STUDY OF GROSS ANATOMICAL AND HISTOLOGICAL ARCHITECTURE OF GASTRO-INTESTINAL TRACT IN VANARAJA BREED OF POULTRY

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Dedicated

to

Baba & Maa

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Certificate

This is to certify that the work embodied in the thesis entitled **"STUDY OF GROSS ANATOMICAL AND HISTOLOGICAL ARCHITECTURE OF GASTRO-INTESTINAL TRACT IN VANARAJA BREED OF POULTRY"**, *submitted by Bhanu Jyoti Sarkar in partial fulfilment of the requirements for the Degree of Master of Veterinary Science in Department of Veterinary Anatomy, Histology and Embryology , Faculty of Veterinary and Animal Science, West Bengal University of Animal and Fishery Sciences, Kolkata – 700037, is a faithful and bona fide research work carried out under my personal supervision and guidance. The research findings presented in the thesis have not so far been submitted for any other degree or diploma. The assistance and help received during the course of investigation have been duly acknowledged.*

Place: Kolkata.
Date: 14.12.2016.

(Prof. Sanjay Ray)
Chairman, Advisory Committee

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(BHANU JYOTI SARKAR)

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APPROVAL OF EXAMINERS FOR THE AWARD OF THE DEGREE OF MASTER OF VETERINARY SCIENCE

(DEPARTMENT OF VETERINARY ANATOMY, HISTOLOGY AND EMBRYOLOGY)

We, the undersigned, having been satisfied with the performance of Bhanu Jyoti Sarkar, in the Viva-Voce Examination, conducted today, the .....22.03.2017..... recommended that the thesis be accepted for the award of the Degree.

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List of Abbreviation

Abbreviation	Full form
±	Plus Minus
%	Percentage
cm.	Centimeter
et al.	Et alll, and others
Fig.	Figure
g or gm	Gram
Viz.	videlicet
µ	Micron
H&E	Haematoxylin and Eosin

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Chapter - 1

Introduction

INTRODUCTION

1.1 INTRODUCTION

The global economy provides a great importance to the agricultural sector. Agricultural sector, which consists of crop cultivation, meat industry, dairy plants, egg production etc., has immense influence on the Indian economy. Proper manipulation and perfect extension of laboratory technology from laboratory to farm is needed throughout the country for betterment of this sector and thus to get healthy economy for the country. Animal husbandry sector contributes a large portion to the agricultural sector; especially poultry industry has now become a very important and prosperous industry. The Indian poultry industry alone provides 17% of income to the Indian agriculture sector. At present India is the third largest country in egg production in the world while in broiler production India is placed in fifth position. The poultry industry of India is rising at the rate of 8 to 10% for egg production and 15 to 20% for broiler (Srivastava, A.K., 2011). Besides that per capita availability of egg and meat are 45 and 2.00 kg respectively in India against the recommended level of 180 eggs and 9.00 kg of meat by Indian Council of Medical Research (Niranjan *et al.*, 2008). In this context, to meet the increasing demands of the growing population, to increase the per capita consumption among the Indians and to get maximum return from this sector India has to adopt various measures like focusing on backyard poultry farming, exploring new technologies and their proper manipulation, establishment of single window system to address different issues regarding poultry industry etc.

In India, most of the rural and tribal masses have been keeping faith on traditional poultry farming for their livelihood and nutritional security since the time of immemorial. Major portion of the farmers are still rearing 10 to 15 numbers of low input indigenous fowls at their backyard to meet the demands of both meet and eggs and to meet their daily expenses and nutritional security. But the native indigenous fowl having low inherent genetic potentiality results very low productivity. A dual purpose high yielding variety of chicken, Vanaraja, developed by Project Directorate on Poultry, Hyderabad was successfully introduced in different parts of India and now it is giving

promising production and reproductive performance under backyard system of farming. Besides Vanaraja birds were fast growing, having good egg production and low mortality in comparison with indigenous desi chicken (Chaurasia,R.K 2015), though they were very prone to predators (Kundu *et al* 2015) As a matter of fact, Vanaraja variety of poultry has now become a thirsty area of research.

