Macroscopic and Microscopic Study of Digestive Tract of Brown Falcon *Falco berigora* in Iraq

Amel A. Al-taee
Dept. of Biology, College of Sciences, Babylon University, Iraq.
amelalialtaee@gmail.com

Abstract

This work was carried to study anatomical and histological properties of the digestive tract of brown falcon *Falco berigora* in Iraq. The gross study revealed that the alimentary canal consist of buccal cavity, esophagus, crop, stomach (proventiculus and gizzard), small intestine (duodenum, jejunum and ileum), large intestine (short cecum, rectum) and cloaca. It revealed that the esophagus was long tube with relatively distensible crop. The stomach is divided into pars glandularis and pars muscularis without isthmus between them. The gizzard is developed and having a cuticle, its wall contains of well-developed smooth muscles, the small intestine consists of duodenum, jejunum and ileum, the last part was the longest one. The large intestine contains a paired of very short not well developed caeca and a short rectum. Histologically, all specimens of different parts taken and processed for histological study. Histological results revealed that the alimentary canal of brown falcon consists of four tunica as other avians: tunica serosa, tunica musculosa, tunica submucosa and tunica mucosa. The mucosa of oesophagus in falcon consists of longitudinal folds, covered with stratified squamous epithelium, the tunica musculosa composed of three layers: inner oblique, middle thick circular layer and outer thin longitudinal layer. Pars glandularis contain simple tubular to simple branched tubular glands. The pars muscularis mucosal have deep, broad crypts in which simple to branched tubular gastric glands open. The gastric cuticle covers the mucosa of the ventriculus, the tunica musculosa in stomach composed of three layers: inner, outer longitudinal layer and middle thick circular layer. Intestinal mucosa is invaginated into villi with marked variation in size, density and shape in the different intestinal regions. Also, the goblet cells gradually increase in frequency from the duodenum to the rectum. The part length and layers thickness in different regions of digestive tract showed significant variation ($p \leq 0.05$).

Key words: falcon, carnivores, alimentary canal, histology

الخلاصة

اجريت الدراسة الحالية لدراسة الصفات التشريحية والنسجية للقناة الهضمية للصقر البني في العراق مظهريا" ونسجيا". اوضحت الدراسة العيانية ان القناة الهضمية للصقر البني*Falco berigora* في العراق. اوضحت الدراسة العيانية ان القناة الهضمية تتالف من التجويف الفمي والمريء العنقي والحوصلة والمريء الصدري والمعدة الامامية والقانصة والامعاء الدقيقة (الاثني عشر والصائم واللفائفي) والامعاء الغليظة (المستقيم والاعور) والمجمع. اوضحت الدراسة ان المريء هو عبارة عن تركيب انبوبي ويحوي على حوصلة متوسعة نسبيا". تقسم المعدة الى معدة امامية غدية ومعدة عضلية خلفية بدون وجود تخصر واضح بينهما. تكون القانصة او المعدة الخلفية متطورة وتحوي على كيوتكل. ويحتوي جدارها على عضلات ملساء متطورة. تقسم الامعاء الدقيقة الى الاثني عشر والصائم واللفائفي والاخير يكون الاطول. تحوي الامعاء الغليظة على زوج قصير جدا" من الزوائد الاعورية الغير متطورة ومستقيم قصير. نسجيا", تم اخذ عينات من الاجزاء المختلفة للقناة الهضمية وعوملت لغرض الدراسة النسجية. اوضحت النتائج النسجية ان القناة الهضمية للصقر البني تتالف من اربعة طبقات رئيسية كما في الطيور الاخرى وهي الطبقة المخاطية والطبقة تحت المخاطية والطبقة العضلية والطبقة البرانية. تحوي الطبقة المخاطية للمريء على طيات طولية مبطنة بنسيج طلائي حرشفي مطبق. تتكون الطبقة العضلية من ثلاث طبقات هي داخلية مائلة ووسطية دائرية سميكة وخارجية طولية رقيقة. تحتوي المعدة الامامية فتحوي غددا" من النوع الانبوبي البسيط الى الانبوبي المتفرع. اما المعدة العضلية فتحتوي على خبايا عريضة وعميقة والتي تفتح فيها الغدد المعدية البسيطة او المتفرعة وتغطى مخاطية المعدة الخلفية بطبقة كيوتكل. تتكون الطبقة العضلية للمعدة من ثلاث طبقات هي داخلية وخارجية طولية رقيقة وطبقة وسطية دائرية سميكة. تندفع مخاطية الامعاء مكونة الزغابات والتي تظهر تغايرا" واضحا" في الحجم الكثافة والشكل في مناطق الامعاء المختلفة. كما يزداد عدد الخلايا الكاسية تدريجيا"من الاثني عشر باتجاه المستقيم. اظهر طول الاجزاء وسمك الطبقات تغايرا" معنويا" ($p \leq 0.05$) في اجزاء القناة الهضمية المختلفة.

الكلمات المفتاحية، صقر، حيوان اكل اللحوم، القناة الهضمية، علم الانسجة.

Introduction

Brown falcon *Falco berigora* is a carnivorous bird belonging to the family Falcinidae and the order of Falconiformes and looks for meat foods only. The avian digestive tract is double–ended tube as in all vertebrates, begin with beak and terminate with anus (Ghali and Daoud, 2014). It shows great diversities according to their food habits (Kadhim *et al*., 2011). Carnivores birds generally have less complicated digestive systems than those eating complex carbohydrates (Duke, 1997).

The avian alimentary canal has undergone a physiological structure in apposite to other animals to accommodate physical and chemical features of a wide variety of food types (Klasing, 1999), and requirements for flight (Denbow, 2000). Also, birds have light weight beak and gizzard instead of heavy bone, muscular and dental structure characteristic of reptiles and mammals. The length and weight of intestine in birds were reduced in comparison with mammal for flight adaptation (Gelis, 2005).

The raptors have an important role in the ecosystems which located in the top of the food web with gastrointestinal tract adapted for a carnivorous diet (Ford, 2010).

The current work was first to be carried in Iraq, it is aimed to report the special anatomical, histological structures of the alimentary canal of the brown falcon, a carnivorous bird, and correlating them with their food.

Material and Methods

The brown falcon was used in the present investigation (as a model of carnivore's birds). It anesthetized by chloroform, and carefully dissected for studying the gross anatomy of the alimentary canal (Fig.1A). In histological study, the contents of the alimentary canal were washed by normal saline; small pieces of oesophagus, stomach (proventriculus, ventriculus), small intestine (duodenum, jeujenum and ileum), and large intestine (caecum, rectum) were fixed rapidly in Bouin's solution for one day and kept at 70% of ethyl alcohol. The specimens were processed for histological staining. The blocks were sectioned at 5µm thickness and stained with routine stain (Mayer's Hematoxylin and Eosin) for general features study (Bancroft and Stevens, 2010). The layer thickness of different digestive tract parts were done by using ocular micrometer after calibration.

Statistical Analysis

The results were shown as Mean ±SE for each digestive tract parts. The statistical analysis was done by using the Analysis of Variance (ANOVA) test at least significant differences (L.S.D) and Duncan, according to the Statistical Package for Social Science (SPSS) system version 23.The level of significance was accepted under level probability (0.05).

Results and Discussion

The mean length of digestive tract was 121.144 cm. Carnivores birds generally have less complicated digestive systems than those eating complex carbohydrates (Duke, 1997).

The Gross Anatomy:

The alimentary tract consists of a buccal cavity, pharynx, oesophagus, stomach (proventriculus, ventriculus (gizzard)), small intestine (consisting of duodenum, jejunum and ileum), large intestine (consisting of paired of very small caeca and a rectum) and cloaca that opens to the outside by the cloacal opening (Fig.1B). This result coincides with the results obtained by Klasing (1999), Hamidi *et al*. (2013). The length of different digestive tract parts showed significant differences ($P \leq 0.05$) (Table -1, Fig.2).

