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SEASONAL VARIATIONS OF THE DIGESTIVE TRACT OF EGYPTIAN ROCK DOVE, *COLUMBA LIVIA:* ANATOMICAL, HISTOLOGICAL AND SCANNING ELECTRON MICROSCOPICAL STUDIES

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This work aims to study the effect of seasonal variations on anatomical, histological, and histochemical structures of the digestive tract of Egyptian rock dove (*Columba livia*). The digestive tract of rock dove consists of oesophagus, crop, stomach, small and large intestine. The regions of the digestive tract of rock dove differ from each other in the type of lining epithelium, the shape of folds formed by these epithelium, the distribution of glands within their layers, finally the thickness of these layers. The oesophagealmucosa is composed of keratinized squamous epithelium which appears thicker in the crop. This epithelium becomes more compressed and converts into simple columnar and cuboidal epithelium to line the glandular and muscular stomach respectively. This simple columnar epithelium also is lining the small and large intestine, caeca and cloaca. Most glands and the goblet cells that are distributed among the mucosa of different regions of the digestive tract indicate the presence of acid and neutral mucopolysaccharide secretions while proteins are observed in the different regions of the digestive tract. The hisomorphometrical studies of the digestive tract of the rock dove during the summer and winter seasons show no significant changes on the morphological and histochemical levels of the digestive tract except the oesophagus region. The present results confirmed that the Egyptian rock dove as a resident bird doesn't often have to face environmental changes.

Keywords: digestive tract , histomorphometrical, rock dove , seasonal

Introduction

The digestive tract of the birds has some unique aspects because the birds are one of animals lack the teeth and ability to chew. The birds have different strategies to cope with these characteristics by possessing many tools which help in manipulation and digestion their food, such as some bird species possess sharp beaks as in raptor birds. These species using their beaks in cutting the prey to small pieces that facilitate in the swallowing process and also the digestion one. Some other species that feed on hard food and grains, the digestive tract exhibit unique modifications like appear special storage chamber (crop) in which the food lubricate and partially digest before reach to the stomach, furthermore, the muscular stomach includes stone granules. the structure of avian's muscular stomach with the presence of stone granules act as crashing machine play important role in partially digestion of these hard substances (Kadhim et al,2011).

Thus, the gastrointestinal tract is a suitable system to study matches between loads and capacities because it is one of the major interfaces between the organism and its environment (Battley and Piersma, 2005). Several previous studies confirmed that the gastrointestinal tract of birds show great diversity according to their respective feeding and dietary habits. The knowledge of the morphology of the alimentary tract in birds has been conducted on many avian species, especially on fowl (Martinez et al., 2000; Rossi et al., 2005; Selvan et al., 2008; Ma, 2009; Kadhim et al., 2011), Elanus caeruleus (Hamdi et al., 2013), migrating blackcaps (Karasov , 2004) and on pigeon and Japanese quails (Hena et al., 2012).

The avian gastrointestinal tract has a large number of organs. The precise anatomic plan of the digestive tract of birds varies somewhat depending on their typical diet.

Many bird species exposed to changes in habitat, diet, energy demand or climate during the year, all of which may influence digestive morphology. Digestive system can be large and metabolically highly active and therefore energetically expensive (Klasing, 1999; Secor, 2001; Dietz and Piersma, 2007).Thermogenesis and adjustment of energy intake are important for the survival of winter-particularly active birds in their natural environment (O’Connor, 1995; Yuni and Rose, 2005).

Rock dove belongs to family Columbidae (granivor0us bird) does not require complex foraging skills but must forage intensively (Soldatini et al., 2006; Silva and Medeiros, 2008). The habitat of rock dove is in temperate zones restricted in western and southern Europe, North Africa, and South Asia (Gibbs et al., 2010).

Temperature is an important environmental condition for seasonal acclimatization in birds (McKechnie et al., 2007; Swanson, 2001; Tieleman et al., 2003 and Vézina et al., 2006). High ambient temperature in Egypt during the summer season generates

a status of stress and causes a combination of behavioral, biochemical, and physiological changes on rock dove (Faisal et al.,2008) ; among these changes, there are less time of feeding, more time of drinking (Mack et al.,2013),that increased agonistic behavior (Bozakova, 2008) and decreased feed intake resulting in decreased body weight(Mujahid et al., 2009).Moreover low-temperature stress during winter in temperate zones may induce an increase in energy consumed during a season of generally decreased food availability (Krams et al., 2010) and this change may be triggered also by environmental factors such as photo period, and diet quality and/or quantity (Starck, 1996 and 1999; Boon et al., 2000; Klaassen et al., 2004). Many birds have a variety of strategies to cope with low temperature stress, such as increasing body mass, food intake and thermogenesis (Bednekoff et al., 1994; Goymann et al., 2006; Krams et al., 2010; Webster and Weathers, 2000; Williams and Tieleman, 2000 and Swanson, 2001).

However the purpose of this study to determine the effect of seasonal variations on the gross, morphometrical, histomorphometrical and histochemical evaluation of the different regions of digestive tract of the Egyptian rock dove. The knowledge gained here will be used for setting up a reference/baseline for the digestive tract of this bird.

Materials and Methods

Healthy ten specimens of the rock dove, *Columba livia*, family Columbidae, order Columbiformes, trapped a live from Abo-Rawash area (Giza- Egypt) at summer and winter seasons. The specimens were dissected carefully in compliance with guidelines of the research ethics committees, Assuit University (www.enrec.org) For gross anatomy, making a longitudinal incision at the mid-ventral line of body to clarified the digestive system then taken the photos by digital camera (The Canon EOS 4000D). Body length, that measured from the tip of the beak to the end of the rump were measured with a tape measure. The position and relation of the digestive tract were examined in situ following a mid-ventral incision. After being removed from the body cavity and cleaned by saline and fixed in 10% neutral buffered formalin. The length of the digestive tract and its segments was measured;

the different measurements of the digestive tract of bird in each season were measured separately.

For Scanning Electron Microscopic investigations (SEM) the digestive tract were cut to small pieces, and directly fixed in 5% glutraldehyde in a cacodylate buffer for at least 48 hrs.

The specimens were mounted and sputter-coated with gold and examined under A Jeol Scanning Electron Microscope (JSM-5400LV), at 15Kv.

For histological study, the contents of the digestive tract were drained by saline solution; small pieces of the various segments were fixed in neutral formalin solution, after fixation, dehydrated, embedded in paraffin wax and then transversely sectioned 6µ thick. Sections were stained with differential double stained haemotoxylin and eosin, Masson's trichrome stain technique (Drury and Wallington, 1980).

For histotochemical detection of mucopolysaccharides and proteins, the following staining procedures were employed: Periodic Acid Schiff's technique (PAS), Alcian blue (pH 2.5) – PAS technique, Alcian blue (pH 2.5) technique for acid mucosubstances and mercuric bromophenol- blue technique (Bancroft and Stevens, 1996).

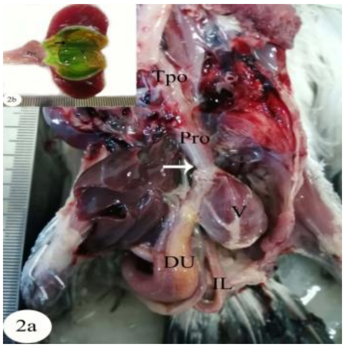
For hitomorphometric analysis of the rock dove digestive tract in the two different seasons; the thickness of tissue layers of the oesophagus, crop, proventriculus, ventriculus, duodenum, ileum, rectum, cloaca, and caeca of the rock dove measured with an Olympus microscope and the results were shown as Mean ±SE for each digestive tract parts. The statistical analysis was done by using statistical Package for Social Science (SPSS) system version 23. The significance of differences between seasons was determined using Student's t-test. The level of significance was accepted under level probability ($P< 0.05$).

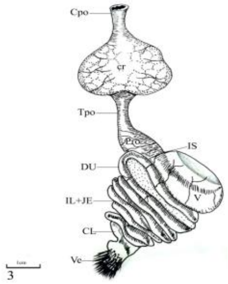
Results

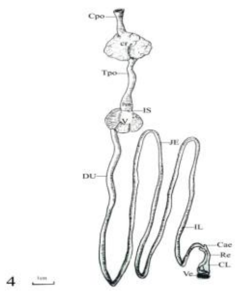
The digestive tract of the rock dove (*Columba livia*) consists of oesophagus, crop, stomach (proventriculus and gizzard), small intestine (duodenum and ileum), large intestine (short caeca, rectum) and cloaca (Figs. 2 a, 3 & 4).

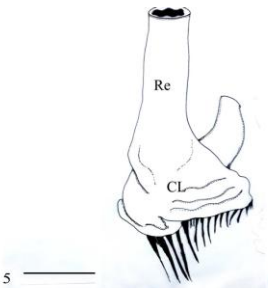
Histologically, the wall of digestive tract of the rock dove consists of four functional tunicae; mucosa, submucosa, musculosa and the outermost serosa, in addition, the muscularis mucosa appears in some parts of the digestive tract.

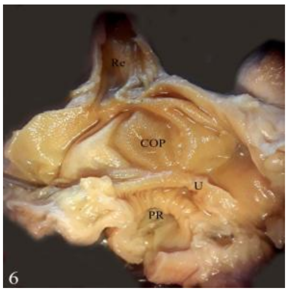
Morphometrically, The average length of the rock dove's body at summer season is (23.4± 2.2cm) and at winter season is (23.4±2 cm), while the average length of the rock dove's digestive tract at summer season is (16.6 ±0.9 cm) and at winter season is (21.2±1.9cm) (Fig. 79).