The economy of poultry industry stands on the effective feed conversion ratio of this species. Therefore it becomes a matter of prime importance to study the normal structural organization of different components of digestive system of Vanaraja chicken for better understanding of the digestive physiology and pathology of the system.

The avian digestive system is consisted of a tubular duct of varying structure together along with associated glands like liver, pancreas etc. The gastrointestinal tract extends from the beak anteriorly to the external opening of cloaca posteriorly. The urinary and reproductive systems also share the cloaca. Therefore, the tract can be subdivided into several parts like the buccal cavity and pharynx, the esophagus and the crop,the glandular stomach proventriculus and the gizzard,the intestine and caeca,and the cloaca. (Hodges,1974).

Previous works have been done on the different parts and organs of digestive system of different species of fowl like emu (Madhu *et al*, 2015), pigeon (Hassan and Moussa, 2012), Japanese quail (Ahmad *et al*, 2012), Red Jungle Fowl (Kadhim *et al*, 2011) etc. But specific literature of vanaraja chicken is still lacking.

Considering the immense importance of the digestive system of Vanaraja chicken and paucity of literature, the present study has been undertaken with the following objectives-

- To study the gross anatomy of gastro-intestinal tract of Vanaraja chicken.
- To study the morphometry of different parts and organs of gastro-intestinal tract of Vanaraja poultry.
- To study the histomorphology of Gastro-intestinal tract of Vanaraja chicken.

Chapter - 2

Review of Literature

REVIEW OF LITERATURE

*I*n the present investigation, the literatures relevant to the work have been reviewed keeping in view the objectives of our studies. The literatures have been arranged below, according to the following subheadings.

2.1.GROSS ANATOMICAL STRUCTURE:

2.1.1 The Crop and Esophagus:

Shehan (2012) described that the esophagus of goose is located in right side of the neck and it is composed of cervical part and thoracic part. The cervical part was longer than thoracic part. The crop was an enlargement of esophagus.

Madhu *et al* (2015) stated that the oesophagus of adult emu bird was a long, muscular tubular structure which was originated from the cranial aspect of the oropharynx and was distinguished by cervical and thoracic part.The internal surface of the oesophagus was of cream colour and posses some longitudinal folds. They also described that the crop was absent in case of emu.

Ghosh and Hegde (1991) described that in pigeon, the mucosal foldings were short and broad in oesophagus while it was long and narrow in case of crop.

Ali (2014) studied that the oesophagus of sea gull was a thin walled, elastic muscular tube which was situated between the oropharynx and glandular part of stomach.

Grazal (1995) narrated that the crop of the hoatzin was folded into two interconnected chambers whereas the lower esophagus was multi chambered structure. Both the crop and the csophagus were posses muscular structure between chambers.

Evans (1996) stated that the oesophagus was dorsal to the trachea in the anterior regions of the neck and then continued along the right side in case of budgerigar.

Bailey *et al* (1997) narrated that in case of captive bustards, crop or any other oesophageal enlargement was absent.

2.1.2 The Proventriculus and Gizzard

Al- Saffar *et al* (2016) described that the stomach of the striated scope owl was composed two externally distinguishable glandular proventriculus and muscular,round shaped gizzard. Longitudinal shaped, thick walled proventriculus was continued cranially with the oesophagus.

Catroxo *et al* (1997) stated that the stomach of red-capped cardinal was composed of glandular proventriculus which was cranially connected to the oesophagus and caudally to the muscular portion of stomach namely gizzard or ventriculus.

Hassan and Moussa (2012) narrated that the pigeon's proventriculus was cone shaped while it was tubular in case of duck and it arose from oesophagus. The proventricular wall was thicker than that of the oesophagus. They also stated that the gizzard or ventriculus was biconvex lens in shape which joined proventriculus by cardiac sphincter and joined the hind gut by the pyloric sphincter. The inner portion of the gizzard in both species exhibited hard membranous lining.

