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A comparative anatomical differences and similarities of the digestive tract in two birds with different food types (*Aquila nipalensis* and *Columba livia*)

Amjad Adham Ahmed

[1] **Lecture PhD, in biology, Department of Biology, College of Education for Pure Science, Diyala University, Diyala, Iraq.**

Email: amjad.adham@uodiyala.edu.iq

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Abstract

The study aimed to identify the anatomical description and conduct a comparative study of the digestive tract in two types of birds that differ in nutrition, namely *Aquila Nipalensis* and *Columba livia*. The study showed the following results:

The digestive tract in the eagle is longer compared to the digestive tract in the pigeon due to the difference in body length, and begins in both types with the mouth surrounded by the beak from the front, and includes the oral cavity, pharynx and tongue, followed by the esophagus and the glandular stomach (anterior), followed by the muscular stomach (gizzard), small intestine, large intestine, rectum and ends with the cloaca.

The tongue is long, thin, and spear-shaped in pigeons and triangular in the eagle. The esophagus in the eagle is thicker and longer compared to the esophagus of the pigeon. The crop in the eagle has a single lobe, is spindle-shaped, and thick-walled compared to the pigeon, which has two lobes, is disc-shaped, and thin-walled. The glandular stomach of the eagle is elongated and larger than that of the pigeon, which is spindle-shaped. The gizzard is disc-shaped in pigeons, while it is cystic in the eagle. The small intestine of the eagle is longer than that of the pigeon. The duodenum is similar in both birds, forming two loops resembling the letter U. It shows the presence of a pair of caecums, which are short and undeveloped in pigeons and vestigial in the steppe eagle.

Keywords: Columba livia, Aquila nipalensis, digestive tract.

1- Introduction

Due to the importance of nutrition and dietary relationships in the growth and productivity of birds, and since wild birds exhibit a wide variety of dietary habits and perform migration, the adaptations possessed by these species enable them to thrive in various environmental and exceptional conditions. These adaptations make birds one of the most significant subjects in diverse research fields [1].

Birds obtain nutrients to sustain their lives, which contribute to their growth, tissue building, and generation of essential energy required for various activities. Accordingly, birds exhibit diverse feeding habits, including herbivorous, seed-eating, insectivorous, and carnivorous behaviors. Among these are predatory birds, such as eagles and hawks, which consume entire animals, including bones, fur, and feathers [1].

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Birds differ significantly in the structure of their digestive systems based on their dietary habits, digestion mechanisms, and the energy they obtain from food, depending on their surrounding environmental conditions. Consequently, numerous studies have been conducted on various bird species from morphological, physiological, and histological perspectives [2]. The digestive system has been described in several studies as consisting of the mouth, defined by the beak, followed by the pharynx and esophagus, which contains the crop. The stomach is composed of two parts: the glandular stomach (proventriculus) and the muscular stomach (gizzard). The intestines include the small intestine, which is divided into three parts (duodenum, jejunum, and ileum), and the large intestine, which comprises the cecum, rectum, and cloaca [3].

The anterior part of the digestive system in birds is specialized for food intake, storage, and partial digestion of starch and proteins, in addition to the accessory glands, namely the liver and pancreas. Birds require food for survival, growth, and reproduction. Food passes through the digestive system in a series of sequential processes, some mechanical and others chemical, starting with food intake, followed by swallowing and digestion, and ending with the excretion of waste [4].

Although research on Iraqi birds, particularly domestic species, has increased, covering life sciences, physiology, and other areas, morphological studies on wild birds have received little attention in the country. Specifically, research on the anatomical differences in the digestive system and associated glands among various wild bird species remains scarce.

The Study aims to:

The current study aimed to describe the morphological anatomy and conduct a comparative study of the digestive tract in two bird species with different feeding habits: the Turanian pigeon (*Columba livia*) and the steppe eagle (*Aquila nipalensis*).

2- Materials and Methods:

2-1- Sample Collection:

Six individuals from each of the two species, the Turanian pigeon and the steppe eagle, were used in this study. The selected birds were active, disease-free, and of different ages. The samples were obtained from a bird market in Diyala Governorate.