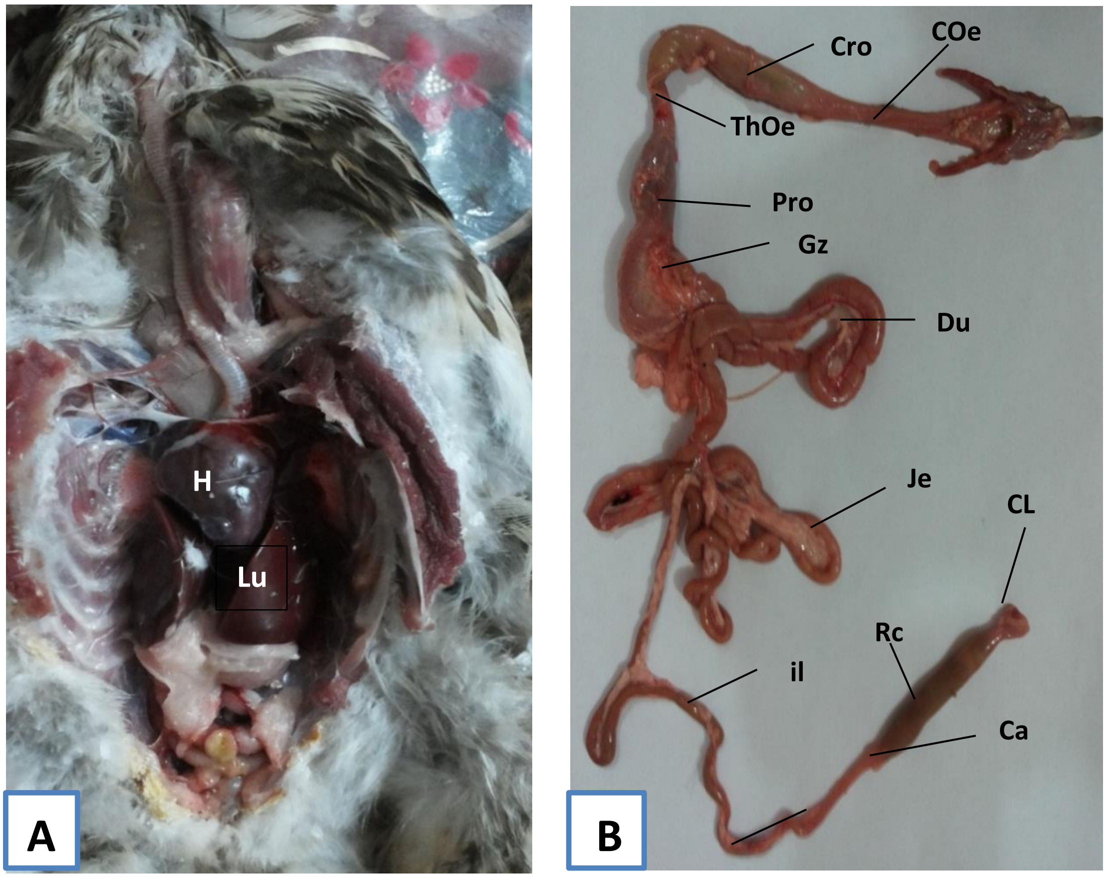


Figure (1): A-Photograph of the dissection of the alimentary tract of brown falcon. Heart: (H), Lung:Lu).

B- Photograph of a fresh isolated alimentary tract of brown falcon. (COe): cervical oeosphagus, (ThOe): thoracic oesophagus , (Cro): crop, (Pro): proventrculus, (Gz):Gizzard, (Du): duodenum, (je): jejunum , (il): ileum, (Ca): Caecum, (L): liver (Rc): rectum and (CL): cloaca.

Table (1): Morphometric comparison between the length of digestive tract parts in brown falcon.

Parts of digestive tract	Length (cm) mean ±S.D	Length(cm) %
Cervical Oesophagus	5.23 ±0.89c	4.31c
Crop	7.55 ±1.05d	6.234d
Thoracic Oesophagus	1.59±0.289ab	1.311ab
Proventiculus	2.25 ±0.402ab	1.857ab
Venticulus	3.38 ±0117bc	2.79bc
Duodenum	23.723±2.026e	19.588e
Ileum	45.5 ±0.684g	34.265g
Jeujenum	25.9±2e	21.379e
Caecum	0.46 ±1c	0.379c
Rectum	5.07 ±0.2a	4.185a
Cloaca	0.894 ±0.3a	0.734a
P value	≤0.05	

*Different symbols mean significant differences (P≤0.05).

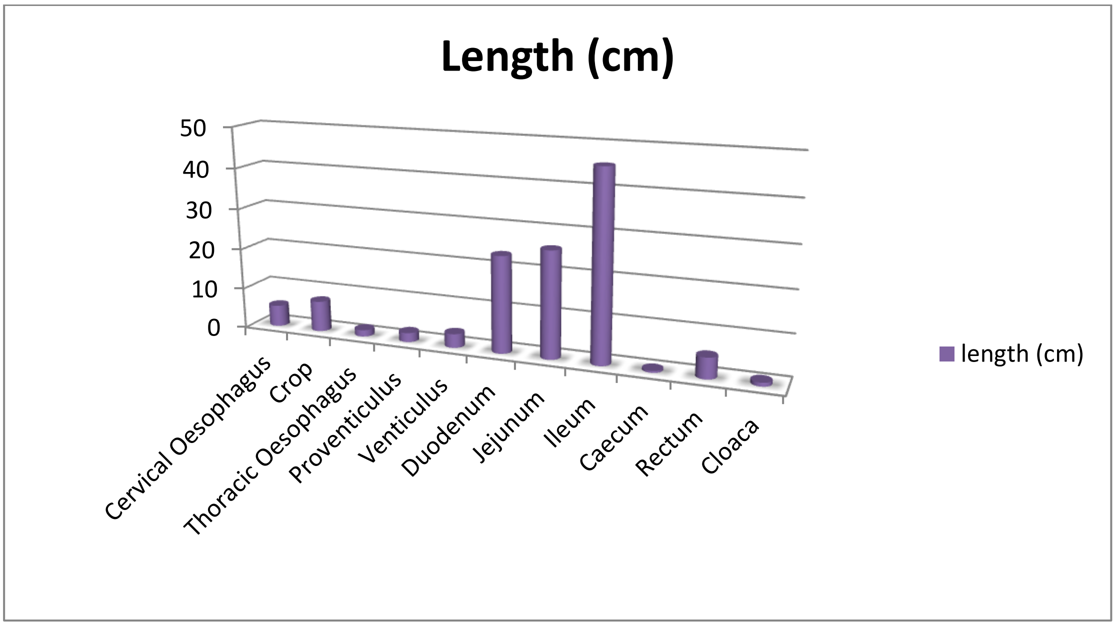


Figure (2): Morphometric comparison between the lengths of digestive tract parts in brown falcon.

The esophagus:

The oesophagus is a thin walled wide distensible long tube to accommodate with swallowing large preys. This finding coincide with Ismail (2000) and Abo-Shaeir (2001), it contains a number of longitudinal folds which provide enlargement (Klasing, 1999). It is distinguished into three distinct anatomical portions from upper to lower (Fig.1B): the cervical part, the crop which represent by a poorly developed muscular pouch and its longer and wider than the other parts with spindle shape enlargement of the oesophagus, it contains longitudinal folds on the inner surface (Fig.3a) thus making it distensible and thoracic part (the cervical part was larger than the thoracic one), which connects with proventriculus , the food passes through the lower oesophagus into the proventriculus. Carnivorous birds need long oesophagus to swallow their large food (prey) (Salem, 1984 and Gelis, 2005). These results are in agreement with those obtained by King and Mclelland (1984), Ismail (2000) Abo-Shaeir (2001), Ford (2010) and Hamidi *et al*. (2013).

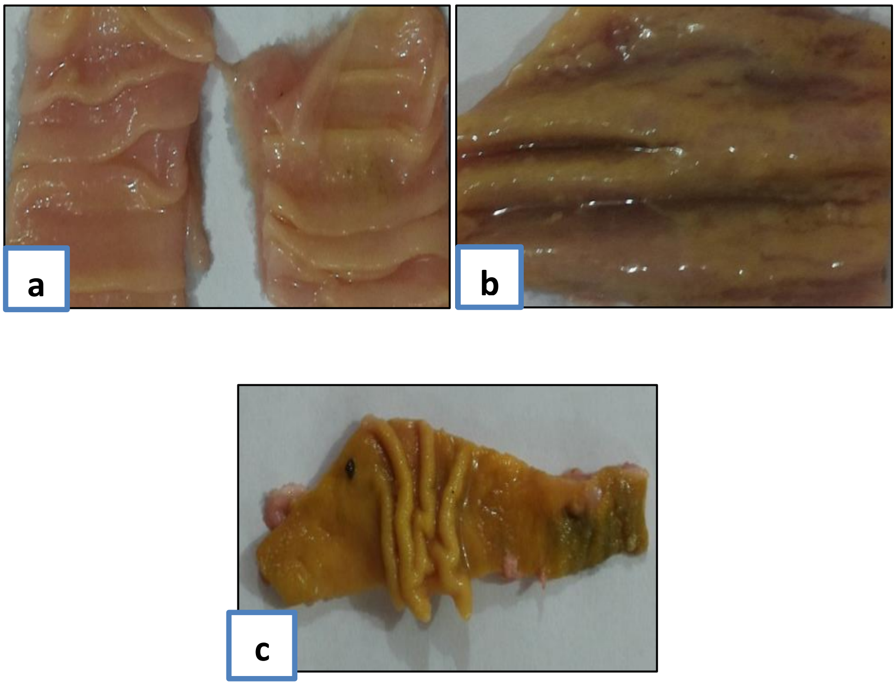


Figure (3): a-Photograph of the inner view in the crop of brown falcon showing the inner longitudinal folds.
b- Photograph of the inner view in the proventiculus of brown falcon showing the inner folds.
c- Photograph of the inner view in the gizzard of brown falcon showing the inner folds.

