almost continuous mass of tissue, 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. The submucosa is constituted by connective tissue, containing blood vessels (Fig. 3).

The muscle tunic (tunica muscularis gastris), 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 is more developed than the outer circular layer. This thick muscular layer occupies the greater part of the thickness of the wall of the proventriculus. The serosa of the proventriculus (tunica serosa) is constituted by connective tissue (Fig. 3).

There is no intermediate zone between the proventriculus and the gizzard but the differenation between them by the internal structure of them: proventriculus is characterized by the extensive folds while the ventriculus by the presence of low gastric folds (Fig. 4).

3.4.2. The gizzard (ventricular or muscular stomach)

The mucous membrane of gizzard (tunica mucosa gastris) presents low folds (plicae), which are lined by simple columnar epithelium. Over the small area of the mucous membrane of ventriculus, which is situated at the area around the pyloric opening only is lined with secretory product of mucosal glands, which solidifies at the surface to form a small weak cuticle layer (cuticula gastrica) while the rest of luminal surface not have cuticle layer, in which the cuticle is sloughed and shed small fine area and very thin membrane and highly closely adherent to the lining surface of gizzard and it is often green, brown or yellow in color because of reflux of bile pigments from the small intestine (Fig. 4).

The surface lining of the tunica mucosa consists of low columnar cells and the simple tubular gland that located under the tunica mucosa followed by lamina mucosa gastris, which is constituted by a dense connective tissue. The lamina mucosa gastris is separated by a thin connective tissue, adjacent to lamina muscularis mucosae; there is the well-developed tunica muscularis gastris with thick inner circular layer and outer longitudinal layer. A submucosa is present. The tunica serosa is constituted by connective tissue (Fig. 4).

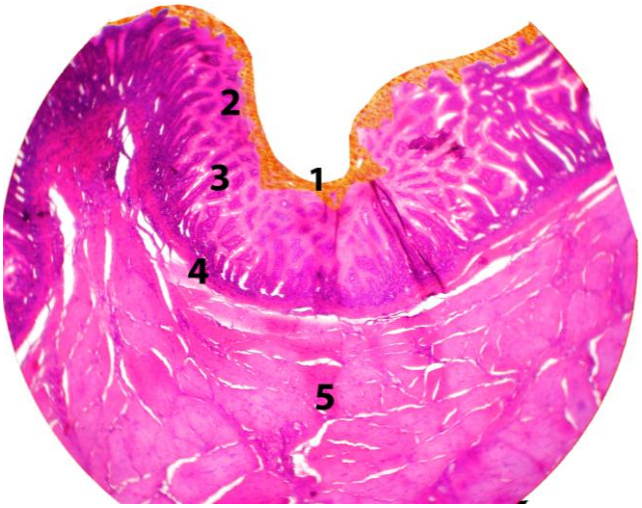

Fig. 4. Photomicrography of the cross section of the gizzard.
1-cuticle layer 2- linning epithelium 3- ventricular glands 4- lamina propria 5- tunica muscularis.

4. Discussion

4.1. Anatomical studies

Our result noted that the falcon stomach is a muscular organ which divided into two distinct different structures; the proventriculus (a cranial glandular part) and the ventriculus (a caudal muscular part), as reported by

(Calhoun 1954) in chicken, (Ziswiler and Farner 1972), (Nickel, Schummer et al. 1977), (McLelland 1979), (Bahadir, Yildiz et al. 1992b), (Bailey, Mensah-brown et al. 1997), (Klasing 1999), (Bacha and Bacha 2000), (Whittow 2000), (Elizabeth and Fredric 2001), (Dursun 2002) in domestic birds, (Catroxo, Lima et al. 1997) in red-capped cardinal, (Nazan, Gulsun et al. 2010) in sea gulls. (Hodges 1974) reported that the stomach of birds consists of three compartments; proventricular, ventricular and pyloric part.

Our observation noted that the falcon stomach is located at the left of median line; agree with that observed by (Sisson and Grossman 1986) and (Baumel, King et al. 1993). Our study observed that the proventricular stomach extended from the level of the 2nd intercostal space to the level of 4th rib, which agree with (Hassouna, 2001a) in kestrel while in goose from 2nd intercostal space to 5th rib, in turkey from 3rd intercostal space to 5th rib, in sparrow and hoopoe from 4th intercostal space to last rib but in owl and darter from 2nd or 3rd intercostal space to 6th rib.

(King and Mclelland 1975) noted that there are species variations: the glandular part of stomach is highly distensible in some species which swallow large masses of food, e.g. albatrosses, cormorants, storks and gulls. The muscular part is 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 agrees with the result noted in the carnivorous birds.

Our observation noted that the proventricular is a fusiform shaped organ and reach to 1.7cm in long and 3cm in wide while the gizzard reach to 1.6cm in long and 3.8cm in wide. (Whittow 2000) agree in shape and added that there are different in size and shape among species, in which it is a small in granivorous species while large and distensible in aquatic carnivores. (Hodges 1974) noted that the proventricular is a short, thick-walled, spindle-shaped organ, 4.5 cm long in the adult fowl. (Bailey, Mensah-brown 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.