2-2- Dissection Procedure:

The pigeons and eagles were euthanized humanely through chloroform anesthesia. The dissection process involved making a longitudinal incision along the midline of the ventral side, from the neck region to the lower abdomen. The entrance to the thoracic cavity and neck was then opened carefully. The body cavity was exposed by cutting the ribs on both sides and lifting the ribcage to reveal the digestive tract.

The digestive tract was carefully separated to perform anatomical measurements of its parts, including length and width. Additionally, macroscopic observations and the anatomical location of the digestive tract components were recorded. All relevant observations regarding the digestive tract, such as color, size, and shape, were documented.

3- Results

The results showed that the digestive tract in birds begins with the mouth, which is surrounded by the beak in front, and ends with the cloaca.

It includes the oral-pharyngeal cavity, tongue, esophagus, crop, glandular stomach, muscular stomach (gizzard), small intestine (which is divided into three parts: duodenum, jejunum, and ileum), and the large intestine, followed by the rectum. and end in the rectum at the cloaca. A pair of tubular structures called caeca are observed at the junction of the small intestine with the rectum.

3-1- Mouth

The results indicated that the digestive tract in pigeons begins with the oral-pharyngeal cavity, surrounded by to front beak, which is cylindrical in shape and relatively long, with a thin pointed end and a slight curvature at the distal end, and its average length is 23 mm. The tongue in pigeons is long and spear-shaped, with a pointed tip and a dark pink surface.

The results showed that the eagle's mouth is surrounded by a beak in the shape of a pointed, curved hook with sharp edges. The shape and size of the beak are adaptations that help the eagle tear apart its prey. Its beak is the heaviest among birds of prey. As for the eagle's tongue, it is triangular in shape and rectangular, pink in color, with a rough, horny surface due to the presence of a thick layer of skin that helps hold the meat in place in the mouth. The tongue is located at the bottom of the oropharyngeal cavity.

3-2- Esophagus

The results showed that the esophagus in pigeons is a muscular tube with an average length of 4 cm, located on the right side of the neck, and is characterized by its thick walls. The diameter of the esophagus is not fixed, as it can expand. The esophagus of pigeons is also characterized by the presence of a large cystic structure at the end of the neck with two wide bulges with thin walls, so that the food can be seen and represents the crop, which is a two-lobed crop type. It has an average weight of 0.11 grams and an average length of 18.51 mm, and an average width of 5.61 mm.

The results indicated that the esophagus in the eagle is a thick-walled muscular tube with the ability to expand, with an average length of 10 cm, with a thick-walled expansion at the end of the first third of the esophagus, which is the fusiform-shaped gizzard that can store food for several hours before transporting it to the stomach, with an average weight of 5.94 grams, an average length of 59.88 mm, and an average width of 7.93 mm.

3-3- Stomach

The results show that the stomach in pigeons is a muscular organ divided into two parts: a slightly expanded anterior part with an elongated shape, which is the glandular or true stomach, with an average weight of 0.101 grams, an average length of 15.60 mm, and an average width of 6.68 mm. It has thick walls compared to the esophagus, and there is no clear distinct area between the lower esophagus and the beginning of the true stomach. As for the posterior extension of the true stomach, it is a short, contracted part that represents the isthmus. The muscular stomach or gizzard, the second part of the stomach, appears in the form of a large disc-shaped structure with two convex faces, as it is disc-shaped, and the isthmus is attached to it on the right side, as well as the duodenum. Its average weight was 0.02 grams, an average length was 3.90 mm, and an average width was 2.83 mm.

The results showed that the stomach of the eagle, as in other birds, is divided into two parts: the glandular stomach and the muscular stomach (gizzard). The glandular stomach is a distinct and large organ with an elongated spindle shape and thick walls thicker than the esophagus. An average weight was 0.469 grams, an average length was 43.03 mm, and an average width was 2.82 mm. The glandular stomach is connected to the gizzard by a very small waist. The gizzard is a muscular, sac-shaped structure. The average weight was 0.36 grams, the average length was 42.61 mm, and the average width was 2.65 mm.