The Stomach

The stomach have complementary roles, it lies in the median part of the abdominal cavity. It was thick walled organ between the esophagus and the small intestine, divided into paris glandularis (proventriculus or true stomach) located caudal to the thoracic oesophaguse, it have a spindle shaped tube located between the oesophagus and the ventriculus, the wall was thicker than that of the thoracic oeosphagus. The inner surface of mucosa is folded extensively as a result of well-developed longitudinal muscle of tunica musculosa (Fig.3b).The proventriculus being buff to green in color, and the second part is the gizzard (pars muscularis) which is located caudal to the proventriculus. The gizzard is a small organ; it lies in the left dorsal and ventral regions of the thoraco-abdominal cavity, placed partly between and behind the lobe of the liver. It is larger and more muscular than the proventriculus. Gizzard being yellowish lined by cuticle and has 4- inner folded in the dorsal region only (Fig.3c). This observation is in agreement with the result of Elizabeth and Fredric (2001), Dursun, (2002) in domestic birds, Vukkicevic *et al*. (2004) in ostrich and Nazan and Gulsun (2010) in sea gulls Hamidi *et al*. (2013) on *Elanus caeruleus* and Abumandour (2014) in *Falco subbuteo*. Hodges (1974) found that the stomach of fowl consists of three parts; proventricular, ventricular and pyloric. The gizzard of brown falcon has a kidney shape as a result obtained by (Abumandour, 2013) on falcon. While the gizzard of was of pearl shape in *Elanus caeruleus* (Hamidi *et al*., 2013) and in *Anas platyrhynchos* (Al-Saffar and Al-Samawy, 2015) and in barn owl was of elongated spindle to pearl shape (Al-Juboury, 2016). The pyloric region of the stomach opens distally into the duodenum by pyloric orifice which is guarded by a small pyloric valve.

In brown falcon, there are no obvious boundary (isthmus) between proventiculus and oesophagus cranially and gizzard caudally, this results were accordance with the result obtained in falcon (Abumandour, 2013), barn owl (Al-Juboury, 2016), *Anas platyrhynchos* (Al-Saffar and Al-Samawy, 2015) and Partridge *Rhynchotus rufescence* (Rossi *et al*., 2005), while the domestic bird had a distinct constriction between the proventiculus and venticulus (Hamidi *et al.,* 2013; Rossi *et al*., 2005; Dyce and Sack, 2010).

The Small Intestine

The long small intestine extends between the pyloric end of the stomach and the large intestine, caeca and colon. It is consists of coiled mass forming a series of loops and lies within the abdominal cavity. It is distinguished into three main parts, the duodenum, jejunum and ileum. The first part begins at the end of ventriculus and forms an elongated loop. Pancreas located between the arms of the duodenal loop and holds the two arms together, while jejunum and the ileum are very long and coiled located caudal to the duodenum end where the bile and the pancreatic ducts are found and terminate at the ileocaecal-colic junction (the point where the small intestine, the two caeca and the colon are meet). These results agreed with Taylor (2000) and Vukicevic *et al*. (2004).

The Large Intestine

Caeca

The large intestine contains a pair of very short and narrow projections, caeca, that extend from the proximal part (lateral walls) of the rectum at its junction with the small intestine (ileum), it may referred to be the lymphoepithelial type . This result as pointed out by Clench and Mathias (1995) on different type of avian, Duke (1997) on the wild birds, Majeed *et al*. (2009) on broiler chicken, Hamidi *et al*. (2013) *on Elnus caeruleus* and Al-Juboury (2016) on wood pigeon. But not agree with result of quail (granivorous) which have a pair of well-developed caeca (Chen *et al*. , 2002) in geese, (Attia, 2008) in quail and barn owl (Al-Juboury, 2016).

Several studies have revealed that the lengths of the caeca increase as the amount of cellulose in the diet increases and vice versa (Rossi *et al*., 2005). If caecal length is an indicator of ingested cellulose, then species consuming the cell walls of higher plants would be expected to have well developed caeca, and those species consuming nectar, fruits, and animal proteins have less caecal development because these foods are easily digested by endogenous lipases, proteases, and carbohydrase (Duke, 1986). The caeca and rectum is the area for use symbiotic bacteria to digestion the fibrous components of food (Klassing, 1999).

Rectum

The rectum is extending from the end of the small intestine until it opens distally in the cloaca in the form of a short and wide straight tube. Similar observation had been pointed out from Abo-Shaeir (2001) and Nasrin *et al.* (2012). Internally, the mucous membrane of the rectum is thrown into numerous distinct longitudinal folds.

Cloaca

The cloaca extends from the end of the rectum to the cloacal opening. It is divided, as it is in birds, into three chambers namely, coprodaeum, uerodaeum and proctodeum.

Liver:

The liver was dark red–brown in color, placed in its natural position. It consists of two lobes, right (large) and the left (small) lobes. The right and the left lobes are connected to both the diaphragm and the ventral body wall by the ligament (Fig .4a). This results in agreement with result obtained by Hamidi *et al*. (2013).

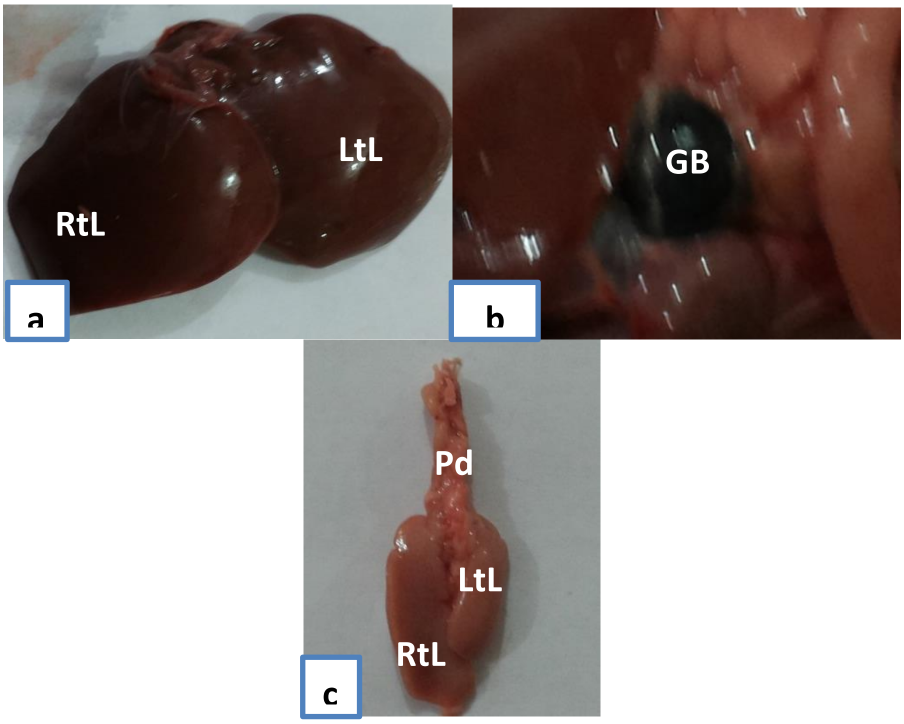


Figure (4): a-Photograph of the liver of brown falcon. *(*RtL): right lobe, (LtL): left lobe.
b- Photograph of the gall bladder of brown falcon. GB: gall bladder
c- Photograph of the pancrease of brown falcon. (RtL): right lobe, (LtL): left lobe, (Pd): pancreatic duct.

Gall Bladder: Is partially embedded on the liver at the posterior surface of the right lobe. It is of oval-shaped thin –walled sac, dark green in color (Fig .4b). This result coincides with that described by Klasing, (1999) and Abo-Shaeir (2001).

The Pancreas: The falcon pancreas is a pale-pink organ with two lobes, right (large) and the left (small) lobes (Fig. 4c). It's located between the ascending and descending loops of the duodenum. The pancreatic ducts opened into the duodenum. This result agreement with that obtained by Hamidi *et al.* (2013).