Bailey *et al* (1997) studied that, in case of captive bustards, the proventriculus was extended from the oesophagus without any distinct demarcation and it was cone- shaped. The ventriculus was oval –shaped and its inner aspect was lined by a hardened membrane.

Abumandour (2013) stated that the stomach of falcon was a muscular structure lying at the dorsal surface of liver and was divided into two different structures – the proventriculus and the gizzard. The glandular structure proventriculus was located cranially and the muscular part gizzard placed caudally.

2.1.3.The small intestine: The small intestine of fowl is divided into three parts- duodenum, jejunum and ileum.

2.1.3.1.The Duodenum:

Jain *et al* (2016) described that the duodenum arose from right aspect of gizzard craniodorsally and joined jejunum which was ventral to the right kidney. The length of the duodenum was ranged as 20 to 30 cm.

Ahmad *et al* (2012) revealed that the 'U' shaped duodenum was located towards the right side of the abdominal cavity in case of Japanese quail. The ascending and the descending loop of the duodenum enclosed the pancreas. Ventrally it was looked like a bulged part of small intestine. The duodenum was extended from the antero-dorsal aspect of the gizzard to the terminal point of ascending limb. It was contacted in its left side to the right side of gizzard while it was related in its right side with the right lobe of liver. Two pancreatic ducts and two bile ducts were opened in the ascending loop of duodenum.

Igwebuike and Eze (2010) reported that the duodenum of the African pied crow was U- shaped tubular structure and was having a proximal descending and a distal ascending limb that were separated by the pancreas. The loop was present in the caudal part of the left side of the abdominal cavity. Two pancreatic and two bile ducts were opened closely to each other into the ascending limb.

2.1.3.2.The Jejunum and Ileum:

Ahmad *et al* (2012) narrated the jejunum of the Japanese quail was arranged in a coil which were suspended by mesentery towards the dorsal portion of the abdominal cavity and it was the longest part of the intestine. Small, straight ileum was located in between two ceca.

Igwebuike and Eze (2010) described that the jejunum was arranged in the form of cone-shaped spiral coils which exhibited centripetal, a sigmoid flexure and centrifugal coils in case of African pied crow. The apex of the cone of the coil was formed by the sigmoid flexure. On the other hand, the short ileum was arisen from the point of origin of ceca. Cranial mesenteric artery marked the demarcation between the jejunum and ileum.

Indu *et al* (2011) narrated that ileum of peafowl was straight, containing a long ascending part and a short descending pat and was extended from the Meckel's diverticulum of jejunum to the ileo-ceco-colic junction. Short, straight colo-rectum was opened into the cloaca caudally.

2.1.4.The large intestine:

2.1.4.1.The Ceca:

McLelland (1989) studied that right and left ceca arise laterally or ventrolaterally at the junction of small and large intestines in most birds. The secretary bird possessed two pairs of ceca. However in many herons and bitterns only one ceca was present. In woodpeckers, hummingbirds, swifts, kingfishers, pigeons, mousebirds, cuckoos and parrots, ceca was absent. Cecum was vestigial, moderately or poorly developed organ and was classified according to its length. Ceca were simple tubular structures in most of the birds whereas succulated or diverticulated ceca were seen in ostrich, rhea, kiwi, red-throated loon, screamers, the satyr tragopan, the great basbard, pin–tailed sand grouse. There was no relationship with the size of the ceca and the length and width of the rectum.

Ince *et al* (2010) depicted that Large intestine was initiated by a pair of rudimentary ceca which located at both sides of the ileum in case of Marmara region sea gulls.

Ghosh (2015) described that fowl exhibited right and left caeca that were connected with the gastro-intestinal tract at the junction between ileum and colo-rectum. Each cecum was divided into three parts. Narrow proximal part was connected with the intestine. Middle part was wide and expanded distal part was terminated in the form of a pointed end.

2.1.4.2.The Colo-rectum:

Indu *et al*.(2011) stated that the light grey coloured colo-rectum was a short and nearly straight line below the lumbo-sacral vertebrae which was opened into the ileum cranially and cloaca caudally in case of pea-fowl.