3-4- Small Intestine

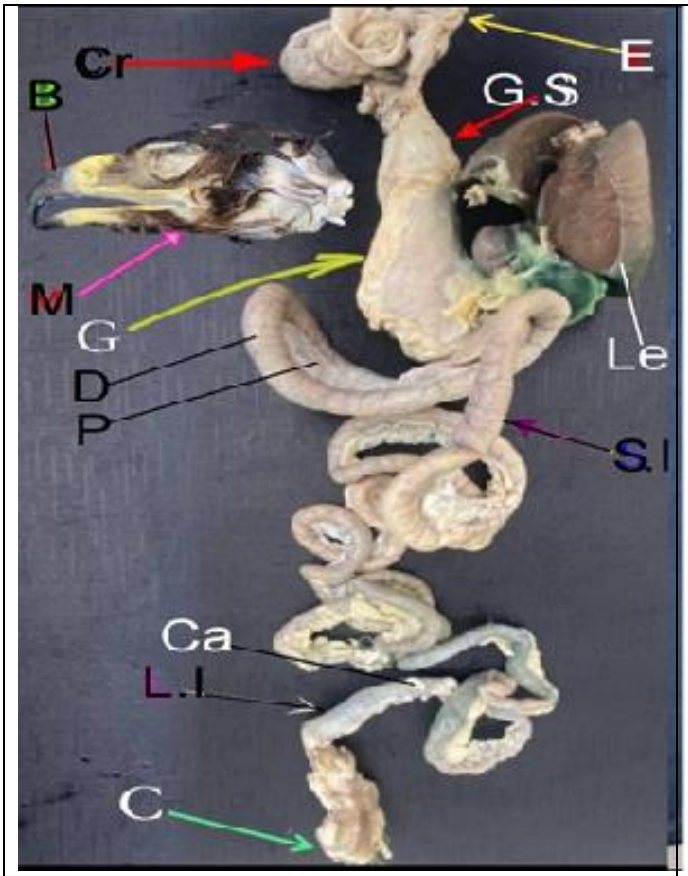
The results showed that the small intestine in pigeons cannot be distinguished into the three parts of the small intestine, has an average weight was 0.027 gram, an average length was 4.30 mm, and an average width was 4.30 mm. The duodenum can be distinguished by its wider diameter than the ileum and forms a single loop in the shape of the letter U,

starting from its exit from the gizzard, and containing the pancreas between its two arms. There is no distinct dividing line between the ascending arm of the duodenum and the jejunum, and the dividing line between the jejunum and the ileum cannot be distinguished. The average length of the duodenum is about 2.83 mm, and it is almost a dark pink color. While the ileum is characterized by its pale color and has a small and narrow diameter, and ends in the area of the cecal valve. The ileum forms several loops in the shape of the letter U, overlapping each other, called the supraduodenal ring.

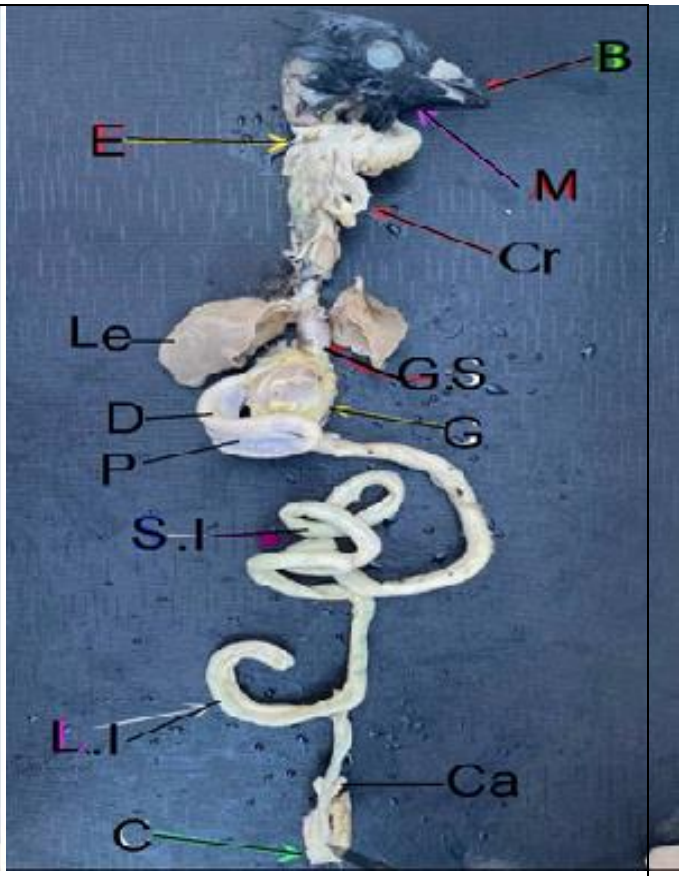
The results showed that the small intestine in the eagle can be distinguished into the duodenum, jejunum, and ileum. In general, the average weight was 0.36 grams, the average length was 42.61 mm, and the average width was 2.65 mm. It starts from the area of its connection to the gizzard and ends at the ileocecal valve. The duodenum is distinguished by its large diameter and pink color, and it has two intertwined U-shaped loops; the second loop includes the pancreas between its arms. It is not possible to determine a dividing line between the end of the duodenum and the beginning of the jejunum, except for the small diameter of the jejunum compared to the duodenum. There is a spiral loop twisted in a counterclockwise direction, which forms the jejunum and the beginning of the ileum, which is distinguished by its narrow diameter and pale color, as it forms a loop with two attached arms.