Histological study of alimentary canal of Falcon

Microscopic examination of digestive canal wall of falcon revealed that it consists of 4-basic layers as found in other avians, this result in accordance with Abou-Dief and El-Akkad (1999). Oesophageal wall consists of tunica mucosa, tunica submucosa, tunica musculosa and tunica adventitia (Fig.5,6a, 6b,7). The mean thickness of tunica mucosa was (225±33.2, 276.6±89.62 and 213.33±95.08 µm) in cervical oesophagus, crop and thoracic oesophagus respectively (Table.2, Fig,15). The crop had thickest layer among the mucosa of the other parts of the oesophagus. In falcon, the mucosa folds in different shapes and length, it lined by stratified squamous epithelium with ducts of the mucosal glands pass through the mucosal layer, This results was similar to that obtained by Ismail (2000), Rajabi and Nabipour (2009) and Al-Juboury (2016).

. The oesophageal glands were small tubule-acinar glands involved by the lamina propria in the oesophagus and crop with excretory ducts pass through the mucosa (Fig.6a, b). Lamina propria consists of a loose connective tissue with lymphatic tissue. These results agreed with Nasrin *et al.* (2012) and Al-Bideri (2011), this agreement may be a cause of the adaptation in the birds for the food type (Farner and King, 1972).

The muscularis mucosa, which is a well-developed continuous layer separating the lamina propria mucosa from submucosa, is formed of smooth muscle fibers.

The mean thickness of tunica submucosa was (258.3±38.18, 203.3±90.73 and 233.3±108.46 μm) in cervical oesophagus, crop and thoracic oesophagus respectively (Table.2, Fig.16). Submucosa is consisting of loose connective tissue with vessels and nerves. It was thicker in meat eater birds than that of seed eater birds; This results as that found in *Ara ararauna* (Rodriques *et al*., 2012) and *Coturinx coturinx* (Zaher *et al*., 2012), the increase in thickness due to the presence of more blood and lymph vessels to nourish the oesophageal gland of falcon. These mucous glands could be considered as another kind of oesophageal adaptation with the nature of food.

The tunica musculosa composed of three layers; inner oblique layer, thick circular layer and outer thin longitudinal layer. The mean thickness of tunica musculosa is (195.6±63.9, 260±20 and 240.6 ±82 μm) in cervical oesophagus, crop and thoracic oesophagus respectively (Table.2, Fig.17)

The big muscular layer parallel to that observed in the oesophagus of *Elanus caeruleus* (Hamidi *et al*., 2013). The bigger muscular layer was the cause to resisted the big size of food as pointed out with Rajabi and Nabipour (2009) in *Columba livia* and Al-Bideri *et al*. (2011) in *Ardeola ralloides*, but not coincide with Rodriques *et al*. (2012) in blue and yellow macaws. The tunica adventitia which surrounded the musculosa was composed of loose connective tissue to binds these parts to the surrounding tissues. It contains nerve fibers and blood vessels. The mean thickness of tunica serosa is (91.66±28.86, 100±20 and 95±25.98 and 191.66±27.73 μm) in cervical oesophagus, crop and thoracic oesophagus respectively (Table.2, Fig. 18). The serosa layer was big to nourish the muscular layer.

Stomach

Microscopically, our results found that the wall of the stomach (proventriculus and gizzard) consists of mucosa, submucosa, musculosa and serosa, this results in accordance to that described by Selvan *et al.* (2008), Ogukoya and Cook (2009), Ahmed *et al*. (2011) and Hassan and Moussa (2012) and Abumandour (2013), but not agree with results obtained by Liman *et al.* (2010) in japanes quail, Zhu *et al.* (2013) on yellow-billed grosbeak and Zhu (2015) on *Porzana bicolor*.

The proventriculus

The mucosa in proventriculus is thrown into branched folds with same heights and groove (Fig.8a, b, c). The mean thickness of mucosa is (336.6±55.07μm) (Table.2, Fig.15), these folds were higher in proventiculus which due to developed thick longitudinal layer of tunica muscularis. This result agrees with Banks (1993). The cuticle layer was not found as a result of *Porzana bicolor* (Zhu, 2015), while Eidaroos *et al.* (2008) revealed that the proventiculus mucosa of some birds was covered by thin layer of cuticle.

The mucosal layer consist of simple tubular gastric glands lined by simple columnar epithelium, this results coincide with that of Rahman *et al*. (2003), Ogukoya and Cook (2009), Zaher *et al.* (2012), Zhu (2015) and Al-Juboury (2016). Some author not referred to this type of gland distribution (Abumandour, 2013). The center of the mucosal folds is occupying by lamina propria which constructed of dense irregular connective tissue.

The mean thickness of submucosa is (1766.6±575.18μm) (Table.2, Fig.16). The submucosa was structured of loose connective tissue containing numerous compound branched alveolar glands (deep gastric glands) (Fig. 8a,b) which secret hydrochloric acid and pepsinogen by secretory cell (oxyntico- peptic cells) (19) to digest its food. The differences in gland location due to species variations. This result was agree with that obtained from Rahman *et al.* (2003), Al-Bideri *et al*. (2011), Batah *et al*.(2012), Nasrin *et al*. (2012) and Al-Juboury (2016), and but disagree with Rodrigues *et al.* (2012) whom found that the submucosa was thin layer and the glands located beneath submucosa in yellow macaw. The compound tubule-alveolar proventricular glands in submucosa represented the thickest part of the proventricular wall supporting results of others (Elizabeth and Fredric, 2001). The existence of two types of glands was previously obtained from Langlois (2003).

The muscularis mucosa extending to the lamina propria and surrounding the bodies of the deep submucosal glands. Musculosa composed of smooth muscle fiber arranged in three layers, inner longitudinal layer, middle circular layer and outer longitudinal layer (Fig.8c), the mean thickness of tunica musculosa is (191.6±27.73µm) (Table.2,Fig.17). This results agree with Oguloya and Cook (2009), but not agree with that of Elizabeth and Fredric (2001), Dyce and Sack (2010), Abumandour (2013) and Al-Juboury (2016). Al-saffar and Al-Samawy (2015) found two layers; inner longitudinal and outer circular layer. Denbow (2000) found that the outer longitudinal layer in parrots, water fowl and some passerines were poorly developed or absent. The serosa consist of thin layer of connective tissue containing blood vessels and nerves, the mean thickness of tunica serosa is (191.6±27.73µm) (Table.2,Fig.18). This finding is in accordance with Ahmed *et al*. (2011) in Japanes quail and Batah *et al*. (2012) in *Fulica atra*.

Gizzard

The gizzard mucosa invaginate into low, thin finger like folds covered by columnar epithelial cells with oval nuclei (Fig.9a,b), the mean thickness of mucosa is (313.6±20.81µm) (Table.2,Fig.15) as a result finding in red jungle fowl (Kadhim *et al*., 2011) and in blue and yellow macaws (Rodriques *et al*., 2012).Whereas, a simple cuboidal epithelium found in coot bird (Batah *et al*., 2012) and in mallared (Al-Saffar and Al-Samawy, 2015).The mucosa was thin in brown falkon, this results was in agreement with Al-Juboury (2016) on *Tyto alba.* The lamina propria composed of dense connective tissue with numerous simple tubular glands which expand in the base of folds. The results obtained from Rocha and Lima (1998) and Abumandour (2013) agreed with results of present study. Muscularis mucosa appeared as thin layer of smooth muscle fiber. This result was not parallel to results achieved by Ogukoya and Cook (2009) and Ahmed *et al*. (2011) on yellow macaw in which this layer was not found. Al-Saffsr and Al-Samawy, (2015) found that the muscle fibers arranged in two layers in muscularis mucosa: inner circular and outer longitudinal layer in *Anas platyrhynchos*

The mean thickness of submucosa is (16.6±5.77µm) (Table.2,Fig.16),the submucosa is a thin layer of loss connective tissue with blood vessels, this result agree with Al-Hamadany (2012) and Al-Juboury (2016) and disagree with Batah *et al*. (2012) whom found that the submucosa was absence in the gizzard of coot bird.

