Damanhour Journal of Veterinary Sciences 12 (2), (2024) 35-54

Damanhour Journal of Veterinary Sciences

Journal homepage: https://djvs.journals.ekb.eg/

E-ISSN 2636-3003 | ISSN 2636-3011

Gross Anatomy of the Intestine of the Adult Female Pekin Ducks (*Anas platyrhynchos*)

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Abstract

To our knowledge, there is no literature to define the comparative anatomical variations of the parts of the intestine in any avian species. birds. In this study, we used ten adult laying and non-laying ducks (n = 5 of each) to reveal the gross morphology and the arrangements of the intestine segments with special regard to their relation to the reproductive organs. We recorded clear gross demarcation between each of the three parts of the small intestine: the duodenum, jejunum, and ilium. Meanwhile، the large intestine formed the dorsal part comprising two ceci, the colon and the rectum, and terminated caudally into the cloaca. In all ducks, each of the descending and ascending duodenum formed a typical U-shaped tube opened cranially. In laying ducks, most parts of the duodenum were located on the left side of the celomic cavity meanwhile، they were in the right side in non-laying ducks. The jejunum started at the entrance of the bile and pancreatic ducts, which is considered as a point of demarcation between the two segments in Pekin ducks. In non-laying ducks, 14 jejunal coils were found most of which were arranged in both the right and left sides of the coelomic cavity, meanwhile، 12 coils were found the most of which were located on the right side, being displaced by the enlarged reproductive organs occupying the left side. Assembly of the jejunal coils are unique in Pekins duck compared to other birds. They were arranged in two distinct portions that differed in diameter and color. The proximal part was deeper, smaller and generally pale green while the distal part was superficial, larger, and darker green to black in color. The ileum started once it was attached to the two ceci by the ileocecal ligament. It was a simple tube in non-laying ducks while it was a sigmoid tube in laying ducks. In non-laying ducks, each cecum is a simple tube expanded at the right and directed cranially to the left where in laying it expanded on the right side, directed cranially to the left side till the middle of the gizzard, and then turned to the right again to merge returned caudally towards the left side to end by a sharp apex. Colorectum that originated at the junction of the ileum and cecum and terminated at the cloaca where In laying ducks, it was compressed by the enlarged uterus, which occupied a narrow space of the coelomic cavity at right side. Our findings were compared with those reported in other birds and their significance was discussed

Key words: Anas platyrhynchos, Anatomy, Intestine, Duck, Pekin

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P ISSN: 2636-3003

EISSN: 2636-2996

DOI: https://doi.org/10.21608/djvs.2024.324316.1139

Received: September 27, 2024;

Accepted: October 11, 2024

Editor-in-Chief:

Ass. Prof /Abdelwahab Alsenosy (editor@vetmed.dmu.edu.eg)

Introduction

Duck farming is a growing industry in Egypt, catering to both hobbyists and commercial producers seeking meat and eggs. (**Qureshi, Ziaullah, Ali, & Asad Manzoor, 2016)** Among the over 40 duck breeds–The white Pekin duck (Anas platyrhynchos) is favored for its egg, meat, and feather production. (Stein, 2012) Compared to mammals, birds have relatively shorter digestive tracts. **(Browne, 1922) .**

The avian intestine is divided into the small and large intestines. The small intestine, consisting of the duodenum, jejunum, and ileum, is where most digestion and nutrient absorption occurs. The large intestine, including the cecum and colon, primarily absorbs water and electrolytes. The cecum is especially important for herbivorous birds, housing bacteria that ferment plant material **(King & McLelland, 1984) & (Konig, 2016)** . The avian small intestine is divided into three sections. The duodenum, the first part, originates from the gizzard and forms a loop encircling most of the pancreas. Following the duodenum is the jejunum, which extends until it meets the ileum at the Meckel's diverticulum. The ileum, the final section, begins at the diverticulum and ends at the junction with the large intestine. **(Lőw et al., 2016)** the duck's small intestine is relatively short and looped, positioned at the caudal of the abdomen. It lies adjacent to the proventriculus and gizzard on the right side of the abdominal cavity **(McCracken, Kainer, & Spurgeon, 2013)** The large intestine of birds consists of two parts: the paired ceca and the colon (or rectum). Unlike the small intestine, it is relatively short. **(McLelland, 1989)** The digestive tract of most birds possesses a pair of ceca, finger-like pouches located where the small intestine meets the large intestine. While typically simple in structure, some bird species have more complex ceca **(Clench, 1999)** The ceca are a pair of blind pouches that extend alongside the small intestine towards the liver. They are attached to the small intestine by the mesentery. Each cecum has three main sections, with the cecal tonsils located at the beginning **(Mahmud et al., 2015).** Unlike most animals, female Balady ducks only have a functional left ovary and oviduct. This single oviduct, located on the upper back of the abdomen (caudal and dorsal), changes size dramatically depending on egg laying. During laying, it becomes much larger (voluminous) and can reach 33-59cm in length. The oviduct connects to various organs: the ovary in front, the cloaca (waste opening) in back, the left kidney above, the gizzard and small intestine below, and the colon on the right side. Two folds of tissue, called dorsal and ventral oviductal ligaments, keep the oviduct in place**(H Mahmoud, Gad, Tawfiek, & Awaad, 2018).**

Histomorphological study of small intestine in indigenous ducks Anasplatyrhynchos was carried as Female had significant higher than male in the mean length, weight and volume of total small intestine and for each intestinal segment separately (**Khaleel 2017)** In laying ducks, the left ovary and oviduct were remarkably enlarged occupying the entire left side of. the celomic cavity pushing the whole intestine towards the right side meanwhile in non-laying the intestine distributed easily between right and left side of coelomic cavity **.**

This study aims to compare the arrangement, morphological characteristics, and differences between the intestine of adult laying and non laying Pekin ducks (*Anas platyrhynchos)*

Materials and Methods

Sampling and Processing

Collection of samples:

Ten adult healthy female white Pekin ducks (Anas platyrhynchos) were used in present study. They were purchased from a private farm in Alfayom governorate. All ducks were brought to the laboratory of anatomy and embryology, faculty of veterinary medicine Damanhour university. The ducks were housed in separate cages and allowed for free access to water and food for a few days until the processing of the experiments.

Dissection and topographical analysis:

All ducks were slaughtered by cutting arteries on each side of the neck, skinned, and then the coelomic cavity were opened using a sharp dissecting scissor. All specimens were fixed in 10% formalin for 72 hrs. Trunk muscles were removed and the intestinal segments were dissected out and projected to the ribs and intercostal spaces of the ducks. Adhesions of the intestine with the proventriculus and gizzard were carefully dissected, and relations of each of segment of the intestine to the neighbored organs were examined.

To examine the position of each intestinal segment in the coelomic cavity in both laying and non-laying female ducks, the gizzard was used as a landmark in all examined specimens. Therefore, the coelomic cavity was divided by 3 transverse planes into cranial, middle and caudal parts **(Fig12&13).** The first plane extended vertically at about the middle of the gizzard between the 7th lumber vertebrae at middle of synsacrum dorsally and the after the end of sternum by 1.5 cm ventrally. The second plane extended at about the caudal border of the gizzard between the sacral 4th vertebrae at end of synsacrum dorsally and after the end of sternum by 3.5 cm ventrally. Meanwhile the 3rd plane at about the middle of the distance between the caudal border of the gizzard cranially and the cloaca caudally. This level extended between the 2nd caudal vertebrae dorsally and the after the end of sternum by 5.5 cm ventrally.

Photos were taken using digital cameras (EOS 2000D 18-55 IS, 24.1 MP, DSLR digital camera),

All procedures were conducted according to guidelines approved by the Ethics Committee of the

Faculty of Veterinary Medicine, Damanhour University, Egypt).

Results

1. Topography of the intestine:

In the investigated specimens of the adult female Pekin ducks, the intestinal mass occupied the caudal 2/3 of the celomic cavity measuring an average about 16 ± 0.85 cm in length and 7 ± 0.25 cm in width. The narrower part of this mass represented the small intestine, which was formed of the duodenum, jejunum, and the ilium without clear gross demarcation between the three parts. Meanwhile the wider part represented the large intestine, which forming the dorsal part of the mass and comprising two ceci, the colon, and the rectum, and continued caudally to open into the cloaca **(Fig. 1 and 4).**

The cranial limit of the intestine, namely the jejunum was formed on the right side of the celomic cavity at about the middle of the 6th intercostal space. It was separated from the right lung by transverse septum and located on the dorsal and right surface of the gizzard, ventral to the cranial lobe of the right kidney, dorsal to the right lobe of the liver and the ovary **(Fig. 2 and 5)**. On the left, the proximal halves of the two ceci extended dorsal to the gizzard and the spleen and being separated from the caudal extremity of the left lung by the transverse septum **(Fig.1 and 4).**

On the other hand, the most caudal limit, which was formed by the rectum extended beyond the caudal extremity of the right kidney corresponding to the end of the pubis and the ischium ventral to the synsacrum vertebra

The dorsal part of the intestinal mass was formed by the ilium, two ceci and the rectum as well as the jejunum, all of which were attached to the synsacrum vertebrae by the mesentery. Meanwhile, the ventral part of the intestinal mass was formed by parts of the descending and ascending duodenum that passed beyond the sternum and rested on the floor (**Fig. 3 and 6).**

2. Gross morphology and arrangement of the intestine

2.1 The Duodenum

In all examined specimens of the adult female ducks, each of the descending and the ascending duodenum formed a typical U-shaped tube, each of which consisted of two limbs separated by a flexure (non-laying ducks; **Fig. 1 – 3, 7 – 8 and 11A,** laying ducks; **Fig. 4 – 6, 9 – 10 and 11B**). In both groups, the first (proximal) limb of the descending duodenum started at the pyloric orifice at the level of 7th rib. In laying ducks, it passed straight caudally on the visceral surface of the gizzard till its mid caudoventral part where it bent to pass cranially and to the left side passing as the 2nd limb (distal), which reached cranially that reached to the level of 6th rib as it hit the follicles of the ovary (**Fig. 9 – 10**). Meanwhile in non-laying ducks, the descending duodenum reached only the middle of the parietal surface of the gizzard where the ascending duodenum began (**Fig.7 – 8 and 11A**). In laying ducks, the proximal limb of the ascending duodenum began on the left side of the isthmus at about the level of the 6th rib, passing caudally and internally completely covered by the distal limb of the descending duodenum, then bent dorsally reaching the most caudodorsal part of the gizzard forming the distal limb that passed cranially toward the right side continuing as the jejunum (**Fig. 9 – 10 and 11B**). In non-laying ducks, the proximal limb of the ascending duodenum began at the left passing caudally parietal to the descending duodenum and bent dorsally reaching the most caudodorsal part of the gizzard where it formed the distal limb that passed cranially toward the right side to start the jejunum (**Fig.7 – 8 and 11A**). We observed most parts of the duodenum in the left side of the celomic cavity in laying ducks meanwhile they were in the right side in non-laying ducks. In both groups of the ducks, three duodenal flexures were observed: a cranial flexure between the distal limb of the descending duodenum and the proximal limb of the ascending duodenum, caudoventral flexure between the two limbs of the descending duodenum, and a caudodorsal flexure between the two limbs of the ascending descending (**Fig. 8 and 10**).