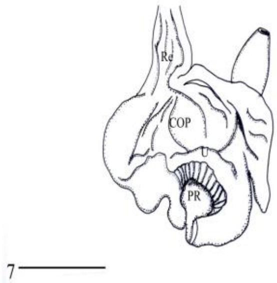


Fig.1. A photograph of the rock dove *Columba livia.*
Fig.2a. Dissected alimentary tract of *Columba livia* showing thoracic portion of oesophagus (Tpo), proventriculus (Pro),ventriculus (V), duodenum (DU) , ilieum (IL) and isthmus (white arrow) .b. Photograph of the dissected stomach of *Columba livia* showing the interior surface of the proventriculus (Pro), ventriculus (V) and the koiline membrane (arrow).
Fig. 3. Drawing of an isolated alimentary tract of *Columba livia* showing the cervical part of oeosphagus (Cpo),crop (Cr) thoracic part of oesophagus (Tpo), proventriculus (Pro),

ventrculus (V),duodenum (DU), isthmus (IS), the cone –shaped of spiral coils of the ilieum and jejunum (IL+JE) ,cloaca (CL) vent (Ve).

Fig. 4. Drawing of an isolated alimentary tract of *Columba livia* showing its different segments ,cervical part of oeosphagus (Cpo), crop (Cr) , thoracic part of oesophagus (Tpo), proventriculus (Pro), ventriculus (V),isthmus (IS) ,duodenum (DU), ilieum (IL), jejunum (JE) ,caeca (Cae) ,rectum (Re) and vent (Ve).

Fig.5. Drawing of enlarged portion of cloaca (CL) and rectum (Re) of *Columba livia*.

Fig.6. Photograph of dissected cloaca of *Columba livia* showing the interior surface of cloaca and its chambers coprodeum(COP),urodeum(U) , proctodeum (PR) and rectum.

Fig.7.Drawing of interior surface of cloaca of *Columba livia* showing coprodeum (COP), proctodeum(PR) , urodeum (U) and (Re).

The oesophagus

The oesophagus located on the right side of the neck, dorsal to the trachea and extends from oropharynx to the proventriculus (Figs. 2 a & 3). The anatomical investigation of the oesophagus of rock dove consists of three parts the cervical, crop and thoracic parts. The cervical oesophagus extends from the oropharynx to the thorax and its wall enlarges posteriorly to form the crop which anatomically located dorsal to the larynx and trachea (Figs.2 a, 3 & 4)

The scanning electron microscopic investigation of the interior surface of the cervical oesophagus shows well demarcated longitudinal folds (Figs. 8a&b). While the crop exhibits presence of few folds with shallow and wide waves (Figs. 10a & b) and the longitudinal folds of the internal surface of the thoracic oesophagus appear less deep than that of the cervical oesophagus with larger space (Figs. 12 a & b), as well as, the appearance of numerous orifices of the oesophageal glands (Figs. 12a ,b).

Histologically, the three regions of the oesophagus differ from each other; the differences represented by the number of the folds, the height of these folds, the presence of the oesophageal glands, the number of these glands and then the thickness of the layers. The results show that the folds in the cervical oesophagus appear as a finger-like shape (Fig. 9a).

While the crop folds are few, shallow with a wide waves (Figs. 11a&b). meanwhile, the folds of the thoracic portion appear as a leaf- like, but these folds appear less and wider than those of the cervical one , as well as, that invaded with a flask-like compound alveolar glands (Figs. 13a&b).

The oesophageal folds are lined by keratinized stratified squamous epithelium which thicker in the crop. The sub mucosa consists of dense collagenous connective tissue incubating the oesophageal glands (in the thoracic portion only), lymph and blood vessels. The muscularis mucosa is located between the mucosa and submucosa. The muscularis externa consists in the cervical oesophagus of inner longitudinal and outer circular muscle fibers separated by connective tissue while in the crop is thicker than that of the cervical oesophagus and it consists of a well-developed outer longitudinal smooth muscle layer and inner circular smooth muscle fibers, notably, the outer longitudinal layer is the biggest and in the thoracic oesophagus the muscularis externa is bigger than that of the two previous portions and it is composed of inner thin circular smooth muscles and outer thick longitudinal smooth muscle fibers. The serosa is composed of thin layer of fibrous connective tissue containing blood vessels (Figs. 9a, b, 11a, b&13a, b).

Histochemically, the oesophageal glands are composed of mucoid alveoli; these glands exhibit strong-PAS reaction and also exhibit marked Alcianophilia at PH 2.5 (Figs. 37, 38&39). Moreover, the oesophagus of the rock dove reveals the presence of an exaggerated amount of protein elements when stained with mercuric bromophenol blue. These protein contents fill the cytoplasm of its stratified squamous epithelium, the muscular layer and the lamina properia (Figs. 32&36). On the other hand, the oesophageal glands exhibit a negative response to the bromophenol blue (Fig. 40).

Morphometrically, at summer season, the average length of oesophagus is (9.25 ± 0.7582cm) while at winter season is (9.83 ± 0.7527cm) (Fig. 79).

Histomorphometric study of the layers of the cervical region of the oesophagus exhibit the average thickness of muscularis is (373.4283± 135.45769µm) at summer season and is (697.2650±196.97130µm) at winter season, the average thickness of mucosa is (568.6950 ±130.83410µm) at summer season, and is (281.9133±130.94078µm) at winter season and the average thickness of epithelium is (70.1933±13.72274µm) at summer season, and is (114.8683±28.20301µm) at winter season. Changes in thickness between layers muscularis, mucosa and epithelium, are significant at summer season compared to winter season; (T = -3.318, P = 0.008), (T = 3.795, P = 0.004), and (T = -3.489, P = 0.006) (Fig. 69).

Meanwhile, the crop showing that the average thickness of muscularis is (466.165±149.1484µm) at summer season, and is (438.728±224.639µm) at winter season, the average thickness of mucosa is (515.0917±181.332µm) at summer season, and is (858.0367±205.982µm) at winter season and the average thickness of epithelium at summer season is (187.1017± 30.26579µm), and at winter season is (96.17±27.05055µm) .Changes in thickness between layers muscularis, mucosa and epithelium, in crop are not significant at summer season compared to winter season; (T= 0.249, P= 0.808), (T= 1.402, P = 0.191), but it change significantly in the epithelial layer in winter season than in summer season; (T= 5.487, P = 0.000) (Fig. 70).

While, the thoracic oesophagus showing that the average thickness of muscularis is (416.7633±184.4871µm) at summer season, and is (285.41±41.83017µm) at winter season, the average thickness of mucosa (with oesphageal glands) is (762.8783±159.7866µm) at summer season, and is (822.4883±95.7148µm) at winter season and the average thickness of epithelium at summer season is (255.5571±65.798µm), and at winter season is (429.300±167.094µm). Changes in thickness between layers muscularis, and mucosa are not significant at summer season compared to winter season; (T= 1.701, P= 0.144), (T= - 0.784, P = 0.451), but epithelial layer change significantly in winter season than summer season; (T= -2.584.P = 0.025) (Fig. 71).

The stomach

The stomach of rock dove consists of two chambers; the glandular stomach or proventriculus and the muscular stomach, or ventriculus (gizzard) situated in the left median part of the abdominal cavity. The proventriculus appears as a fusiform -shape separated from the gizzard by isthmus. The gizzard is lined by yellowish-green tissue and contains irregular pleated of longitudinal folds (koilin).The anatomical observation reveals the presence of grits inside the gizzard (Figs. 2a, b, 3&4).

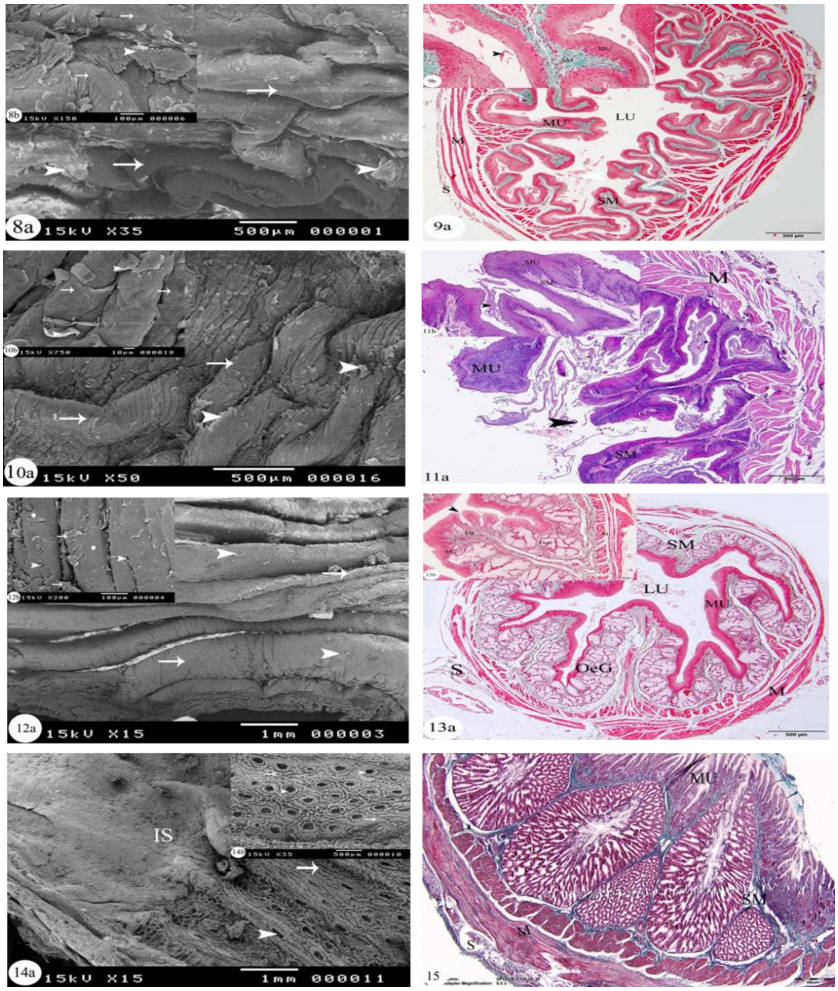


Fig. 8a. Scanning electron micrographs of the cervical oesophagous of *Columba livia* showing the longitudinal folds (arrows) with deciduous cell (arrowheads). **b**. High magnification of Fig. 8a, showing the deciduous epithelium of the oesophagus (arrowhead) and the folds of the oesophagus (arrows).