Musculosa consist of smooth muscle fiber arranged in three forms, inner longitudinal layer, thick circular and outer thin longitudinal muscle (Fig.9a,b)., the mean thickness of musculosa is (1050.6±390.04µm) (Table.2,Fig.17). This layer was thin in carnivore’s birds. Our results was similar to that in study of Kadhim *et al*., (2011) in red jungle fowl and broiler breed and Al-Saffar and Al-Samawy (2015) in mallared, but disagree with results obtained by Batah *et al*. (2012) on coot birds and Al-Hamadany (2012) on *Agaporins fischeria* and *larus canus*, and also disagreed with Rodriques *et al.* (2012) on yellow macaw, Zaher *et al*. (2012) on *Coturinx coturinx* and Al-Juboury (2016) on wood pigeon and barn owl, these authors found that this tunica composed of two layers and the thick circular smooth muscle layer interspersed with irregular elastic fibers in garminivores, while it interspersed with regular elastic fiber in carnivores birds. The serosa layer composed of connective tissue, the mean thickness of tunica serosa is (183.6±65.06μm) (Table.2, Fig.18).

The Small Intestine

It is divided into three main regions, duodenum, jejunum and ileum. All divisions composed histologically of 4 layers: mucosa, submucosa, musculosa and serosa. The intestinal mucosa was invaginated into longitudinal villi (the villi was wavy in duodenum) which differ in density, shape and size in the different intestinal regions, the mean thickness of mucosa is (1350±132.28, 1041±260.2and 818.3±345.9 μm) (Table.2, Fig.15). Intestinal villi gradually decrease in length and size from the duodenum to the ileum, villi in ileum relatively short, broad and numerous (Fig.10a-12b). The mucosa is invaginated in the bases of villi into straight tubular glands called crypts of Leiberkuhn continued with columnar epithelium covered the villi. The crypts are numerous and crowded in duodenum. The crypts are embedded in the lamina propria. These crypts have been described in other avian species (Banhawy *et al*., 1995; Clench and Mathias, 1995; El-Sayyad, 1995; Abo-Shaeir, 2001; Vukicevic *et al*., 2004 and Hamidi *et al*., 2013).

The intestine is lined by epithelial membrane formed by simple columinar cells, with elongated nuclei, and goblet cells. Goblet cells are neumerous in ilium than duodenum and more in rectum which due to the composition of its food more than granivorous birds (Farner and King, 1972). Goblet cells in the ileum, which having slender bases, secrete mucous to protect from the intestinal secretion. Leznicka (1971) revealed that these cells are correlated with the structure of the bird's food types. This observation agreed with Hamidi *et al.* (2013) on *Elanus caeruleua* and Walli and Kadhiom (2014) on broilers chicken.

Lamina propria composed of loose connective tissue located between the crypts of leiberkuhn and the core of villi with vertical strands of muscularis mucosa. The muscularis mucosa is composed of a narrow part of longitudinal muscle fibers. It extends inside the mucosal villi; it merges gradually into the submucosa, this result in accordance with the results obtained in *Elanus caeruleua* (Hamidi *et al*., 2013) and barn owl (Al-Juboury, 2016).

The mean thickness of submucosa is (23.33±3.21, 33.33±5.77and 35±5 μm) (Table.2, Fig.16). It consists of loose connective tissue with blood vessels. It's thin in brown falcon, this observation like that in barn owl (Al-Juboury, 2016) and doesn't agree with the study of Rodriques *et al*. (2012) on blue and yellow macaws.

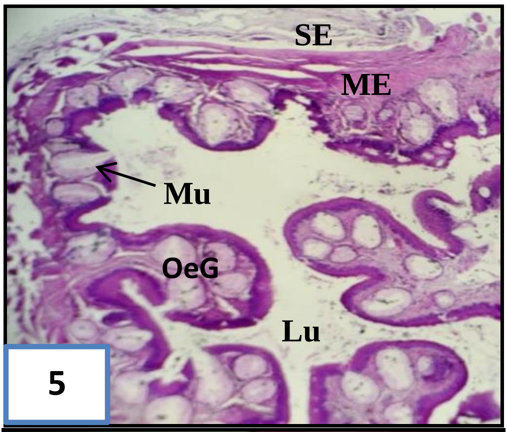
The mean thickness of tunica musculosa is (196.66±20.81, 176.6±11.54and 243.3±28.86 μm) (Table.2, Fig.17). Tunica musculosa consists of two layers of muscle fibers; outer longitudinal for peristalsis movement to exit the digested food and inner circular layers for normal contraction, this finding is parallel with that of AbdEl-Aziz (1984) in *Ardeola ibis ibis*. It could be an adaptation to the nature of the bird's food. This data agrees with Klasing (1999). The serosa is made up of flattened simple squamous epithelium with vein, the mean thickness of serosa is (46.6±22.16, 23.33±3.33and 23.3±11.5 μm) (Table.2, Fig.18).

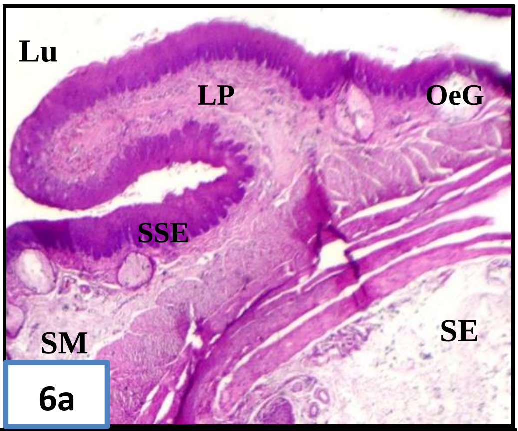
Large intestine

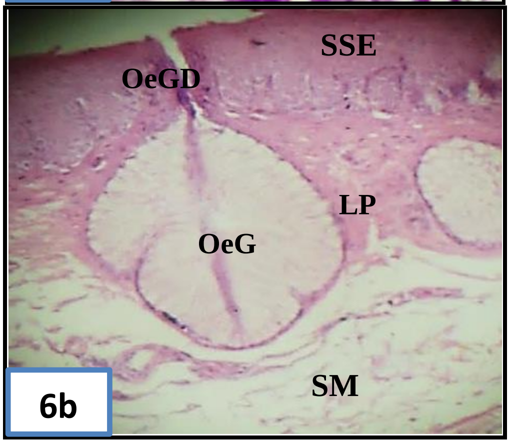
The mucosa is protrude into long and leaf- like villi covered by simple columnar epithelium with goblet cells (Fig.13a, b), the mean thickness of mucosa is (493.33±68.06 µm) (Table.2, Fig.15).The rectal villi are shorter than other intestinal regions. The goblet cells are numerous in number and open into the rectal lumen. This result agrees with Abd El-Aziz (1984). Rectal glands (simple tubular) are found in the base of folds and it covered with simple columnar epithelium and goblet cells. This observation was recorded by Abo-Shaeir (2001) and Al-Juboury (2016) on *Tyto alba*. Lamina propria is characterized by small lymphocytes. Muscularis mucosa is composed of longitudinal muscle fibers that extend inside the folds as vertical muscle fiber strands. Submucosa composed of loose connective tissue and blood vessels and it contains the bodies of tubular glands, the mean thickness of submucosa is (20±1 µm) (Table.2, Fig.16). Musculosa layer consist of two muscle layers; outer thin longitudinal and inner thick circular one, the mean thickness of musculosa is (146.6±5.77µm) (Table.2, Fig.17). The serosa is a thin layer consist of simple squamous epithelium, the mean thickness of serosa is (950±288.31 µm) (Table.2, Fig.18). This result was in agreement with result obtained from Majeed *et al*. (2009) and Hamidi *et al*. (2013) in *Elanus caeruleus.*

The Rectal Caeca

In brown falcon there are two small rectal caeca observed. These caeca are of lymphoid type (14a, b). The mean thickness of mucosa is (373.3±92,91 µm), submucosa is (30±10µm), musculosa is (130±15 µm) and serosa is (510±135.27 µm) (Table.2,Fig.15,16,17 and 18) . The rectal caecum has the same histological structure of the rectum with numerous numbers of lymphocytes in the sub-mucosa and mucosa and the mucosal folds. This result is in agreement with result obtained from Majeed *et al*. (2009) in broiler chicken and Hamidi *et al*. (2013) on *Elanus caeruleus.*







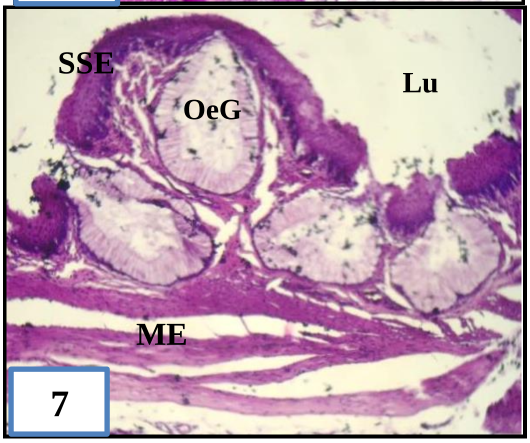


Figure (5): A transverse section of the cervical part of oesophagus in brown falcon showing the lumen (Lu), oesophageal gland (OeG), mucosa (Mu), muscularis externa and serosa (S). H&E stain, 40X.

