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Morphology and Histology of Pekin Duck (*Anas platyrhynchos domesticus*) Liver

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ABSTRACT

The liver is a vital organ in animals, particularly in poultry, and having a detailed understanding of its anatomy and histology is important for veterinary and comparative anatomical studies. The present study aimed to examine the macroscopic and microscopic characteristics of the liver in healthy male Pekin ducks. Ten male ducks, aged 6-8 months and weighing 3.5-4 kg, were obtained from different areas of Baghdad, Iraq, to examine the anatomical size and internal structure of their livers. The size, color, lobes, and gallbladder position of the Pekin duck liver were assessed through macroscopic observation. Histological examination was performed to assess the capsule, hepatic tissue structure, sinusoids, hepatocytes, portal areas, and lymphocytic aggregates. The present results indicated that the Pekin ducks' livers were dark red to reddish-brown and located ventrally in the abdominal cavity. Pekin ducks' livers consisted of two lobes without any secondary lobulation. The right lobe measured 78 mm in length, 35 mm in width, and the left lobe measured 51 mm in length and 33 mm in width. The liver was surrounded by Glisson's capsule with thin septa. Hepatocytes were arranged in radial cords around the central vein, with sinusoids containing Kupffer cells. The portal area contained branches of the portal vein, hepatic artery, bile duct, and lymphatics. Lymphocytic aggregates were observed in hepatic cords and portal areas. The present findings provided baseline morphological and histological data on the Pekin duck liver, supporting future anatomical and veterinary investigations.

Keywords: Duck, Hepatocyte, Liver, Sinusoid

INTRODUCTION

The liver plays essential roles in several important processes, including metabolizing proteins, fats, and carbohydrates, generating plasma proteins, and synthesizing coagulation factors, including prothrombin and fibrinogen (Hassani, 2022). The liver detoxifies medications and purifies the blood of bacteria and other toxic materials (Mohajan, 2025). The liver is considered one of the organs responsible for homeostasis (Ibegbulem et al., 2015). In poultry, liver is involved in blood cell synthesis, a process that persists until the bone marrow assumes this role in adults (Turk, 1982). Liver plays a key role in breaking down hemoglobin in aging erythrocytes to form the heme component, which is then converted into bile pigments such as bilirubin, giving the granules a yellowish appearance. Furthermore, the liver serves as a major reservoir of iron, mainly stored in ferritin and hemosiderin (Mohajan, 2025), and contains endocrine and exocrine glands. Anatomically, the liver in poultry comprises a large right lobe and a smaller left lobe, which are joined at the front of their central region (Maher, 2019). The gallbladder is under the right lobe of the liver, stores bile, and connects to the liver via the bile duct (Hassani, 2022). The hepatic parenchyma consists of hepatic cords, sinusoids, central veins, and portal areas. The portal area's components include branches of the bile duct, lymphatic vessels, the hepatic portal vein, and the hepatic portal artery.

Based on the taxonomic criteria reported by Zhu et al. (2017), Pekin ducks belong to the kingdom Animalia, phylum Chordata, class Aves, order Anseriformes, family *Anatidae*, Genus *Anas*, species *platyrhynchos*, and subspecies *domesticus*. Pekin duck, also known as the American Pekin or Long Island duck, is an American breed that originated in China (Qu et al., 2009). Pekin ducks are among the most widely distributed duck breeds worldwide, especially in the Middle East, raised for eggs and meat, and often kept as pets. Adult Pekin ducks have orange legs and beaks and creamy white feathers, though black-and-white variations also occur (Tsao, 1999). Pekin ducks are characterized by long wings (20–30 cm) and an elongated body with a broad chest that measures between 11.7 and 12 cm. Adult ducks weigh 3 to 4 kg, and females are notable for laying a substantial number of eggs, estimated at 200 to 300 annually (Trela et al., 2025). The present study aimed to characterize the morphological features and histological structures of the liver in Pekin ducks.

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MATERIALS AND METHODS

Ethical approval

Ethical approval for the study was obtained from the Ethics Committee of the University of Baghdad, Baghdad, Iraq, at the College of Education for Pure Science (Ibn Al-Haitham), with an approval number EC-99.

Source of duck

Pekin ducks were obtained from the EL-ABED duck farm and the AL-Ghazil market in Baghdad, Iraq. The present study was conducted with 10 adult male Pekin ducks (approximately 6-8 months old, weighing 3.5-4 kg).

Morphological investigation

Eight Pekin ducks were anesthetized with 2-3 ml of chloroform (BDH, England) and then dissected following the method described by Smith (2024). Then, the Pekin ducks were placed in an anatomy dish after being pinned. Feathers and skin were removed, then the sternum was cut caudally at its cranial articulation with the coracoid bone. Following this, the liver was lifted after the mesentery was cut. Liver samples (350-650 g) were fixed in 10% formalin (SIKMA Atorich, Germany) for 48 hours. After fixation, the tissues were washed with running tap water for 30 minutes and then transferred to 70% ethyl alcohol. The tissue sections were prepared according to the method described by Aboghanima et al. (2025). After fixation and washing, the liver tissues were dehydrated by passing them through a series of ascending concentrations of ethyl alcohol (70%, 80%, 90%, 95%, 100%) to remove water. The clearing process was performed using a 1:1 mixture of absolute ethyl alcohol and xylene for 30 minutes. Then, the samples were transferred to pure xylene and embedded in paraffin wax melted at 58°C. Finally, sections were cut at 7 µm using a rotary microtome.