Getty (1975) depicted that the rectum was short and light gray to green in colour which was located ventral to the lumbo-sacral vertebrae. It extended from the ileum cranially and was continued almost as an straight tube to the cloaca. It was suspended from the dorsal wall of the abdominal cavity by a short part of mesentery.

Ghosh (2015) studied that the colo-rectum was a straight portion and was extended from the ileum to the cloaca. It was located dorsally in the left part of the abdominal cavity.

2.1.5.The Pancreas:

Clara (1924) reported that in fowl, along with two lobes (dorsal and ventral) a smaller lobe, which was extending from the head of the pancreas towards the spleen was reported and this lobe was named as splenic lobe.

Mikami and Ono (1962) observed that an additional subdivision of the lobes of the pancreas was established. The ventral lobes were composed of ventral lobe proper and the third lobe based on the latter's independent structure and peculiar distribution of the islets.

Getty (1975) reported that the pale yellowish and reddish pancreas exhibited dorsal, ventral and splenic main lobes. The dorsal, ventral and third lobes were long, thin and were extended longitudinally in the dorsal mesentery joining the ascending and descending parts of the duodenum. The gland possessed three main excretory ducts which were opened into the ascending part of the duodenum.

Guha and Ghosh (1978) studied that the avian pancreas was a tongue-shaped structure characterized generally by three morphologically distinct lobes; splenic, dorsal and ventral.

Al-Agele and Mohammed (2012) observed that the short, semi-wide pinkish coloured pancreas of golden eagle was bilobed which were found to be extended from the origin of duodenal loop to one third length of the duodenal loop. An additional small lobe was originated from the end of the dorsal lobe towards the spleen was termed as splenic lobe.

Al-Sharoot and Ali (2016) narrated that the pancreas of early hatched goose was trilobed, pale pinkish in colour, situated between the descending and ascending duodenal loops on the right side of the abdominal cavity was covered by mesentery pancreatic duodenal ligament.

2.1.6.The Liver:

Selman (2013) reported that the liver of the coot bird located in the ventral part of the abdominal cavity and was found to be red brown in colour. It consisted of right and left lobes.

Stornelli *et al* (2006) studied that left lobe of the liver of ostrich were subdivided into three lobes while right lobe was undivided. Gall bladder was absent in ostrich.

Moslem (2015) depicted that in case of ostrich, the undivided right lobe of the liver was larger than that of the left one. Ostrich liver did not possess any gall bladder. On the other hand, the right lobe of the bi-lobed poultry liver was having gall bladder but the left one did not.

Ghosh (2015) described that the both right and left lobes of fowl liver were attached ventrally by peritoneal fold and the lobes were placed at abdominal cavity floor. He also depicted that the right lobe possessed a large gall bladder while the left one was devoid of gall bladder. The hepato-cystic and hepato-enteric duct were arouse from right and left lobe respectively and were opened into the ascending limb of duodenum.

2.2 HISTOLOGICAL STRUCTURE:

2.2.1.The Crop and Esophagus:

Shehan (2012) studied that the cervical part of esophagus of geese is composed of mucosa, submucosa, muscular and serosa layer. Keratinized stratified epithelium is absent in mucosa .Some mucous gland, nodular lymphatic tissues are present within the connective tissue of lamina propia. The submucosa contained fibrous tissue. The muscular tunica consists of an inner circular and outer longitudinal layer of smooth muscle. The serosa is composed of thin loose connective tissue, collagen and elastic fibre. He also studied that the structure of crop of geese was similar with the cervical part and was composed of non keratinized stratified squamous epithelium. The muscular layer constituted by an inner circular and outer longitudinal layer of smooth muscle and the serosa layer is composed of loose connective tissue with collagen and elastic fibrous. The submucosa layer is composed of loose connective tissue and the muscular layer is composed of an inner and outer longitudinal layer.

