

Morphological And Histological Comparison of The Internal Organs of Birds

Ziad Ahmad Alabdallah *

Department of Anatomy -Histology and Embryology, Al Furat University, Deirez-ZOR, College of Veterinary, Syria.

*Correspondence Author: Ziad Ahmad Alabdallah, Department of Anatomy -Histology and Embryology, Al Furat University, Deirez -ZOR, College of Veterinary, Syria.

Received Date: November 30, 2023 | Accepted Date: December 20, 2023 | Published Date: January 03, 2024

Citation: Ziad Ahmad Alabdallah. (2024), Morphological and histological comparison of the internal organs of birds, *Clinical Reviews and Case Reports*, 3(1); DOI:10.31579/2835-7957/051

Copyright: © 2024, Ziad Ahmad Alabdallah. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Birds are considered an important livestock resource and play an important nutritional role for humans in terms of producing meat and eggs. It is considered one of the laboratory animals on which many studies are conducted. Therefore, it is important to know the physiological, topographic, anatomical, and histological characteristics of the internal organs of birds in order to compare them with pathological tissues when birds are infected with bacterial, viral, and parasitic diseases. The difference occurs in the morphological and histological changes occurring in the digestive, respiratory, cardiac, and urinary systems according to the surrounding environmental conditions. In order to adapt and suit the environment, we notice here some changes that occur in the body systems of birds, and a difference can be noticed when comparing females and males as well. Birds that live in an aquatic environment differ in structure from birds that live in a desert or dry environment. Therefore, it is important to study the internal systems of birds and know their morphological and histological changes.

Keywords: digestive system; respiratory system; cardiac system; urinary system; organ bird

Introduction

The physiological makeup of birds, or their anatomy, demonstrates a variety of unusual adaptations, most of which are beneficial to flying. Birds are able to fly because of their light skeleton, strong muscles, and respiratory, digestive, and urinary systems, which can all function at extremely high metabolic rates and deliver oxygen.

Digestive System

The development of the digestive system is a critical component of avian performance. During the last stage of embryonic development, the organs that comprise this system undergo significant development. Approximately 1% of the embryo's weight is made up of them during 18 days of incubation, and by the time they hatch, that weight has already increased to 3.5%. This increase in intestinal weight is attributed to the growth of intestinal villi [124]. The digestive tract of the bird is physically complete at hatch, but it lacks functional capability. Significant physiological and morphological changes occur in the gastrointestinal tract, improving the efficiency of the digesting and absorption processes [11;91]. The mucosa, submucosa, muscularis, and serosa are the four tunics that make up the avian esophagus [34]. In all age groups, there were no gender differences observed in the histological characteristics of the esophagus in Ross broilers, which is consistent with findings published by Olsen et al. [2002] in Adelie penguins. Three layers make up the esophageal wall of kingfishers, according to histopathological observation: adventitia, muscularis, and mucosa. The submucosal layer wasn't there. The outcome was accepted

[15]. Hoopoe's esophagus is divided into four separate functioning layers: the outermost serosa, muscular, submucosa, and mucosa. In addition, no crop was seen in the esophagus of the hoopoe species. This might be because food is stored along the length of the esophagus of bird species that do not have crops. The mucosal folds expand, leaving only a small channel in the esophageal centrum [1]. found with a different search. At D1, D14, and D28, the average esophageal lengths were 3.73 ± 0.278 cm, 8.45 ± 0.210 cm, and 13.75 ± 0.478 cm, respectively. The mean weights of the esophagus at D1, D14, and D28 were 0.75 ± 0.067 gm, 4.13 ± 0.153 gm, and 7.45 ± 0.341 gm, in that order [87]. The majority of research on birds [44, 134] concurred that the stomach appeared in both birds as comprised of two parts: the proventriculus and the gizzard. Like other birds, the native sparrow has four layers in its proventriculus: mucosa, submucosa, muscular, and serosa [101]. There have also been reports of four levels in the construction of the starling proventriculus [108]. Additionally, findings indicate that proventriculus has four layers in red junglefowl [65], seagulls [112], and domestic ducks and pigeons [56]. Nevertheless, reports indicate that the yellow-billed grosbeak's proventriculus only possesses three layers: mucosa, muscularis, and serosa [135]. The stomach of a quail weighed 4.06 ± 0.22 g and measured 2.38 ± 0.20 cm, with a relative weight of 31.6% and a relative length of 2.54%, respectively [2]. The pigeon's stomach measured 6.86 ± 0.69 g and 2.75 ± 0.25 cm in length, however its relative weight percentage was 3.2% and its stomach weight was 45.3%, according to reference [58]. The gizzard muscles of quails were characterized by Starck & Rahman

[119] as consisting of smooth muscles that were divided by layers of connective tissue, giving the gizzard muscles their onion-like form. According to Mathias and Abdul Rahman [80], Japanese quails that were two weeks old had gizzard muscles that were around 180.52 mm thick. After being exposed to the experiment for two weeks, the average gizzard mass was 4.8 ± 0.5 g. It's interesting to note that in Japanese quail, gizzard size increased during a 4-week period, peaking at 6.01 ± 0.5 g [119]. Following the abdominal cavity's exposure, the intestines emerged as a tube-like structure that divided into the small and big intestines and extended from the gizzard to the cloaca. The big intestine was divided into the caecum and colorectum, while the small intestine consisted of the duodenum, jejunum, and ileum. The duodenum, which resembled a U-shaped loop, was the initial portion of the small intestine. There were ascending and descending limbs in this duodenal loop. The duodenum's ascending and descending limbs are where the pancreas is situated. The anterodorsal side of the gizzard, which terminates at the terminal portion of the ascending limb, is where the duodenum starts. The jejunum, caecum, and ileum covered the dorsal side of the duodenum, while the left side was connected to the gizzard. The liver and lateral body wall were observed to be in touch with the right side of the duodenum [129]. Numerous previous investigations, such as those conducted on houbara birds by Bailey et al. [21], quails by Zaher et al. [134], and barn owls by Oyelowo et al. [94], also identified the small (duodenum, jejunum, and ileum) and big (caecum and colorectum) intestines. Additionally, Dyce et al. [36] in poultry and Oyelowo et al. [94] in barn owls noted the U-shaped loop of the duodenum. The duodenum ceased at the terminal portion of the ascending limb and began at the anterodorsal face of the gizzard. The jejunum, caecum, and ileum covered the dorsal side of the duodenum, while the left side was connected to the gizzard. The liver and lateral body wall were observed to be in touch with the right side of the duodenum. These results are consistent with observations made by Nasrin et al. [87] and Dyce et al. [36], although Partha et al. [98] were unable to identify any notable differences in the topographic architecture of the duodenum between ducks, quails, and poultry. The jejunum is the longest segment of the gut and is the duodenum's continuation after the ascending limb. It is shaped like coils and is held in place by mesenteric folds. The jejunum loops were connected to the duodenum and gizzard ventrally and were visible in the dorsal part of the abdominal cavity. There was no discernible gross difference between the jejunum and the duodenum. The jejunum was described as the longest portion of the intestine by King and McLelland [70], Nickel et al. [88], Verma [125], and Hassouna [57], in agreement with the results of the current investigation. In contrast, the ileum was shown to be the longest segment of the intestine in quails and three native genotypes of chicken from Nigeria, respectively, by Zaher et al. [134] and Mahmud et al. [77]. Nonetheless, the ileum was shown to be the smallest portion of the barn owl's small intestine by Oyelowo et al. [94]. Different bird species may be the cause of the difference in gross architecture observed in different intestinal segments. The ileum was observed as a short, straight tube between two caecae near the jejunum's end. There was no discernible difference between the ileum and the jejunum. These findings are completely consistent with those of Fitzgerald [43] about Japanese quail, Hodges [62] regarding poultry, Nickel et al. [88], and Hassouna [57] regarding birds. There were two caecae—the right and left—that originated ventrolaterally, around the point where the ileum and colorectum meet. The peritoneal folds that connected both the caecal and the ileum were known as ileocaecal ligaments. Every caecum displayed three sections: the proximal, middle, and distal segments. The distal segment of the caecum displayed a blind-ended structure resembling a rounded cul-de-sac. The

colorectum was a short, straight tube that extended from the caeca's origin to the cloaca. It was likewise the continuation of the ileum. The comparable origin and architecture of the caeca in quails and the broiler chickens' Nasrin et al., [87], as well as the results of Kumary et al., [73], Zaher et al., [134], Rajathi [100], and EI Deeb et al., [39], are in support of these findings.