Histological investigation

Histological sections were stained with Harris's hematoxylin-eosin (H&E) according to the method described by Suvarna (2018). Three histological sections were randomly selected for examination using a compound light microscope at different magnifications (10x, 40x, and 100x). The histological sections were photographed with a Canon camera (Sony, Japan) attached to a compound microscope (Olympus, Japan) in the Advanced Embryology Laboratory at the College of Education for Pure Science (Ibn Al-Haitham), University of Baghdad, Baghdad, Iraq.

RESULTS

Morphological structures

The anatomical findings of the Pekin duck's liver revealed that it occupies a large portion of the coelomic cavity, positioned in the upper thoracoabdominal region within the rib area. The upper front part of the liver is situated near the apex of the heart, while its lower part extends into the gizzard (Figure 1).

Pekin duck liver had two surfaces; a smooth, convex dorsal surface and a smooth, concave ventral surface, and was bilobed, with the right lobe about twice as large as the left. Secondary lobules were absent, and the organ appeared dark red to reddish-brown (Figure 2). In the Pekin duck, the gallbladder appeared as a spindle or pear-shaped, dark green structure on the visceral side of the right lobe, and it was composed of three parts, including the head, body, and neck.

The length of the right lobe was approximately 78 mm, while the length of the left lobe was approximately 51 mm. The width of the right lobe was about 35 mm, and the left lobe was approximately 33 mm. The weight of the liver was about 37.39 g (Figure 3A and B).

Histological structure

Histological analysis of the Pekin duck's liver indicated that the hepatic parenchyma, situated under Glisson's capsule, was encircled by a thin layer of simple squamous epithelial tissue. Since interlobular septa were absent, the delicate trabeculae did not divide the liver into distinct lobules (Figure 4A). The fundamental component of the hepatic parenchyma is the hepatocyte, which has a polygonal or polyhedral shape, resembling cube-like cells with uniform cytoplasm and one or two nuclei. These hepatocytes were arranged in structures called hepatic cords, which were branched and irregularly intertwined around the portal areas and radially around the central veins (Figure 4B).

Hepatic sinusoids are spaces between the hepatic cords in liver tissue. These sinusoids were narrow and irregular, lined with endothelial cells. Sinusoids were spindle-shaped, flat, and not tightly connected to each other in the liver. Other cells, called Kupffer cells, were identified as irregularly shaped phagocytic cells with a dark, oval, or spherical, unstable nucleus. Kupffer cells were larger than endothelial cells (Figure 5).

The portal areas were scattered throughout the hepatic parenchyma and supported by surrounding connective tissue, with irregularly branched hepatic cords intermingling among them. The hepatic portal vein branch had a large, wide, non-convoluted lumen with a thin wall composed of endothelial cells, encircled by one or two layers of circular smooth muscle. Nucleated red blood cells were present in the lumen. On the other hand, a branch of the hepatic portal artery was identified by its thick wall and small, convoluted cavity, which were attributed to the presence of the internal elastic membrane. The lumen was lined by endothelial cells and surrounded by two to three layers of circularly arranged smooth muscle fibers. The bile duct branch was lined with a single layer of simple cuboidal epithelium resting on a few smooth muscle fibers, whereas the lymphatic vessel branch had a small lumen lined with a single layer of spindle-shaped endothelial cells (Figure 6).

The current findings revealed two clusters of lymphatic cells within the hepatic parenchyma of Pekin ducks. These clusters were found among the hepatic cords and ranged in size from small to large aggregates. In addition, lymphatic cells were found around some portal areas within the surrounding connective tissue (Figure 7).