Figure (6): a- A transverse section of the crop of brown falcon. Showing the oesophageal gland (OeG), lumen (Lu), stratified squamous epithelium (SSE), lamina propria (LP), submucosa (SM), serosa (S), H&E stain, X40.

b- Enlarged part of oesophageal gland Showing the oesophageal gland (OeG), stratified squamous epithelium (SSE), oesophageal duct (OeGD), Lamina propria (LP), H&E stain, X100.

Figure (7): A transverse section of the thoracic part of oesophagus in brown falcon showing the lumen (Lu), oesophageal gland (OeG), Stratified squamous epithelium (SSE), muscularis externa, and serosa (S). H&E stain, 100X.

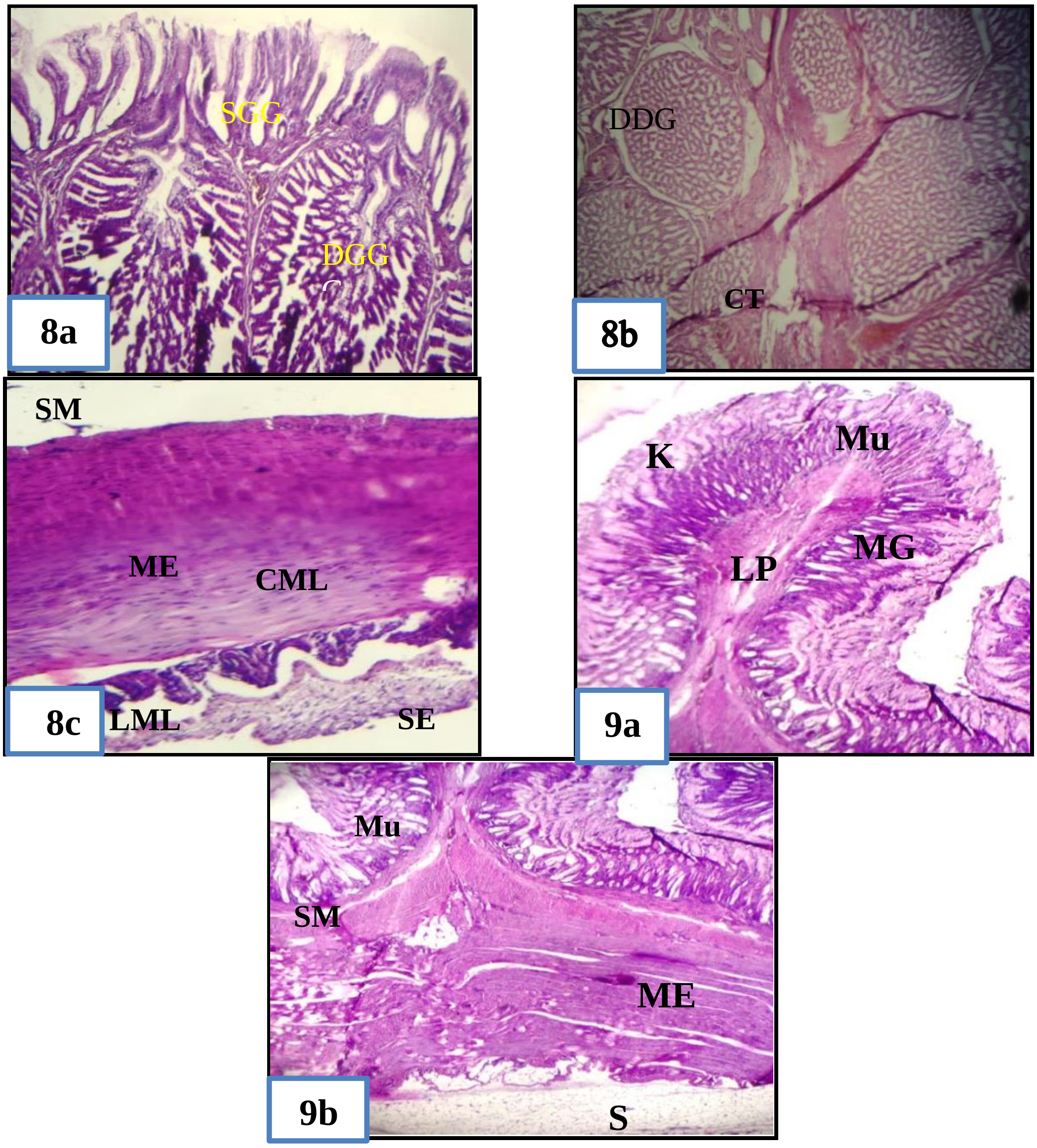


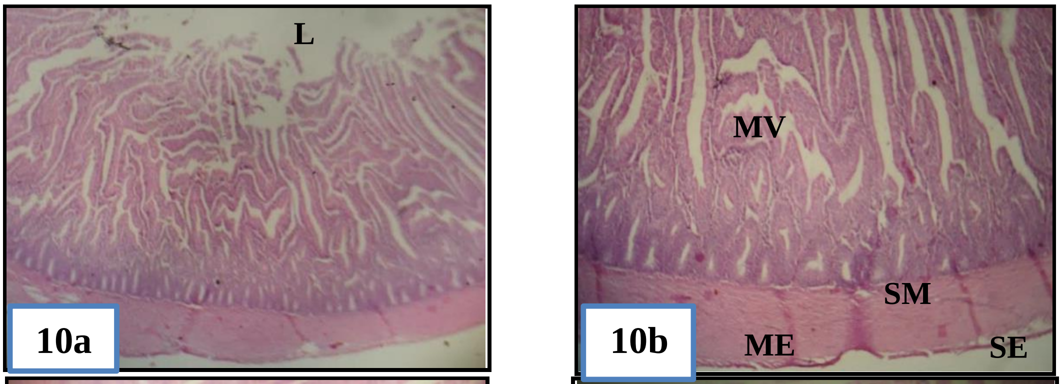
Figure (8): a-A transverse section of the proventriculus of brown falcon,. Showing the sub mucosal deep gastric gland (DGG), and superficial gastric gland (SuGG). H&E *stain*, X 40.

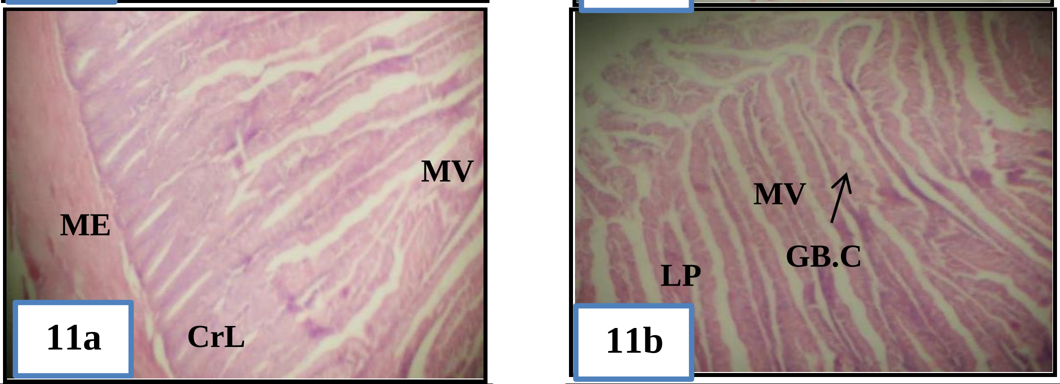
b- Enlarged portion of the deep gastric gland (DGG) in proventriculus of *Falco*,submucosa (SM), H&E *stain*, X 100.

c- Enlarged portion of the proventriculus of brown falcon, showing submucosa (SM),Muscularis externa (circular and longitudinal layer (CML&LML), serosa (SE), H&E *stain*, X 100.

Figure (9): a- A transverse section of the ventriculus of brown falcon, Showing the mucosa (Mu), mucosal gland (MG), lamina propira (LP) and koilin (K). H&E stain, X40.

b- A transverse section of the ventriculus of brown falcon,. Showing the mucosa (Mu), submucosa (SM), muscularis externa (ME), serosa (S), H&E stain, X40.