Fig. 9a. Transverse section of the cervical oesophagus showing serosa (S), musculosa (M), mucosa (MU), lumen (LU) and submucosa(SM). **b.** Enlarged portion of a transverse section of the cervical oesophagus showing the stratified squamous epithelium forming the mucosa (MU). Trichrome stain

Fig. 10a. Scanning electron micrographs of crop showing the longitudinal shallow and wide waves (arrow) with deciduous epithelium (arrowhead). **b.** High magnification of **Fig. 10a.**showing the crop folds (arrow) and the keratinized epithelium (arrowhead)

Fig. 11a. Transverse section of crop showing musculosa (M), mucosa (MU), and submucosa (SM). **b.** Enlarged portion of a transverse section of crop showing, stratified squamous epithelium forming the mucosa(MU) ,the keratinized epithelium (arrowhead) and submucosa (SM). H&E stain

Fig. 12a. Scanning electron micrographs of the thoracic portion of the .oesophagus showing the longitudinal folds (arrows) and the openings of the oesophageal glands (arrowheads). **b.** High magnification of **Fig. 12a.** showing folds with deciduous epithelium of the oesophagus (arrows) and the openings of the oesophageal glands (arrowheads).

Fig. 13a. Transverse section of the thoracic oesophagus showing the oesophageal gland (OeG), stratified squamous epithelium forming the mucosa (MU), musculosa(M), circular and longitudinal layers , and lumen (LU). **b.** Photomicrograph of enlarged portion of a transverse section of the thoracic oesophagus showing the oesophageal gland (OeG) ,submucosa (SM) and mucosa (MU). Trichrome stain

Fig.14a. Scanning electron micrograph of the interior surface between the proventriculus (PV) and the ventriculus (V) showing the proventricular papillae (arrowheads) and the openings of the proventricular glands (arrows) and the well-developed shallow folds of the interior surface of the ventriculus (arrow), and the isthmus constriction between the proventriculus and the ventriculus (IS). **b.** Scanning electron micrographs of the interior surface of the proventriculus showing the mucosal papillae (arrows) and the openings of the proventricular glands (arrowheads)

Fig. 15. Transverse section of the proventriculus showing the serosa(S), musculosa (M), mucosa(MU) and submucosa (SM). (Masson's Trichrome stain)

The scanning electron microscopic investigation of the proventriculus reveals the presence of papillae along entire mucosal surface of proventriculus. These papillae presented by folds which are arranged in concentric rings around the openings of the proventricular glands (Figs. 14a, b&16), while the scanning electron microscopic investigation of the interior surface of the gizzard is often strongly folded with many grooves of the mucosa (Figs. 18a & b).

Histologically, the mucosal epithelium is compressed, crowded with plicae which are separated by sulci; these plicae are lined with simple columnar epithelium with cells of clear cytoplasm and oval dark nucleus. The epithelium of mucosa rests on loose connective tissue represents by lamina propria which contains blood vessels, lymph cells and simple tubular glands lining with columnar epithelial cells called the superficial glands opens at the base of each sulci. The submucosa composes of loose connective tissue with blood vessels supply and large oval to conical compound tubuloalveolar glands called deep gastric glands filling most of the proventriculus wall and are separating from each other by connective tissue. The histological examination reveals that the deep gastric glands consists of numerous adenomas appears with different shapes and diameter. The muscularis consists of inner thick circular muscle fibers and outer thin longitudinal muscle fibers. The outermost layer is the serosa which composed of loose connective tissue containing blood and lymph vessels and nerve ends (Figs. 15&17).

Meanwhile the mucosa of the ventriculus (gizzard) exhibits, thin finger-like projections toward the lumen appear as folds separated by gastric pits. These folds are lined by simple cuboidal epithelial cells, these cells become columnar. The histological examination reveals that there is a layer of koilin in front of the epithelial folds and adjacent with it, sub mucosa appears as a connective tissue rich with lymph cells, blood vessels and few simple tubular glands near the bases of the gastric pits, these glands are lined with simple cuboidal epithelial cells. In the present study, the muscularis mucosa is clearly represented in the gizzard (Figs. 19a&b).

Histochemically, the ductular cells in the proventriculus and the glandular tubules indicate strongly positive reaction with PAS (Fig. 41), strong reaction (blue color) with Alcian blue at PH 2.5 and the secretory material within the lumen of the glandular tubules show a moderate reaction for Alcian blue at PH 2.5 (Fig. 42).The ductular cells of the proventriculus give purple color with Alcian blue- PAS stain (Fig. 43).

Meanwhile, the tubular glands in the ventriculus have strong affinity to Alcian blue and negative to PAS reaction (Figs. 45&46).The secretory materials within the lumen of the glandular tubules show a moderate reaction for Alcian blue and PAS reaction (burble color) (Fig. 47).The ductular cells of the proventriculus also show moderate reaction with the mercuric bromophenol blue, in the other hand the cytoplasm of the simple cuboidal epithelial cells that lined the deep gastric gland, the muscularis and the connective tissue of lamina propria stained deeply (Fig. 44).moreover, the cells of the tubular glands and crypts of the ventriculus indicates a strong response to the bromophenol blue method (Fig. 48).

Morphometrically, the average length of the stomach at summer season is (4.833±0.7527cm), and in winter season is (6.1667±1.3662cm) (Fig. 79).

Histomorphometric study of layers of the proventriculus showing the average thickness of muscularis at summer season is (138.1750 ± 41.94415µm), and at winter season is (254.4017±115.04991µm) ,the average

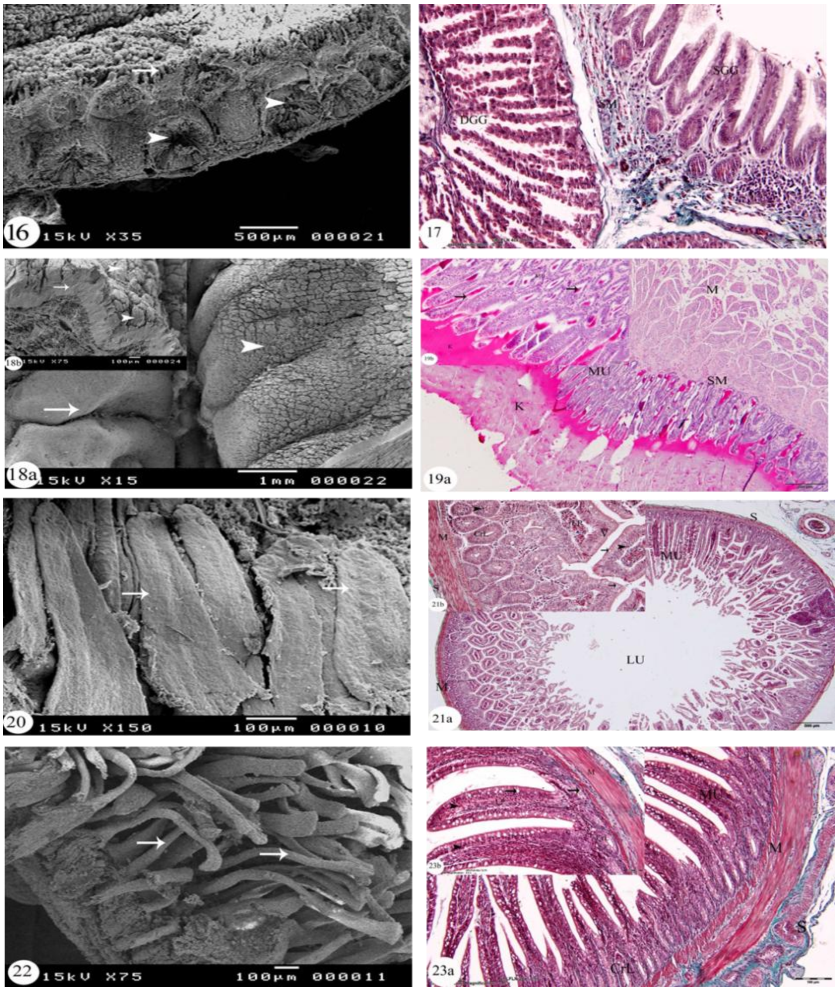


Fig. 16. Scanning electron micrographs the lateral side of the proventricular portion showing the proventricular glands (arrows) and the openinings of the proventricular glands (arrowhead).

Fig.17. Enlarged portion of a transverse section of the proventriculus showing the deep gastric gland (DGG),lumen of the deep gastric gland ,the superficial gland (SGG) and its epithelium and submucosa(SM). (Masson's Trichrome stain)

Fig.18a. Scanning electron micrograph of the interior surface of the anterior portion of the ventriculus of *Columba livia* showing the ventricular folds (arrow)and the ventriculus cuticle folds (arrowhead).**b.** Scanning electron micrographs of the wall of the ventriculus showing the cuticle folds resembled bundles of rods (arrowhead) and mucosa (arrow)

Fig. 19a. Transverse section of the ventriculus showing the musculosa (M), mucosa (MU), submucosa (SM) and the koilin membrane (K) .**b.** Photomicrograph of enlarged portion of a transverse section of the ventriculus showing the mucosa (MU), the tubular gastric gland secretion (arrows) and the koilin membrane (K) .H&E stain

Fig.20. Scanning electron micrographs of the interior surface of duodenum of rock dove showing the leaf like villi (arrows) .

Fig. 21a. Transverse section of the duodenum showing the musculosa (M), mucosa (MU), and the lumen (LU) of the duodenum. **b.** Photomicrograph of enlarged portion of a transverse section of the duodenum showing the crypts of Leiberkun (Cr.L), the villi (V) with goblet cells (arrows)and lymphocytes (arrowheads) .Trichrome stain

Fig.22. Scanning electron micrographs of the interior surface of ilieum of rock dove showing the finger like elongated villi (arrows) .