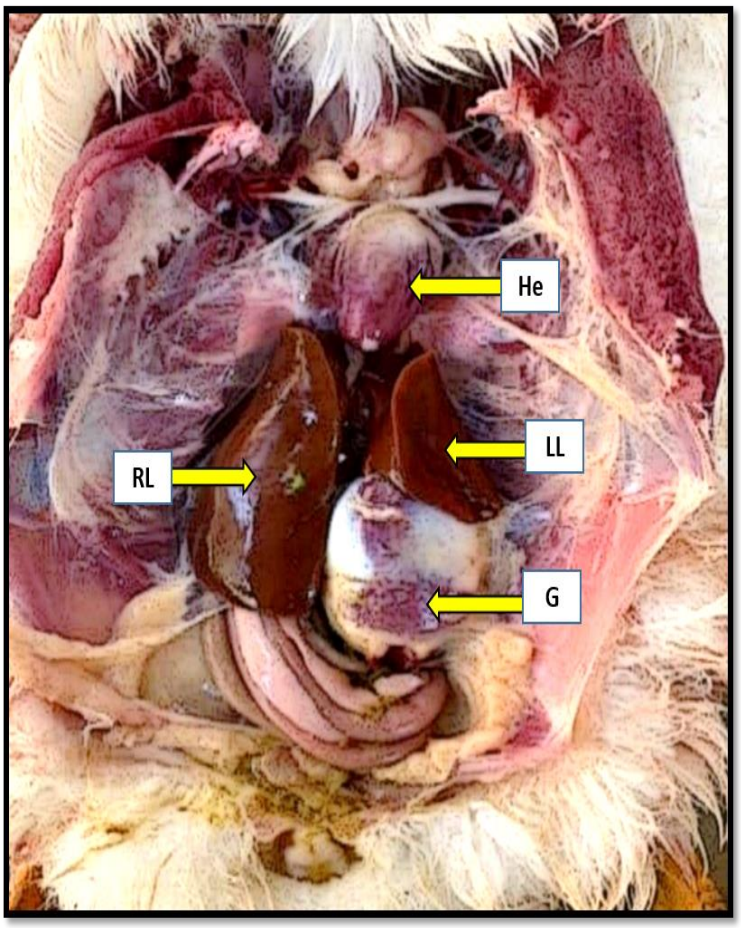

Figure 1. Position of the liver in the abdominal cavity of the healthy male Pekin duck. RL: Right lobe of the liver, LL: Left lobe of the liver, He: Heart, G: Gizzard

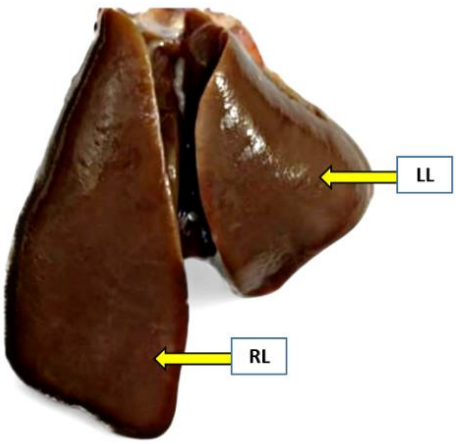

Figure 2. Morphology of a healthy male Pekin duck liver. RL: Right lobe, LL: Left lobe

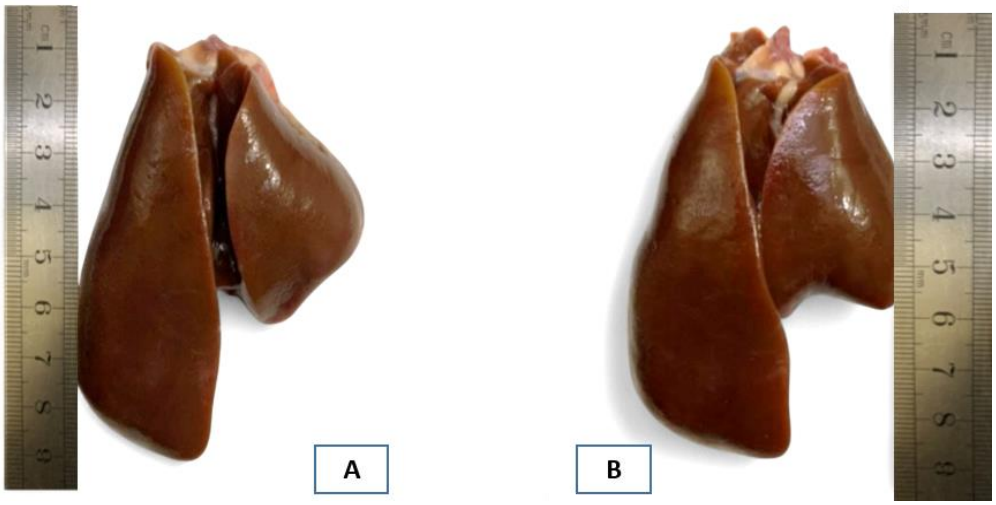

Figure 3. Morphology of a healthy male Pekin duck liver. **A:** Measurement of the length of the right lobe, **B:** Measurement of the length of the left lobe