Our observation noted that there are no macroscopic papillae in the internal surface of the proventricular. (Bailey, Mensah-brown et al. 1997) in bustards, there are raised papillae on the mucosal surface over its entire surface. (King and Mclelland 1975), (Nickel, Schummer et al. 1977) and (Bacha and Bacha 2000) noted that the in most species a series of papillae project into the lumen of proventriculus. These papillae are low and wide, on the lumen of chicken (Rossi, Baraldi-Artoni et al. 2005); (Dyce, Sack et al. 1996) and (Bailey, Mensah-brown et al. 1997) in bustards. (Mina, Paria et al. 2011) in ostrich reported that the proventriculus has papillary and no papillary region.

Our observation noted that the proventricular was arises without any distinctly demarcated boundary from oesophagus. (Nickel, Schummer et al. 1977), (King and Mclelland 1975), (Baumel, King et al. 1993) in fowl, (Bailey, Mensah-brown et al. 1997) in bustards and Rossi et al. (2005) in partridge. The proventriculus and gizzard of domestic birds is divided by a constriction (isthmus) from each other (Dyce et al., 2010), (King and Mclelland, 1975), Nickel et al. (1977), Rossi et al. (2005) in partridge while in our observation noted that the proventriculus and gizzard not separated by intermediate zone (isthmus) from each other and the stomach appear as one chamber. (Sisson and Grossman 1986) and (Baumel, King 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.

Our observation noted that the ventricular take the kidney shape while Hassouna (2001a) in kestrel and owl reported that the ventricular shape is oval sac-like. (King and Mclelland 1984) and (Rossi, Baraldi-Artoni et al. 2005) noted the gizzard resembles a biconvex lens. (Hodges 1974) noted that the gizzard is flattened sphere in shape. (Bailey, Mensah-brown et al. 1997) the gizzard was oval-shaped. (Chikilian and DE Speroni 1996) noted that the gizzard of Nothura maculosa and Nothoprocta cinerascens have round format, and in Crypturellus tataupa it presents an oval format.

Our result noted that the gizzard is lined by the gastric folds while externally, it is formed by two thick masses of muscle that inserts on glistening tendinous centers, one on each surface (dorsolateral and ventrolateral muscles) and there are two thin muscles that cover the blind sacs (craniodorsal and caudoventral) which agree with (Hodges 1974). A white and brilliant sheet is observed in the center of the gastric ventriculus of partridge characterizing a tendinous connective tissue, also found in chicken (Turk 1982) and (Dyce, Sack et al. 1996).

Our result noted that, in relation to the gizzard, the body separates the two tapering ends, the saccus craniodorsalis and saccus caudoventralis agree with (Bailey, Mensah-brown et al. 1997) in bustards. The gizzard is

covered by a peritoneal coat and the tendinous layer at the central points, called a tendinous aponeurosis and there are no muscles fibres present at the center of aponeurosis, agree with (Hodges 1974).

Our result noted that the gizzard is separated from the small intestine by a pyloric opening which guarded by very small pyloric sphincter in addition to the two small pyloric folds. (Vergara, Ferrando et al. 1989) and (Bailey, Mensah-brown et al. 1997) the pyloric region, connecting the gizzard and duodenum arose from the right face of gizzard. In lorikeets and honeyeaters, the proventricular and pyloric openings of gizzard lie in a median plane, (Ziswiler and Farner 1972).

The gizzard consists of two pairs of opposing muscles; the caudoventral and craniodorsal thin muscles and cranioventral and caudodorsal thick muscles, are responsible for the powerful grinding contractions, as noted by (Ziswiler and Farner 1972), (Bailey, Mensah-brown et al. 1997) and (Whittow 2000). The gizzard contains two pairs of opposing circular muscle that one is thin and the other is thick (Whittow 2000). The gizzard is consists by four semiautonomous muscles, two thick, the caudodorsalis and the cranioventralis, and two thin, the craniodorsalis and the caudoventralis, according to the results of (Bailey, Mensah-brown et al. 1997). A white and brilliant sheet is observed in the center of the gizzard of partridge characterizing a tendinous connective tissue, as noted by (Klasing 1999).

4.2. Histological studies

Our histological results disclosed that the structure of the proventricular and of the gizzard is nearly similar to those of other birds, according to what is described by several authors (Calhoun 1954); (Hodges 1974) and (Fieri 1984). So, we could observe that the mucous membrane of the proventriculus and of the gizzard present several folds, as in other birds (Calhoun 1954; McLelland 1979; Fieri 1984) the folds of the gizzard are lower. In the gizzard, among several kinds of birds, the folds of the mucosa are described as longitudinal ((Jain 1976) in P. krameri; (Menin, David et al. 1990) in Coragyps atratus foetens), and high ((Lima 1979) in Columba livia) but in our study in the falcon, the folds of proventriculus in the form of elongated folds which separated by grooves due to presence of well-developed thick longitudinal layer of tunica muscularis, while the folds of gizzard in form of low fold with not characteristic shape. (King and Mclelland 1975) and (Bacha and Bacha 2000) reported that the mucosa of proventriculus is thrown into folds and sulci. (Hodges 1974) agrees with that (Banks 1993) reported that the tunica mucosa of proventriculus is extensively folded into flattened ridges separated by grooves.