Rossi *et al* (2006) studied that the oesophagus mucosa of the partridge was constituted by stratified squamous epithelial layer and possessed mucous glands and lymphatic tissues. Serosa layer was composed of three layers. The structure of crop was similar to that of oesophagus except there was reduction in size of mucous glands. The lymphatic tissues were dispersed in the connective tissue. Long with these, there was a thin stratum of smooth muscle, longitudinal and circular musculature.

Rajabi and Nabipour (2009) stated that, keratinised stratified epithelium was present in oesophagus and crop in case of Rock Dove, Collared Dove, Rose-ringed Parakeet, Kestrel, House Sparrow and Linnet. The glands are absent in the cervical part of oesophagus and in the crop in case of rock dove, rose-ringed parakeet and collared dove. Smooth muscle fibers formed the thick muscularis mucosa. The tunica submucosa was a loose connective tissue which contained vessels and nerves. The tunica muscularis was composed by smooth muscle and was surrounded by the tunica adventitia at the cervical portion and crop and by the tunica serosa in case of thoracic part.

Madhu *et al* (2015) described that the mucous membrane of the oesophagus of the adult emu was having some irregular folds and was lined by non keratinized stratified squamous epithelium. Lamina propria showed diffused and aggregated lymphocytes. A single layer of columnar cell having small round basal nuclei lined the oesophageal glands. The tunica muscularis was composed of an inner thick circular and outer thin longitudinal layer. Between these layers, nerve plexus and blood vessels were present.

Kadhim and Mohamed (2013) studied that the mucosa of oesophagus of the homing pigeon was composed of four layers; tunica mucosa, tunica submucosa, tunica muscularis and tunica adventitia. The mucosa was formed by non-keratinized squamous epithelium while lamina propia was a loose connective tissue which contained mucous glands. The mucous glands were less developed in cervical part than that in thoracic part of oesophagus. The submucosa and mucosa were thicker in case of cervical oesophagus. Muscular layer was composed of a circular and longitudinal layer of smooth muscle and this layer was thicker in case of thoracic oesophagus. The longitudinal muscular layer folds of the cervical oesophagus were deeper than that in the thoracic.

Ghosh and Hegde (1991) stated that multilayered mucosa layer of was well defined in case of crop and oesophagus of pigeon. The submucosal glands were almost absent in oesophagus and crop. The muscular layer of oesophagus was thicker than that of the crop. The crop possessed differential thickness of mucosa, submucosa and muscular layer at the upper, middle and lateral regions whereas the oesophagus did not revealed significant structural alteration along its length.

Parchami *et al* (2011) narrated that the muscularis mucosa was a well developed continuous layer of smooth muscle. The simple branched mucous glands were present in both cervical and thoracic oesophagus .The mucous glands were well developed in thoracic part of the organ than in the cervical part. Presence of mucous glands was an important feature of the oesophagus of the common quail.

Zhu *et al* (2015) described that the oesophageal glands were mucous glands and their numbers were more in cervical part than that in the thoracic part. They also stated that in lamina propia there were two types of glands such as simple tubular glands and compound tubular glands.

Ali (2014) stated that the oesophagus of sea gull was composed of four layers. The first layer was lined by stratifified keratinized epithelium and lamina propia contains mucous glands in the thoracic oesophagus. The submucosal layer consisted of mucous glands and muscular layer composed of circular inner layer and longitudinal external layer.

Rodrigues *et al* (2012) stated that, in case of macaw the mucosal folds were lined by non keratinised stratified squamous epithelium. The lamina propria was consisted of dense connective tissue. The single branched oesophageal mucous glands were confined to lamina propria. The crop and oesophagus were histologically similar.

2.2.2.The Proventriculus and Gizzard:

Kadhim *et al* (2011) stated that, tunica mucosa of stomach of Red Jungle Fowl was lined by simple prismatic epithelium. Lamina propria of both proventriculus and gizzard contained simple tubular glands. Simple cuboidal cells lined the ventricular glands. The glands of proventriculus were located between the inner and outer layers of

lamina muscularis mucosae. The proventricular tunica submucosa was very thin. Oblique muscle fibers were also present in addition with inner circular and outer longitudinal smooth muscle layers which formed the inner most layer of tunica muscularis.