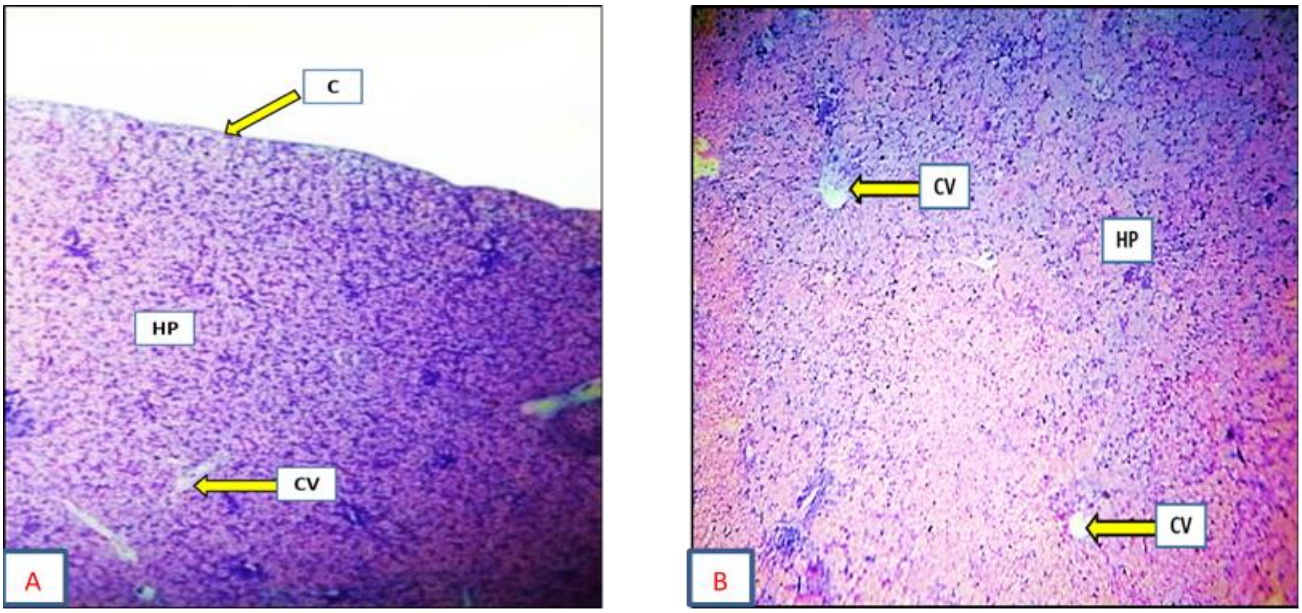

Figure 4. Histological structure of a healthy male Pekin duck liver. **A**: Lower resolution (4x), **B**: Higher resolution (10x, H&E), C: Capsule, HP: Hepatic parenchyma, CV: Central vein

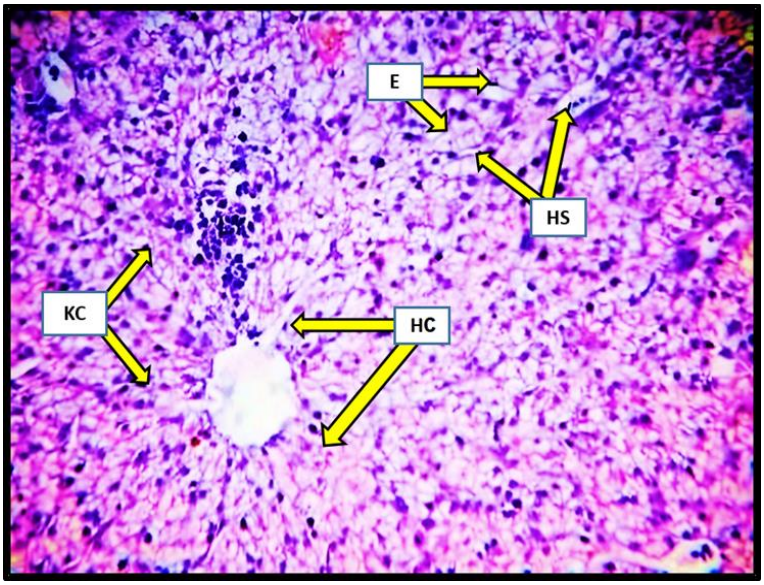

Figure 5. Histological structure of a healthy male Pekin duck liver. HC: Hepatic cord, HS: Hepatic sinusoids, KC: Kupffer cell, E: Endothelial cell (H&E, 40x).