Digestive system accessories Pancreas

According to several theories, the pancreas in vertebrates always develops from the rear end of the foregut, with variations in the number of primordia [115]. However, in the bulk of the vertebrates, the number is believed to have never gone over the maximum of 3 [68, 105]. No matter how many primordia there were, a rat's pancreas could only function when all of the primordia fused together [49]. A review of the literature found that there hasn't been much research done on the histogenesis of the pancreas in Japanese quail. As a result, efforts have been undertaken to investigate this topic as much as possible [117]. The dorsal, ventral, and splenic lobes, which are situated between the duodenum's ascending and descending loops [62, 72], make up the avian pancreas. There is also another lobe that is referred to as the third lobe. In chickens [72], quails [118], and geese [52], the pancreas is split into four lobes; in ducks and many other bird species, however, only three lobes are recognized [103]. The glandular epithelial cells, known as acinus cells, with their small and large excretory ducts, make up the exocrine pancreas. The acinar cytoplasm contains a high concentration of rough endoplasmic reticulum, crystal-type mitochondria, free ribosomes, and secretory zymogene granules [85]. Centro-acinus cells, so termed because of their euchromatic nuclei and presence in the lumen of acini, are not observed in chickens but occasionally occur in starlings [131] and domestic geese [52]. Acinus cell secretions are expelled into the duodenum by excretory channels that are intercalated, intralobular, interlobular, and interlobar [38]. The dorsal and ventral pancreatic ducts, as well as a third duct in some other bird species, are the primary excretory ducts in birds that enter into the duodenum [24]. Alpha, beta, and mixed islets, which are tiny and big islets, make up the endocrine pancreas of avian species [30]. Silver-stained alpha islets are also referred to as black islets, while beta islets without a silver stain are referred to as light islets [62, 84]. Chickens' A, D, and B cells and quails' A, D, and Type IV cells make up the large population of alpha islets that are located in the caput area of the splenic lobe and third lobe [122]. A, B, and D cells make up beta islets, which are abundant in all lobes [122]. B and D cells are found in chickens [84], quails [118], and geese [52]. The embryonic development, immunohistochemistry, and electron microscopic architecture of the alpha and beta cells in the fowl pancreas (usually in chickens) have been described in earlier research [24,30,103,116;128].

Liver

Duck The liver of quails is made up of left and right lobes. The liver's caudal side contains the gallbladder and extrahepatic biliary system. The quail tract contains two primary ducts: the hepatic-enteric duct and the cystic-enteric duct, in contrast to the one duct seen in the human biliary system [95, 96]. The ducts begin in the center of the liver, between the lobes on the left and right, and go straight along a parallel path toward the duodenum. The little branches are not visible. Subsequently, both biliary ducts open at the same location to the duodenum's ascending portion. The extrahepatic region is not where the two ducts form anastomoses. The cystic-enteric duct is the sole conduit connecting the gallbladder. These two biliary ducts also have a duodenal entrance that gives birth to the dorsal and ventral pancreatic ducts. The ventral duct connects to the ascending portion of the

duodenum, whereas the dorsal pancreatic duct continues to the pancreatic lobe, which joins to the descending portion. The celiac artery trunk serves as the origin of the major arteries in the hepatobiliary system. The common hepatic artery and the left gastric artery are the two main arteries that emerge from the celiac trunk. The biliary tract is supplied by the former after it travels straight to the right hepatic artery. In order to serve the pancreas and duodenum, the gastroduodenal artery splits off from the common hepatic artery. The hepatobiliary system is supplied by the portal vein. The pancreaticoduodenal vein is big and provides several minor branches in the duodenum, matching the length of the duodenum. Certain segments of the hepatic-enteric duct do not travel parallel to the portal vein, but the distal portion does [114;45]. There are several structural distinctions between the quail and pigeon hepatobiliary systems. The pancreatic and bile ducts of the quail had a common intestinal entry, but the pigeon's ducts opened to the duodenum at distinct levels. Thus, the entire morphology of the biliary system changed, in addition to gallbladder status. It is unclear, nevertheless, if biliary tract variations are connected to gallbladder loss. The anatomy of the biliary system is one of the vertebrate body's most malleable parts. For instance, rats possessing a gallbladder have several ductal variants. The duodenal entrance of the pancreatic duct and the biliary duct are completely distinct in many situations, while many rodents have the same opening for both ducts [50]. In other circumstances, the biliary tract branches as shown in chinchillas [92]. It is believed that dietary and life history variables have little impact on this difference in connection. Despite these difficulties, comparing our findings with those of other research should assist elucidate the evolutionary patterns of the avian biliary system and determine whether system is more ancestral—the quail or the pigeon system. According to the current study, the quail's hepatobiliary system's topology is quite similar to that of the chicken, which is a close relative [95, 96]. The branching architecture of the biliary system seen in modern quails is similarly retained throughout a number of duck species, despite the lack of knowledge regarding blood vessels [75]. The Japanese bush warbler, brambling, Japanese quail, duck, tiny egret, pigeon, tree sparrow, and chicken were all studied in comparison by Yamagishi [132]. There are two biliary ducts present in these animals. Nearly all of the duodenum's branches originate from the ascending portion, despite minor variations in the locations of the pancreatic ductal and bile trunks. The pancreatic duct opens to the ascending part of the duodenum, separate from the biliary duct [23]. Hence, although the blood vessel pattern remains unclear, the hepatobiliary system of the ostrich is largely the same as that of the pigeon, with the exception of the cystic-enteric duct. The above comparisons suggest that avian gallbladder loss may be related to changes in the connectivity of the biliary tract itself. However, given the plasticity of the biliary tract in rodents, this hypothesis requires additional evidence. To further evaluate gallbladder loss in birds, morphological data are needed from columbiform taxa that have not lost their gallbladder, such as *Ptilinopus*, *Ducula*, and *Gymnophaps* [45, 53]. Separate from the biliary duct, the pancreatic duct opens to the ascending portion of the duodenum [23]. Thus, the ostrich's hepatobiliary system is similar to the pigeon's, except for the cystic-enteric duct, even if the blood-vessel arrangement is yet unknown. The aforementioned parallels imply that alterations in the biliary tract's connection may be connected to the disappearance of the gallbladder in birds. However, more proof is needed for this theory because of how flexible the biliary system is in rodents. Morphological data from columbiform taxa—such as *Ptilinopus*, *Ducula*, and *Gymnophaps*—that have not lost their gallbladder is required in order to assess gallbladder loss in birds in greater detail [45, 53]. Similar to mammals, avian hepatobiliary system arteries are fed by the celiac trunk, while the portal