We also observed that the terminal parts of four ducts entering into the distal part of the ascending duodenum at or near the duodenal papilla (**Fig.7 and 9**). The craniocaudal order of these ducts were constantly: cysticoenteric duct, hepatoenteric duct and two pancreatic ducts.

2.2 The jejunum

In both groups of ducks, the jejunum started just after the entrance of the bile and pancreatic ducts at the duodenal papilla and arranged in several U-shaped coils. In non-laying ducks, the number of jejunal coils and flexures were 14 with 13, respectively (**Fig. 1 – 3, 7 – 8 and 11A**), and in laying ducks were 12 with 11 respectively (**Fig. 4 – 6, 9 – 10 and 11B**). In non-laying ducks, most of the jejunal coils were found in both right and left sides of the coelomic cavity. In contrast in laying ducks, most of the jejunal coils were located on the right side, being displaced by the enlarged reproductive organs that were located on the left side.

Based on the color and the diameter of the jejunal coils, two distinct parts were differentiated in both non-laying and laying ducks. The proximal (deeper) part was generally pale green and smaller of which diameter was similar to that of the duodenum. In non-laying ducks, this segment extended into the left side to invaginate between the gizzard and the left kidney. The distal (superficial) part was darker green to black and larger and was primarily located on the right side in both groups (**Fig 1 – 2 and 7**). In laying ducks, the jejunum's position and structure are significantly influenced by the reproductive organs. The deeper segment is hidden by the superficial one and runs along the uterus. The superficial part maintains a similar position to that in non-laying females in the right side , but with fewer coils and limbs (**Fig. 4 – 6 and 9**). In all investigated ducks, Meckel's diverticulum appeared as a small projection 1cm length at the beginning of the superficial part of the jejunum (**Fig 6**).

2.3 The ileum

The ileum began at the left side about the level of the middle of the 7 th intercostal space beyond the caudoventral aspect of the gizzard and above the spleen where it was attached to the two ceci by ileocecal ligament. It was a simple tube in non-laying ducks, where it passed cranially dorsal to the ascending duodenum and bent caudally towards the right side to open in the colon (**Fig. 1 – 3, 7 – 8 and 11A**). In laying ducks, the illum was a sigmoid tube started at the right side and forming three craniocaudal flexures and passing in the right side along the visceral surface of the uterus till it opened in the colon with the two ceci (**Fig. 4 – 6, 9 – 10 and 11B**).

2.4 The cecum

In both non-laying and laying ducks, right and left caeca arise from the lateral walls of the rectum, close to the junction with the ileum in retrograde fashion. Each cecum presented a short proximal part, a long body and a short apex (**Fig.7 and 9,** respectively). The proximal part exhibited a beaded appearance, paler color and smaller diameter meanwhile the apex was short and located caudally near the pubis. In non-laying ducks, the cecal body had a thinner wall, dark green to brown color, and extended from the cranial to the caudal end of gizzard (**Fig.7 – 8**). In laying ducks, the proximal part expanded on the right side at the cranial part of the visceral surface of the uterus as non-laying ducks, directed cranially to the left side till the middle of the gizzard, then turned to the right again to merge with the wider cecal body which in this case starts near the ovarian follicles that returned caudally towards the left side to end by a sharp apex (**Fig.9 – 10**).

2.5 Colorectum

The final segment of the large intestine in both laying and non-laying ducks originated at the junction of the ileum and cecum and terminated at the cloaca. In non-laying ducks, the rectum extended caudally along the right side, positioned ventral to the right kidney. It was supported dorsally by the mesentery and measured approximately 9 cm in length (**Fig. 7**). In laying ducks, the rectum was compressed by the enlarged uterus, which occupied a narrow space of the coelomic cavity at right side. The rectum was shifted towards the right side. In both non-laying and laying ducks, the rectum was sustained dorsally by the mesentery and had an approximate length of 9 cm (**Fig. 9**).

3. Relationship of the intestinal mass to ovary and oviduct

In non-laying ducks, the ovary and oviduct were remarkable small in size occupying the left side of the coelomic cavity being dorsal to the proventriculus and the intestinal mass, respectively **(Fig. 11A).** The ovary was located in the first third of the coelomic cavity and had several small follicles ranged between 2 to 3 cm, while the oviduct appeared as a long cylindrical tube passing dorsal to the left kidney and ended by a small uterus into the cloaca. In laying female ducks, the ovary and oviduct were remarkable enlarged in size being dorsal to the proventriculus and the intestinal mass, respectively **(Fig. 11B)**. The later was pushed more to the right side of the celomic cavity. The ovary contained several large follicles 7 to 8 cm and occupied the cranial 2/3 of the coelomic cavity while the oviduct occupied the caudal 1/3 of the cavity.

Fig. 12 and 13 presented the spatial arrangement of the parts of the intestinal mass in relation to the genital tract in non-laying and laying female ducks, respectively. Along the cranial 1/3rd of the celomic cavity of non-laying ducks, the small-sized ovary was located on the left of the dorsal half of the gizzard and dorsal to the jejunum (**Fig. 12/1**). It is noteworthy that the ascending and descending duodenum were demonstrated only on the right aspect of the gizzard. Along the middle 1/3rd of the cavity, the oviduct was located on the left of the dorsal half of the gizzard and dorsal to the flexure between the descending and ascending duodenum as well as the jejunum (**Fig. 12/2**). Along the caudal 1/3rd of the cavity, the uterus was located on the left side dorsal to the jejunum, the ileum and the 2 ceci as well as ventrally the ascending and descending duodenum (**Fig. 12/3**). Along the cranial 1/3rd of the celomic cavity of the laying ducks, the ovary was remarkable large and presented several large follicles occupying almost the 2/3rd of the dorsal part of the coelomic cavity above the gizzard and the ascending and descending duodenum (**Fig. 13/1**). Along the middle 1/3rd of the cavity, the ovarian follicles occupied the middle part of the coelomic cavity locating dorsal to the gizzard and both of the ascending and descending duodenum (**Fig. 13/2**). Most of the caudal 1/3rd of the celomic cavity was occupied by the uterus which extended dorsal to the jejunum, the ileum and the 2 ceci as well as the ascending and descending duodenum (**Fig. 13/3**). It is noteworthy that the ascending duodenum passed medial to the descending only along the cranial 1/3rd of the cavity.

Contrast to the non-laying ducks where the colorectum had direct contact with the right kidney, the uterus pushed the colorectum ventrally to the right with no contact with the right kidney in laying ducks.

In all investigated specimens of the female ducks, most of the jejunum was located on the right side of the celomic cavity lateral to the gizzard but only a small part of the jejunum was found on the left lateral to the gizzard along the cranial 2/3rd of the cavity in non-laying ducks (**Fig. 12/1 and 2**). Both of the ileum and the two ceci began beyond the caudal extremity of the gizzard and passed cranially on the right aspect of the celomic cavity.

V. Discussion

There is general agreement among morphologists that the small intestine of birds comprises duodenum, jejunum and ileum without with clear gross demarcation of each of the three parts (**king & McLelland, 1984** in fowl**; Hassouna et al, 2011 in most avian species; AL-Samawy et al., 2017 in mallard ducks; Yovcvhev et al., 2021 in turkey).**

In the present study, we found that the small intestine was formed of the duodenum, jejunum, and the ilium with clear gross demarcation between the three parts. Only **Hamdi et al., (2012)** who found the small intestine differentiated into duodenum and ileum in the black winged kite.

In the present study, we found that each of the descending and ascending duodenum formed a typical U-shaped tube, each of which consisted of two limbs separated by a flexure, which is in agreement with **MA Hassouna et al., (2011)** in duck; **Mahmud et al., (2015)** in chicken**; Oyelowo et al, (2017)** in owl **; Khalaf et al., 2023)** in geese**.** In contrast, the duodenum of the kestrel is comma or incomplete U-shape **(AL-Aaraji et al., 2016)** or twisted in Black Stork **(Pachauri et al., 2024)**. Only in laying ducks, we found the distal limb of the ascending duodenum to cross the proximal limb of the descending duodenum, which may be attributed to the pressure of the large-sized ovarian structure.

We found four ducts constantly entering into the distal part of the ascending duodenum at or near the duodenal papilla; cysticoenteric duct, hepatoenteric duct and 2 pancreatic ducts. This is in agreement with **Igwebuike et al., (2010)** in African pied crow, **Khalaf et al., (2023)** in geese. Only one bile duct was recorded draining in the duodenum in the canary (**Hristov et al., 2017),** meanwhile three pancreatic ducts were observed in the domestic fowl (**King and McLLelland, 1984)** and in the mallard duck **(Al-Samawy et al., 2017).**

We also found the entrance of the bile and pancreatic ducts at the duodenal papilla to demarcate between the duodenum and the jejunum, which contrasts most of previous studies that reported no clear gross demarcation between the two parts (**king & McLelland, 1984**; **AL-Samawy et al., 2017, Yovcvhev et al., 2021**).

The present study is precisely the first to note that the assembly of the jejunal coils are unique in the Pekin duck compared to other birds. They were arranged in two distinct portions differed in diameter and color. The proximal part was deeper, smaller and generally pale green while the distal part was superficial, larger and darker green to black in color. In non-laying ducks, most of the jejunal coils were found in both the right and left sides of the coelomic cavity. In contrast in laying ducks, most of the jejunal coils were located on the right side, being displaced by the enlarged reproductive organs that were located on the left side.