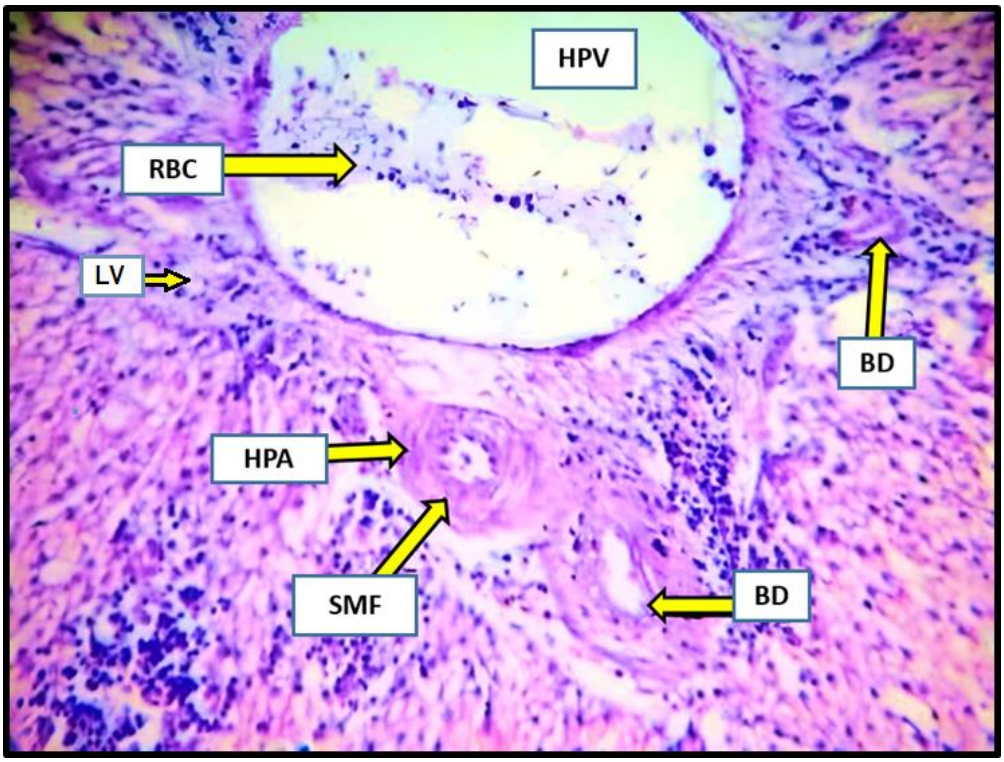

Figure 6. Transverse section of the liver in a healthy male Pekin duck. HPV: A branch of the hepatic portal vein, HPA: A branch of the hepatic artery, SMF: Smooth muscle fibers, BD: A branch of the bile duct, LV: A branch of the lymphatic vessel, RBC: Red blood corpuscle (H&E, 40x).

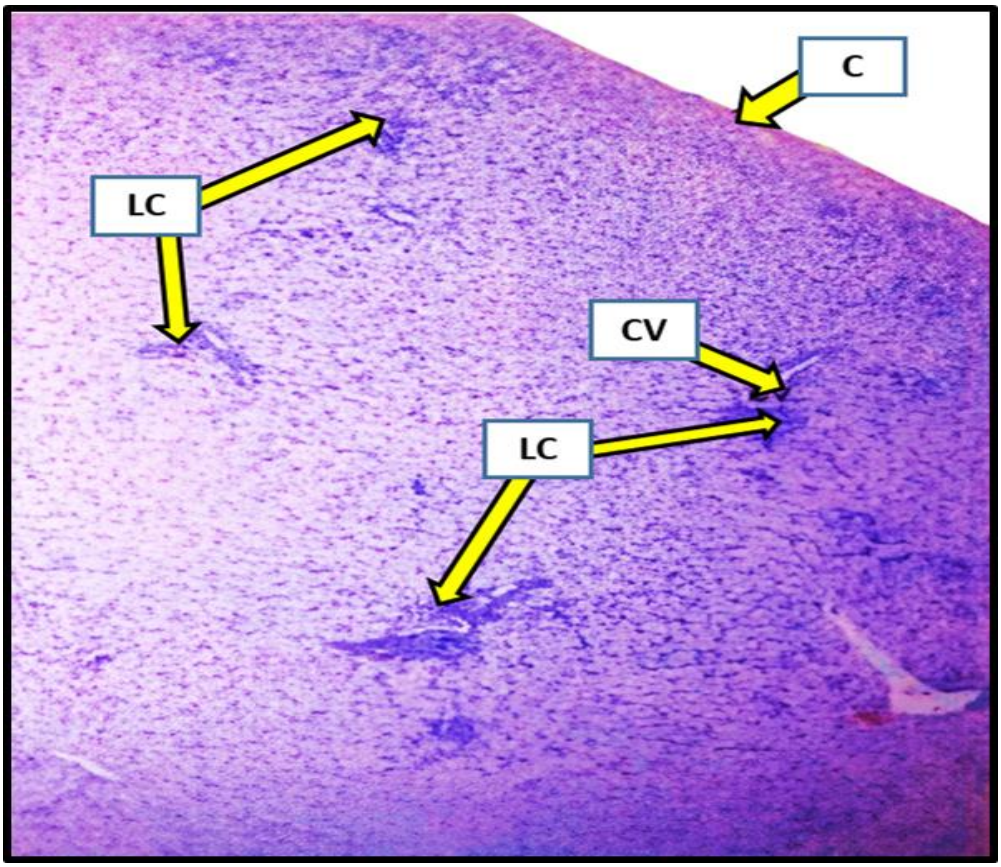

Figure 7. Transverse section of the liver in a healthy male Pekin duck. C: Capsule, CV: central vein, LC: Lymphatic cluster (H&E, 10x).

DISCUSSION

Morphological structure

Consistent with previous studies in poultry (Zaefarian et al., 2019; Schmidt et al., 2024) and in *Gallus gallus domesticus* (Tarek et al., 2019), the liver occupies a large portion of the body cavity, and the heart is located cranial to the liver, partially covering the gizzard. As observed in the present study, Pekin duck liver was bilobed, consistent with earlier findings in domestic chickens (Hodges,1974) and Muscovy ducks (Alshammary et al., 2021; Schmidt et al., 2024).