Fig. 23a. Ttransverse section of the ilieum showing the musculosa (M), mucosa (MU), serosa (S) and crypts of Leiberkun (Cr.L). **b.** Photomicrograph of enlarged portion of **Fig.23a** transverse section of the ilieum showing the musculosa (M), the crypts of Lieberkühn (Cr.L), and the villi (V) with goblet cells (arrow) and lymphocytes (arrowheads) .Trichrome stain

height of superficial gland at summer season is (381.4317± 254.76768µm), and at winter season is (493.8067 ± 256.92352µm), the average length of lumen of gland at summer season is (386.0467± 145.30972µm), and at winter season is (596.7783 ± 296.26554µm) and the average thickness of the epithelium at summer season is (14.9517 ± 3.02756µm), and at winter season is (22.48 ± 5.33796µm).Changes in thickness and height between layers muscularis, superficial gland and lumen of glands, are not significant at summer season compared to winter season; (T= -2.325, P= 0.057), (T= -0.761, P = 0.464), and (T= -1.564,P= 0.160),but between epithelium was significant (T= -3.005,P = 0.013) (Fig. 72).

While the histomorphometric study of layers of the anterior portion of ventriculus exhibits that the average height of the gastric gland at summer season is (177.0517 ± 32.79712µm), and at winter season is (89.9617 ±77.29842µm), the average thickness of koilin layer at summer season is (363.285 ± 70.259µm),and at winter season is (407.61 ± 58.4864µm) and the average thickness of the epithelium at summer season is (9.8967 ± 2.9658µm),and at winter season is (9.6933 ± 1.6925µm) .Changes in height and thickness between gastric glands are significant at summer season compared to winter season; (T= 2.541, P= 0.040), but between koilin and epithelial layers, is not significant at summer season compared to winter season; (T= 2.541, P= 0.040), (T= -1.188, P = 0.262), and (T= 0.146,P= 0.887) (Fig. 73).

Meanwhile, the posterior portion of gizzard shows that the average height of the gastric gland at summer season is (212.215 ± 62.5653µm), and at winter season is (95.8 ± 38.2286µm),the average thickness of koilin at summer season is (395.2917 ± 76.706µm), and at winter season is (300.2267 ± 49.0608µm) and the average thickness of the epithelium at summer season is (11.98±3.9769µm), and at winter season is (11.288 ± 5.7839µm).Changes in height and thickness between layers of gastric gland, and koilin, are significant at summer season compared to winter season; (T= 3.889, P= 0.003), and (T= 2.557, P = 0.029), but changes in the thickness of the epithelial layers is not significant at summer season compared to winter season ;(T=0.241, P=0.814) (Fig. 74).

The small intestine

The small intestine of rock dove is long and consists of a coiled mass forming a series of loops lies within the abdominal cavity. It is distinguished into the duodenum and ilieum (Figs. 2a, 3&4).

The duodenum begins at the end of ventriculus and forms an elongated loop. The pancreas lies between the arms of the loop and actually holds the two arms together by connective tissue (Fig. 2a), while the ileum is long – coiled tube lie on the right side of the abdominal cavity and terminate at the junction where the small intestine, the two caeca and the colon all meet (Figs. 2a, 3&4).

The scanning electron microscopic observation of duodenum reveals that the presence of a leaf -like crowded villi, with curved tips above each other (Fig. 20), and the finger-like shape villi appears on the interior surface of ileum (Fig. 22).

Histologically, the small intestine shows four tunicae: mucosa, submucosa, musculosa and serosa. The mucosa of the intestine is thrown into villi which show a marked variation in density, shape and size in the different regions of the intestine. Intestinal villi gradually decrease in length and size moving from the duodenum toward the ileum. The mucosa consists of a simple columnar epithelium and a tunica propria. Goblet cells frequently occur amongst the columnar or absorptive cells. The goblet cells increase from the duodenum towards the rectum. Lymphocytes are scattered amongst

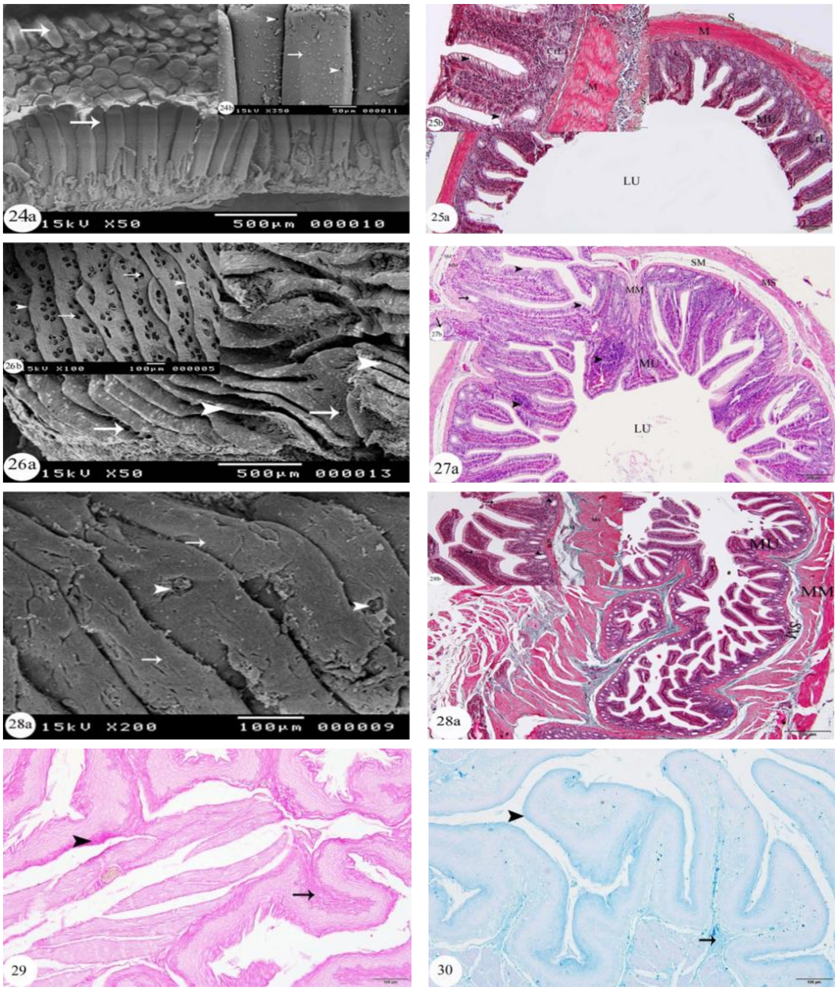


Fig.24a. Scanning electron micrograph of the interior surface of rectum of rock dove showing the finger like and crowded short villi (arrows) . **b.** High magnification of **fig.24a.**showing the surface of the finger like villi of the rectum (arrows) with pore like openings (arrowheads).

Fig. 25a. Transverse section of the rectum showing the musculosa (M), mucosa (MU) , serosa (S) , crypts of Leiberkun (Cr.L)and the lumen (LU) of the rectum. **b.** Photomicrograph of enlarged portion of a transverse section of the rectum showing the musculosa (M), the crypts of Lieberkühn (Cr.L), and the villi with goblet cells (arrowheads). Trichrome stain

Fig.26a. Scanning electron micrograph of the interior surface of intestinal caeca of *Columba livia* showing numerous folds (arrowheads) and scattered openings(arrows). b.High magnification of **Fig.26a.**showing the surface of intestinal caeca folds of *Columba livia* (arrowheads) with numerous pores(arrows).

Fig. 27a. Transverse section of intestinal caeca of *Columba livia* showing musculosa (MS), sub mucosa (SM), lymphocytes (arrowheads) and muscularis mucosa (MM). **b.** Photomicrograph of enlarged portion of a transverse section of intestinal caeca of *Columba* *livia* showing the musculosa (MS), muscularis mucosa (MM) the crypts of Leiberkun (arrow), and the villi with numerous goblet cells (arrowhead) .H&E

Fig.28a . Scanning electron micrograph of the internal surface of cloaca of *Columba livia* showing the longitudinal folds (arrow) and the openings of the epithelial tubular glands (arrowheads).**Fig .28 b.** Photograph of cloaca of *Columba livia* showing the different layers, serosa (S), muscularis (MS),submucosa (SM) ,muscularis mucosa(MM) and mucosa (MU). trichrome stain **Fig.28c.** Enlarged portion of Fig (29) showing villi of cloaca of *Columba livia* with numerous goblet cells (arrows), crypts of Liberkuin (arrowheads) and muscularis mucosa (MM).

Fig. 29. Transverse section of the cervical oesophagus, showing the carbohydrate contents (PAS positive stain).

Fig. 30. Transverse section of the cervical oesophagous, showing the acid mucopolysaccharide content (Alcian blue stain).

the bases of the columnar epithelial cells. Crypts of Lieberkühn, being more numerous and too crowded in the duodenum. They are built of cells similar in structure to those of the mucosal epithelium. The cores of the villi are formed of the areolar connective tissue of the tunica propria. They contain blood vessels and capillaries, lymph vessels and numerous darkly stained lymphocytes. The submucosa is thin, narrow and hardly distinguished in some regions .The muscularis mucosa is composed of thin layer of longitudinal muscle fibers which merges gradually into the submucosa and extends into the core of the villi. The musculosa consists of two smooth muscle layers; outer thin longitudinal layer and inner thick circular muscle layer. All muscle fibers are of un-striated type. The serosa is made up of flattened simple squamous epithelium (Figs. 21 a, b & 23a, b) .

Histochemically, small intestine (duodenum and ilieum) show that the villi possess goblet cells which exhibits strong PAS reaction (Figs. 49&53), Alcian blue (pH 2.5) – PAS (Figs. 51&55) and Alcian blue (pH 2.5) (Figs. 50&54) while, show negative reaction with the bromophenol blue stain (Figs. 52&56).