We found the jejunum having several U-shaped coils comprising 14 limbs and 13 flexures in non-laying ducks, and 12 limbs with 11 flexures in laying ducks. In contrast, **Naser et al., (2020)** found only 6 – 9 flexures in adult bronze turkeys. **Igwebuike et al. (2010)** reported that the jejunum is formed of cone-shaped spiral coils in African pied crow. The cone-shaped jejunum had centripetal coils, a sigmoid flexure and centrifugal coils. The centrifugal coils embedded within the core of the cone-shaped structure, while the centripetal coils were on the external surface. **AH AL-TAAI et al. (2022)** reported in pigeon the duodenum to anastomose with the jejunum at an ascending limb, and the later was formed of cone-like spiral coils.

We found the Meckel's diverticulum appeared as a small projection 1cm in length at the beginning of the superficial part of the jejunum where The ileum began at the left side about the level of the middle of the 7^{th} intercostal space beyond the caudoventral aspect of the gizzard. It was attached to the two ceci by ileocecal ligament. so we consider this point of demarcation between jejunum and ileum , which in agreement with **Koch et al. (1973)** and **Nickel et al., 1977** in chicken; **Oyelowo et al. (2017)** in owl and **Anwar et al. (2021)** and **Khalaf et al. (2023)** in geese). This contrasts the reports mentioned that Meckel's diverticulum is the gross demarcation between the jejunum and the ileum in chicken **(Dyce et al., 2009)**, in coturnix **(Zaher et al., 2012)**, in starlings **(North et al., 2016)**, and in mallard duck **(Al-Samawy et al., 2017)**. In Iraqi Black Partridge, there is no separation between the jejunum and the ileum as Meckel's diverticulum is absent (**Mnati et al., 2021)**.

In agreement with previous studies in birds, the ileum was a simple tube only in non-laying ducks. This contrasts its arrangement in laying ducks where it appeared as a sigmoid tube forming 3 flexures and passing in the right side along the visceral surface of the uterus till it opened with the two ceci in the colon.

As in most avian species, we found right, and left caeca arise at the junction of the colon with the ileum. Each cecum presented a short proximal base, a long thin-walled body, and a short distal apex directed backward. **McLelland et al. (1990)** reported that the caeca were sacculated in Ostrich while they were finger-like sac in chicken, turkey, quail and small bud-like in pigeons **(Saleh et al., 2022)**. **Oyelowo et al., (2017)** reported that each cecum is a microphone or matchstick shape in owl with an ovoid-shaped proximal part and a straight distal part. In the present study, the arrangement of the cecum was unique and strictly parallel that of the ilium being simple in the non-laying ducks and sigmoid in the laying ducks.

As generally believed in birds, the colorectum originated from the ileococolic junction and terminates at the cloaca in the dorsal part of the celomic cavity.

The present findings present substantial significance of the status of the reproductive organs on the arrangement of each part of the intestine. In non-laying ducks, the ovary and oviduct were remarkable small in size occupying the left side of the coelomic cavity being dorsal to the proventriculus and the intestinal mass. The ovary was located in the first third of the coelomic cavity and had several small follicles ranged between 2 to 3 cm, while the oviduct appeared as a long cylindrical tube passing dorsal to the left kidney and ended by a small uterus into the cloaca where intestine freely distribute between right and left side of coelomic cavity. In laying female ducks, the ovary and oviduct were remarkable enlarged in size being dorsal to the proventriculus and the intestinal mass. The later was pushed more to the right side of the celomic cavity. The ovary contained several large follicles 7 to 8 cm and occupied the cranial 2/3 of the coelomic cavity while the oviduct occupied the caudal 1/3 of the cavity. This arrangement may have an impact on the digestive and abosportive capcity of the intestinal parts which needing more histological studies and more time to indicate it in the near future .

Conclusion

We hope that the generated data may provide valuable contributions to the impact of reproductive tract on morphology and the arrangement of intestine in laying and non-laying female ducks

Conflict of interest statement

No conflicts of interest

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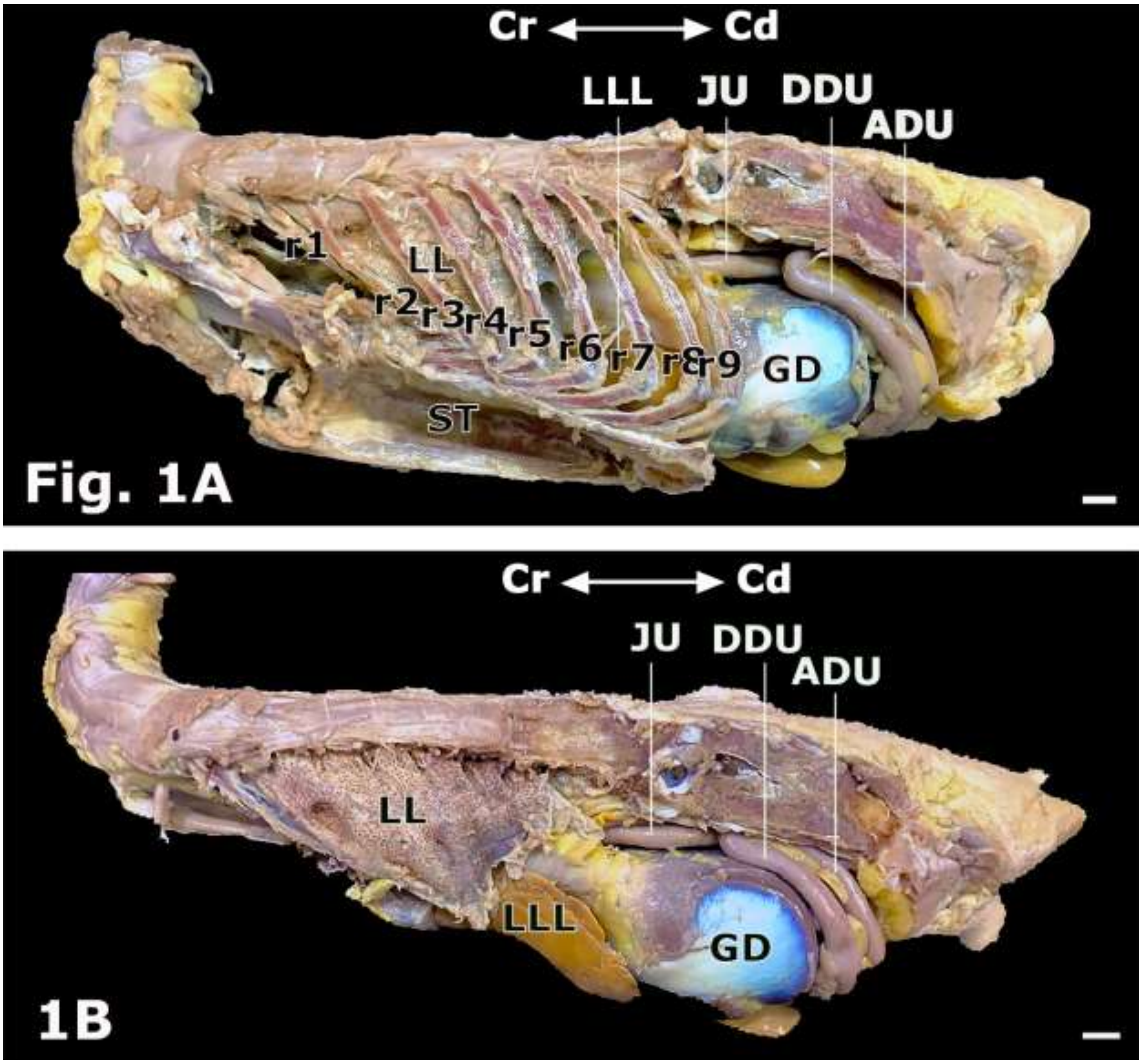


Fig. 1: Topography and morphology of the intestine of a non-laying Pekin duck, left views. A. surface anatomy of the trunk where nine ribs (r1-9) are distinct while the intercostal muscles were removed. B. the same specimen after removing the ribs. ADU. Ascending duodenum, DDU. descending duodenum, GD. Gizzard, JU. Jejunum, LL. Left lung, LLL. left lobe of liver, ST. Sternum. Scale bar = 1cm.