The current study revealed that the right lobe was larger than the left lobe, consistent with the findings of Hussein and Hussein (2016). Al-Hamadawi (2017) examined the white-throated kingfisher, laughing dove, and common kestrel and reported that the right hepatic lobe was larger than the left lobe in the first two species, a finding consistent with the current study. Conversely, the common kestrel exhibited a smaller right hepatic lobe compared to the left lobe, thereby demonstrating interspecies variation. These current results contrast with earlier reports in the parakeet (*Psittacula krameri*) by Zwarg et al. (2023) and in the common kestrel (*Falco tinnunculus*) by Al-Hamadawi et al. (2017), both of which described the left lobe as larger than the right. Additionally, the current findings contrast with Faraj et al. (2018), who reported that the liver of the western marsh harrier (*Circus aeruginosus*) consisted of two equal-sized lobes.

The present study found that the left lobe of the Pekin duck liver was not divided into secondary lobes, which aligns with the report by Faraj et al. (2016) on the western marsh harrier. The current study identified a bile sac on the ventral visceral surface of the Pekin duck's right lobe, consistent with the findings of Schmidt et al. (2024) in avian species. This observation contrasts with the findings of Umar et al. (2021), who reported the absence of a bile sac on the ventral visceral surface of the right lobe of the ostrich liver.

Histological structure

The hepatic visceral tissue of the Pekin duck in the present study was surrounded by a Glisson's capsule consisting of a thin squamous epithelial layer, within which dense, irregular connective tissue was interspersed with collagenous fibers. This observation was consistent with that of Al-Shamary et al. (2017) in the ruddy shelduck (*Pallas*). The present study revealed that the liver consisted of thin, shallow septa that did not separate it into distinct lobules. Similarly, this finding has been reported by Hodges (1974) in chickens, as well as in a histological examination of the goose liver (*Anser anser domesticus*) by El Karmoty and Tolba (2019). The hepatic parenchymal tissue of the Pekin duck consisted of polygonal or polyhedral hepatocytes, similar to cuboidal cells, with one or two nuclei, which aligns with the findings of Ismaeil and Emam (2023) on pigeons (*Columba livia domestica*) and cattle egret (*Bubulcus ibis).* Similarly, Faraj (2018) documented that hepatocytes in the livers of western marsh harriers (*Circus aeruginosus*) exhibited a polygonal morphology. Conversely, the hepatocytes of the seagull (*Larus hyperboreus*) were oval to irregular, which is consistent with the observations of Hussein et al. (2025) in their study on the seagull liver.

The hepatic cords were arranged radially around the central veins and lined by a thin layer of simple squamous cells, representing endothelial cells. Similar results were reported by Abed and Al-Bakri (2011) in the house sparrow (*Passer domesticus*) and by Hussein and Hussein (2016) in the domestic chicken (*Gallus gallus domesticus*) and the moorhen (*Gallinula chloropus*) in southern Iraq. The current study revealed that hepatic sinusoids form a three-dimensional network of spaces through which blood flows. The sinusoids were narrow and irregular, lined with spindle-shaped and flat endothelial cells that were not tightly connected. Additionally, Kupffer cells, which are macrophages, were observed. These cells were either in contact with endothelial cells or floating in the hepatic sinusoidal lumen. Kupffer cells were irregularly shaped and larger than endothelial cells. The present findings are consistent with those of Binkowski et al. (2013), who studied the liver of *Anas platyrhynchos domesticus*.

The current study revealed the presence of one portal space within the hepatic parenchyma at the boundaries of the hepatic lobule in a scattered form and supported by the surrounding connective tissue. These spaces were surrounded by irregularly shaped, branched hepatic cords that interlocked with one another. Each portal space contained a branch of the hepatic portal vein, a branch of the hepatic artery, branches of the bile duct, and a small branch of a lymphatic vessel. These findings aligned with those of Abed and Al-Bakri (2011), who investigated the structural morphology and histology of the liver of the local sparrow. Additionally, Al-Hamadawi (2017) reported the same pattern of liver branches in laughing dove (*Spilopelia senegalensis*), the white-throated kingfisher (*Halcyon smyrnensis*), and the western marsh harrier (*Circus aeruginosus*) in Iraq. Meanwhile, Faraj and Al-Bairuty (2016) reported that the portal area consisted of 1-2 branches of the hepatic portal vein and 1-4 branches of the bile duct and branches of the hepatic artery in the migratory starling (*Sturnus vulgaris*) liver, which was contrasted to the present findings. The variation in the number of components within the portal area might be related to interspecies differences, as well as differences in birds size, liver size, blood supply requirements, and bile production.