vein supplies the venous system. The avian vasculature is mostly similar to that of mammals, despite the fact that the peripheral arteries in this area, at least in the major arterial trunks, tend to display notable diversity even within the same species [60;71; 82;83]. The existence of two bile channels is the most distinctive aspect of the avian hepatobiliary system. Given that other amniotes only have a single ductal trunk, this twin biliary trunk is a developed feature based on evolutionary theory. As members of the same Archosauria ancestry as birds, crocodilians "nearly" have two bile ducts [130]. The many anastomoses between the two bile trunks of *A. mississippiensis*'s most prevalent pattern set it apart from birds. But even within the same species, morphology varies, and a small percentage of individuals have a split double-trunk condition, which is a pattern like that of birds [130]. Therefore, it seems that the twin biliary duct originated in the archosaurian lineage in a sequential manner. In addition to the twin biliary duct, birds also seem to have a highly derived developmental mechanism. The majority of the morphology of the hepatobiliary primordia is preserved over the pharyngula phase, despite significant variance in the early embryonic stages [40]. As a hepatic diverticulum, the hepatobiliary system initially emerges from the ventral side of the posterior foregut [114]. After that, the diverticulum gives birth to many hepatic buds as well as one biliary branch in non-avian vertebrates. A dorsal pancreatic bud emerges from the dorsal side of the foregut at the same time as a ventral pancreatic bud forms in the area caudal to the biliary bud [61, 114]. Although the ventral pancreatic bud is typically single, it can occasionally be split into left and right halves [41, 67]. Hepatic buds can vary in number, but throughout development, they are usually grouped inside a single duct and proceed straight to the biliary duct [109, 126]. In any event, it is believed that the lack of a biliary bud during the whole developing period causes gallbladder loss in mammals [61]. In the meantime, birds have two hepatobiliary buds. The hepato-enteric duct originates from the cranial one, and the cystic-enteric duct from the caudal one. These are divided craniocaudally. Many bird species, such as chickens [25], quail [74], and black-tailed gulls [66], have been seen to do this. How these two hepatobiliary buds relate to the original hepatic and biliary buds is unknown. These primordia have a similar topology and are present throughout development in pigeons as well [110]. Moreover, the posterior hepatic duct gives rise to an apparent biliary bud in pigeon embryos; the gallbladder subsequently "degenerates" throughout development [110]. Therefore, the loss of the gallbladder in birds is a reflection of secondary degeneration of the biliary bud during development; this is not the case in rats, whose biliary bud never develops during development [61], but rather is comparable to the loss of the eye in cavefish [64]. This is also different from the lamprey, which matures and loses its gallbladder [110;133]. Therefore, it's possible that developmental alterations in mammals and birds may not lead to gallbladder loss in the same way. The creation or maintenance of the gallbladder primordium may be mediated by a shared molecular process; however, this is unknown. If the mechanisms are comparable, there may be differences in time between the effects in these two animal species.

Respiratory System

Animals' respiratory systems are generally similar, but because of differences in function and complexity, different species exhibit different morphologic, morphometric, and physiological variances [104]. Accurate diagnosis and prognosis of illnesses, as well as a deeper comprehension of physiology, depend on an awareness of morphological standards and the factors that lead to their changes [107]. The organs that enable the union of blood and air to enable gas exchange are known as the respiratory system [63]. With mean body weights of

159.51±8.19g for the Japanese quail and 265.78±4.88g for the pigeon, respectively, all the birds employed were adults, and this was deemed to be highly significant. The quail's tracheal weight, length, and diameter were 0.55±0.06g, 7.61±0.37cm, and 0.47±0.04 cm, respectively, whereas the pigeon's comparable values were 0.79±0.11g, 8.13±1.10 cm, and 0.51±0.06 cm. The lower respiratory tract was seen to extend from the caudal area of the mouth cavity to the neck and thoracic region in both the quail and the pigeon. The trachea, syrinx, bronchus, lungs, and the structures that support them make up the lung and respiratory tract (LRT), although in this research the syrinx was regarded as a component of the trachea. The trachea, bronchus, and lungs were the LRT structures utilized in this investigation [59]. The quail's mean total weight of the LRT features was 2.38±0.18g, or around 1.49% of its entire body weight; the pigeon's mean total weight of the LRT features was 4.03g, or 1.52% of its total body weight. In contrast to the data given by Ajayi et al. [3], who reported 1% as the weight of the LRT relative to the body weight in grasscutter, the comparative proportion of the overall weight of the LRT in both bird kinds was roughly 1.5% of their entire body weights. Since these birds are fliers, their respiratory systems must be subjected to greater demands, which might account for the larger weight percentage of the respiratory apparatus in these animals. In both quail and pigeons, the trachea was found to be ventral to the esophagus along the neck's length. In the quail, the tracheal weight, length, and diameter were 0.55±0.06g, 7.61±0.37cm, and 0.47±0.04 cm, respectively [59]. In contrast, the pigeon had a tracheal weight, length, and diameter of 0.79±0.11g, 8.13±1.10 cm, and 0.51±0.06 cm, respectively. The mean tracheal diameter measured in this study for both bird species is different from Reznik's [104] findings, which indicated that adult rats had a diameter of 0.2 to 0.3 cm. It has been noted that in both species, the right and left bronchus enter the corresponding left and right lobes of the lungs after emerging from the trachea. The lengths of the right and left bronchus in the quail and pigeon, however, revealed very substantial variances. The weights of the bronchi in both bird kinds were not measured because they were too small. Both birds had their bronchial diameters measured, although the observed differences were not statistically significant. A linear relationship was observed by Choi et al. [29] between the number of mucous glands in mammals and the tracheal diameter. They deduced that an increase in the size of a conductive airway, indicated by an increase in tracheal diameter, causes an increase in the inspired air's inflow velocity, which in turn causes an increase in the rate of foreign body deposition. The thoracic vertebrae make contact with the dorsal surface of the lungs of both quail and pigeons, causing them to become brilliant red in color and leaving a distinct vertebral impression on the lung surfaces. The quail's right lung's weight, length, and diameter (thickness) were 0.92±0.15g, 2.26±0.13cm, and 0.66±0.04cm, respectively, whereas the pigeon's counterpart values were 1.53±0.28g, 2.78±0.37cm, and 0.52±0.07cm, respectively. Despite this, there was no statistically significant difference between the two. The quail's left lung measured 0.91±0.15g in weight, 2.29±0.14cm in length, and 0.73±0.03cm in diameter. In contrast, the pigeon's left lung measured 1.71±0.34g, 2.61±0.36cm, and 0.52±0.07cm in weight, length, and diameter, respectively. The thickness of the left lung was deemed statistically significant, although the weight and length of the lung were not [59]. The lung is a fairly tiny compartment that serves as a large surface area for gas exchange with the blood. It is a very hard structure that does not expand or retract with breathing. The degree to which each lung was entrenched into the ribs in the two birds under study is a highly significant observation that led to a separation of the lungs into portions. This observation is consistent with the results of research conducted on guinea fowl by Ibe et al. [63]. Similar observations on ostriches were

also made by Maina and Nathaniel [79]. According to the research [106], the lungs in both birds were compactly placed against the dorsal wall of the thorax and did not expand or contract. The lungs' primary duties include storing blood from the right side of the heart until it enters the systemic circulation, filtering blood, and facilitating gas exchange. The digestion of proteins and fats, the activation or inactivation of hormones, and the metabolism of foreign substances that may enter the lungs by the airways or the vasculature are other metabolic tasks carried out by the lungs. Despite their diminutive size, birds' lungs are linked to eight or nine air sacs that circulate throughout their bodies and are subsequently connected to air gaps found inside their bones. Despite having 27% fewer lungs per unit body mass than mammals, birds' stiff lungs have allowed for a significant increase in respiratory surface area through intensive internal subdivision [87].

Circulatory system

Since the Cretaceous, birds have expanded into an extremely diversified group that now inhabits almost every type of surface habitat. Because of their diversity, birds can survive in a wide range of challenging conditions, including soaring over the hypoxic Himalayan peaks, swimming in the icy seas of the Antarctic, and sprinting across the scorching Mojave Desert sands [4; 10; 17; 48]. The avian cardiovascular system (or "CVS") is not designed to survive in such harsh environments. In order to fulfill the needs of such a demanding niche market, the respiratory system has developed to deliver enough oxygen and metabolic substrates throughout the body [27, 111]. The ability of avian CVS to effectively eliminate metabolic waste products is another adaptation that helps preserve cellular function and bird body temperature [27, 46]. Endotherms, like birds and mammals, need an efficient cardiovascular system (CVS) that is facilitated by a four-chamber heart, high systolic blood pressure, and a high resting metabolism to perform high levels of aerobic exercise, such as flying [27, 123]. The hearts of birds and humans are situated in front of the thoracic cavity along the midline. In birds, the long axis of the heart points slightly to the right of the midline; in humans, it points slightly to the left. Compared to mammals, birds' hearts are bigger and typically pump more blood in a given amount of time [28; 55].