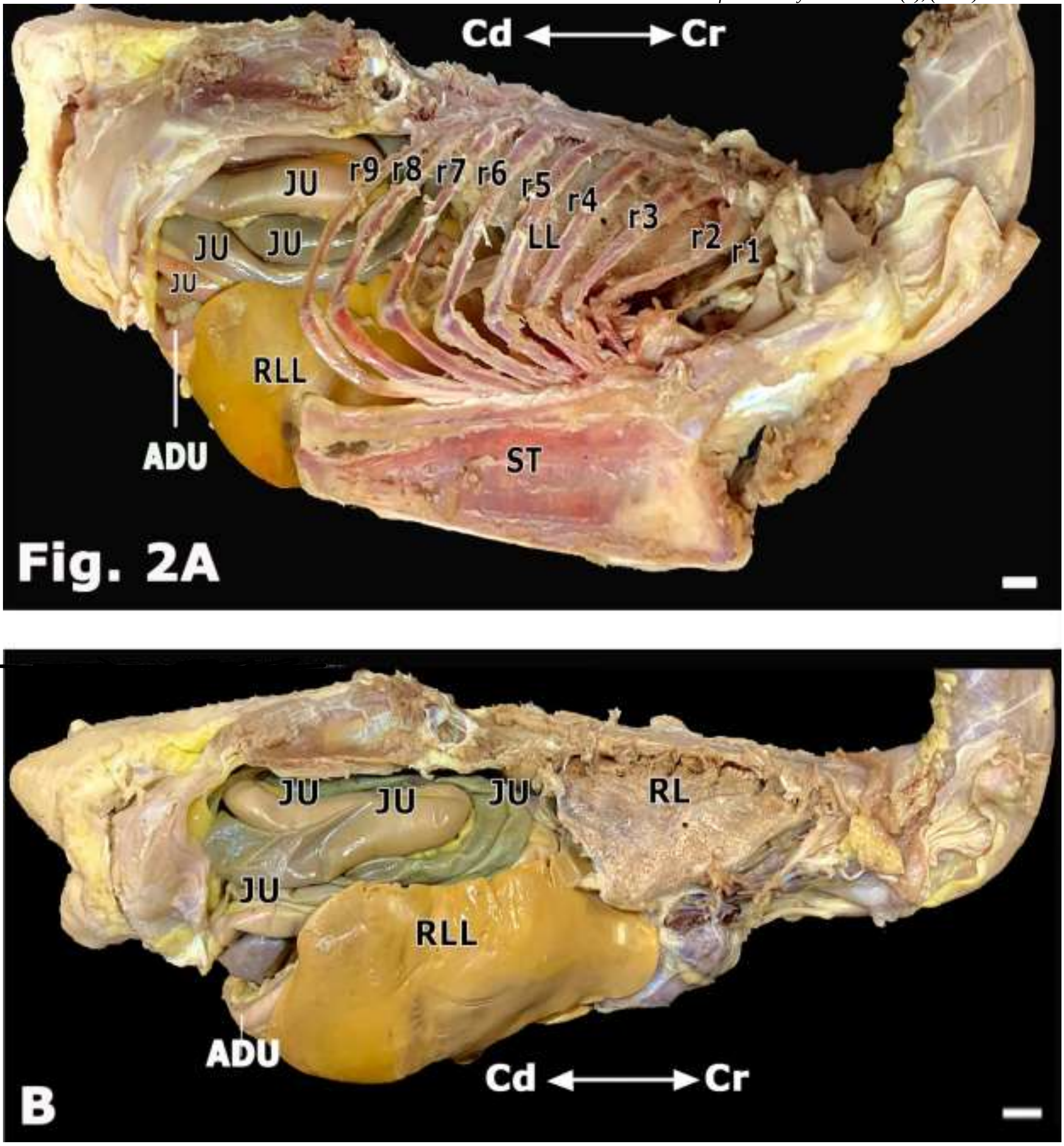


Fig. 2: Topography and morphology of the intestine of a non-laying Pekin duck, right views. A. surface anatomy of the trunk where nine ribs (r1-9) are distinct while the intercostal muscles were removed. B. the same specimen after the removal of the ribs. ADU. Ascending duodenum JU. Jejunum, RL. Right lung, RLL. Right lobe of liver, ST. Sternum. Scale bar = 1cm.

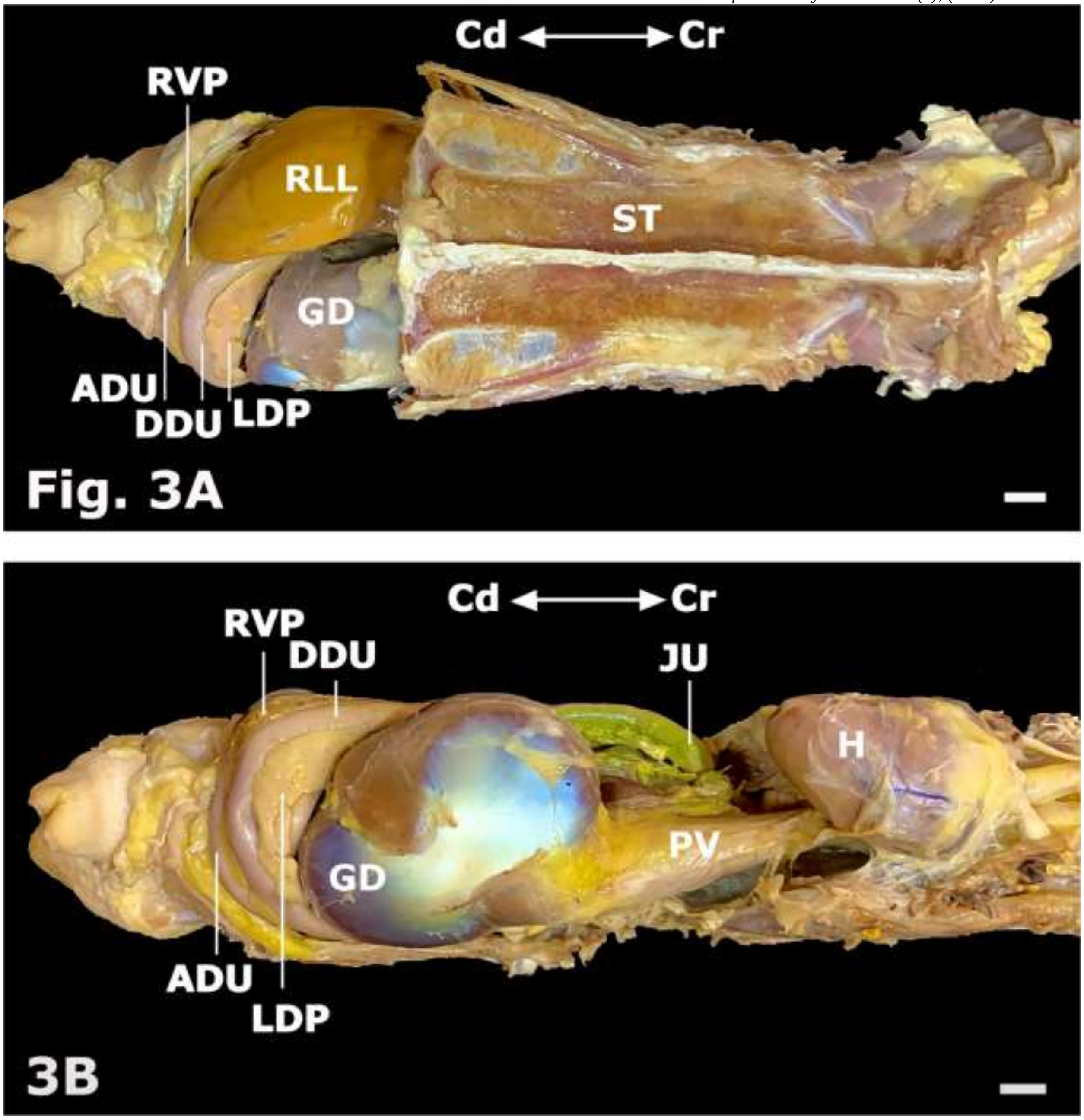


Fig. 3: Topography and morphology of the intestine of a non-laying Pekin duck, ventral views. A. surface dissection with showing the whole sternum hiding most of the intestinal mass. B. the same specimen after removing the sternum and the liver moved slightly upward to the left. ADU. Ascending duodenum, DDU. Descending duodenum, LDP. left dorsal pancreas, RVP. Right ventral lobe of pancreas, GD. gizzard, H. Heart, PV. Proventriculus, RLL. Right lobe of liver, ST. sternum. Scale bar = 1cm.

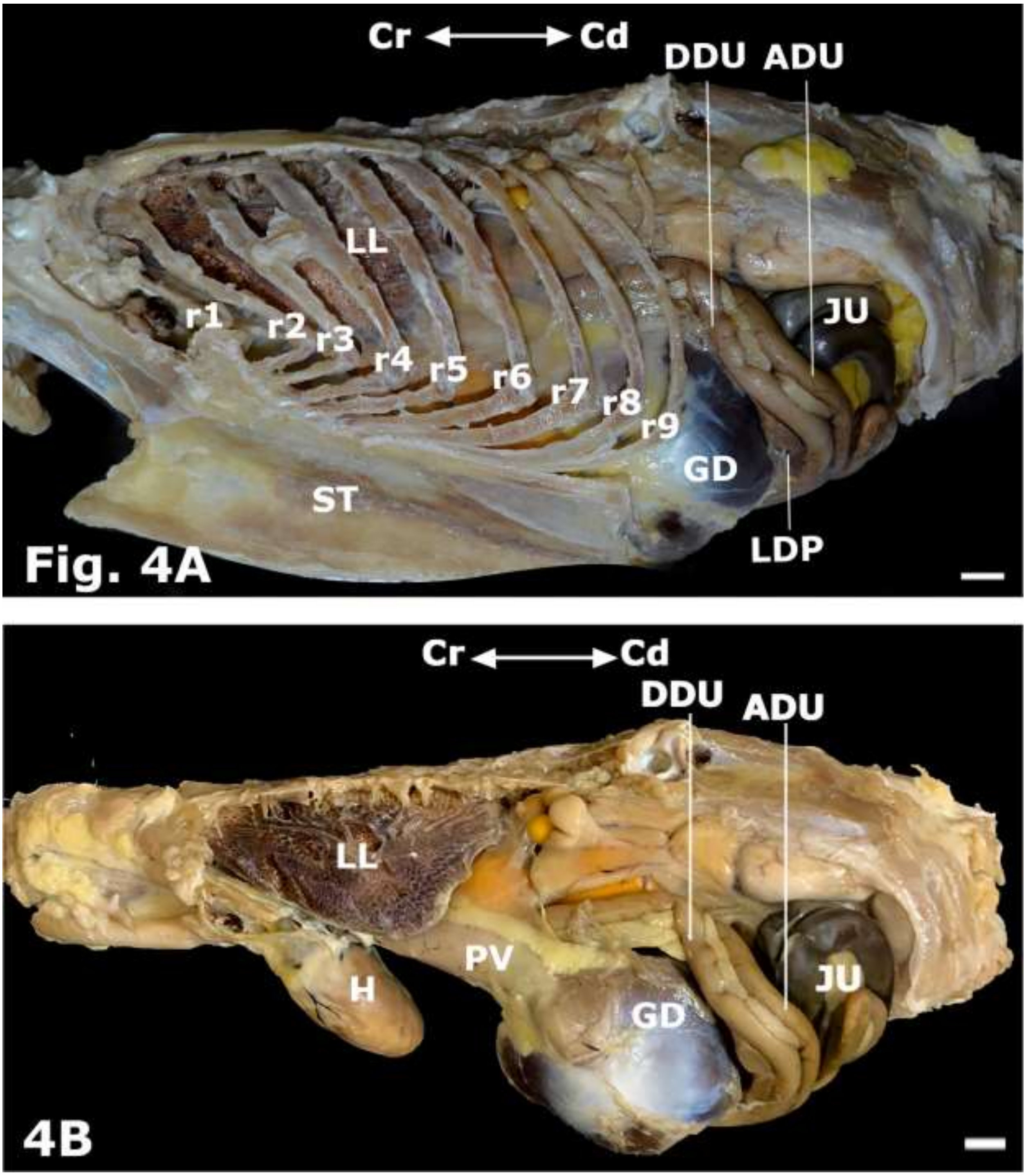
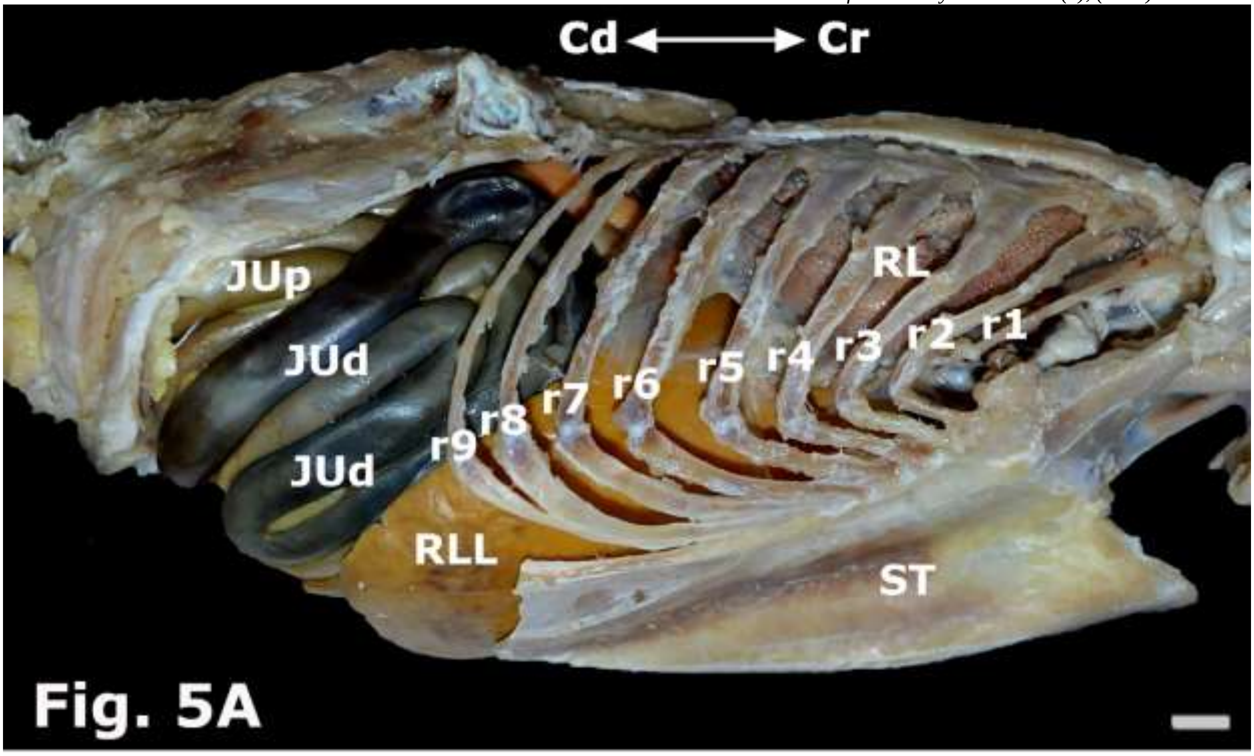