Morphometrically, the average length of duodenum at summer season is (9.666±0.9831cm), and is (9.750 ±1.5411cm) at winter season, while the average lengths of the ileum is (44.25±5.5834cm) at summer season, and is (39.50±5.7532cm) at winter season

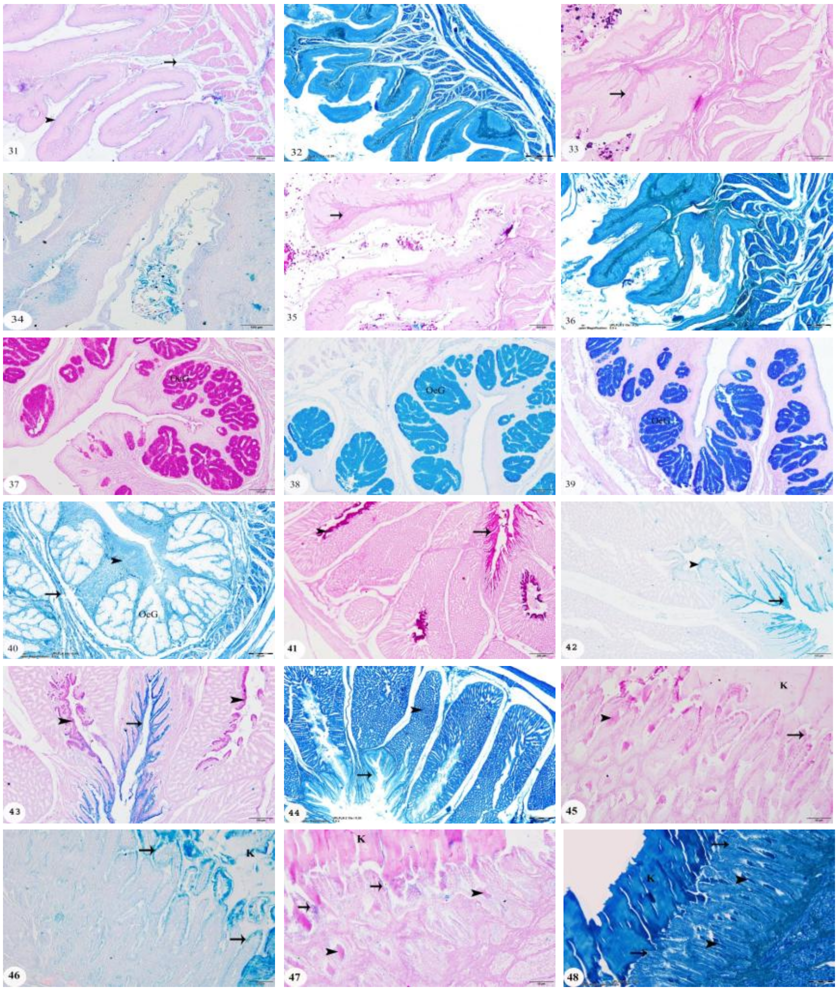


Fig. 31. Transverse section of the cervical oesophagus, showing the mucopolysaccharide content (PAS-Alcian blue stain).**Fig. 32**. Transverse section of the cervical oesophagus, showing the protein content (Bromophenol blue stain).**Fig. 33.** Transverse section of the crop, showing the carbohydrate contents (PAS positive stain).**Fig. 34.** Transverse section of the crop, showing the acid mucopolysaccharide content (Alcian blue stain).

Fig. 35. Transverse section of the crop, showing the mucopolysaccharide content (PAS-Alcian blue stain). **Fig. 36.** Transverse section of the crop, showing the protein content (Bromophenol blue stain).**Fig. 37.** Transverse section of the thoracic oesophagus, showing the carbohydrate contents (PAS positive stain).**Fig. 38.** Transverse section of the thoracic oesophagus, showing the acid mucopolysaccharide content (Alcian blue stain).

Fig. 39. Transverse section of the thoracic oesophagus, showing the mucopolysaccharide content (PAS-Alcian blue stain).**Fig. 40.** Transverse section of the thoracic oesophagus, showing the protein content (Bromophenol blue stain).**Fig. 41.** Transverse section of the proventriculus, showing the carbohydrate contents (PAS positive stain).

Fig. 42. Transverse section of the proventriculus, showing the acid mucopolysaccharide content (Alcian blue stain). **Fig. 43.** Transverse section of the proventriculus, showing the mucopolysaccharide content (PAS-Alcian blue stain). **Fig. 44.** Transverse section of the proventriculus, showing the protein content (Bromophenol blue stain).**Fig. 45.** Transverse section of ventriculus, showing the carbohydrate contents (PAS positive stain).**Fig. 46.** Transverse section of ventriculus, showing the acid mucopolysaccharide content (Alcian blue stain).**Fig. 47.** Transverse section of ventriculus, showing the mucopolysaccharide content (PAS-Alcian blue stain). **Fig. 48.** Transverse section of ventriculus, showing the protein content (Bromophenol blue stain).

Histomorphometric study of layers of the duodenum reveals that the average thickness of muscularis at summer season is (104.5967± 41.61858µm), and at winter season is (131.9433 ± 61.82414µm), the average height of mucosa (villi +Lieberkühn) at summer season is (499.1933± 148.1594µm), and at winter season is (446.4167 ±176.8611µm) and the average thickness of the epithelium at summer season is (36.59 ±3.57176µm), and at winter season is (27.715 ± 6.2133µm). Changes in thickness between layers muscularis, and mucosa are not significant at summer season compared to winter season; (T=-0.899, P= 0.390), (T= 0.560, P = 0.588), but changes in thickness between epithelial layers are significant at summer season compared to winter season; (T= 3.204, P = 0.009) (Fig. 75).

While the histomorphometric study of layers of the ileum show the average thickness of the muscularis at summer season is (149.4767±25.49266µm), and at winter season is (176.0633±89.20778µm), the average height of mucosa (villi+ Lieberkühn) at summer season is (382.9750±69.08558µm), and at winter season is (424.0367±139.05625µm) and the average thickness of the epithelium at summer season is (21.6083±4.6514µm), and at winter season is (32.5217±9.5252µm). Changes in thickness and height between layers muscularis, and mucosa are not significant in summer season compared to winter season; (T=-0.702, P= 0.510), (T= -0.648, P = 0.537), but changes in and thickness between layers and epithelium are significant in summer season compared to winter season; and (T= -2.522, P = 0.030) (Fig. 76).

The rectum

The rectum is relatively short and straight tube extends in the dorsal part of the abdomen between the ilieum and cloaca (Figs. 4,5,6&7).

The scanning electron investigation indicates that the mucous membrane of the rectum internally is thrown into numerous fingers like villi (Figs. 24a&b).

Histologically, the wall of the rectum is made up of serosa, musculosa, submucosa, muscularis mucosa and mucosa. The serosa is a thin layer composed of simple squamous epithelium with flattened nuclei. The musculosa is composed of longitudinal and thick circular one. The submucosa consists of loose connective tissue holding blood vessels. The muscularis mucosa is composed of longitudinal muscle fibers. This layer extends inside the mucosal folds as vertical muscle fiber strands. The mucosa is thrown up into numerous villi, all covered by simple columnar epithelium containing goblet cells. At the base of the mucosal folds, rectal glands (simple tubular) are noticed. These glands are crypts as in the small intestine, lined with simple columnar epithelium and goblet cells (Figs. 25a&b).

Histochemically, the goblet cells and the surface mucous epithelium react positively by PAS technique (Fig. 57). Strong bluish coloration is observed in the goblet cells, reddish coloration in the basal regions of these cells with Alcian blue (pH 2.5) – PAS (Fig. 59). Strong bluish coloration is observed in the goblet cells with Alcian blue (pH 2.5) (Fig. 58). Application of mercuric bromophenol blue method, indicates the absence of total proteins in the goblet cells, however, it is localized in the absorptive cells of the mucosal folds (Fig. 60).

Morphometrically, The average length of rectum is (3.0833±1.2416cm) at summer season, and is (2.4167±0.9174cm) at winter season (Fig. 79).

Histomorphometric study of layers of the rectum show the average thickness of muscularis at summer season is (266.8617 ± 98.21993µm), and at winter season is (332.82 ± 215.38163 µm), the average height of mucosa (villi + Lieberkühn) at summer season is (226.6750 ± 52.46119 µm), and at winter season is (198.3867 ± 154.22318µm) and the average thickness of the epithelium at summer season is (35.93 ± 7.26927µm), and at winter season is (30.0117 ± 8.37064 µm).Changes in thickness between layers muscularis, mucosa and epithelium are not significant in summer season compared to winter season; (T= - 0.683, P = 0.510) ; (T =

0.425, P = 0.685), and (T= 1.308, P = 0.220) (Fig.77).

The intestinal Caeca

The left and right caeca rise from the rectum close to the junction with the ileum, on the lateral wall of the intestine .Caeca are very small and directing cranially from their origin on the rectum (Figs. 4).

Scanning electron microscopic observations showing distinct longitudinal folds (Figs. 26 a& b).

Histologically, the mucous membrane of the intestinal caeca consists of simple villi. The villi are lined by a simple columnar epithelium whose cells resemble those of the small intestine, these villi have goblet cells and crypts, and the muscle layer is thicker. The muscularis mucosa is composed of thin layer of longitudinal muscle fibers. Accordingly, the narrow and thin submucosa connective tissue layer merges into that at the lamina propria. The musculosa consists of two layers of unstriated muscle fibers: an outer longitudinal layer and inner circular one. The outer longitudinal muscle layers are quite thin. The caecum is covered externally with a thin serosal layer; composed of simple squamous epithelial cells (Figs. 27a, b).

Histochemically, carbohydrates are localized in the goblet cells which showing positive PAS reaction (Fig. 61), Acid and neutral mucopolysaccharides are demonstrated by Alcian blue (pH 2.5) – PAS in the goblet cells (Fig. 63) ,also the goblet cells give strong positive reaction (dark blue) with Alcian blue (pH 2.5) procedure (Fig. 62) ,while reacts negatively with mercuric bromophenol blue method, indicates the absence of total proteins in the goblet cells, however, it is localized in the absorptive cells of the mucosal folds (Fig. 64).