Glerean and Katchburian (1964) depicted that the epithelial lining of proventricular glands was constructed by cubic to prismatic cells in case of Gallus gallus domecticus.

Al- Saffar *et al* (2016) described that the wall of proventriculus and gizzard of striated scope owl consisted of the four layers such as tunica mucosa, submucosa, tunica muscularis and tunica serosa. The gizzard lacked the smooth muscles fibre and keratinoid lining of the mucosal surface was absent.

Zhu (2015) experimented that the wall of the proventriculus and gizzard were composed of a mucous membrane (tunica mucosa gastris), a muscular layer (tunica muscularis gastric) and the serosa (tunica serosa gastris) in case of black tailed crake. The mucous membrane of proventriculus was lined by a simple columnar epithelium. The lamina muscularis mucosa of proventriculus was composed of a layer of longitudinal muscle. The mucous membrane of gizzard was lined by high columnar cells and the epithelium was invaginated to form folds and sulci.

Bradley and Grahame (1951) narrated that in case of domestic fowl, the mucous membrane of proventriculus and gizzard possessed several folds. The muscular layer of proventriculus was consisted of an inner longitudinal, a median circular and a discontinued external circular layer of smooth muscle.

Catroxo *et al* (1997) narrated that the mucous lining of proventriculus and gizzard of Red Capped Cardinal possessed simple prismatic epithelium and a thick cuticle was laid over the mucosa of the gizzard. The lamina propia exhibited simple tubular glands in both the organ. Deep proventricular glands were present in submucosa layer. The submucosa of the gizzard could not be differentiated from lamina propia due to absence of muscularis mucosae. The muscle tunic of proventriculus was composed of a inner longitudinal layer, of an intermediary circular layer and of an external discontinuous layer of smooth muscle while the gizzard consisted of an inner longitudinal and of an outer circular layer. The serosa was composed of a connective tissue lining.

Ahmed *et al*.(2011) revealed that the stomach of the Japanese quail was composed of mucosa, submucosa, muscularis and serosa layer. Sulci and plicea were formed by mucosa of the proventriculus. The muscularis mucosa possessed compound tubule-alveolar glandular lobules. The gizzard mucosa formed the tubular glands in the lamina propia and the glands are lined by cuboidal cells. Muscularis mucosa is absent in case of gizzard of Japanese quail.

Hassan and Moussa (2012) studied that the tunica mucosa of the proventriculus and ventriculus of the duck was lined by columnar epithelium while in pigeon it was lined by cuboidal epithelium. The ventricular glands that were situated in lamina propia were lined by simple cuboidal cells. The proventricular glands were located between the inner and outer layers of the lamina muscularis mucosae. The tunica submucosa was not separated from the lamina propia in ventriculus due to absence of tunica muscularis mucosae while it was very thin in proventriculus. An additional layer of oblique muscle formed inner layer of the ventriculus.

Toner (1964) stated that the mucosa of the gizzard of the domestic fowl was composed of simple tubular glands and the surface layer of gizzard was lined by hard protein material.

Rossi *et al* (2005) studied that the proventriculus of the partridge consisted of several glands and lobes and its mucosa was formed by folded simple cubic epithelium. The mucosa of biconvex lens shaped muscular stomach was formed by folds and was lined by columnar cells. There were existences of crypts in the base of the folds. The serosa was composed of dense connective tissue sand some smooth muscle cells.

2.2.3.The small intestine:

2.2.3.1.The Duodenum:

Dellman (1971) described that the surface of the tunica mucosa of the duodenum was studded with finger like projections, the intestinal villi, which varied in length depending upon the region and the species. The intestinal glands (crypts), which were opened into the pits between the bases of the villi, penetrated the mucosa as far as the lamina muscularis. Blood and lymph vessels were present within the lamina propria.