3-5- Large Intestine

The results show that the rectum in pigeons is a short tube with an average weight of 4.93 g, an average length of 78.71 mm and an average width of 10.42 mm, elongating from the posterior part of the ileum from the junction of the cecum with the intestine, it can also be distinguished by its large diameter compared to the diameter of the ileum and its light pink color. The cecum is a small protrusion with an average length of 3.2-4.6 mm and is located at the junction of the ileum and the rectum, and is pale white. The rectum ends with the cloaca. The urinary tract and the anal tract, which open to the outside through a transverse and contracted slit, represent the opening of the cloaca. The results showed that the rectum in the eagle follows the small intestine and is in the form of a short tube with an average weight of 0.36 grams, an average length of 43.03 mm, and an average width of 2.82 mm. At its beginning, in the area of its connection to the small intestine, it contains two scars representing the vestigial caecum. The diameter of the rectum is slightly larger than the diameter of the ileum and is dark reddish-brown. The cloaca is an extension of the rectum with expandable walls and is composed of the defecation tract, the urinary tract, and the anal tract, which opens to the outside through the cloaca opening.



(Figure 1) A photograph showing the parts of the digestive tract in (*Aquila Nipalensis*).
Beak(B)، Mouth (M)، Esophagus(E) ،Crop(Cr)، glandular Stomach (G.S) ،(G) Gizzard ،Duodenum (D) ، Liver(L)،Pancreas (P) ،Small Intestine (S.I) ، (L.I) Large Intestine، caecums (Ca) Cloacae (C) .



(Figure 2) A photograph showing the parts of the digestive tract in (*Columba livia*).
Beak(B) ، Mouth (M) ، Esophagus(E) ، Crop(Cr)، glandular Stomach (G.S) ،(G) Gizzard ،duodenum (D) ، Liver(L)،pancreas (P) ،Small Intestine (S.I) ،(L.I) Large Intestine، caecums (Ca) Cloacae (C) .

(Figure 3) A photograph showing the parts of the digestive tract in (*Aquila Nipalensis*).

(Figure 4) A photograph showing the parts of the digestive tract in (*Columba livia*).

(Table 1) Medium of some morphological parameters of the digestive tract in the study animals *Aquila Nipalensis* and *Columba livia*.

Species / Parameter		weight Mean ± SE	width Mean ± SE	Length Mean ± SE
Columba livia	Crop	0.11 ± 0.002 g	5.61 ± 0.12 mm	18.51 ± 0.09 mm
	Stomach	0.101 ± 0.001 g	6.68 ± 0.03 mm	15.60 ± 0.07 mm
	Gizzard	0.02 ± 0.001 g	2.83 ± 0.01 mm	3.90 ± 0.02 mm
	Small intestine	0.027 ± 0.001 g	3.20 ± 0.02 mm	4.30 ± 0.02 mm
	Large intestine	4.93 ± 0.002 g	10.42 ± 0.005 mm	78.71 ± 0.01 mm
Aquila Nipalensis	Crop	5.94 ± 0.0005 g	7.93 ± 0.008 mm	59.88 ± 0.017 mm
	Stomach	0.369 ± 0.001 g	2.82 ± 0.14 mm	43.03 ± 0.01 mm
	Gizzard	0.36 ± 0.0006 g	2.65 ± 0.18 mm	42.61 ± 0.06 mm
	Small intestine	0.36 ± 0.0006 g	2.65 ± 0.18 mm	42.61 ± 0.06 mm
	Large intestine	0.36± 0.001 g	2.82 ± 0.014 mm	43.03 ± 0.01 mm