(Klem, Finn et al. 1983; Klem, Parker et al. 1984) described the mucous membrane of the gizzard of Passer domesticus and Turdus migratorius 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 falcon gizzard is clear developed low folds.

The lining epithelium of the folds of mucous membrane of the proventricular is of simple columnar type, which coincides with the observations of most of the authors (Calhoun 1954; Selander 1963; Sturkie 1965; Singh 1973; Vial, Garrido et al. 1977; Lima 1979; Klem, Brancato et al. 1982; Bee De Speroni and Chikilian 1983; Klem, Parker et al. 1984; Lima and Sasso 1985; Rocha 1991; Rocha and De Lima 1998). The lining epithelium of the folds of gizzard is of simple prismatic type. Similar to our observations (Rossi, Baraldi-Artoni et al. 2005) in partrigde, (Glerean and Katchburian 1964) describe a high prismatic type epithelium of Gallus. (Hodges 1974) and (Elizabeth and Fredric 2001) noted that the gastric epithelium of proventriculus is simple columnar. (Bacha and Bacha 2000) agree with that except that at the base of the sulci, where it is cuboidal. (Mina, Paria et al. 2011) in ostrich noted that it is simple columnar.

The cuticle, observed by (Lima and Sasso 1985; Rocha and De Lima 1998) in owl whose described it as a thick covering plate, lining the mucous membrane of the gizzard, agree with (Catroxo, Lima et al. 1997) in red-capped Cardinal, (Toner 1964; McLelland 1979; Fieri 1984; Klem, Parker et al. 1984; Landolt 1985; Akester 1986; Dyce, Sack et al. 2010). In our observation, we found that, over the small area of the mucous membrane of gizzard, which is situated at the area around the pyloric opening only is a small weak cuticle layer while the rest of the luminal surface not have cuticle membrane, in which this cuticle is sloughed and shed small fine area and very thin membrane and highly closely adherent to the lining surface of gizzard and it is often green or yellow in color. (Hodges 1974) reported there is a thick, horny layer lining the lumen of organ as (Bailey, Mensah-brown et al. 1997) in bustards, (King and Mclelland 1975), (Banks 1993) and (Rocha and De Lima 1998) in owl. (Gionfriddo and Best 1996) refer to that the thickness of the cuticle is highly correlated with food consumed; thick in granivores, thin in frugivores and nectarivores and it is often green, brown or yellow in color. The inner aspect of the gizzard of

partridge is lined by a fine cuticula gastrica, with yellowish color (Rossi, Baraldi-Artoni et al. 2005). (Taylor 2000) the cuticle layer is thick in species with well-developed, muscular stomachs, but in our study, it may occasionally be sloughed and shed, which may be green, brown or yellow in color.

Our result in the falcon, found well-developed tunica muscularis gastris of proventricular, presents an inner layer of longitudinal muscular fibers and another outer, of circular fibers, in which, this thick muscular layer occupy the greater part of the thickness of proventricular wall. (Calhoun 1954) have noted, in proventriculus of birds in general, the muscle tunic as constituted by external layer of longitudinal muscle fibers and a circular inner layer. Most of the authors reported that the inner circular layer is thicker than the external longitudinal one ((Hodges 1974; Bee De Speroni and Chikilian 1983; Fieri 1984; Rocha 1991)). (Turk 1982; Rocha 1991) in owl, (Rossi, Baraldi-Artoni et al. 2005) in partridge and (Elizabeth and Fredric 2001) noted that a well-developed tunica muscularis is arranged as inner circular and outer longitudinal layers of smooth muscle. (Denbow 2000) added that the outer longitudinal layer is poorly developed or absent in parrots, waterfowl and some passerines. While (Nickel, Schummer et al. 1977) noted that the musculature of proventriculus has three layers.

In our research, we find the muscle tunic of gizzard is constituted by an inner circular layer and longitudinal arranged external layer, much developed. Regarding the arrangement of its layers, our results agreed to some authors (Jain 1976), in P. krameri and in A. tristis; (Fieri 1984), in Nothura maculosa, (insectivorous and granivorous bird); Rocha in Speotyto cunicularia (carnivorous bird); (McLelland 1979; Turk 1982), in birds in general. Those same researchers also related that the circular layer is 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) described three layers in the muscle tunic of gizzard of Fulica armillata (granivorous bird). (Imaizumi and Hama 1969) also related the existence of three muscular layers in the gizzard of Urolonchа domestica.

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