The current findings revealed the presence of several clusters of lymphoid cells within the hepatic parenchymal tissue. Lymphoid clusters with different sizes, small, medium, and large, were located between the hepatic cords. Moreover, lymphoid cells were present in the connective tissue surrounding some portal areas. This observation was consistent with the findings of Umar et al. (2021), who reported the same pattern in the ostrich liver and those of Moslem (2015), who studied the African ostrich liver. Furthermore, Pendl and Schmidt (2024) reported that the presence of these lymphoid aggregates between the hepatic cords and around the portal area is a normal feature in the liver tissues of different bird species. These lymphoid clusters represent concentrated aggregations of lymphocytes and function as immune sites, compensating for the absence of typical lymph nodes in birds.

CONCLUSION

The liver of the Pekin duck exhibited a simple two-lobe structure, with the right lobe considerably larger than the left lobe. The histological structure of the liver in Pekin ducks, including radial hepatocyte cords, central veins, and well-defined sinusoidal spaces, reflected typical avian hepatic structure. Lymphocytic aggregates were occasionally observed within the parenchyma and portal regions, suggesting localized immunological activity. Future studies should incorporate higher-resolution micrographs to provide a greater understanding of these histological characteristics.

DECLARATIONS

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Authors' contributions

The manuscript was conceptualized by Dalia H. Al-Hamawandy and Asmaa Basheer Abed. Dalia H. Al-Hamawandy was responsible for the methodology, data curation, and original draft preparation. Asmaa Basheer Abed conducted the histological analysis. Wijdan Basheer Abid provided a thorough review and editing of the manuscript. All authors have read and approved the final edition of the manuscript.

Competing interests

The authors declare no conflict of interest.

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The present study received no external funding.

Ethical considerations

The authors declared that this manuscript is original and is not being considered elsewhere for publication. Ethical issues, including consent to publish, misconduct, fabrication of data, and redundancy, have been checked by all authors. The authors did not use any AI applications for writing the full text of this article. However, Quillbot Premium was used to revise some sentences linguistically, and then the article was reviewed and edited by the authors. All authors take full responsibility for using AI tools for language editing.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Abed EH and Al-Bakri NA (2011). Gross and microscopic studies on the stomach of domestic duck (Anas platyrhynchos) and domestic pigeon (Columba livia domestica). Journal of Madenat Alelem University College, 3(2): 49-61.

Aboghanima ZK, El Sharaby A, Aboelnour A, Abumandour MM, and Nomir AG (2025). The White Pekin duck's liver: New perspectives on its anatomical gross, casting, and histological features. Tissue and Cell, 103073. DOI: https://www.doi.org/10.1016/j.tice.2025.103073

Al-Hamadawi HA, Al-Naely AJ, Alumeri J, and Albideri A (2017). Comparative anatomical and histological study of the liver in three species of wild birds in Iraq. Journal of Global Pharma Technology, 10(9).

Al-Shamary ER, Jarad AS, Taher IA, Al-Saffar FJ, and Naji WA (2017). Some histo-morphometric and histochemical comparison aspects of the duodenum in collard dove, ruddy shelduck and owl in South Iraq. Journal of Entomology and Zoology Studies, 5(6): 923-928. DOI: https://www.doi.org/10.13140/RG.2.2.14400.7936

Alshammary A, and Kareem H (2021). Histomorphological study of the liver in Muscovy duck (Cairina moschata domestica). Tikrit Journal of Agricultural Sciences, 21(3): 112-118. DOI: https://www.doi.org/10.25130/tjas.21.3.14

Binkowski ŁJ, Sawicka-Kapusta K, Szarek J, Strzyżewska E, and Felsmann M (2013). Histopathology of liver and kidneys of wild living mallards (Anas platyrhynchos) and coots (Fulica atra) with considerable concentrations of lead and cadmium. Science of the Total Environment, 450: 326-333. DOI: https://www.doi.org/10.1016/j.scitotenv.2013.02.002

El Karmoty AF, and Tolba AR (2019). Angioarchitectural study on the intrahepatic blood supply of geese (Anser anser domesticus) with special reference to its biliary system. Approaches in Poultry, Dairy and Veterinary Sciences, 6(1). DOI: https://www.doi.org/10.31031/apdv.2019.06.000630

Faraj SS (2018). The morphological structure of the liver in marsh harrier bird in Iraq (Circus aeruginosus). International Journal of Scientific Research, 7(1): 528-532.

Faraj SS, and Al-Bairuty GA (2016). Morphological and histological study of the liver in migratory starling bird (Sturnus vulgaris). Al-Mustansiriyah Journal of Science, 27(5): 11-16. DOI: https://www.doi.org/10.23851/mjs.v27i5.161

Hassani M (2022). Liver structure, function and its interrelationships with other organs: A review. International Journal of Dental and Medical Science Research, 4(1): 88-92. DOI: https://www.doi.org/10.35629/5252-04018892

Hodges RD (1974). The histology of the fowl. London Academic Press, pp.35-88.