4- Discussion

The morphological anatomical characteristics of the intestine of birds can be largely determined by the type of diet consumed by each species of bird. Both the pigeon and the steppe eagle in the present study belong to specific groups of birds with special behavioral and nutritional adaptations. The pigeon is classified as a granivore, while the steppe eagle is a carnivore and a predator. The anatomical results showed that the digestive tract of the studied birds is a continuous tube that starts from the mouth and ends at the cloaca. It consists of the mouth, then the esophagus, the glandular and muscular stomach (gizzard), followed by the small intestine, then the large intestine, the rectum, and ending with the cloaca. These results agree with the study of [5]. In his study on the black-winged kite, and agrees with the study of [6] in his study on the Iraqi Khadiri bird.

The beak of the horned pigeon is characterized by being cylindrical in shape, relatively long, with a thin pointed end and a slight deviation, while the tongue is long, lance-shaped, with a thin end and a dark pink surface. This is consistent with the study of [7], which indicated that the structure of the beak has an effect on the selection of seeds and the speed of their capture in pigeons, and that the duration and speed of capturing grains depend on the structure of the beak. While the beak of the steppe eagle is hook-shaped or hooked and has a sharp and strong end that helps in tearing and carrying the prey, in addition to the elongated tongue with a rough and hard surface due to the presence of a thick layer of skin that helps in fixing pieces of meat in the mouth. Carnivorous birds are characterized by this type of beak and tongue, and this is consistent with the study of [8,9].

The shape and size of the beak and the modifications of the tongue are regular with the nutrition method and the species of the food article for the two species. This is consistent with what many researchers have sure during their studies of bird modification, the article of feeding, and the relationship of this to the shape and size of the beak.

The esophagus in pigeons is a short tube, but its internal folds are thicker and higher, meaning it has a larger diameter. The crop, as observed, is developed and large in size, has two lobes, and has a large capacity to expand due to containing many thick longitudinal folds. This is consistent with the study by [10].

The esophagus and crop act as a warehouse for storing and softening food in grain eaters, and the grains eaten by pigeons and grain eaters in general are softened in the crop. While the esophagus in the eagle was observed to be long in the neck part and the crop is small in size and thin-walled, as carnivores need crops that can expand greatly to swallow large prey and eat large quantities of food. This is consistent with the studies by [11,12].

The current study did not agree with the study by [6], in his study on the Iraqi Al-Khadiri, and the study by [10], in his study on the Alcedinidae bird, as they indicated in their study the absence of a crop for storing food.

The shape and size of the esophagus and crop vary greatly depending on the feeding habits and type of food consumed in different bird species. This difference between the two birds is because difference in the species and the article of nutrition.

The stomach of pigeons and eagles is divided into: the glandular stomach (anterior) and the muscular stomach (gizzard), and is attached them a slim structure famed as the isthmus. The results of the present study are regular with other studies, that as those study by [13], on parrots and partridges, and the study of [14], on Japanese quail.

The stomach is one of the more influential parts of the digestive tract in birds, as it is influenced by the kind of food consumed and the nutritional behavior of birds. The shape and size of the stomach in birds show noticeable variation due to the amount of food consumed and their nutritional behavior [15]. This was supported by the present study, from showed the

anatomical differences in the stomachs of pigeons and eagles. The pigeon has a small, anterior glandular stomach, which is consistent with [6], but it is characterized by a highly developed, large, muscular stomach with a hard lining and containing fine gravel particles. The specialized muscular stomach and the developed muscles are crucial because the Eurasian Collared Dove swallows grains without peeling or crushing them in the upper digestive tract. The muscular stomach, its tough lining, and the grit particles help to peel, crush, and grind the grains, as well as mix the food with digestive enzymes secreted by the true stomach.