The pattern of development of chicken embryo FH may be described as a function of body weight and is not directly correlated with the growth in embryo weight. Moreover, variations in FH with fetal age were not linked to increases in embryonic mass in other bird species where developmental patterns of embryonic FH have been examined [99]. Studying the morphology of important and uncommon bird hearts is challenging. However, according to body weight, heart size is significant for several bird species, including poultry [51], Hartman, F.A., [55], and Brush, A.H., [26], and heart weights in various birds have been reviewed by [32]. The physical and biological components of an indoor duck's heart are described [32], and a thorough breakdown of the adult heart's gross microscopic anatomy is provided [76]. Few studies have been done on the histological and morphological alterations in the heart that are related to gender effects, despite the fact that several have been done on the histomorphological assessment of the heart in particular bird species [102]. In a hybrid B-6 turkey strain, [97] evaluated the morphological impact of sexual activity on heart weight, ventricular wall mass, and auricle wall mass. They demonstrate that there were no distinctions made between the sexes. Thaxton [120] Measurements were taken of the male and female broiler hearts' weight, length, diameter, and thickness of the left and right ventricles. Males were shown to have larger hearts than females in terms of weight, length, and left ventricular wall thickness [33]. The results of cardiac

morphometry indicated that there was no statistically significant difference between male and female body weight, length, or total heart weight. According to the current study, male birds have a noticeably bigger left myocardium than female birds. It is theoretically possible that testosterone receptors in male cardiomyocytes are connected to the thicker cardiac myocardium [33]. Male birds have testosterone, which induces the myocardial cells to respond. This results in an increase in the heart's thickness and other histological parameters like size and diameter. The myocardial cells also have testosterone receptors. Males are said to have larger hearts than females, with the left and right ventricles growing more. Gill et al. [48] contended that androgen receptors are present in the atrial and ventricular cardiomyocytes of female rhesus monkeys and baboons' hearts. Additionally, the study demonstrated that there was a statistically significant variation in the heart diameter between men and women. The rise in right ventricular thickness matched the increase in left and right ventricular total thickness but was not statistically significant when taking into account the effects of the testosterone hormone on the heart's myocardium. Male appear to experience a statistically greater increase in heart diameter than female [33]. The findings indicated that there was no significant difference in the overall diameter of the broiler heart between the sexes; however, the males' left ventricular wall thickness was higher than the females'. The relative cardiac mass steadily dropped as people aged. Our findings align with comparable comparative research [121]. The heart's contractile force is maintained by individual cardiac myocytes, which are functional units of the heart muscle. The diameter of cardiomyocytes from domestic chicken, duck, and pheasant varies between 3.5 and 6.3 μm [113]. The myocardium's separate functional units, or cardiomyocytes, are what provide the heart with its contractile force. In LD birds, the diameter and cross-sectional area of cardiomyocytes were 7.7 μm and 47.4 μm^2 , respectively, while in Ross birds, they were 7.4 μm and 39.8 μm^2 [54]. It has been demonstrated that as birds mature, their cardiomyocytes get larger but cease to divide at hatch [127]. Anatskaya and Vinogradov [16] showed in 31 distinct bird species that cardiomyocyte hypertrophy was the cause of the rise in ventricular wall thickness with increasing bird age. Cardiomyocyte counts were similar but greater in LD hens, according to a study where the ventricular walls of both genetic lineages remained identical in age-matched pairs [54]. This implies that, compared to Ross chickens, LD chickens have less ventricular wall connective tissue.

Urinary system

The majority of the species in the Galliformes order, which includes quail, are medium-sized birds and are regarded as rather primitive birds. Their physical appearance and mannerisms are comparable to those of farmed hens. The elongated, paired kidneys and the muscular ureters that drain each kidney and open into the urodeum of the cloaca make up the urine system in birds [20]. Birds lack a urine bladder and renal pelvis [19, 20]. Indeed, in birds, the kidneys provide a variety of essential functions. The kidney's main function is to eliminate extra water and metabolic wastes [22]. The kidneys of birds also help the liver detoxify. Compared to mammals, birds have various renal disorders due to differences in their renal anatomy and physiology. Out of all the kidneys in vertebrates, the avian renal system is very different [37]. By supplying a balance between glomerular filtration, renal tubular secretion volume, osmolality, ionic content, and pH of bodily fluids, the kidneys play a key organ function in both mammals and birds, helping to preserve the constant nature of the internal environment. An essential component of preserving homeostasis is the kidney. Birds lack a bladder; instead, their urinary system is made up of two massive, paired kidneys that are symmetrically positioned on either side of the spinal

column and emptied by ureters that enter into the oedeum of the cloacae [31]. Numerous tiny, rough structures with little depressions between them cover the surface of the kidney. All these anatomical structures originate from the cortical kidney. Urine is drained into one medullary cone by a group of eight or ten of these cortical units. The solitary medullary cone into which their urine passes and a few elongated units of cortical tissue make up the renal tissue area known as the lobules. In essence, medullary lobules are cones with connective tissue wrapping around them. One end of the cone is connected to a main urethral branch, while the other is open to the cortex [42]. The avian kidney is composed of two types of nephrons: the medullary type, which has a nephron loop that penetrates the conical medullary region of the lobule and is similar to that found in mammals, and the cortical type, which is reptilian in form, devoid of a nephron Henle loop, and restricted to the cortical region of the lobule [69, 137]. The occurrence of two different kinds of nephrons, one with and one without a Henle loop, is one of the most distinctive features of avian kidneys [20, 138; 141; 142]. Since the majority of avian nephrons are loopless or cortical [14; 86], the avian kidney's capacity to concentrate urine is restricted and inferior to that of mammals [37]. Every nephron in a mammal has a Henle loop, although some are longer than others. Nephron structure may be connected to the capacity to save water and ions. Numerous tiny, rough structures with little depressions between them cover the surface of the kidney. Each of these anatomical units comprises the cortical kidney. Similar to its human cousin, the avian glomerulus is smaller and has a less complex capillary loop arrangement surrounding the mesangial cell core. Distinct from the proximal convoluted tubule (PCT), the distal convoluted tubule (DCT) is characterized by the absence of a brush border on the lining epithelium's cells and an approximate cuboidal form on the epithelial cells [42]. According to morphological findings, a bird's kidneys are divided into three sections: the middle, caudal, and cranial portions [6; 12; 13; 89; 90]. The cortex and medulla are the two zones that make up the kidneys, according to the results [5]. observed an abnormality pattern in the lab that is frequently highly linked with various kinds of renal illness in birds [7; 8; 18; 136; 139]. The three-lobed bird's kidneys had a large skull (28 ± 0.15 mm long and 13 ± 0.08 mm wide) and a small caudal lobe (length of 13 ± 0.07 mm and 4 ± 0.08 mm middle lobe) with a length of 30 ± 0.08 mm and 7.5 ± 0.10 mm, but the tail lobe in these birds was significantly higher ($P < 0.01$) based on current study criteria in chickens. According to Dhyaa et al. [35], the average total length of the kidney in the turtle was significantly longer than that of the majority of chickens. This finding is in line with a report by Islam et al. [47] that stated that the kidneys' total length was 7 cm and that the right kidney's mean total length was 60.6 ± 0.047 mm and the left kidney's mean total length was 60.6 ± 0.081 mm in Rhode Island red chickens. The average kidney lobe width in chickens was reported by Dhyaa et al. [35]. Comparatively speaking, the average skull lobe length (20 ± 0.1 mm) and middle lobe width (5 ± 0.5 mm) were both statistically substantially greater than those of the molard (10 ± 0.3 mm) (8.02 mm) and chicken (15 ± 0.2 mm) (4 ± 0.4 mm), therefore. The hardest weight to manage was the median kidney weight (5.8 ± 0.20 g), which was much more than the weight of chickens (6.8 ± 0.10 g) and billionaires (8.9 ± 0.11 g) when compared to the overall body weight. The findings revealed (Batha, 2012) that every college is made up of three sections: the middle section, which is average length 30 ± 0.08 mm in width and 7.5 ± 0.10 mm in width; the small caudal, which is average length 13 ± 0.07 mm and width 4 ± 0.08 mm; and the large skull, which is average length 28 ± 0.15 mm and width 13 ± 0.08 mm [35].