Fig. 4: Topography and morphology of the intestine of a laying Pekin duck, left views. A. Surface anatomy of the trunk where nine ribs (r1-9) are distinct while the intercostal muscles were removed. B. the same specimen after removing the ribs. ADU. Ascending duodenum, DDU. Descending duodenum, GD. Gizzard, JU. Jejunum, LL. Left lung, LDP. Left dorsal pancreas, ST. Sternum, PV. Proventriculus Scale bar = 1cm.



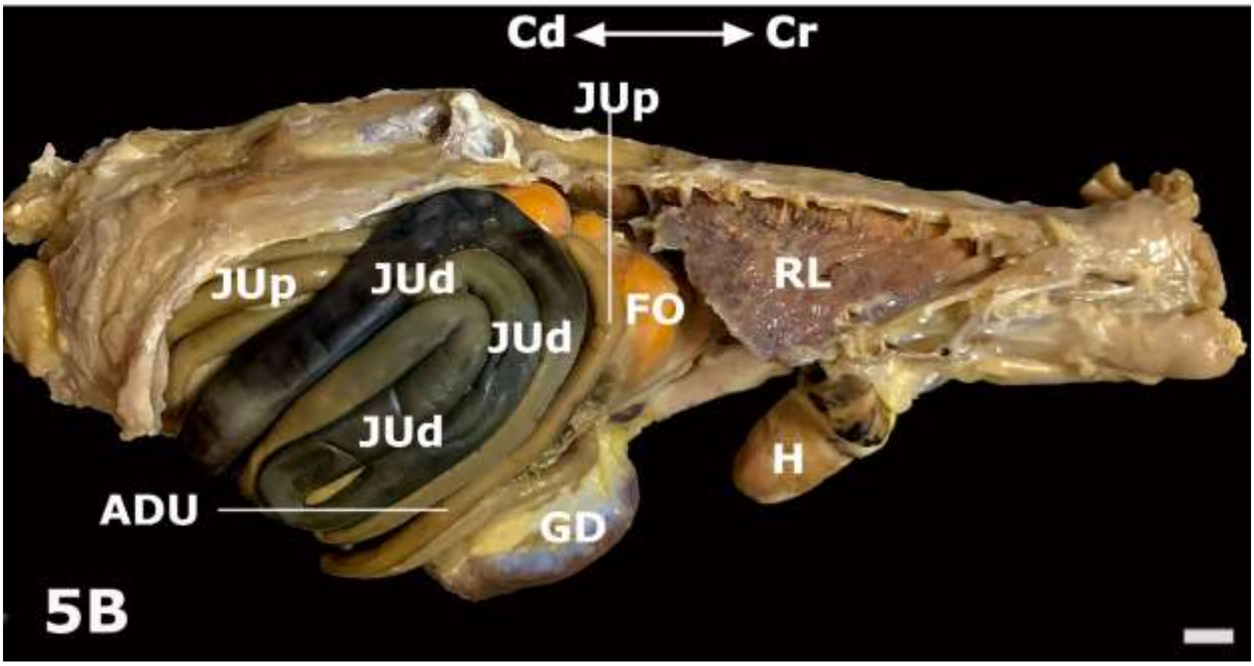
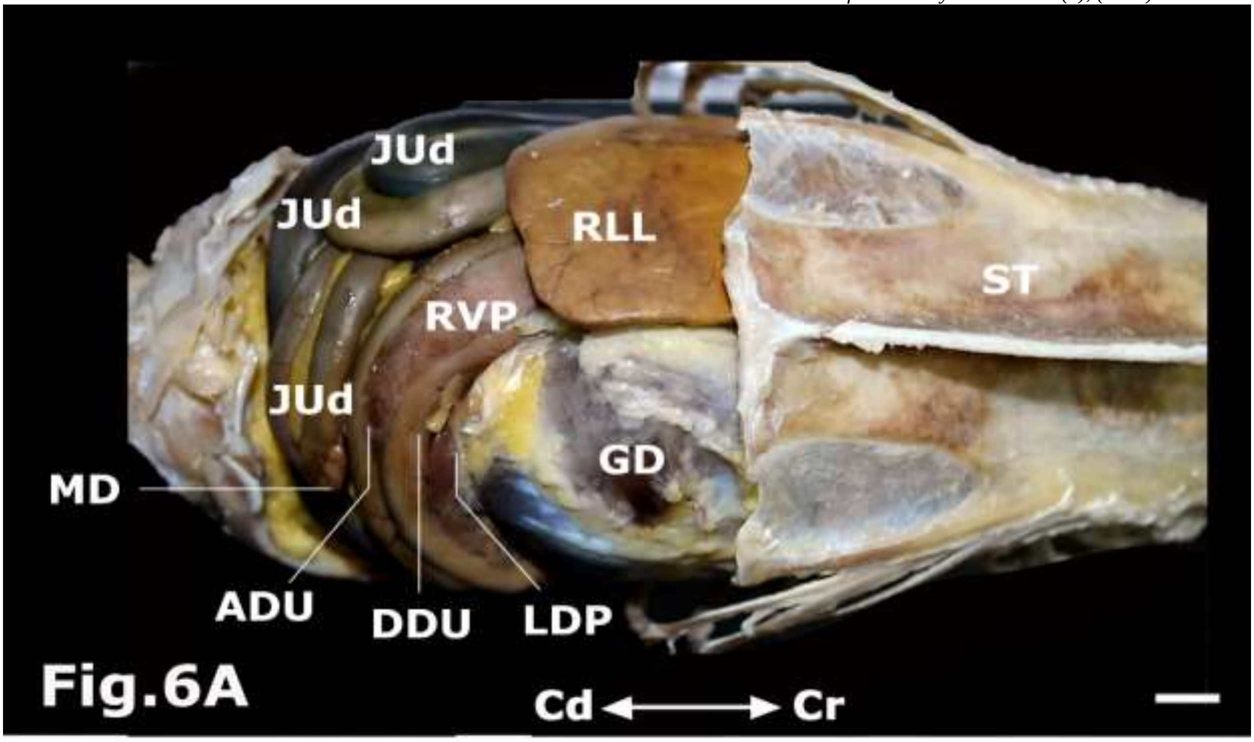


Fig. 5: Topography and morphology of the intestine of a laying Pekin duck, right views. surface anatomy of the trunk where nine ribs (r1-9) are distinct while the intercostal muscles were removed. B. the same specimen after the removal of the ribs. ADU. Ascending Duodenum, GD gizzard, H. Heart, JUd. distal part of jejunum, JUp. Proximal part of jejunum, RL. Right lung, RLL. Right lobe of liver, ST. sternum, FO. Follicle, Scale bar = 1cm.