The size of the gizzard can change depending on the type of food consumed. This agrees with [15] on the Japanese quail. The disc-like shape of the gizzard in the Eurasian Collared Dove agrees with [16], a study on pheasants, while it differs from the findings in [5], which reported a pear-shaped gizzard in the Black-winged Kite. The Steppe Eagle's stomach is spindle-shaped and elongated, divided into two regions: the glandular stomach and the muscular stomach. This adaptation is suitable for the large meals consumed by carnivores, as seen in gulls, sparrow hawks, and woodpeckers, where the stomach is used to store food, as well as secrete pepsin and gastric acid in the glandular stomach to adapt to the high protein content of these meals.

The loss of thick and thin asymmetric muscles in the muscular stomach of the Eurasian Collared Dove makes the gizzard's function in the Steppe Eagle limited to mixing food components with pepsin and gastric acid during its passage through the glandular stomach, rather than grinding the food. This is where protein digestion begins, which aligns with the studies of [17,18].

The small intestine in eagles is longer than that in pigeons due to the variance in body size and length, as shown in the study. The duodenum in pigeons is characterized by length, which allows a longer enzymatic digestion time for the food consumed, chiefly grains rich in fats and starches. This agrees with [19], who showed that birds that nutrition on grains and fruits have long intestines due to the rise rate of carbohydrates in their food system. The existence of long pleats along the ileum increases the surface space of absorption, allowing it to benefit from the food consumed. Anatomically, the duodenum in pigeons forms a solitary U-shaped ring, while the remnant of the small intestine is formed of an intertwined ring. This agrees with the study of [20,21], while the small intestine in the eagle is stumpy concerning body length. However, the duodenum forms a solitary U-shaped ring identical to pigeons, while the remnant of the small intestine forms a spiral ring in a counterclockwise direction, which agrees with the study of [22], which showed that the ileum in some carnivorous birds forms a spiral ring. The results also show that the rectum in the eagle is taller than the rectum in the pigeon, which permits it to reabsorption as much water from the waste before expulsion. This difference is due to the eagle's high metabolic average ratio to its mass and movement, as well as its exposure to high temperatures, which is dependent on its nature of living in an open area. This is Agree with the study of [18,23], As for the cecum, which is located at the area of the rectum and the ileum, it is small and undeveloped in the pigeon, and is of the lymphatic kind, compared to the cecum in the eagle, which shows a vestigial cecum in the form of scar at the linkage of the rectum to the ileum. According to [24], the cecum in falcons and eagles is of the lymphatic kind and is non-functional or lost, which agrees with the results of the current study.

5- Conclusions

1. The digestive tract of the eagle is longer than that of the pigeon due to the variance in body size and length. In the two kinds of birds, it starts with the mouth opening, encompassed by the beak in front. The oral cavity contains the pharynx and tongue, followed by the esophagus and crop, then the glandular and muscular stomach (gizzard), followed

by the small intestine, the large intestine, and the rectum, ending with the cloaca.

2. The presence of several anatomical differences in the shape and size of all parts of the digestive tract between the two birds, due to the differences in Nutrition and the method of Nutrition in the two birds.

6- Recommendations

1. Procedure is a comparative study to recognize the enzymes secreted by the glands in the digestive tract of birds with different nutritional habits.

2. Procedure: A comparative study to recognize the blood supply to the parts of the digestive tract.

3. Procedure comparative studies to recognize the histological structure of the parts of the digestive tract.

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References:

[1] Leonardo ,E. L; Alexandre ,M. F; Matthew, C. I. M; Miguel, A. M. (2016) A classification scheme for avian diet types, J. Field Ornithol. 0(0):1–14.

[2] Al-Nasery, Sh.h.(2012). A comparative anatomical and histological study of the digestive system in broiler chickens from one day old until sexual maturity. Master's thesis. College of Education for Girls.

[3] Al-Saad,M.abd-aljawad. (2008). Poultry Anatomy. First Edition, National Library, Benghazi, Libya. Omar Al-Muhtar University, Libya, pp. (118-155).

[4] Al-Somadaa, M.A.H.(2017). Comparative anatomical and histological study of the digestive system in two species of domestic birds,(*Cochin Chicken*) and (*coturnix Coturnix*).

[5] Hamdi, H; El-Gareeb, A; Zaher, M; Abuamod, F.(2013). Anatomical, histological and histochemical adaptations of avian alimentary canal to their food habits: II-Elanus caeruleus. International Journal of Scientific & Engineering Research, 4(10):1355-1364.