Hussein AJ and Hussein DM (2016). Morphological and histological comparative study of the liver in adult female domestic fowl (Gallus gallus) and common moorhen (Gallinula chloropus) in South Iraq. Kufa Journal of Veterinary Medical Sciences, 7(1): 36-45. DOI: https://www.doi.org/10.36326/kjvs/2016/v7i1b4276

Hussein HA, Musa ZA, Shehan NA, and Khaleel SJ (2025). Histological and histochemical insights into kidneys in the sea gull (Larus armenicus). Journal of Animal Health and Production, 13(S1): 196-201. DOI: https://www.doi.org/10.17582/journal.jahp/2024/13.s1.196.201

Ibegbulem CO, Chikezie PC, and Dike EC (2015). Functional assessments and histopathology of hepatic and renal tissues of Wistar rats fed with cocoa containing diets. Journal of Nutrition and Food Sciences, S11: 002. DOI: https://www.doi.org/10.4172/2155-9600.s11-002

Ismaeil SAA, and Emam H (2023). Morphological, histological and histochemical comparative investigations of the liver in young homing pigeon (Columba livia domestica) and cattle egret (Bubulcus ibis). Advances in Animal and Veterinary Sciences, 10: 607-620. DOI: https://www.doi.org/10.17582/journal.aavs/2022/10.3.607.620

Maher MA (2019). Descriptive anatomy of hepatic and portal veins with special reference to biliary duct system in broiler chickens (Gallus gallus domesticus): A recent illustration. Brazilian Journal of Poultry Science, 21: eRBCA-2019.

Mohajan HK (2025). A study on functions of liver to sustain a healthy liver. Innovation in Science and Technology, 4(1): 77-87. DOI: https://www.doi.org/10.56397/ist.2025.01.08

Moslem D (2015). Histological study of the African ostrich liver and anatomical comparison of it with poultry liver. Biological Forum – An International Journal, 7(1): 1185-1188. DOI: https://www.doi.org/

Pendl H and Schmidt RE (2024). Lymphatic and hematopoietic system. Pathology of Pet and Aviary Birds, pp. 307-341. DOI: https://www.doi.org/10.1002/9781119650522.ch9

Qu L, Liu W, Yang F, Hou Z, Zheng J, Xu G, and Yang N (2009). Origin and domestication history of Peking ducks determined through microsatellite and mitochondrial marker analysis. Science in China Series C: Life Sciences, 52(11): 1030-1035.

Schmidt RE, Struthers JD, and Phalen DN (2024). Pathology of pet and aviary birds. John Wiley and Sons. DOI: https://www.doi.org/10.1002/9781119650522

Smith D (2024). Anatomy and postmortem examination. Pathology of Pet and Aviary Birds, 1: 1-64. DOI: https://www.doi.org/10.1002/9781119650522.ch1

Suvarna KS, Layton C, and Bancroft JD (2018). Bancroft's theory and practice of histological techniques. Elsevier Health Sciences, pp. 173-186. DOI: https://www.doi.org/10.1016/b978-0-7020-6864-5.00010-4

Tarek K, Amine B, and Eddine RD (2019). Morpho-histological comparisons of liver between the broiler chicken and wild boar in Algeria. Advances in Animal and Veterinary Sciences, 7(1): 24-29. DOI: https://www.doi.org/10.17582/journal.aavs/2019/7.1.24.29

Trela M, Sołtysik W, Kustra K, Januszewska A, Lis MW, and (2025). Developmental stages of the Pekin duck (Anas platyrhynchos f. domestica) and the Mulard duck in artificial incubation. Poultry Science, 104(8): 105132. DOI: https://www.doi.org/10.1016/j.psj.2025.105132

Tsao CM (1999). Utilization of waterfowl products, Proc.1st waterfowl world conference. Taichung, Taiwan: National Chung Hsing University, pp.38-49.

Turk DE (1982). Anatomy of the avian digestive tract as related to feed utilization. Poultry Science Journal, 61(7): 1225-1244. DOI: https://doi.org/10.3382/ps.0611225

Umar Z, Qureshi AS, Shahid RU, and Deeba F (2021). Macroscopic, microscopic and histomorphometric analysis of intestine, liver and pancreas of ostrich (Struthio camelus) with advancement of age and sex. Pakistan Veterinary Journal, 41(3): 113-320. DOI: https://www.doi.org/10.29261/pakvetj/2020.029

Zaefarian F, Abdollahi MR, Cowieson A, and Ravindran V (2019). Avian liver: The forgotten organ. Animals, 9(2): 63. DOI: https://www.doi.org/10.3390/ani9020063

Zhu F, Gao Y, Lin F, Hao J, Yang F, and Hou Z (2017). Systematic analysis of feeding behaviors and their effects on feed efficiency in Pekin ducks. Journal of Animal Science and Biotechnology, 8(1): 81. DOI: https://www.doi.org/10.1186/s40104-017-0212-2

Zwarg T, Raso TF, de Carvalho MPN, Santos RL, Dos Santos DO, Llano HA, and Soares RM (2023). Acute, fatal Sarcocystis falcatula infection in rose-ringed parakeets (Psittacula krameri). Veterinary Parasitology: Regional Studies and Reports, 46: 100935. DOI: https://www.doi.org/10.1016/j.vprsr.2023.100935