Morphometrically, the average length of intestinal caeca is (0.65±0.1974cm) at summer season, and is (0.5167±0.1602cm) at winter season (Fig. 79).

Histomorphometric study of layers of the intestinal caeca indicates the average thickness of muscularis at summer season is (78.4633±31.6829µm), and at winter season is (100.2517±29.5441µm), the average height of mucosa

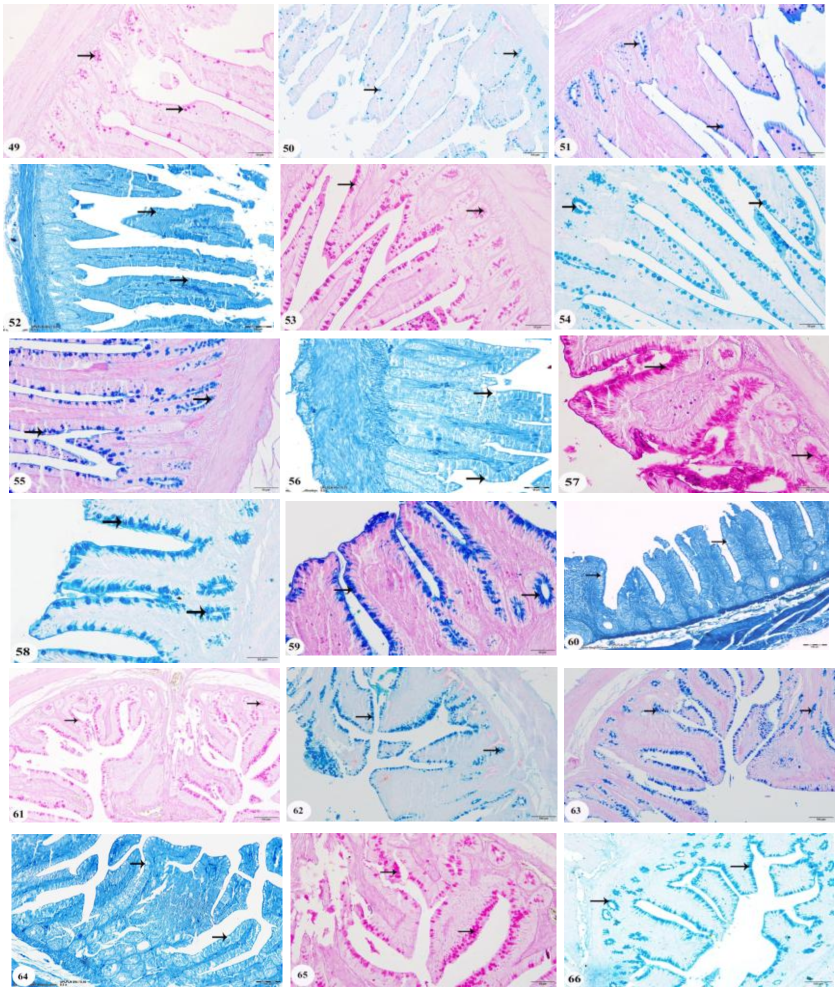


Fig. 49. Transverse section of the duodenum, showing the carbohydrate contents (PAS positive stain).**Fig. 50.** Transverse section of the duodenum, showing the acid mucopolysaccharide content (Alcian blue stain). **Fig. 51.** Transverse section of the duodenum, showing the mucopolysaccharide content (PAS-Alcian blue stain).

Fig. 52. Transverse section of the duodenum, showing the protein content (Bromophenol blue stain).**Fig. 53.** Transverse section of the ilieum, showing the carbohydrate contents (PAS positive stain). **Fig. 54.** Transverse section of the ilieum, showing the acid mucopolysaccharide content (Alcian blue stain).

Fig. 55. Transverse section of the ilieum, showing the mucopolysaccharide content (PAS-Alcian blue stain). **Fig. 56.** Transverse section of the ilieum, showing the protein content (Bromophenol blue stain).**Fig. 57.** Transverse section of the rectum, showing the carbohydrate contents (PAS positive stain). **Fig. 58**. Transverse section of the rectum, showing the acid mucopolysaccharide content (Alcian blue stain).

Fig. 59. Transverse section of the rectum, showing the mucopolysaccharide content (PAS-Alcian blue stain).**Fig. 60.** Transverse section of the rectum, showing the protein content

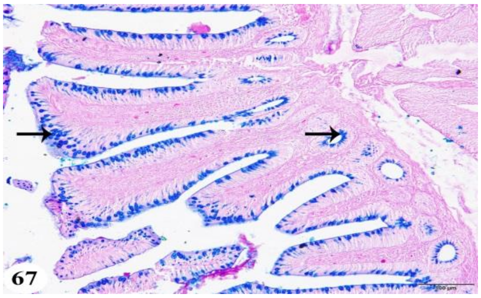
(Bromophenol blue stain).**Fig. 61.** Transverse section of intestinal caeca, showing the carbohydrate contents (PAS positive stain).
Fig. 62. Transverse section of intestinal caeca, showing the acid mucopolysaccharide content (Alcian blue stain).**Fig. 63.** Transverse section of intestinal caeca, showing the mucopolysaccharide content (PAS-Alcian blue stain).
Fig. 64. Transverse section of intestinal caeca, showing the protein content (Bromophenol blue stain).**Fig. 65.** Transverse section of cloaca, showing the carbohydrate contents (PAS positive stain). **Fig. 66.** Transverse section of cloaca, showing the acid mucopolysaccharide content (Alcian blue stain).

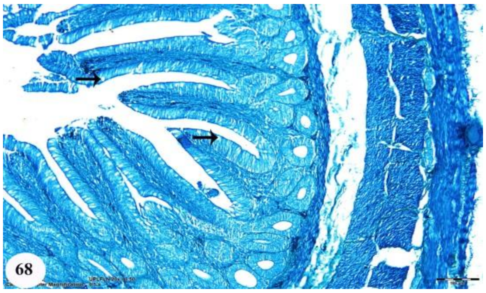
(villi+ Lieberkühn) at summer season is (261.8433±126.76503µm), and at winter season is (254.1967±33.74829µm) and the average thickness of the epithelium at summer season is (26.7750±2.64378µm), and at winter season is (24.04±2.29940µm). Changes in thickness between layers muscularis, mucosa and epithelium are not significant at summer season compared to winter season; (T=-1.232, P= 0.246); (T= 0.143, P = 0.891), and (T= 1.912, P = 0.085) (Fig. 78).

Cloaca

The cloaca of rock dove is a bulbous structure internally shows three separate compartments; the coprodeum, urodeum and proctodeum. The coprodeum is the largest compartment which continued cranially with the terminal end of the rectum. A courourodeal fold separated the coprodeum from urodeum (Figs. 4, 5, 6&7). SEM investigation showing multiple of irregular folds (Fig. 28).

Histologically; the wall of coprodeum is thin and its tunica mucosa has thrown into spares, short, and flat villi, the lamina propria composes of single layer of wide epithelial crypts of Lieberkuhn. The lining epithelium of the coprodeum is tall mucous secreting simple columnar epithelium which showing secretory activity. The lamina propria is loose connective tissue display numerous of lymphocytes with plasma cells and macrophages. The muscularis mucosa is well developed. Urodeum is the narrower compartment of the cloaca. Histologically the tunica mucosa of the urodeum shows tall branching pyramidal mucosal villi, the villi are lined with mucous secreting columnar cells, the lamina propria consists of cellular loose connective tissue occupying by lymphocytes, the muscular mucosa composed of smooth muscle fibers. Tunica muscular is appears thick and consists of thick inner





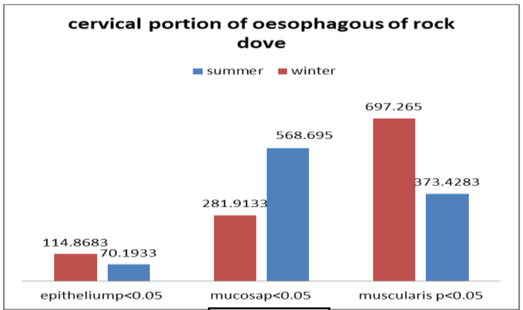
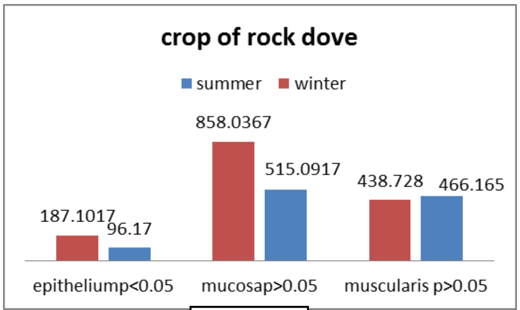


Fig 69



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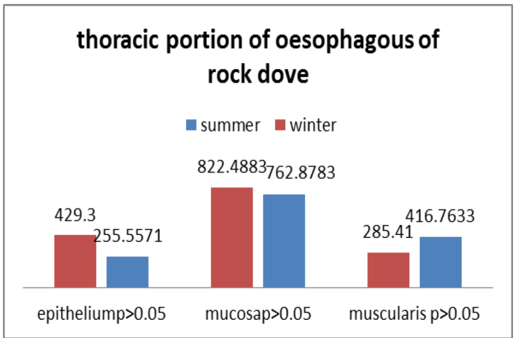

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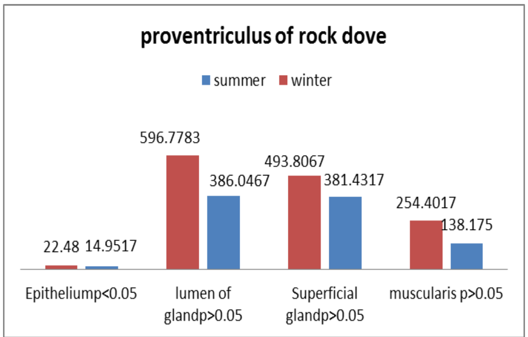

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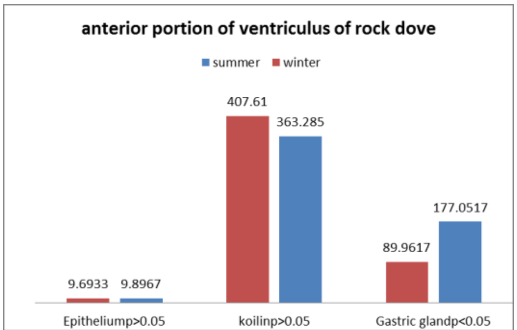

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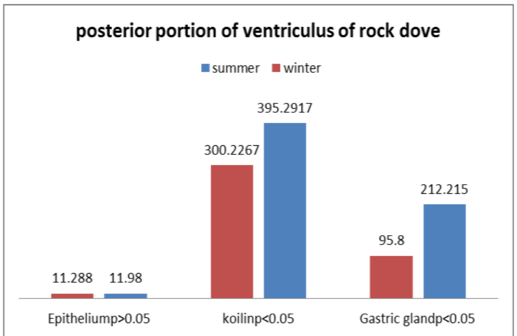


Fig 74

Fig. 67. Transverse section of cloaca, showing the mucopolysaccharide content (PAS-Alcian blue stain).**Fig. 68.** Transverse section of cloaca, showing the protein content (Bromophenol blue stain).