Conclusion

We found that studying the morphological and histological changes in birds' organs helps us to discover how birds can adapt to their external surroundings, and this reveals to us the importance of studying the birds' internal organs and the way their changes are observed in them according to the adopted way of living and their adaptation, and also comparing them to the changes that occur in infected birds when studying disease cases.

Acknowledgment

None.

Conflict of Interest

None.

References:

1. AbdElnaeem, A., Elshaer, F., & Rady, M. (2019). Histological and histochemical studies of the esophagus and stomach in two types of birds with different feeding behaviors. *International Journal of Development*, 8(1), 23-40.
2. Ahmed Abd-Galil Y, Kamel G, Ahmad A. Abo-El-Magd. Histomorphological studies on the stomach of the Japanese quail. *Asian J Poult. Sci.* 2011;5(2):56-67.
3. Ajayi, I. E., Salami, S. O., Danjuma, F. A., Ayo, J. O., Ibe, C. S., & Ojo, S. A. (2009). Morphologic and morphometric studies of the lower respiratory system of the grasscutter (*Thyromomys swinderianus*). In *The proceedings of the 46th Annual congress of the Nigerian Veterinary Medical Association "Anambra 2009"*. Pp 1 (Vol. 5).
4. Alabdallah AZ, Nikishov AA, Volkova NA, Vetokh AN, Rebouh NY, Semenova VI, Petrov AK, Rystsova EO, Bolshakova MV, Krotova EA, Drukovsky SG. Histological and morphometric characteristics of chicken embryos with different genotypes. *EurAsian Journal of BioSciences.* 2020 Jan 1;14(1):719-25.
5. Alabdallah A, Norezzine A, Gurina R, Il'yasovna Khairova N. Influence of different genders of Japanese quail on the functional state of kidneys. *Archives of Razi Institute.* 2021;76(3):667.
6. Alabdallah Z, Nikishov A, Vatnikov Y, Al-Ragawi A, Seleznev S. The effect of high protein in the feed mixture on the morphological changes in the kidneys of quail birds. *Journal of Chemical Health Risks.* 2021 Dec 1;11(4):383-92.
7. ALABDALLAH ZA, NIKISHOV AA, KARAMYAN AS. Sex-related of some haematological and serum biochemical changes, fed high-protein diet in Japanese quail (*Coturnix japonica*). *Iranian Journal of Ichthyology.* 2021 Aug 23;8:150-4.
8. Alabdallah ZA. DETECTION OF THE EFFECT OF GFP ON CELLS AND THE INFLUENCE OF GENE ENGINEERING MANIPULATIONS ON CHICKEN EMBRYOS. In *Innovative in Agriculture 2018* (pp. 128-131).
9. Alabdallah, Z. (2022). Histological Comparison of Kidneys between Female and Male Quail Birds at Different age Stages. *Journal.*
10. Alabdallah, Z. A., Nikishov, A. A., Angel Daniel, P. U., Jhonn Lenon, C. J., Laura Candelaria, C. H., & Dorcas Stella, N. S. D. (2023). Influence of the ratio of the mass and volume of quail eggs on their morphometric indicators and incubation results. *Caspian Journal of Environmental Sciences*, 21(3), 629-646.
11. Alabdallah, Z. A., Nikishov, A. A., Jhonn Lenon, C. J., & Ortiz Manzano, M. L. (2023). Influence of using probiotic on the productivity and morphometry of the organs in the visceral cavity of broiler chicks. *Caspian Journal of Environmental Sciences*, 21(2), 431-437.
12. ALABDALLAH, Z. AGE-AGED MORPHOLOGICAL CHANGES IN QUAIL KIDNEYS. *INTERNAUKA Founders: Limited Liability Company "Internauka"*, 12-14.
13. ALABDALLAH, Z. MORPHOLOGICAL CHANGES IN QUAIL KIDNEYS DEPENDING ON SEX. *INTERNAUKA Founders: Limited Liability Company "Internauka"*, 18-20.
14. Al-Ajeely R, Mohammed FS. Morpho-histological study on the development of kidney and ureter in hatching and adulthood racing pigeon (*Columba livia domestica*) *Int J Sci Nature.* 2012;3:665-77.
15. Al-Kinany, M.J. (2017). Histological study of esophagus in white breasted Kingfisher (*Halcyon symernensis*). *Wasit J. Sci. & Medicine*, 10(1): 33-42.
16. Anatskaya OV, Vinogradov AE. Myocyte ploidy in heart chambers of birds with different locomotor activity. *J Exp Zool.*2002; 293(4):427-441.
17. Angel Daniel PU, Jhonn Lenon CJ, Laura Candelaria CH, Alabdallah Z, Nikishov AA. Alterations in the mass of quail eggs of different densities during storage. *Caspian Journal of Environmental Sciences.* 2022 Dec 1;20(5):1163-6.
18. Arfenia K, Sachivkina N, Liseitse A, Alabdallah Z, Byakhova V. Biochemical parameters of quail blood in experimental gastrointestinal tract candidiasis. *InFEBS Open Bio* 2022 Jul 1 (Vol. 12, pp. 292-292). 111 RIVER ST, HOBOKEN 07030-5774, NJ USA: WILEY.
19. Aughey E, Frye FL. *Comparative veterinary histology with clinical correlates*: CRC Press. 2001
20. Bacha Jr WJ, Bacha LM. 3rd ed. USA: John Wiley & Sons; 2012. *Color atlas of veterinary histology.*
21. Bailey, T.A., Brown, E.P.M., Samour, J.H., Naldo, J., Lawrence, P. and A.Garner (1997) *Comparative morphology of the alimentary tract and its glandular derivatives of captive bustard.* *J. Anat.* 191: 387- 398.
22. Batah, A. L. (2012). Morphological and histological study for the kidneys of coot birds (*Fulica atra*). *Bas. J. Vet. Res.*, 11: 128-136.
23. Bezuidenhout, A. J. 1986. The topography of the thoraco-abdominal viscera in the ostrich (*Struthio camelus*). *Onderstepoort J. Vet. Res.* 53 : 111-117.
24. BÖCK P., MONEIM M., EGERBACHER M.: Development of pancreas. *Microsc. Res. Techn.*, 1997, 37, 374-383.
25. Brouha, M. 1898. Recherches sur le développement du foie, du pancréas, de la cloison mésenterique et des