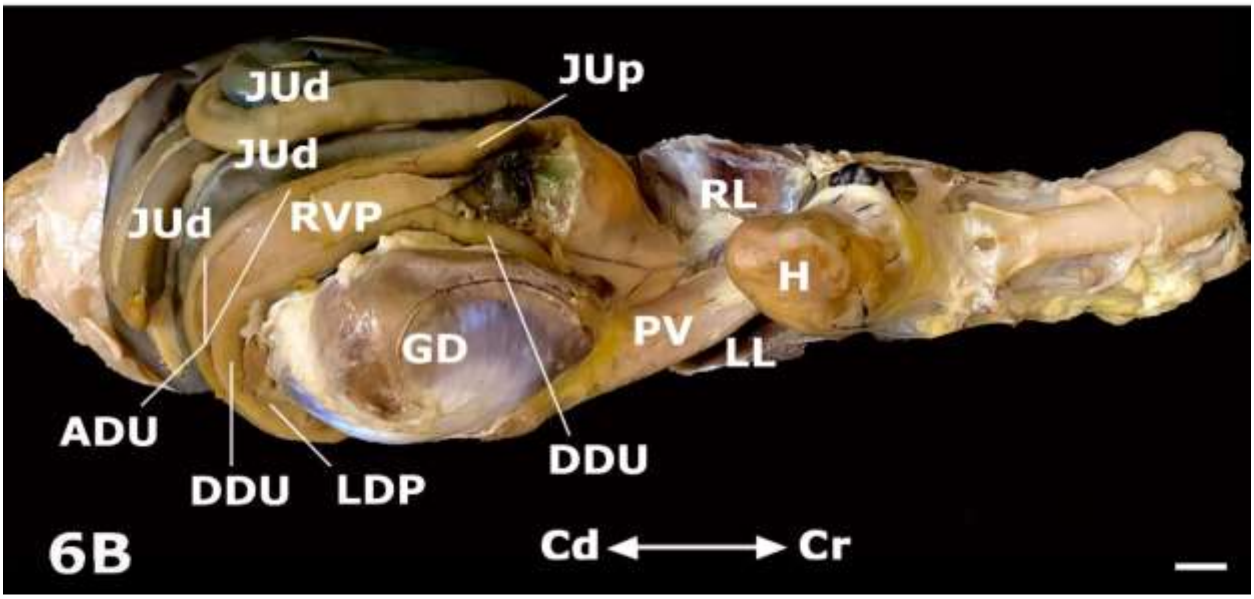


Fig. 6: Topography and morphology of the intestine of a laying Pekin duck, ventral views. A. surface dissection showing the whole sternum hiding most of the intestinal mass. B. the same specimen after removing the sternum and the liver moved slightly upward to the left. ADU. Ascending duodenum, DDU. Descending duodenum, GD. gizzard, H. Heart, LDP. Left dorsal pancreas, LL. Left lobe of liver, PV. Proventriculus, RL. Right lobe of liver, RVP. Right ventral lobe of pancreas, ST. Sternum, JUd. distal part of jejunum, JUp. Proximal part of jejunum, Scale bar = 1cm.

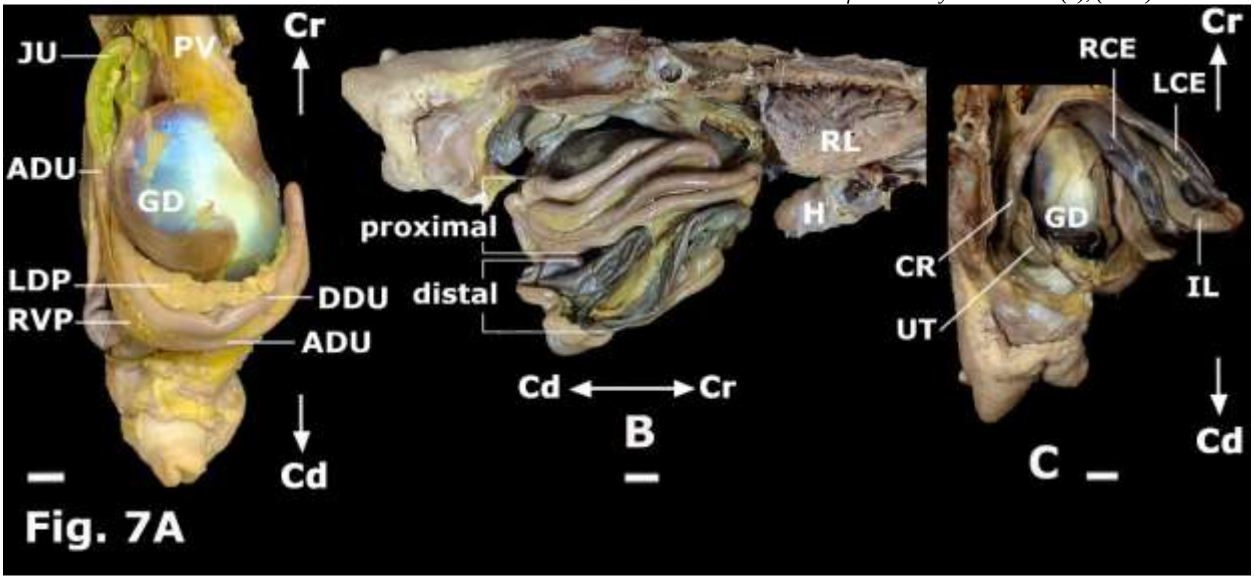


Fig. 7: Gross morphology and arrangement of the intestinal parts of a non-laying Pekin duck. A. ventral view showing the U-shape of the duodenum. B. Right view showing the proximal (deep) and distal (superficial) parts of the jejunum. C. Ventral view showing the ileum and the 2ceci as well as the colon. ADU. ascending duodenum, DDU. descending duodenum, GD. Gizzard, PV. Proventricules, H. Heart, JU. Jejunum, LDP. Left dorsal lobe of pancreas, RVP. Right ventral lobe of pancreas, IL. ileum, LCE. Left cecum, RCE. right cecum, CR. Colorectum, UT. Uterus. Scale bar = 1cm .

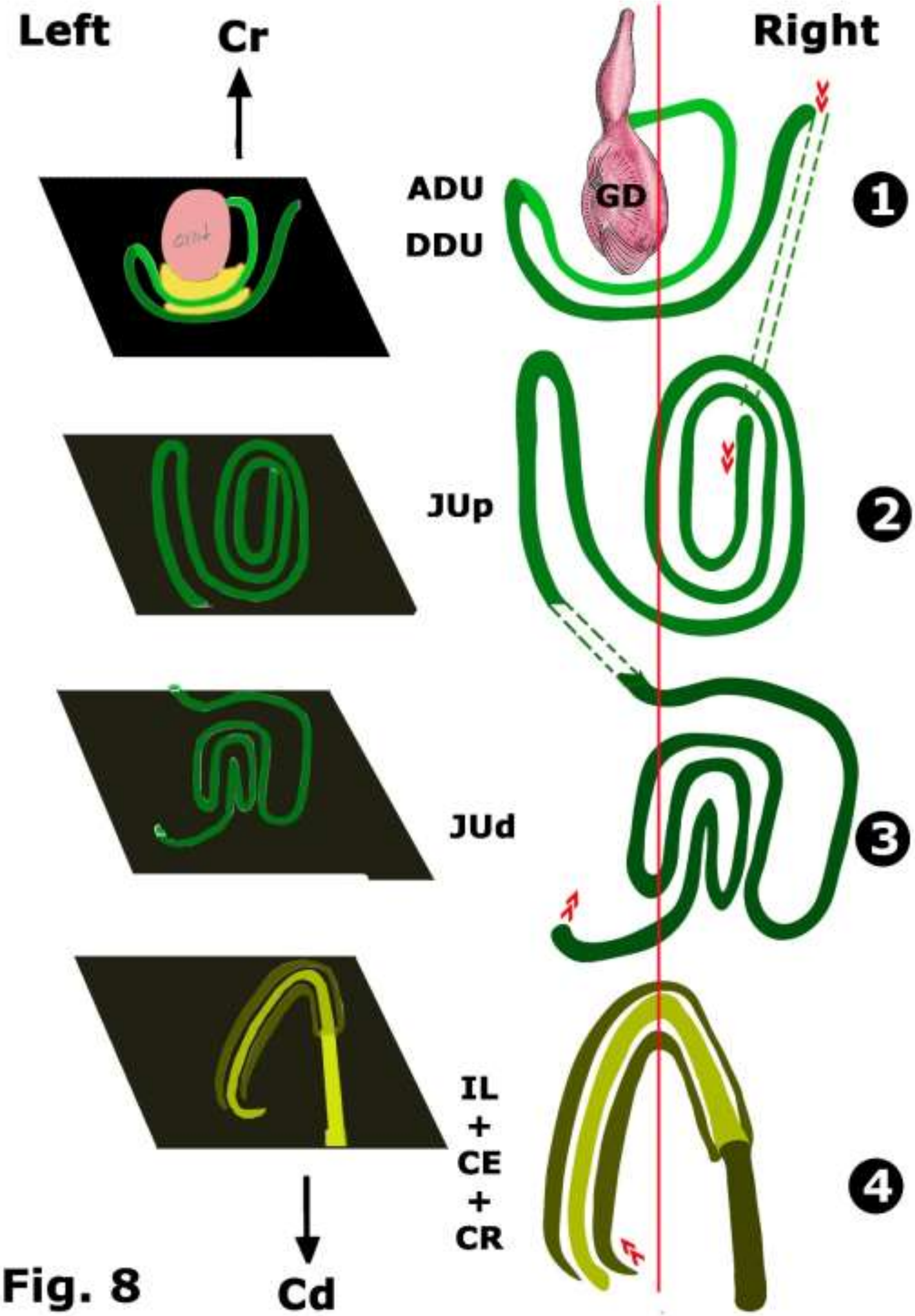


Fig. 8: Graphic drawing of the arrangement of the parts of the intestinal mass of non-laying ducks. This drawing is based on the ventral views of 4 successive layers arranged from the most ventral or floor of the cavity (1) to the most dorsal or roof of the cavity (4). (1) duodenum, (2) proximal and deep part of jejunum, (3) distal and superficial part of jejunum, (4) ileum with 2 ceci and colon. ADU. Ascending duodenum, DDU. Descending duodenum, GD. Gizzard, JUp. jejunum proximal, JUd. Jejunum distal, IL. Ileum, CE. Cecum, CR. Colorectum.