Fig. 69. Comparison between means of the thickness (µm) of cervical oesophagus of the rock dove histometric layers (muscularis,mucosa and epithelium). Indicate significant differences among layers (P≤0.05), at summer and winter seasons.

Fig. 70. Comparison between means of the thickness (µm) of crop of the rock dove histometric layers (muscularis,mucosa and epithelium). Indicate significant differences among epithelial layers (P≤0.05), at summer and winter seasons.

Fig. 71. Comparison between means of the thickness (µm) of thoracic oesophagus of the rock dove histometric layers (muscularis,mucosa and epithelium). Indicate significant differences among epithelial layers (P≤0.05), at summer and winter seasons.

Fig. 72. Comparison between means of the thickness (µm) of proventriculus of the rock dove histometric layers (muscularis, superficial glands,lumen of deep gastric gland and epithelium). Indicate significant differences among epithelial layers (P≤0.05), at summer and winter seasons.

Fig. 73. Comparison between means of the thickness (µm) of the anterior portion of ventriculus of the rock dove histometric layers (gastric gland, koilin and epithelium). Indicate significant differences among gastric gland layers (P≤0.05), at summer and winter seasons.

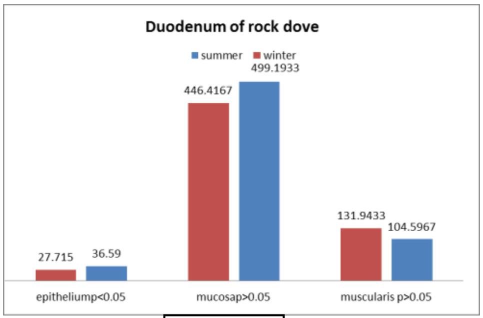
Fig. 74. Comparison between means of the thickness (µm) of the posterior portion of ventriculus of the rock dove histometric layers (gastric gland, koilin and epithelium). Indicate significant differences among gastric glands,koilin layers (P≤0.05), at summer and winter seasons.

circular and thin outer longitudinal layers of smooth muscle fibers (Figs. 29 a &b). .

Histochemically, the goblet cells in the mucosal villi and crypts of Leiberkuin of the cloaca compartments reacts positively by PAS revealing the presence of general carbohydrates(Fig.65), also these glands reacts positively with Alcian blue and Alcian blue - PAS(Figs.66&67). Reactions indicating the presence of both neutral and acid mucin, while these goblet cells are stained negatively by bromophenol blue (Fig.68).

Morphometrically, the average length of the cloaca is (3.0833±1.2416cm) at summer season, and is (2.4167±0. 0.9174cm) at winter season (Fig. 79).

Histomorphometric data of layers of the cloaca don't apply in the present study.



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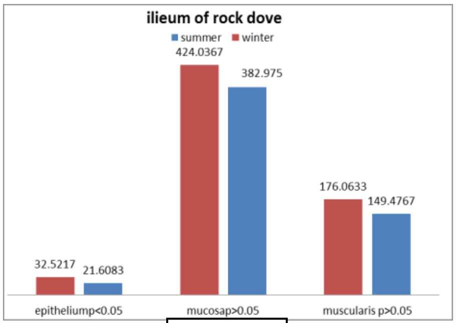

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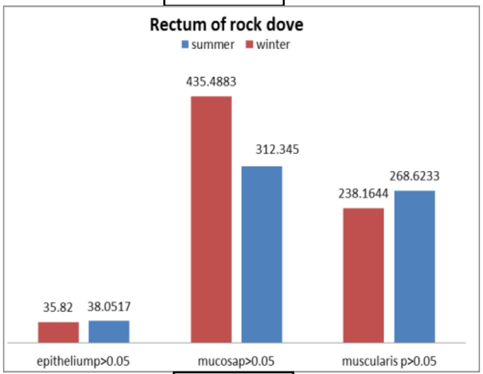

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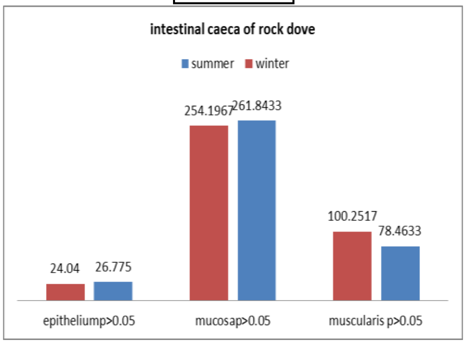

Fig 78

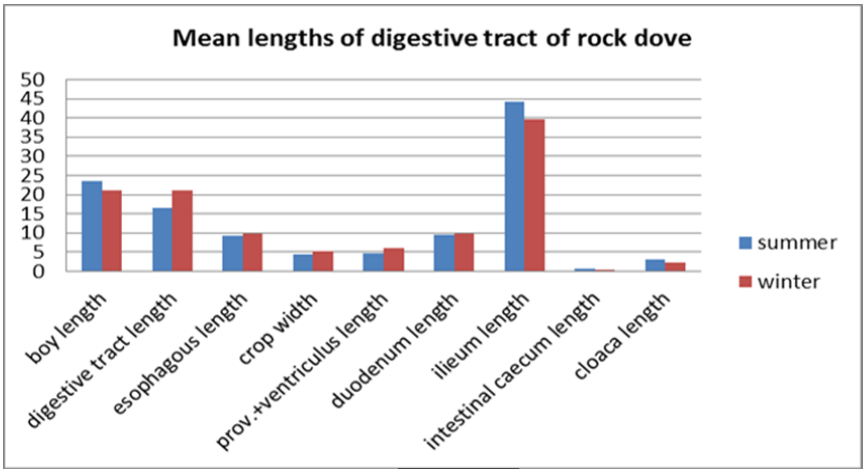

Fig 79

Fig. 75. Comparison between means of the thickness (μm) of the duodenum of the rock dove histometric layers (muscularis, mucosa and epithelium). Indicate significant differences among epithelial layers ($P \leq 0.05$), at summer and winter seasons.

Fig. 76. Comparison between means of the thickness (µm) of the ilieum of the rock dove histometric layers (muscularis, mucosa and epithelium). Indicate significant differences among epithelial layers ($P \leq 0.05$), at summer and winter seasons.

Fig. 77. Comparison between means of the thickness (µm) of the rectum of the rock dove histometric layers (muscularis, mucosa and epithelium). Indicate no significant differences among layers ($P \geq 0.05$), at summer and winter seasons.

Fig. 78. Comparison between means of the thickness (µm) of intestinal caeca of the rock dove histometric layers (muscularis, mucosa and epithelium). Indicate no significant differences among layers ($P \geq 0.05$), at summer and winter seasons.

Fig. 79. Comparison between lengths (cm) of body, digestive tract, oesophagus,crop width, proventriculus+ventriculus, duodenum, jejunum+ ileum, intestinal caecum and cloaca of rock dove at summer and winter seasons , showing no significant differences ($P > 0.05$).

Discussion

The passage of food through the digestive tract follows a specific digestive sequence including premoistening and softening, acidifying, grinding, hydrolyzing, emulsifying and propulsion of the end products (Klasing, 1999). The portions of digestive tract of birds vary according to the feeding habits (Hamdi et al, 2013).

The anatomical investigation showed that the digestive tract of Egyptian rock dove like almost granivorous species is composed of oesophagus, crop, proventriculus, ventriculus (gizzard), intestine, intestinal caeca, rectum and cloaca.

The avian oesophagus is a thin-walled distensible tube, delivers food from the oropharynx to the proventriculus. In rock dove, the oesophagus exhibits great variations in its anatomical and histological structure compared to any region of the digestive tract. The present study indicates that the oesophagus is divided into two regions: the thoracic and cervical regions. The cervical oesophagus expands at the entrance of the thoracic oesophagus to form the crop The internal surface of the cervical oesophagus of the rock dove has longitudinal folds which deeper than that in thoracic oesophagus, these folds facilitate the oesophagal distensibility which appear large and more extensive in birds which swallow whole prey items like owls, or those that store large amounts of food material as gulls. But in the rock dove and other grainivorous birds exhibit minimal oesophageal folds development and possess a relatively narrow oesophagus, these results was confirmed by

(Taylor, 2000, Rus et al, 2000 and Rodrigues et al, 2012) in their study on white stork and blue & yellow macaws..

The crop has varying degree of development in different avian species, the rock dove obtains a well-developed one, that it has two large lateral diverticula on both sides of the trachea and small enlargement in the median.