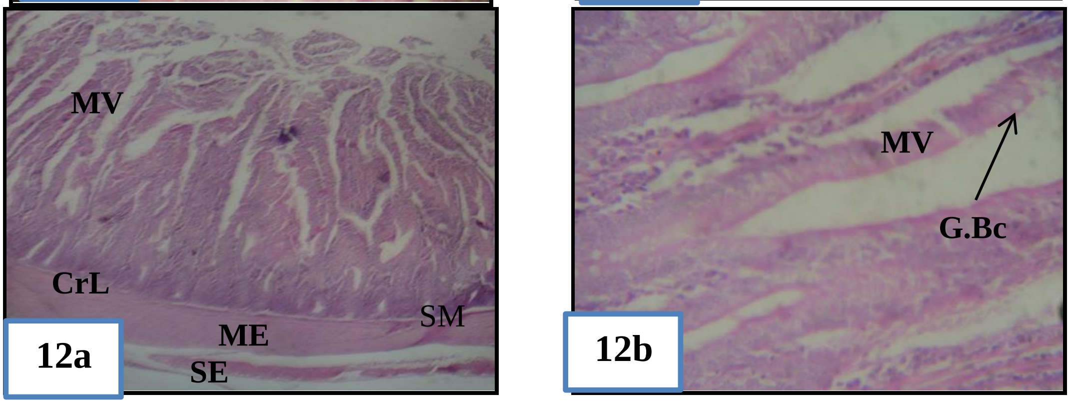


Figure (10): a-A transverse section of the duodenum of brown falcon H&E stain, X40.
b- Enlarged portion of the duodenum of brown falcon, showing the mucosal villi (MV), crypts of leiberkühn(CrL),submucosa (SM), muscularis externa (circular and longitudinal layers (CML&LML), and serosa (SE), H&E stain, X100.
Figure (11): a-Trasveres section of duodenum fold of brown falcon, in the mucosal layer showing muscularis externa (longitudinal and circular muscle fiber), crypts of leiberkühn(CrL),submucosa (SM), mucosal villi (MV). H&E stain, X100.
H&E stain, X100
b- A transverse section of the ileum of brown falcon, showing the goblet cells (GB.C),lamina propria (LP), mucosal vili (MV) H&E stain, X100.
Figure (12): a- A transverse section of the jeujenum of brown falcon, showing the serosa (SE), muscularis externa (ME), crypts of leiberkühn (CrL), mucosal villi (MV), goblet cell (GB.C). H&E stain, X40.
b- Enlarged portion of jeujenum of brown falcon, showing goblet cells (GB.C), mucosal villi (MV), H&E stain, X100

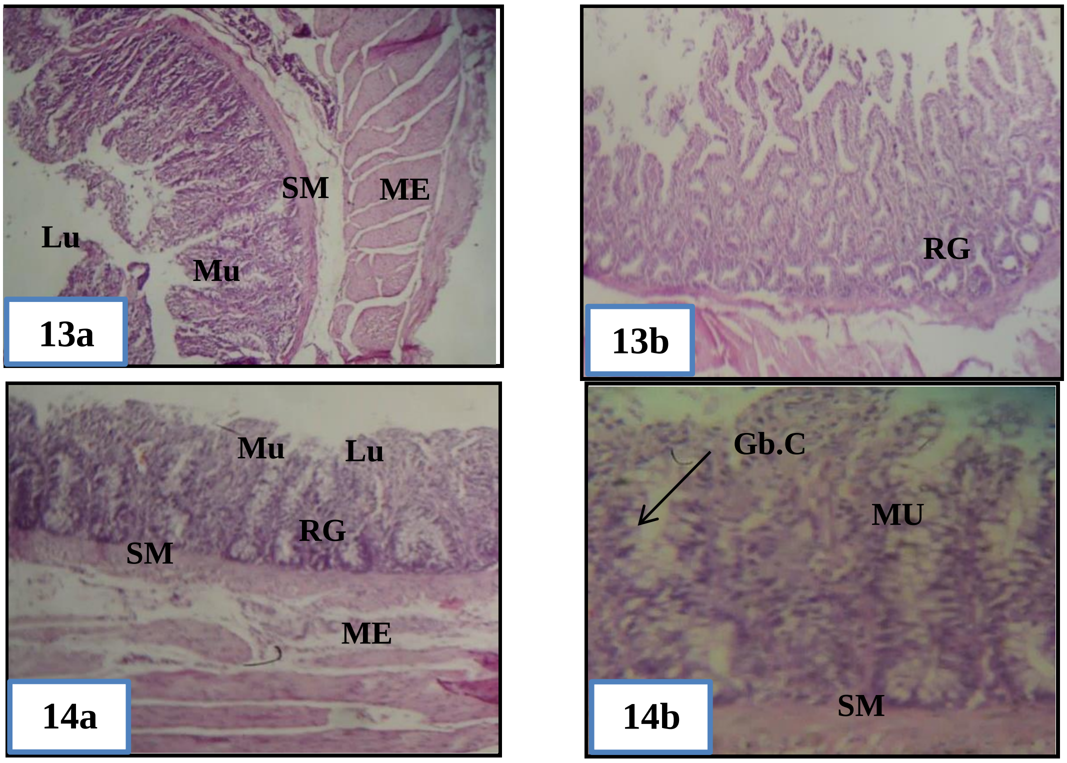


Figure (13): a- A transverse section of rectum of brown falcon Showing the lumen (Lu), mucosa (mu), submucosa (SM), muscularis externa (ME), H&E stain, X40.
b- Enlarged portion of rectum of falcon in the mucosal layer showing rectal gland (RG) H&E stain, X100.
Figure (14): a-A transverse section of the caecum of falcon, Showing the lumen (Lu), mucosa (Mu), mucosal gland (MG), sub mucosa (SM), ,muscularosa (circular and longitudinal layers (CML&LML), H&E stain, X100.
b- Enlarged portion of caecum of falcon in the mucosal layer showing goblet cells (GBC), submucosa (SM), H&E stain, X400.

Table (2): Histological comparison between the thickness (μm) of digestive tract parts of brown falcon.

Layers / Parts of digestive tract	Tunica Mucosa(µm) mean±S.D	Tunica Submucosa(µm) mean±S.D	Tunica Muscularis(µm) mean±S.D	Tunica Serosa(µm) mean±S.D
Cervical Oesophagus	225±43.3 a	258.3±38.18 a	195.6±63.93 a	91.66±28.86 a
Crop	276.6±5.77 a	203.3±90.73 a	260±20 a	100±20 a
Thoracic Oesophagus	213.66±14.08 a	233.3±108.46 a	240.6±82 a	95±25.98 a
Proventiculus	336.6±55.07 a	1766.6±575.18 b	505±48 b	191.6.6±27.73 a
Venticulus	313.33±20.81 a	16.66±5.77 a	1050±390.04 c	183.33±65.05 a
Duodenum	1350±132.28 d	23.33±3.21 a	196.66±20.81 a	46.6± 25.16 a
Jejunum	1041.6±260.2 cd	33.33±5.77 a	176.6±11.54 a	23.33±3.33 a
Ileum	818.3±345.9 bc	35±5 a	243.3±28.86 a	23.3±11.5 a
Caecum	373.3±92.91 a	30.±10 a	130±15 a	510±135.27 b
Rectum	493.33 ±68.06 ab	20±1 a	146.6±5.77 a	950±288.31 c

* Different symbols mean significant differences (P≤0.05).

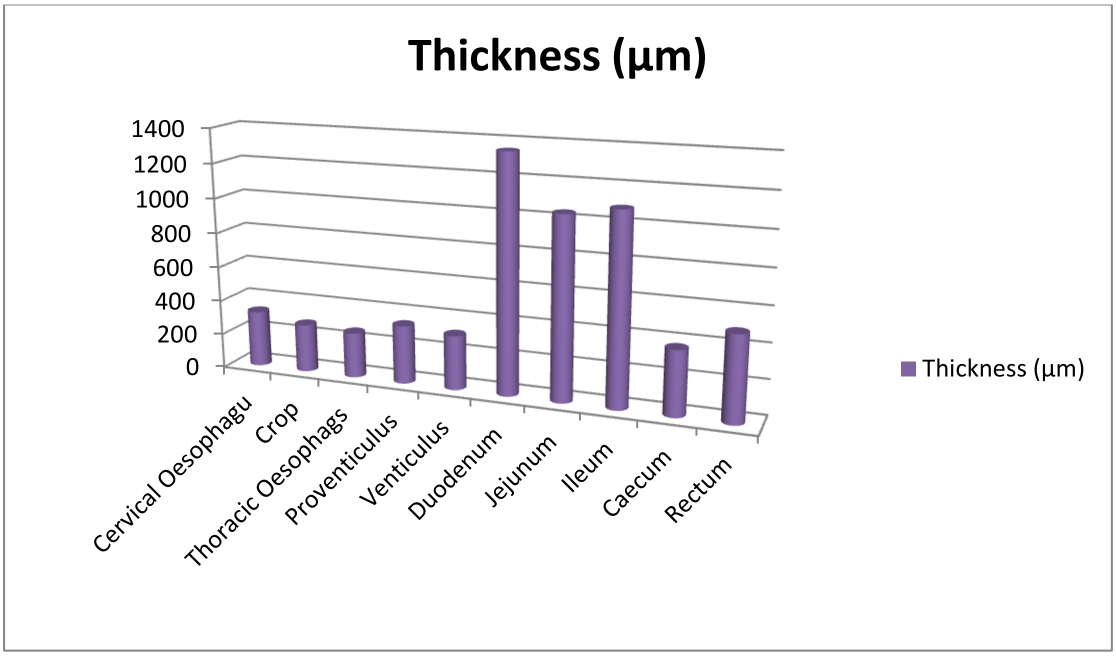


Figure (15): Histological comparison between the thickness (µm) of mucosa layer in different digestive tract parts of brown falcon.