Hodges (1974) reported that the intestinal mucosa was formed into large number of long, leaf-shaped villi which were arranged in a zigzag pattern, varied in number, shape and size according to their location. The crypts of Lieberkuhn, short and simple, slightly sinuous ducts opened in between the villi.

Ahmad *et al* (2012) narrated that finger shaped, tallest villi of intestine were found in duodenum in case of Japanese quail. The population of the villi were maximum in number in duodenum. The epithelium of villus was lined by columnar cells and between these cells, goblet cells and few number of entrochromaffin cells were observed.

Kachave *et al* (2009) described that in case of broiler and layer poultry birds, the villi of duodenum were lined by simple, tall columnar cells, goblet cells and entrochromaffin cells. The crypts of Lieberkuhn were bordered by columnar cells with goblet cells and entrochromaffin cells.

Jain *et al* (2016) reported that the height of the simple columnar epithelium that lined the mucosa was significantly more at the middle of the villi in case of Vanaraja chicken. Narrow, tall, finger shaped villi which were placed zigzag pattern were more varied in height and shape in vanaraja than in CARI shyama. The long villi were significantly tall and the small villi were less number in vanaraja layer. Tunica muscularis formed the major part of total wall thickness while lamina propia and submucosa contributed more in case of vanraja layers.

Rodrigues *et al* (2012) showed that in rhea, a pseudostratified squamous epithelium containing goblet cells lined the long villi of the duodenum. The mucosa layer was thicker than the serosa layer and the submucosa layer consisted of loose connective tissue fibers.

Igwebuike *et al* (2010) described that the tunica mucosa of the duodenum was lined by simple columnar epithelial cells and the goblet cells were not very prominent in case of African pied crow. The lamina propria that was consisted of loose connective tissue was situated beneath the epithelial layer. The tunica muscularis of duodenal layer was composed of an inner circular and an outer longitudinal layer.

2.2.3.2.The Jejunum and Ileum:

Rodrigues *et al* (2012) showed that the villi of jejunum were lined by goblet cells containing pseudostratified squamous epithelium in case of rhea. The submucosa layer was thin. However the muscular and serosa layers were having typical structure. The lamina propria was consisted of loose connective tissue and numbers of tubular glands. The villi of ileum were lined by simple columnar epithelium.

Indu *et al* (2011) reported that, in case of pea fowl the wall of the ileum was formed by only three layers viz. tunica mucosa, tunica muscularis and tunica serosa. The mucosal layer was formed by surface epithelium, lamina propria and lamina muscularis. Between the bases of the villi and the muscularis mucosa, the crypts of Lieberkuhns were located in lamina propria. The simple columnar epithelium containing chief cells and the goblet cells lined the villi. The lamina propria was composed of loose connective tissue, blood vessels, nerves and glandular tissue. In the core of the villi, diffused lymphocytic tissues were observed. Longitudinal smooth muscle fibers formed the thick .muscularis mucosa. The tunica muscularis was composed of a well developed inner circular and weakly developed outer longitudinal layer.

Igwebuike *et al* (2010) described that the villi of the ileum were short while in jejunum they were long and wavy in case of African pied crow. The epithelium of ileum exhibited many goblet cells.

Kachave *et al* (2009) observed that tunica mucosa, tunica muscularis and tunica serosa formed the wall of the jejunum and ileum in case of broiler and layer poultry birds. The villi of the mucosal layer were lined by simple columnar cells, goblet cells and entrochromaffin cells. Simple tubular type crypts were having globular bulged base and they were opened into the lumen between the bases of villi. The lymphatic nodules were located in lamina propria. The lamina propria consisted of loose connective tissue, capillaries, smooth muscles fiber. The tunica muscularis was consisted of inner longitudinal, middle circular and outer longitudinal layer of smooth muscle.

Ahmad *et al* (2012) studied that the villi were found to be tongue shaped and spatula shaped in juejunum and ileum respectively in case of Japanese quail. Columnar, goblet, enterochromaffin and vacuolated cells lined the different shaped intestinal glands. The

tunica muscularis was consisted of inner longitudinal, middle circular and outer longitudinal smooth muscles layer.