The avian crop (ingluvies) present in most omnivorous and herbivorous bird's species (Godoy-Vitorino et al., 2008). They were concluded that the size of the crop and its shape constitute species-specific features and adapted to the diets, environment and behavior. Stevens and Hume, (1998) and Gelis, (2006) confirmed that the omnivores and herbivores, including granivorous birds, are characterized by a larger crop than carnivorous predators.

The most important functions of the crop are, food moistening and creating a favorable environment for the development of probiotic microbiota, and producing a holocrine secretion from the crop epithelium - "crop milk" - which is fed to the squabs during the breeding season. The crop milk is mainly a protein and fatty acid source for chicks, and is devoid of carbohydrate and calcium. Both males and females produce crop milk. The crop also provides an important immunological function in pigeons feeding squabs (Horseman and Buntin, 1995).

Histologically, the wall of the oesophagus of the rock dove consists of mucosa, submucosa, muscular tunic, serosa, and submucosal layers ,the peristaltic contractions of inner circular and outer longitudinal muscles propel food posteriorly through the oesophagus this result agree with (Klasing, 1999)and (Sagsöz& Liman, 2009) in their study on Japanese quails.

The oesophagus and crop mucosa of rock dove are lined by a keratinized stratified squamous epithelium, the degree of keratinization of the stratified squamous epithelium in oesophagus varies with the avian species like in common wood pigeon, the mucosa of the cervical oesophagus is composed of keratinized stratified squamous epithelium, while the mucosa of barn owl composed of non-keratinized stratified squamous epithelium (Al-Juboury ,2016) also the results obtained by (Rodrigues et al.,2012) on macaw's oesophagus reveals a squamous stratified non-keratinized thick epithelium.

Obviously, there is a relationship between the histological structure of the digestive tract and the type of nutrition, such as the keratinization which appears on the mucosa of oesophagus of rock dove, it appears as a protection against any harmful effect occurs during passage of hard food (grains) through it. Moreover, this keratinized become thicker in crop region. This region has more capacity for store a large amount of food consequently it becomes more exposed to large friction force from food items. This result is opposite in raptors which feeding on the soft flesh, furthermore, they lack the crop (Gelis, 2013).

The thickness of layers of oesophagus of rock dove in the winter and summer season indicates that the thickness of muscularis, mucosa and epithelium layers of the cervical region increased significantly in winter season compared to summer season, this result may be expected during the times of year (winter) the size of digestive organs can be greatest as a result to high intake of food and may due to low available energy food, rapid processing rates, or high metabolic demand as mentioned by (Karasov and Douglas,2013).

Furthermore, the thickness of layers of the crop of the rock dove also gave significant variation in the epithelial layer in winter season. This may be as a result of continuous proliferation for the stratified squamous epithelium consequated by desquamation (breakdown) of this layer responding to the prolactin hormone in order to mix the produced sloughy fluid with the food to facilitate the digestion of young as stated by(Ghali and Dauod, 2014; Kent and Carr, 2001; Kardong, 2006).

The histological study of the oesophagus of rock dove showed that the oesophageal glands disappear in the cervical oesophagus and the crop and appear in thoracic one, like other granivorous species such as some parrots, pigeons, chickens and finches they have a large number of glands to assist in swallowing the dry feeds (Denbow, 2000).The oesphageal glands of the thoracic region may be important for lubrication and protecting of the mucosa for the passage of food particles to the stomach, as well as, they secrets acid and neutral mucopolysaccardies.

The rock dove as different bird's species granivorous, omnivorous and insectivorous which feed on hard food items, possess the thin-walled proventriculus, while the ventriculus is muscular which are separated by isthmus and that help to differentiate them grossly from each other, but in carnivorous and piscivorous bird species, the proventriculus and ventriculus are very distensible and difficult externally differentiate between them. According to the type of food fleshy or hard and how the bird ingest; the size and shape of the proventriculus and ventriculus are affected (Denbow, 2000and Taylor, 2000).

The food passes through the proventriculus very quickly where it is coated with hydrochloric acid and pepsin, with little enzymatic digestion. The food is propelled into the ventriculus where most of the mechanical digestion occurs by a combination of coordinated muscle contractions and the action of grits as mentioned by (Taylor, 2000).

In the rock dove, there are two types of glands in the proventriculus; these glands distributed throughout the entire organ .While in the Ostrich the glands are located only in the papillary region (Tadjalli et al., 2011).Moreover, the simple tubular glands show an intensive positive AB reaction and a poor intensive positive PAS reaction .Selvan et al., 2008 suggests that the mucin lined the epithelium is neutral and acid mucopolysaccharides, which forms a resistant mucosal barrier to protect the epithelium.

The histological structure of ventriculus of rock dove also indicates the four known tunicae forming the wall of the ventriculus of most avian species such as red capped cardinal, *Paroaria gularis gularis* (Catroxo et al,1997) and guinea fowl, *Numida meleagris* (Selvan et al, 2008). The Egyptian rock dove have well-developed ventriculus and possesses thick koilin layer. The presence of the koilin layer was previously documented in different avian species and they were indicated a relationship between the koilin layer and the type of food consumed by the bird (Bailey et al, 1997: Taki-El-Deen, 2017) the thickness of koilin layer is highly correlated with food consumed, thick koilin layer appears in granivores and a thin in frugivores.

Moreover, the koilin layer in rock dove reveals positive reaction to PAS as it is present in the epithelial lining observed in Guinea fowl *Numida meleagris* (Selvan et al, 2008), in quail (Zaher et al.,2012) and in the black-winged kite, *Elanus caeruleus* (Hamdi et al.,2013).

However, the proventriculus and ventriculus vary in function and morphology according to the species, sex ,age ,hormonal factors, diet and weather conditions of the bird (Piersma et al., 1993; Starck, 1999) and seasonal change especially ambient temperature (Özbey et al., 2004) may influence the gastric texture. This is opposed to present results on the stomach of rock dove in which season don't effect on its histo-morphometric results.

The small intestine of the rock dove is similar to that of other avian species in that it is composed mainly of the duodenum and ileum. However, the morphological organization of the ileum of rock dove differs from what has been reported for most birds (Casotti, 2001; Działa-Szczepańczyk and Wesołowska, 2008; Lavin et al., 2008; Wang and Peng, 2008). The ileum of the rock dove is made up of cone shaped spiral coils. The cone-shaped spiral coils of the ileum may be an adaptation to maximize the utilization of available space in the abdominal cavity, and provide larger surface area for digestion this agree with (Igwebuike et al,2014) in the African pied crow. This cone-shaped spiral of the ileum of the African pied crow is similar to what has been reported of the ileum of the pigeon (Sack et al., 2002; Igwebuike and Eze, 2010).

The histology and histochemical results of the small intestine of the rock dove agree with the report of previous authors on the histo-morphology and histochemical results of the avian small intestine, as in quail (Zaher et al., 2012), rock dove (Albideri et al., 2011), African pied crow, *Corvus albus* (Igwebuike and Eze, 2010) and pigeon (*Columba livia*) (Al Sheshani, 2006) that the mucous membrane of the small intestine consists mainly of numerous villi lined by columnar epithelium showing higher numbers of goblet cells which indicates positive reactions by PAS, PAS-AB (pH 2.5) teqniques conducted to view the presence or absence of neutral mucins and acidic mucins while stained negatively by bromophenol .

Numerous previous studies confirmed that there are relationship between the food content and length of intestines (Casotti, 2001; Lavin et al., 2008, Igwebuike and Eze, 2010; Wang and Peng, 2008; Mobini, 2011) (Karasov & del Rio, 2007). The birds living on material with high fiber content have larger intestines and caeca than those that eat seeds and fruits. But the present study reported that the seasonal changes of the rock dove don’t effect on the morphological and histological level of small and large intestine.

Conclusion

The egyptian rock dove as a resident bird don’t often have to face changes in the environmental conditions like other migratory birds .That the hisomorphometrical studies of the digestive tract of the rock dove during the summer and winter seasons show no significant changes on the morphological and histochemical levels of the digestive tract except the oesophagus region.

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الملخص عربى

التغيرات الموسمية في الجهاز الهضمي للحمامة الصخرية المصرية:" دراسات تشريحية ونسيجية ومسح ضوئي الكترونى"

يهدف هذا العمل الى دراسة التغيرات الموسميه على التراكيب التشريحيه والنسيجيه والهستوكيميائيه للقناه الهضميه للحمامه الصخريه المصريه .تتكون القناه الهضميه للحمامه الصخريه المصريه من المرئ ، الحوصله، المعده، والامعاء الدقيقه والغليظه .تختلف مناطق القناه الهضميه للحمامه الصخريه المصريه عن بعضها البعض فى نوع البطانه الظهاريه وشكل الطيات التى تتشكل بواسطة هذه الظهاره وتوزيع الغدد

داخل طبقاتها واخيرا سمك هذه الطبقات .يتكون الغشاء المخاطى الذى يبطن مناطق المرئ من ظهاره حرشفيه طبقيه متقرنه تظهر اكثر سمكا فى الحوصله تصبح هذه الظهاره اكثر انضغاطا وازدحاما وتتحول الى ظهاره عموديه ومكعبه بسيطه لتبطين المعده الغديه والعضليه على التوالى.هذا النوع من الخلايا العماديه البسيطه يبطن الامعاء الدقيقه والغليظه والمذرق. تشير معظم الغدد والخلايا الكأسيه الموزعه بين الغشاء المخاطى للمناطق المختلفه فى القناه الهضميه الى وجود افرازات حمضيه وعديدات السكاريد المتعادله بينما يتم ملاحظة البروتينات فى مناطق مختلفه من القناه الهضميه .لم تظهر القياسات الهستومورفومتريه للمناطق المختلفه للقناه الهضميه فى الحمام الصخرى المصرى خلال الموسمين (الصيف والشتاء) اي تغيرات مهمه على المستويات المورفولوجيه والهستوكيميائيه باستثناء منطقة المرئ. اكدت النتائج الحاليه ان الحمام الصخري المصري كطيور مقيمه لا يتعين عليه فى كثير من الاحيان مواجهة التغيرات البيئيه.