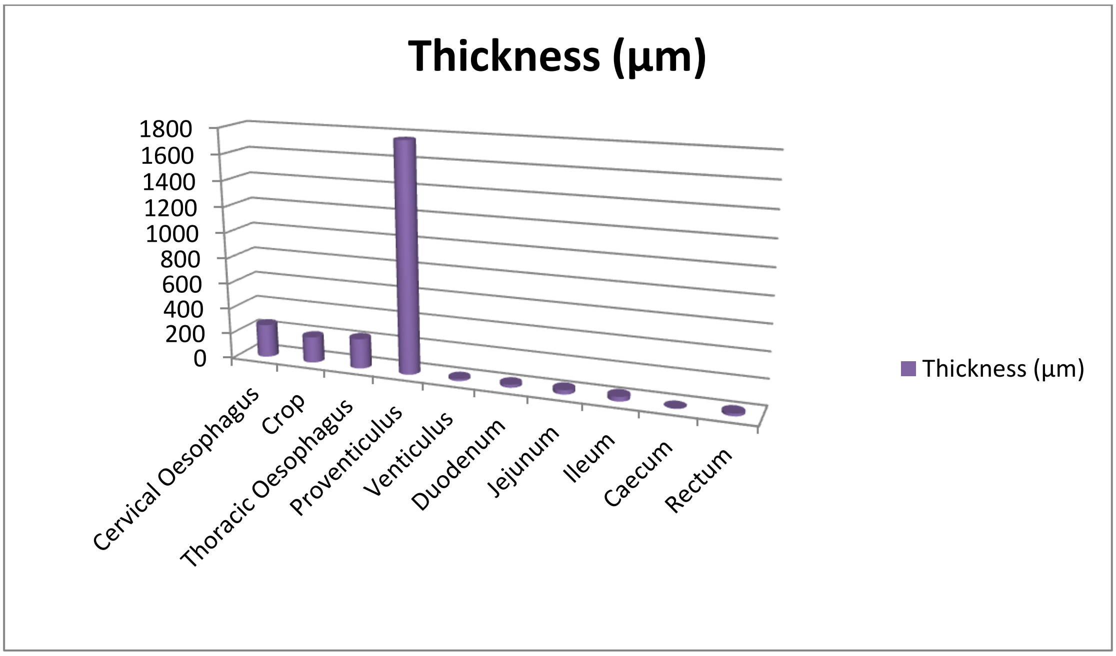


Figure (16): Histological comparison between the thickness (µm) of sub-mucosa layer in different digestive tract parts of brown falcon.

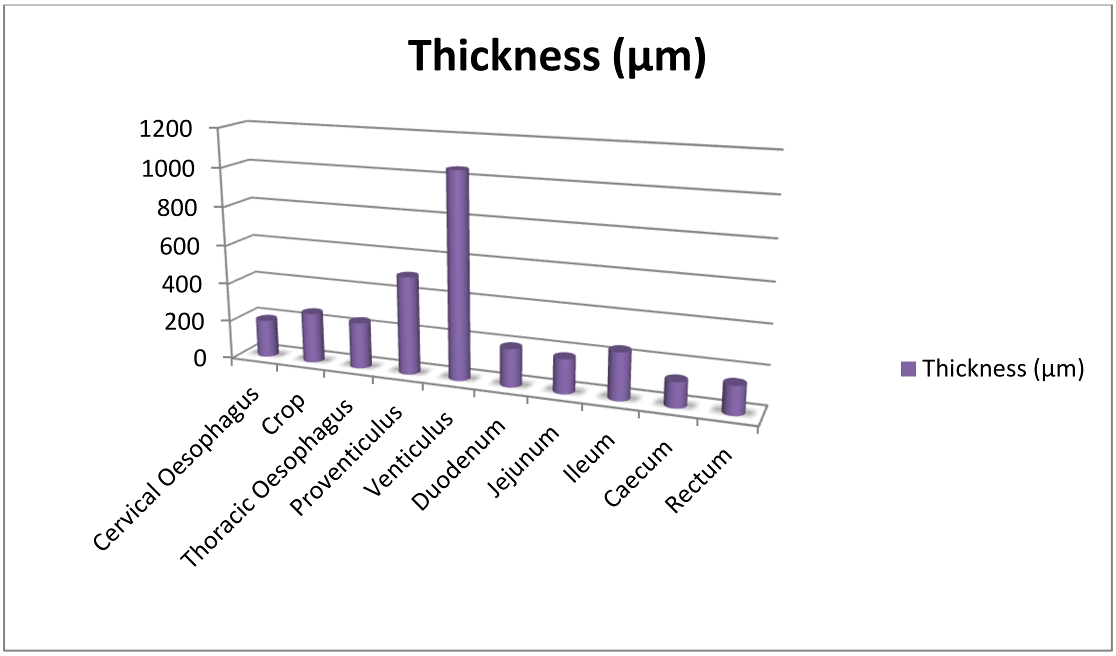


Figure (17): Histological comparison between the thickness (µm) of muscularis externa layer in different digestive tract parts of brown falcon.

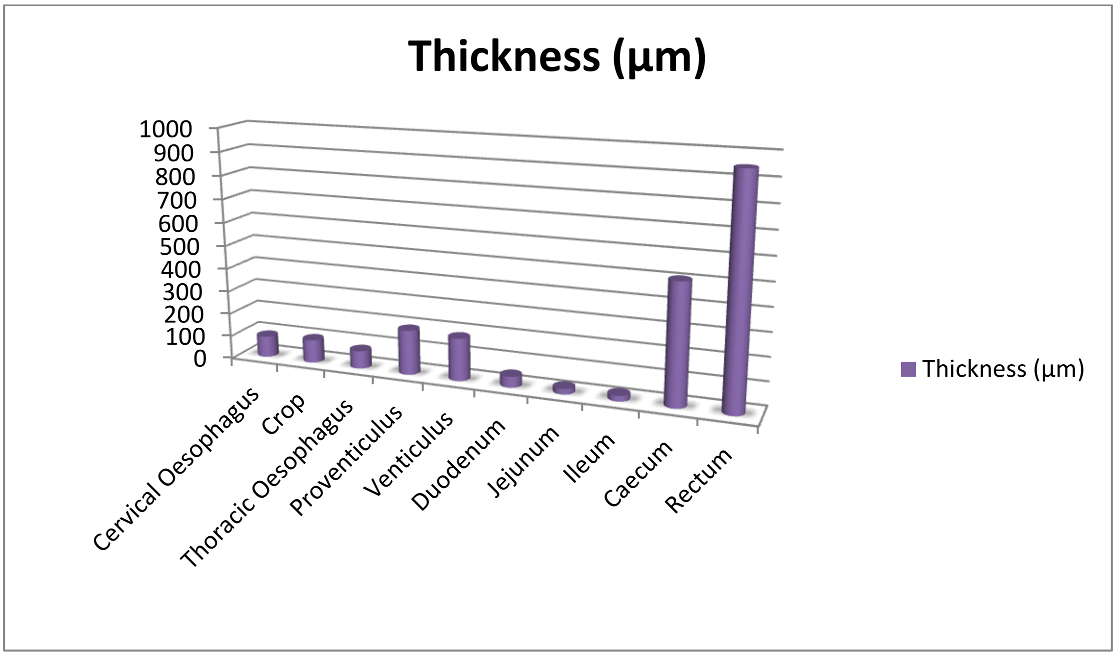


Figure (18): Histological comparison between the thicknesses (µm) of serosa layer in different digestive tract parts of brown falcon.

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