- cavités héptoentériques chez les Oiseaux. *J. de l'Anat. et Physiol. Par.* 34: 305–363.
26. Brush, A.H., 1966. Avian heart size and cardiovascular performance. *AUK*, 83: 266-274.
 27. Butler, P.J. The physiological basis of bird flight. *Philos. Trans. R. Soc. B: Biol. Sci.* 2016, 371, 20150384.
 28. Butler, P.J.; West, N.H.; Jones, D.R. Respiratory and cardiovascular responses of the pigeon to sustained, level flight in a wind tunnel. *J. Exp. Biol.* 1977, 71, 7–26.
 29. Choi, H.K., Finkbeiner, W.E., Widdicombe, J.H.A., 2000. Comparative study of mammalian tracheal mucous glands. *J. Anat.* 197, 361-372.
 30. COWAP J.: The first appearance of endocrine cells in the splenic lobe of the embryonic chick pancreas. *Gen. Comp. Endocrin.*, 1985, 60, 131-137.
 31. D HR. The renal system .2nd ed. London and New York: Academic press; 1974.
 32. Das, R.K., U.K. Mishra and S.C. Mishra, 1997. Gross and biometrical observations on the heart of Indian duck (*Anas platyrhynchos*). *Ind. J. Poult. Sci.*, 32(1): 93-96.
 33. Dehkordi, R. A. F., & Parchami, A. (2010). The Pattern Comparison of Changes of Heart Macro-Structure in the Fowl. *Global Veterinaria*, 5(5), 291-293.
 34. Dellmann H.D., Eurell J.A. Textbook of veterinary histology. 5th ed, Lippincott Williams and Wilkins, Baltimore. 1998.
 35. Dhyaa , Ab.Abood ; Ali,F. Reshag;Azhar, S.K.andMyson, A. Ahmed. 2014- Comparative anatomical and histological features of the kidney in Harrier (*Circus aeruginosus*), Chicken (*Gallus domesticus*) and Mallard duck (*Anas platyrhynchos*)-TheIraqi Journal of Veterinary Medicine, 38(1):017–003.
 36. Dyce, K.M., Sack, W.Z.O. and C.G.J. Wensing (2002) Avian Anatomy. In: Textbook of Veterinary Anatomy. 3rd edn. Philadelphia: W.B. Saunders Company. PP. 819-824.
 37. Echols M. Evaluating and treating the kidneys. *Clinic avian med.* 2006;2:451–92.
 38. EGERBACHER M. and BÖCK P.: Morphology of the pancreatic duct system in mammals. *Microsc. Res. Tech.*, 1997, 37, 407-417.
 39. El Deeb, R.M., Abdel Razik, H.F., Abd El Wahab, M.S. and S.A. Eltatawy (2017) Macroscopical and scanning electron microscopic studies on the Rectal caeca of three different habitually feeding birds. *Curr. Sci. Int.* 6(2): 292-302.
 40. Elias, H. 1955. Origin and early development of the liver in various vertebrates. *Acta Hepatol.* 3: 1–56.
 41. Evans, L. T. 1935. The development of the choledochus and pancreatic ducts in the gecko, *Gymnodactylus kotschy*. *Zeitschrift für Anat. Entwicklungsgeschichte* 104: 258–265.
 42. Farner D S KJR. The urinary system of the birds. New York and London: Academic press; 1972.
 43. Fitzgerald, T.C. (1969). The Coturnix quail: anatomy and histology. The Iowa state university Press. Ames. Iowa, P.223.
 44. Foromo, D., Sahar, E., Alabdallah, Z. A., & Seleznev, S. B. (2023). Morphometric and histological characteristics of the stomach and reproductive organs in Japanese quail. *Caspian Journal of Environmental Sciences*, 21(2), 375-388.
 45. Garrod, A. H. 1874. On some points on the anatomy of the Columbæ. *Proc. Zool. Soc. Lond.* 17: 249–259.
 46. Gavrilov, V. M. (2013). Origin and development of homiothermy: A case study of avian energetics. *Advances in Bioscience and Biotechnology*, 4(08), 1-17.
 47. Getty R. The Anatomy of the Domestic Animals, 5th ed. W.B. Saunders Co., Philadelphia, USA. 1975.
 48. Gill, F.B.; Prum, R.O. Ornithology; WH Freeman: New York, NY, USA, 2019.
 49. Githens S. 1986. Differentiation and development of the exocrine pancreas in animals, The Exocrine pancreas: Biology, Pathology and Diseases. (fide V L W Go et al. Ch.,J. New York: Raven Press.)
 50. Grace, P. A., McShane, J. and Pitt, H. A. 1988. Gross anatomy of the liver, biliary tree, and pancreas in the black-tailed prairie dog (*Cynomys ludovicianus*). *Lab. Anim.* 22: 326–329.
 51. Grubb, B., 1983. Allometric relations of cardiovascular function in birds. *Am. J. Physiol.*, 245: 567-572.
 52. GÜLMEZ N., KOCAMIS H., ASLAN S., NAZLI M.: Immunohistochemical distribution of cells containing insulin, glucagon and somatostatin in the goose (*Anser anser*) pancreas. *Turk. J. Vet. Anim. Sci.*, 2004, 28, 403-407.
 53. Hagey, L. R., Schteingart, C. D., Ton-Nu, H. T. and Hofmann, A. F. 1994. Biliary bile acids of fruit pigeons and doves (*Columbiformes*): presence of 1- β -hydroxychenodeoxycholic acid and conjugation with glycine as well as taurine. *J. Lipid Res.* 35: 2041–2048.
 54. Harash, G., Richardson, K. C., Alshamy, Z., Hünigen, H., Hafez, H. M., Plendl, J., & Al Masri, S. (2019). Heart ventricular histology and microvasculature together with aortic histology and elastic lamellar structure: A comparison of a novel dual-purpose to a broiler chicken line. *Plos one*, 14(3), e0214158.
 55. Hartman, F.A. Heart Weight in Birds. *Condor* 1955, 57, 221–238.
 56. Hassan, S. A., & Moussa, E. A. (2012). Gross and microscopic studies on the stomach of domestic duck (*Anas platyrhynchos*) and domestic pigeon (*Columba livia domestica*). *Journal of Veterinary Anatomy*, 5(2), 105-127.
 57. Hassouna, E.M.A. (2001) Some anatomical and morphometric studies on the intestinal tract of chicken, duck, turkey, pigeon, dove, quail, sparrow, heron, jackdaw, hoopoe, kestrel and owl. *J. Vet. Med.* 44(88): 47- 48.
 58. Hena .S.A., Sonfada .M.L., Danmaigoro .A, Bello .A, Umar A.A. Some comparative gross and morphometrical studies on the gastrointestinal tract in pigeon (*Columba livia*) and Japanese quail (*Coturnix japonica*). *Scientific Journal of Veterinary Advances* (2012) 1(2) 57-64.
 59. Hena, S. A., Sonfada, M. L., Bello, A., Danmaigoro, A., & Tanimomo, B. K. (2012). Comparative