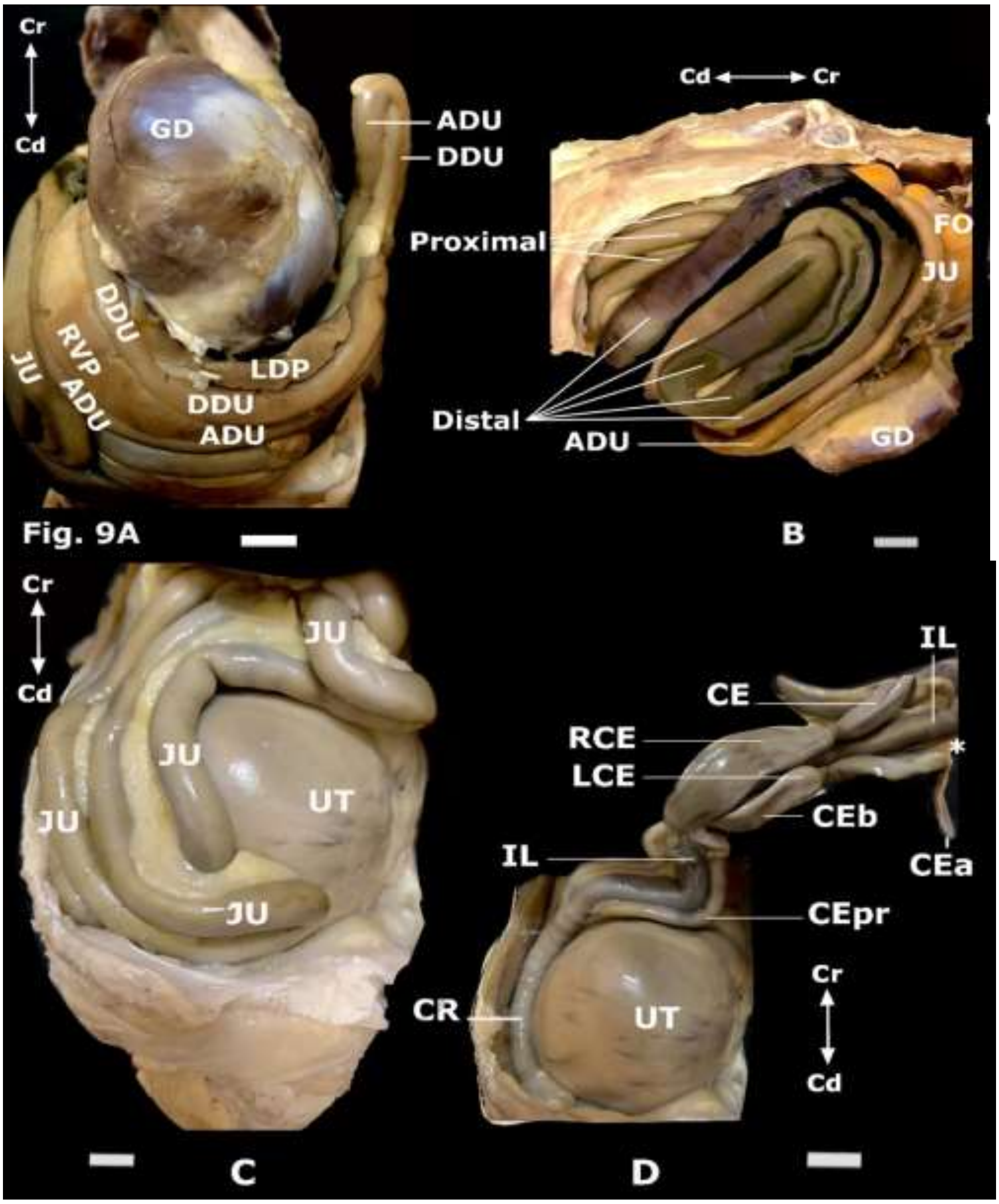


Fig. 9: Gross morphology and arrangement of intestinal parts of a laying Pekin duck. A. ventral view showing the U-shape of the duodenum. B. Right view showing the proximal (deep) and distal (superficial) parts of the jejunum. C. Ventral view showing the proximal (deep) part of the jejunum. D. Ventral view showing the ileum and the 2ceci as well as the colon. ADU. ascending duodenum, DDU. Descending duodenum, GD. gizzard, LDP. Left dorsal lobe of pancreas, RVP. Right ventral lobe of pancreas, JU. Jejunum, RCE. Right cecum, LCE. Left cecum, CEa. Apex of cecum, CEb. Base of cecum, CEpr. proximal of cecum, CR. Colorectum, IL. Ileum, UT. Uterus, FO. follicles, *. ileocecal ligament. Scale bar = 1cm

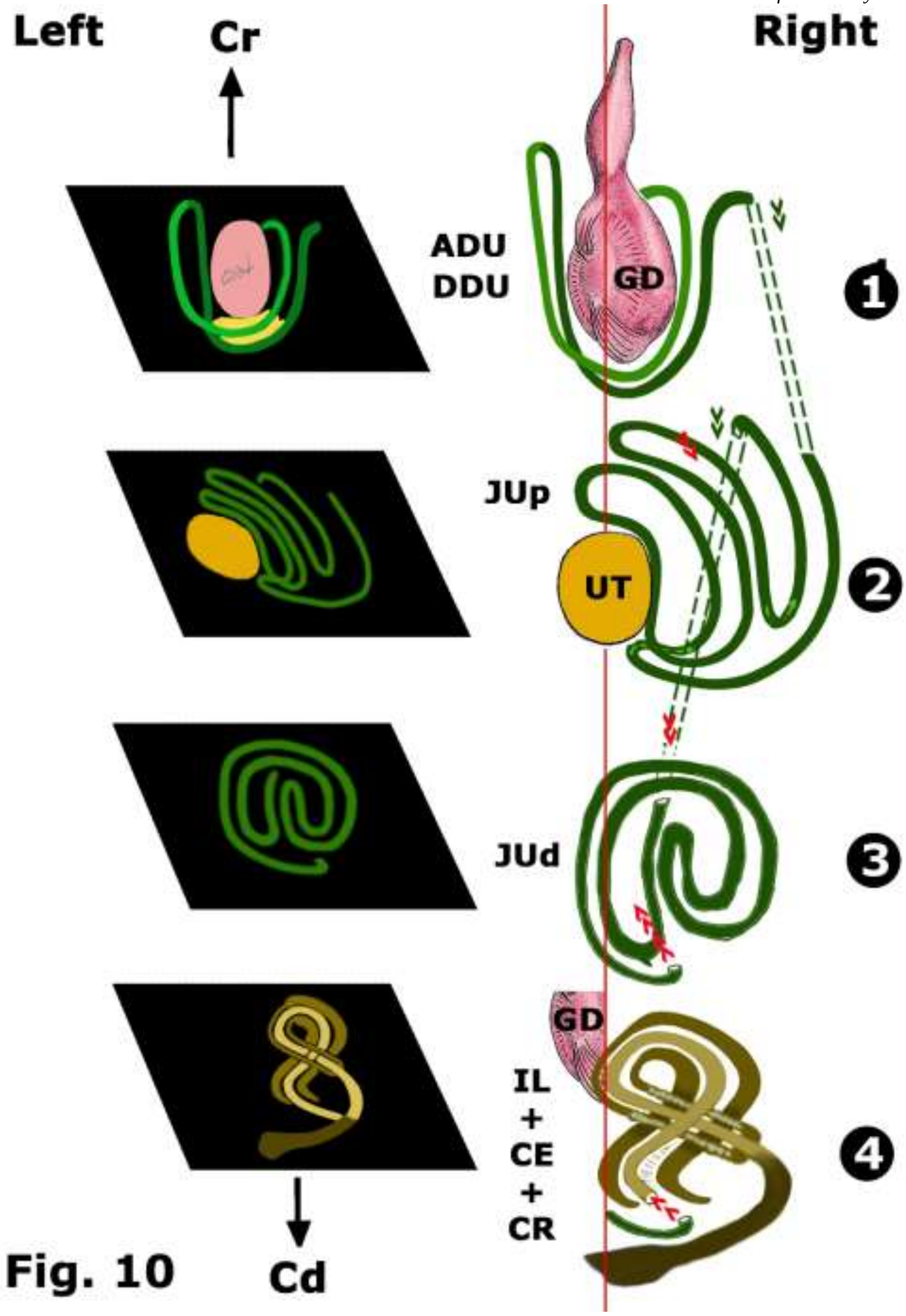


Fig. 10: Graphic drawing of the arrangement of the parts of the intestine mass of laying Pekin ducks. This drawing is based on the ventral views of 4 successive layers arranged from the most ventral or floor of the cavity (1) to the most dorsal or roof of the cavity (4). (1) duodenum, (2) proximal and deep part of jejunum, (3) distal and superficial part of jejunum, (4) ileum with 2 ceci and colon. Red arrows indicate the direction of the flow of the tube. ADU. Ascending duodenum, DDU. Descending duodenum, GD. Gizzard, JUp. jejunum proximal, JUd. Jejunum distal, IL. Ileum, CE. Cecum, CR. Colorectum

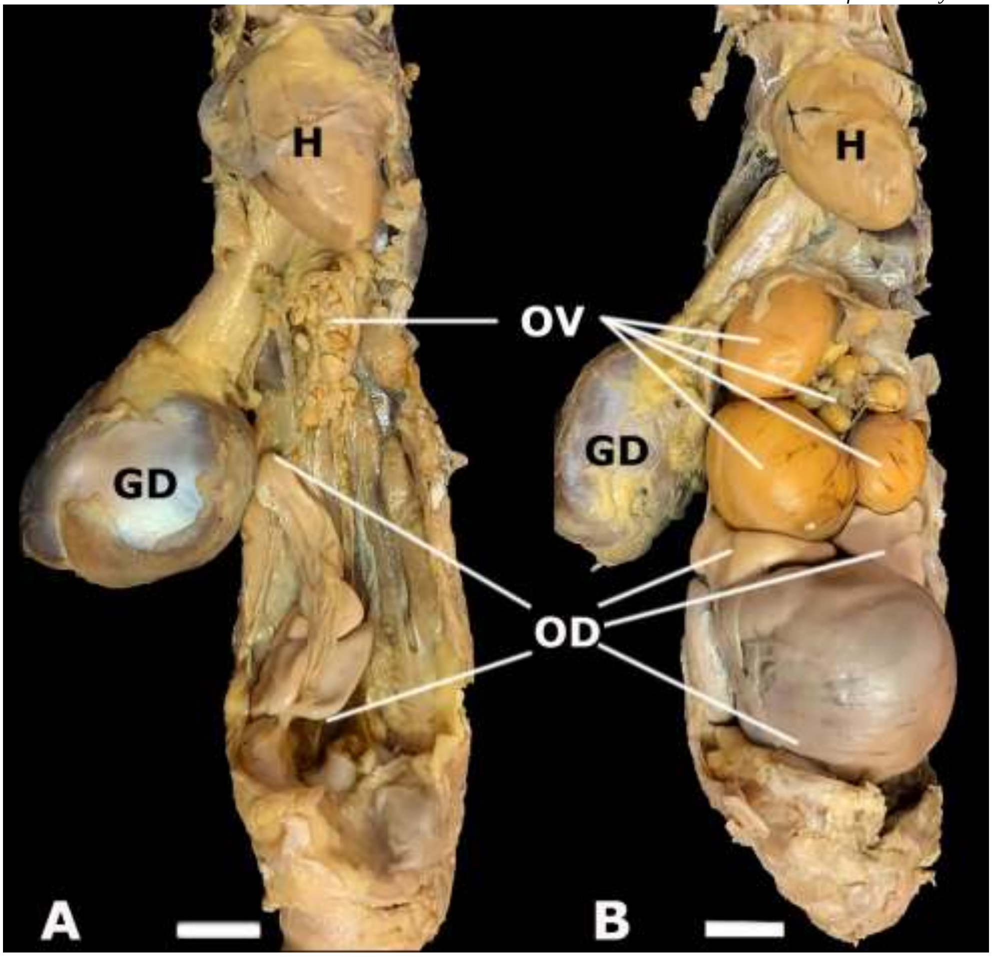


Fig. 11: Gross morphology and arrangement of the gentile tract of a non-laying (A) and laying (B) Pekin duck, Ventral views after removing the ribs and the sternum. H. Heart, GD. Gizzard, OD. Oviduct, OV. Ovary. Scale bar = 1cm.