[6] Al-Har, M. S. M. (2023). A comparative anatomical and histological study of some components of the digestive system in Iraqi AlKhudairi from different environments, Ph.D of Biology – Zoology, University of Kerbala College of Education for pure science Department of Biology.

[7] Hrabar, H. and Perrin, M. (2002). The effect of bill structure on seed selection by granivorous birds.Afri.Zool.,37(1): 67-80.

[8] Al-Sheshiny, A. A.Y. (2006). Comparative anatomical and histological study of the digestive tract in two species of granivorous birds, (Columba livia Gmelin, 1789) And carnivores (Accipiter nisus Linnaeus,1758) Master's thesis. College of Education, Tikrit University.

[9] Espen,M.K.(2007).Beak morphology in extant birds with implications on beak morphology in ornithomimids. Oslo.

[10] Ahmed H.; AbdElnaeem, F. M; Mohammed I. R.(2019). Histological and histochemical studies of the esophagus and stomach in two types of birds with different feeding behaviors, International Journal of Development, Vol.8, No.(1) : 23-42.

[11] Lei,Z. (2015). Histological study of the Esophagus and Stomach in Grey-Backed Shrike (Lanius tephronotus). Int. J. Morphol,33 (2):459- 464.

[12] Rodrigues, M.N.; Abreu, J.A.P.; Tivane ,C.; Wagner, P.G؛.Campos, D.B. ;Guerra, R. R. ; Rici, R. E. and Miglion, M. A.)2012). Microscopical study of the digestive tract of blue and yellow macaws, Curr. Micr. Cont. Adv. Sci. Technol.: 414-421.

[13] Al-Samawy, E; Shaima K. W.; Al-Uboody Wissam S.H.and Mustafa S. H. (2021). Histomorphometric and Histochemical Finding of the Proventricular and Ventricular Stomach between the African Grey Parrot (Psittacus erithacus) and Black Francolin francolinus) in South Iraq. Medico-legal Update, January-March, Vol. 21, No. 1.

[14] Ahmed, Y., G. K and Ahmad, A. (2011). Histomorphological studies on the stomach of the Japanese Quail. Asian Journal of Poultry Science, 5, 56-67.

[15] Jawid, J.M.(2016). Morphological description of the digestive tract in the Japanese amniote. Journal of the University of Babylon/Pure and Applied Sciences, Issue 4/ Volume 24.

[16] Al-Saffar, F. and Al-Samawy, E. (2016). Histomorphological and histochemical study of stomach of domestic pigeon (Columba livia domestica). The Iraqi Journal of Veterinary Medicine, 40, 89-96.

[17] Smith, D. M.; Grasty, R.; Theodosiou, N. A.; Tabin, C. J. and Nascone-Yoder, N. M. (2004). Evolutionary relationships between the amphibian, avian, and mammalian stomachs. Evolution and development; 2(6): 348-359.

[18] Hewitt, D. (2004). Anatomy and physiology of the avian digestive tract. http://Users.tamuk.edu/david_hewitt/nutrition /Digastive%20tract.htm

[19] Taha, A. M; Abdulaziz, S. (2020). Morphological description of the digestive canal in Taeniopygia guttata (zebra finch) and Sturnus vulgaris (starling), The Journal of Basic and Applied Zoology, 81:24.

[20] Iman M.K. and Ghassan D.A. (2017).Morphological and Histochemical Study of Small Intestine In Indigenous Ducks (Anasplatyrhynchos) e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 10, Issue 7 Ver. II (July 2017), PP 19-27.

[21] Al-shaeli, S.J.J. (2010). Anatomical and histological study of pancreas in local breed ducks (Anas platyrhynch Mallard).M.Sc. Thesis. University of Baghdad.

[22] Al-Hasany,D.H.(2000). Physiology of domestic birds, Directorate of Dar Al-Kutub for Printing and Publishing - Baghdad. 269 - 292.

[23] Saleem, G. (2012). Necrotic enteritis, disease induction, predisposing factors, and novel biochemical markers in broilers chickens. PhD. Thesis, Scottish Agriculture College, University of Glasgow.

[24] Victoria, A.; Melanie, C; Catherine, P. (2015). Introduction to Veterinary Anatomy and Physiology Textbook. Third edition. Elsevier Ltd. All rights reserved