- morphologic and morphometric studies on the lower respiratory tract of adult Japanese quail (*Coturnix japonica*) and pigeon (*Columba livia*).
60. Higashiyama, H., Sumitomo, H., Ozawa, A., Igarashi, H., Tsunekawa, N., Kurohmaru, M. and Kanai, Y. 2016. Anatomy of the murine hepatobiliary system: A whole-organ-level analysis using a transparency method. *Anat. Rec. (Hoboken)* 299: 161–172.
 61. Higashiyama, H., Uemura, M., Igarashi, H., Kurohmaru, M., Kanai-Azuma, M. and Kanai, Y. 2018. Anatomy and development of the extrahepatic biliary system in mouse and rat: a perspective on the evolutionary loss of the gallbladder. *J. Anat.* 232: 134–145.
 62. Hodges, R.D. (1974) *The Histology of the Fowl*. London: Academic Press. PP. 35-112.
 63. Ibe, C.S., Onyeausi, B.I., Salami, S.O., Umosen, A.D., Maidawa, S.M., 2008. Studies of the major respiratory pathways of the West African guinea fowl (*Numida meleagris galeata*): the morphometric and macroscopic aspects. *Inter. J. Poult. Sci.* 7(10), 997-1000.
 64. Jeffery, W. R. 2005. Adaptive evolution of eye degeneration in the Mexican blind cavefish. *J. Hered.* 96: 185–196.
 65. Kadhim, K. K., Zuki, A. B., Noordin M. M., & Babjee S. M. (2011). Histomorphology of the stomach, proventriculus and ventriculus of the red jungle fowl. *Anatomia Histologia Embryologia*, 40(3), 226-233.
 66. Kanatu, H. 1939. Studien über die Entwicklung der Pankreasanlage bei den Embryonen von *Larus crassirostris*. *Okayama Igakkai Zasshi* 52: (174-184).
 67. Keibel, F. 1904. Zur entwicklung der leber, des pankreas und der milz bei *echidna aculeata* var. *typica*. *Denkschr. Med. Naturwiss. Ges. Jena* 6 : (207-228 in German).
 68. Kent G C. 1978. Comparative Anatomy of the Vertebrates. 4th edn, pp.253. The C.R. Mosby Co" Missouri.
 69. King A S MJ. The histology of the kidney. 2nd ed. London: Bailliere Tindal; 1984.
 70. King, A.S. and J. McLelland (1975) *Outlines of Avian Anatomy*. 1st edn. Bailliere Tindall, London. PP. 33-42.
 71. Kooops, A., Wojciechowski, B., Broering, D. C., Adam, G. and Krupski-Berdien, G. 2004. Anatomic variations of the hepatic arteries in 604 selective celiac and superior mesenteric angiographies. *Surg. Radiol. Anat.* 26: 239–244.
 72. KU S.K., LEE J.H., LEE H.S.: An immunohistochemical study of the insulin-, glucagon- and somatostatin- immunoreactive cells in the developing pancreas of the chicken embryo. *Tissue Cell*, 2000, 32, 58-65.
 73. Kumary, S., Venkatesan, S. and R. Geetha (2009) Microanatomical studies on the caecum of Japanese quail. *Indian Journal of Animal Sciences*. 79(10): 1011-1014.
 74. Kurachi, M. 1935. [Studies on the development of the pancreatic anlage (On the birds, especially in the embryos of *Coturnix coturnix*)]. *Okayama Igakkai Zasshi* 48: 1791–1808 (in Japanese).
 75. Liu, J. W., Evans, H., Larsen, P., Pan, D., Xu, S. Z., Dong, H. C., Deng, X. B., Wan, B. and Gi, T. 1998. Gross anatomy of the pancreatic lobes and ducts in six breeds of domestic ducks and six species of wild ducks in China. *Anat. Histol. Embryol.* 27: 413–417.
 76. Lu, Y., T.N. James, S. Yamamoto and F. Teraski, 1993. Cardiac conduction system in the chicken gross anatomy plus light and electron microscopy. *Anat. Rec.*, 236: 493-510.
 77. Mahmud, M. A., Shaba, P., Shehu, S. A., Danmaigoro, A., Gana, J. and W. Abdussalam (2015) Gross morphological and morphometric studies on digestive tracts of three Nigerian indigenous genotypes of chicken with special reference to sexual dimorphism. *J. World's Poult. Res.* 5(2): 32-41.
 78. Maina, J.N., King, A.S., Settle, G., 1989. An allometric study of the pulmonary morphometric parameters in birds, with mammalian comparison. *Phil. Trans. Royal Soc., London B* 326, 1–57.
 79. Maina, J.N., Nathaniel, C., 2008. A qualitative and quantitative study of the lungs of an Ostrich, (*Struthio camelus*). *J. Experimental Biol.* 204, 2313-2330.
 80. Mathias, S. J and G. H. Adul Rahman (2003). Phenotypic flexibility of structure and function of the digestive system of Japanese quail. *J. Exp. Biol.* 206: 1887-1897.
 81. Mentzer, S. H. 1929. Comparative anatomy of the biliary system: with illustrative drawings by Saxton Temple Pope, MD. *Cal. West. Med.* 30:321-315.
 82. Michels, N. A. 1951. The hepatic, cystic and retroduodenal arteries and their relations to the biliary ducts with samples of the entire celiac blood supply. *Ann. Surg.* 133: 503–524.
 83. Michels, N. A. 1966. Newer anatomy of the liver and its variant blood supply and collateral circulation. *Am. J. Surg.* 112: 337–347.
 84. MIKAMI S.I., ONO K.: Glucagon deficiency induced by extirpation of alpha islets of the fowl pancreas. *Endocrinology*, 1962, 71, 464-473.
 85. MOTTA M.P., MACCHIARELLI G., NOTTOLA S.A., CORRER S.: Histology of the exocrine pancreas. *Microsc. Res. Tech.*, 1997, 37, 384-398.
 86. Nabipour A, Alishahi E, Asadian M. Some histological and physiological features of avian kidney. *J Appl Anim Res.* 2009;36(2):195–8.
 87. Nasrin, M., Siddiqi, M. N. H., Masum, M. A., & Wares, M. A. (2012). Gross and histological studies of digestive tract of broilers during postnatal growth and development. *Journal of the Bangladesh Agricultural University*, 10(452-2016-35577), 69-77.
 88. Nickel, R., A. Schummer and E. Seiferle (1977) *Anatomy of the Domestic Birds* (Translated by W. J. Siller and P.A. L. Wright), Verlag Paul Parey, Berlin: Pp.75-81.
 89. Nikishov AA, Ziad A, Seleznev SB. The Topographic And Anatomical Characterization Of Kidneys In Japanese Quail, 155 (2), 215-215.
 90. Nikishov, A. A., Alabdallah, Z., Vetoshkina, G. A., & Kulikov, Y. V. (2020). Morphometric Characteristic

- Of Kidneys In The Japanese Quail. *Morphology*, 157(2-3), 154-155.
91. Nitsan, Z., I. Turro-Vincent, G. Liu, E. A. Dunnington, and P. B. Siegel. 1995. Intubation of weight-selected chicks with soybean oil or residual yolk: Effect on early growth and development. *Poult. Sci.* 74:925–936.
 92. Nowak, E., Kuchinka, J., Szczurkowski, A. and Kuder, T. 2015. Extrahepatic biliary tract in chinchilla (*Chinchilla laniger*, Molina). *Anat. Histol. Embryol.* 44: 236–240.
 93. Olsen M.A., Myklebust R., Kaino T., Elbrønd V.S., Mathiesen S.D. The gastrointestinal tract of Adélie penguins – morphology and function. *Polar Biology*. 2002. 25. P. 641–649.
 94. Oyelowo, F., Usende, I., Abiyere, E., Adikpe, A. and A. Ghaji (2017) Comparative gross morphology and morphometric investigations on the alimentary tract of three age groups of barn owl (*Tyto alba*) found in North-central Nigeria. *International Journal of Veterinary Science*. 6(1): 7-12.
 95. Paik, Y. K., Nishida, T. and Yasuda, M. 1969. [Comparative and topographical anatomy of the fowl. LVII. The vascular system of the pancreas in the fowl]. *Nihon Juigaku Zasshi* 31: 241–251 (in Japanese).
 96. Paik, Y., Fujioka, T. and Yasuda, M. 1974. [Comparative and topographical anatomy of the fowl. LXXVIII. Division of pancreatic lobes and distribution of pancreatic ducts (author's transl)]. *Nihon Juigaku Zasshi* 36: 213–229 (in Japanese).
 97. Pannwitz, G. and R. Berg, 1998. Morphometric studies into the myocardium, kidney and adrenal glands of turkeys (fattening hybrid strain Big-6). *Archives eür Geflügelkunde*, 62(5): 229-233.
 98. Partha, D.R and M.M. Mondal (2002) Comparative histomorphological study on the duodoneum of fowl (*Gallus gallus*), duck (*Anas boscas*) and quail (*Coturnix coturnix*) *J. Interacademia*. 6 (2): 202-205.
 99. Pearson, J. T., Tsuzuki, M., Nakane, Y., Akiyama, R. and Tazawa, H. (1998). Development of heart rate in the precocial king quail, *Coturnix chinensis*. *J. Exp. Biol.* 201, 931–941.
 100. Rajathi, S. (2017) Comparative morphology and morphometry of the caecum in pigeon and quail short title caecum in pigeon and quail. *Int J Sci Environ Technol.* 6(1): 885-888.
 101. Raji, A. R., & Asadi, M. (2013). Histological and histochemical study of the proventriculus and gizzard of the *Passer domesticus*. *Veterinary Journal (Pajouhesh & Sazandegi)*, 26(3), 2-9.
 102. Rajpal, D.K., A.M. Shrivastava, M.R. Malik, J.S. Taluj and M.L. Parmar, 1992. Studies on circumference and crosssectional area of ventricles in heart of pre- and post-hatch fowl. *Ind. J. Anim. Sci.*, 62(12): 1164-1166.
 103. RAWDON B.B.: Morphogenesis and differentiation of the avian endocrine pancreas, with particular reference to experimental studies on the chick embryo. *Microsc. Res. Tech.*, 1998, 43, 292-305.
 104. Reznik, G.K., 1990. Comparative anatomy, physiology and upper respiratory tract. Retrieved from <http://www.ehponline.org/members/1990/85023.PDF>.
 105. Rugh R. 1951. The Frog-Its Reprodlction alld Developmčni. The Blakiston Co., Toronto.
 106. Sakas, P.S., 2002. Basic Avian Anatomy. In: Essentials of Avian Medicine: A Guide for Practitioners, Second Edition. Published by the American Animal Hospital Association Press.
 107. Sarwar, A.M.N., Chaudhary, I.R., Khan, S.A., Majeed, M.A., 1991. Eight serum biochemical values of one-humped camel (*Camelus dromedarius*) in summer: Effect of sex, age in males and lactation and pregnancy in females. *Pakistan Vet. J.* 11(2), 62-68.
 108. Sayrafi, R., & Aghagolzadeh, M. (2020). Histological and histochemical study of the proventriculus (*Ventriculus glandularis*) of common starling (*Sturnus vulgaris*). *Anatomia Histologia Embryologia*, 49(1), 105-11.
 109. Scammon, R. E. 1913. The development of the elasmobranch liver. I. The early development of the liver II. The development of the liver ducts and gall-bladder. *Am. J. Anat.* 14: 333–409.
 110. Scammon, R. E. 1916. On the development of the biliary system in animals lacking a gall-bladder in postnatal life. *Anat. Rec.* 10: 543–558.
 111. Scott, G. R. (2011). Elevated performance: the unique physiology of birds that fly at high altitudes. *Journal of Experimental Biology*, 214(15), 2455-2462.
 112. Selvan, P. S., Ushakumary, S., & Ramesh, G. (2008). Studies on the histochemistry of the proventriculus and gizzard of post-hatch guinea fowl (*Numida meleagris*). *International Journal of Poultry Science*, 7(11), 1112-1116.
 113. Shibata Y. Comparative ultrastructure of cell membrane specializations in vertebrate cardiac muscles. *Arch Histol Jpn.* 1977; 40(5):391–406.
 114. Shiojiri, N. 1997. Development and differentiation of bile ducts in the mammalian liver. *Microsc. Res. Tech.* 39: 328–335.
 115. Shumway Wand Adamstone E B 1954. *Pancreas. illIrodLICliolJ to Vertebrate Emblyology*. 5th edn. John Wiley and Sons, New York.
 116. Simsek, N., & Alabay, B. (2008). Light and electron microscopic examinations of the pancreas in quails (*Coturnix coturnix japonica*). *Revue de Medecine Veterinaire*, 159(4), 198-206.
 117. Sivakumar, M., Ramesh, G., & Vijayaragavan, C. (2012). Histogenesis of the pancreas of Japanese quail (*Coturnix coturnix japonica*).
 118. SMITH P.H.: Pancreatic islets of the coturnix quail. A light and electron microscopic study with special reference to the islet organ of the splenic lobe. *Anat. Rec.*, 1974, 178, 567-585.
 119. Starck, J. M., & Rahmaan, G. H. A. (2003). Phenotypic flexibility of structure and function of the digestive system of Japanese quail. *Journal of Experimental Biology*, 206(11), 1887-1897.
 120. Thaxton, J.P., 2002. Heart growth in broilers. *Brit. Poult. Sci.*, 43: 24-27.
 121. Tickle PG, Paxton H, Rankin JW, Hutchinson JR, Codd JR. Anatomical and biomechanical traits of broiler chickens across ontogeny. Part I. Anatomy of the musculoskeletal respiratory apparatus and changes