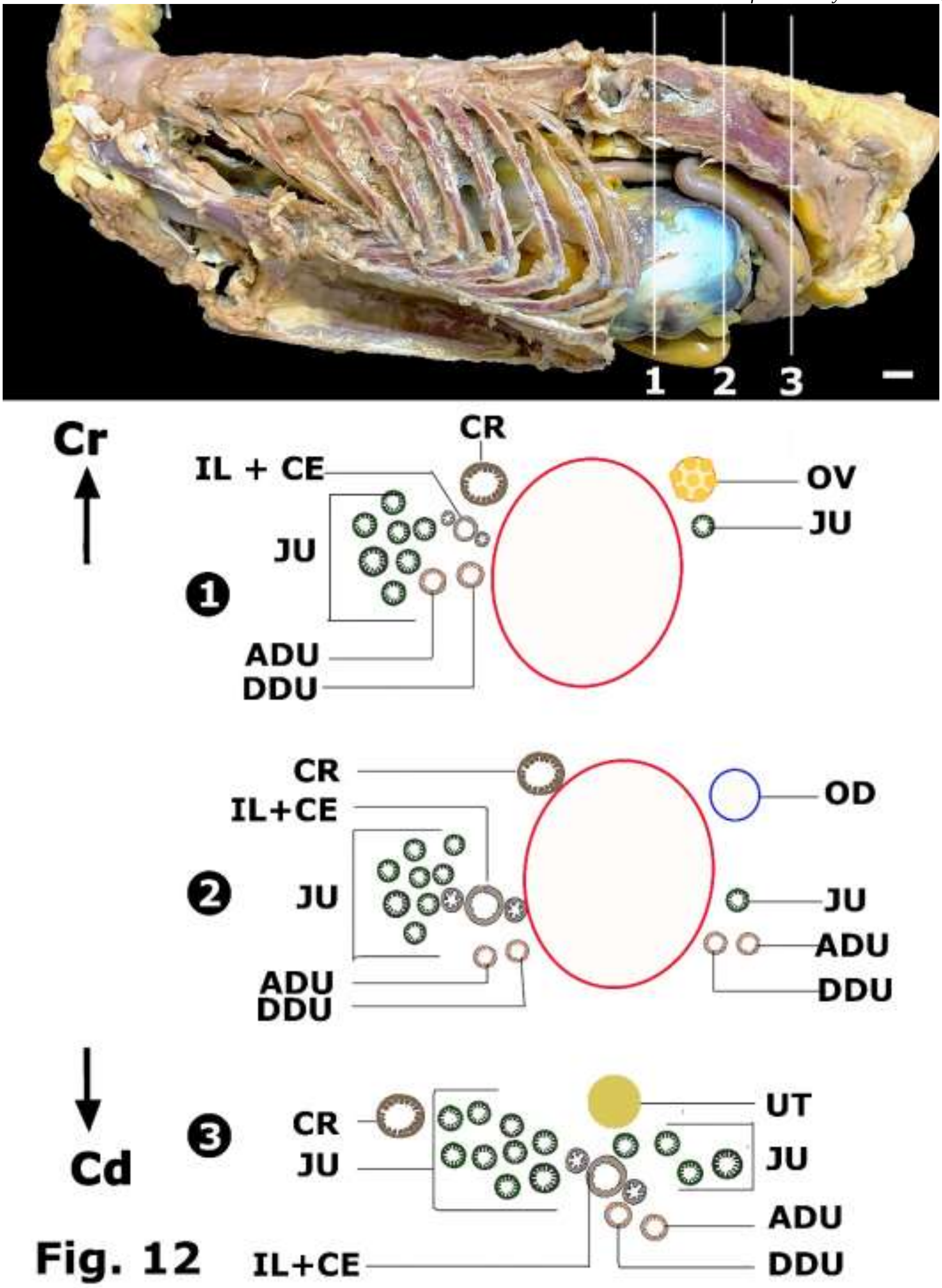


Fig. 12. Fig. 12: Graphic diagram represents 3 successive cross sections of the celomic cavity of the non-laying female Pekin ducks as illustrated in the above photo showing the relationship of the parts of the intestinal mass with the parts of the genital tract. 1. At the level of the 7th lumbar vertebra, 2. At the level of the 4th sacral vertebra and 3 at the level of the 2nd caudal vertebra. ADU. Ascending duodenum, CE. Cecum, CR. Colon, DDU. Descending duodenum, JU. Jejunum, IL. Ileum, OV. Ovary, UT, Uterus. Scale bar = 1cm.

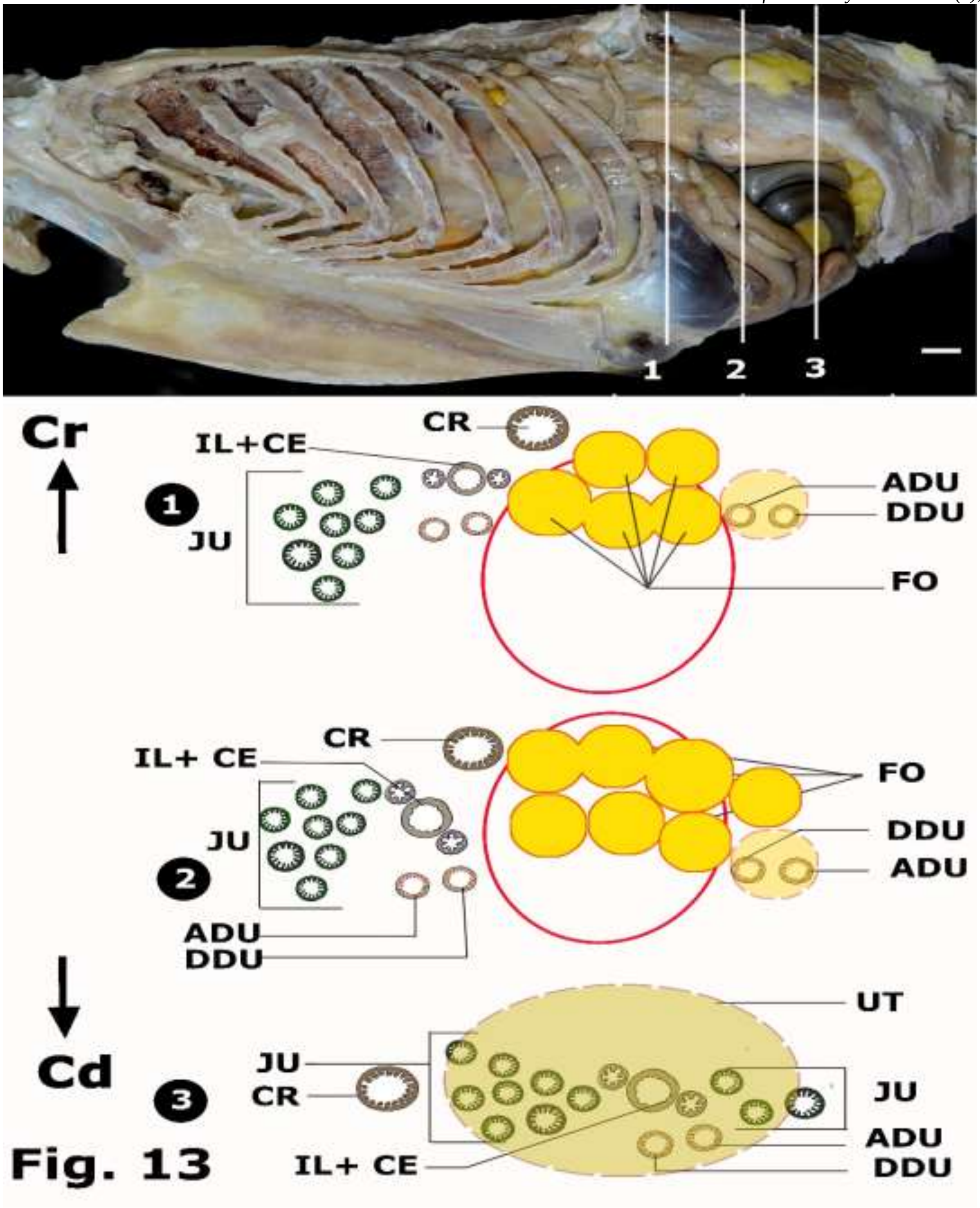


Fig. 13: Graphic diagram represents 3 successive cross sections of the celomic cavity of the laying female Pekin ducks as illustrated in the above photo showing the relationship of the parts of the intestinal mass with the parts of the genital tract. 1. At the level of the 7th lumbar vertebra, 2. At the level of the 4th sacral vertebra and 3. at the level of the 2nd caudal vertebra. The stripped lines of the follicles in 1 and 2 as well as the uterus in 3 indicate coverage of the underlying intestinal parts. ADU. Ascending duodenum, CE. Cecum, CR. colon, DDU. Descending duodenum, FO. Follicles, IL. Ileum, JU. Jejunum, UT. Uterus. Scale bar = 1cm.