- in organ size. PeerJ. 2014; 2:e432. <https://doi.org/10.7717/peerj.432> PMID: 25071981
122. TOMITA T., DOULL V., POLLOCK H.G., KIMMELL J.R.: Regional distribution of pancreatic polypeptide and other hormones in chicken pancreas: reciprocal relationship between pancreatic polypeptide and glucagon. *Gen. Comp. Endoc.*, 1985, 58, 303-310.
 123. Tucker, V.A. Oxygen consumption of a flying bird. *Science* 1966, 154, 150–151.
 124. Uni, Z., E. Tako, O. Gal-Garber, and D. Sklan. 2003. Morphological, molecular, and functional changes in the chicken small intestine of the late-term embryo. *Poult. Sci.* 82:1747–1754.
 125. Verma, D. (1998) Pre and post-hatch morphogenesis of digestive system in fowl (*Gallus domesticus*). M.V.Sc. Thesis, JNKV, Jabalpur: PP. 24-57.
 126. Völker. 1901. Beiträge zur Entwicklung des Pankreas bei den Amnioten. *Arch. f. mikrosk. Anat.* 59: 62–93.
 127. Wakatsuki T, Schlessinger J, Elson EL. The biochemical response of the heart to hypertension and exercise. *Trends Biochem Sci.* 2004; 29(11):609–617.
 128. WATANABE T., CHIKAZAWA H., YAMADA J.: Catecholamine containing pancreatic islet cells of the domestic fowl. Light, fluorescence and electron microscopy, and immunohistochemistry. *Cell Tissue Res.*, 1984, 237, 239-244.
 129. Wilson, W. O. (2023). GROSS ANATOMY OF THE SMALL AND LARGE INTESTINE IN JAPANESE QUAIL: AN OVERVIEW. *Interdisciplinary Journal of Agriculture and Environmental Sciences (IJAES)*, 10(1), 32-36.
 130. Xu, G., Elsey, R. M., Lance, V. A., Javors, B., Chen, T. S., Salen, G. and Tint, G. S. 1997. A study on biliary ductal system and bile fistula in the American alligator, *Alligator mississippiensis*. *J. Exp. Zool.* 279: 554–561.
 131. YAKISIK M.: Tavuklarda pankreasın yapısal ve histokimyasal özellikleri, alloxan verilmiş tavuklarda endokrin pankreasta görülen değişiklikler. 1988, Doktora Tezi, Uludağ Üniv. Sag. Bil. Ens. Bursa.
 132. Yamagishi, K. 1930. The comparative anatomy of the biliary tract, Part III. *Jikken Shokaki Byogaku* 5: 1052–1080 (in Japanese).
 133. Youson, J. H. 1993. Biliary atresia in lampreys. *Adv. Vet. Sci. Comp. Med.* 37: 197–255.
 134. Zaher, M., El-Ghareeb, A.W., Hamdi, H. and F. Abu Amod (2012) Anatomical, histological and histochemical adaptations of the avian alimentary canal to their food habits: *I-Coturnix coturnix*. *Life Science Journal.* 9(3): 253-275.
 135. Zhu, L., Wang, J. J., Shi, X. D., Hu, J., & Chen, J. G. (2013). Histological observation of the stomach of the yellow-billed grosbeak. *International Journal of Morphology*, 31(2), 512-515.
 136. Ziad A. BIOCHEMICAL PARAMETERS ASSOCIATED WITH KIDNEY INJURY IN BIRDS. *Innovative approaches in modern science 2021* (pp. 130-134).
 137. Ziad A. Changes in the morphological and anatomical structures of kidney in birds. *Innovative approaches in the modern science.* 134-139.
 138. Ziad A. Histological structure differences of kidney in birds. *Innovative approaches in the modern science.* 72-76.
 139. Ziad A. Morphometric Parameters Of Chick Embryos With Different Genotype. *In Innovative in Agriculture 2018* (pp. 97-99).
 140. Ziad, A. (2021). Dynamics of kidney morphological changes in females and males of the quail birds. In *Materials of the All-Russian scientific conference of young scientists and specialists with international participation, dedicated to the 155th anniversary of the birth of N.N. Khudyakov, Moscow, 7* (p. 128).
 141. Ziad, A. (2022). HISTOLOGICAL COMPARISON OF BAUMANN'S CAPSULE BETWEEN FEMALES AND MALES OF QUAIL AT DIFFERENT AGE STAGES. In *Innovation processes in agriculture* (pp. 187-190).
 142. Ziad, A. (2022). HISTOLOGICAL COMPARISON OF LOOP OF HENLE IN MALE AND FEMALE QUAILS AT DIFFERENT AGE STAGES. In *Innovation processes in agriculture* (pp. 183-187).

Ready to submit your research? Choose ClinicSearch and benefit from:

- fast, convenient online submission
- rigorous peer review by experienced research in your field
- rapid publication on acceptance
- authors retain copyrights
- unique DOI for all articles
- immediate, unrestricted online access

At ClinicSearch, research is always in progress.

Learn more <http://clinicsearchonline.org/journals/clinical-reviews-and-case-reports>



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.