2.2.4.The large intestine:

2.2.4.1.The Ceca:

Chen *et al* (2002) narrated that finger shaped, tongue shaped or peak shaped villi were found only in the proximal cecum and their height were decreased far from the proximal cecum in case of domestic geese. The middle portion of cecum possessed parallel ridges and did not posses villi. Circular band plicae were observed in middle cecum. The distal cecum possessed saw shaped villi and no parallel ridges were found. The distal cecum possessed saw shaped villi while parallel ridges were absent.

Rodrigues *et al* (2012) depicted that simple columnar cells and some tubular glands lined the cecal mucosa of rhea. Submucosa layer was thin and was composed of loose connective tissue cells. Well defined muscular and serosa layers were observed. Loose connective tissue formed the tunica propria.

Udoumoh *et al* (2016) depicted that in case of common pigeon, the cecal wall was consisted of typical four layers of intestine in which the luminal surface of the cecum was covered by simple columnar epithelium. The tunica muscularis was composed of inner longitudinal, middle circular and outer longitudinal layers of smooth muscle. The lamina propria contained many lymphocytic aggregations.

Calhoun (1954) reported that the lamina propria of the cecum of chicken was infiltrated with lymphoid cells but this layer was devoid of any lymphoid nodules.

2.2.4.2.The Colo-rectum:

Rodrigues *et al* (2012) described that the mucosal layer of the colo-rectum was similar to that of the cecum in case of rhea. Simple columnar cells and some tubular glands lined the mucosa of the colo-rectum. Loose connective tissue and several polymorphonuclear

leucocytes formed the tunica propria. Very thin muscular layer was observed.

Indu *et al*(2011) narrated that in peafowl, the villi and glands were lined by simple columnar epithelium. The goblet cells were more in mucosal epithelium of the colo-rectum than that in the ileum. Depth and size of the crypts were significantly reduced in colo-rectum than that of the ileum. Lamina propria was composed of loose connective tissue, blood vessels, nerve fibers and tubular glands. Diffuse lymphatic tissues were present in the core of the villi. Thick, well developed inner circular and thin outer longitudinal layers formed the tunica muscularis of colo-rectum.

2.2.5.The Pancreas:

Batt (1926) observed that the pancreas of poultry did not possess distinct interlobular connective tissue which was very much distinct in case of mammalian pancreas. All the indistinct interlobular septa were merged with a delicate fibrous capsule at the peripheral portion. Histologically the collecting ducts from the acini were hardly distinguishable. For this reason many a times in during research work we were unable to determine the branching pattern of the collecting tubules. Very short intralobular tubules were converted into intermediate tubules while entering into the lobules. These intermediate tubules were slender and were covered by a single layer of flattened epithelium. Most of these epithelial cells exhibited large nucleus. The epithelial cells became cuboidal with the increase of the size of the ducts. The cells became columnar when the duct was converted into the main branch of the pancreatic duct.

Zeigel (1962) narrated that, in case of post hatched chick, the acinar cells the nuclei were large, basal and round, having true pores which were the distinct connection between and the nuclear membrane and the endoplasmic reticulum. The Golgi body was composed of small circular vesicles, pairs of smooth membrane and large membrane bound vacuoles. These granules created the prozymogen granules while the mature zymogen granules were large and spherical.

Ham(1969) delineated that in case of mammals a prominent connective tissue capsule separated the pancreatic tissue from the

adjuncent architecture was significantly thin and it scarcely merits which was being called a capsule.

Dellman (1971) studied the pancreatic islets were different shaped, such as, spherical or oval. The structures were intermixed with the exocrine tissue of pancreas. There were five types of cells, viz. A (alpha), B (beta), C, D, and F cells. Alpha cells contained the water soluble granules. A-cells contributed 25% to the islets population. Poly angular shaped B cells were much abundantly present in the islets. It contributed about 75% of the islets population.

Ladukar *et al.(1996)* depicted that the islets of Langerhans were very much vuscularised due to sinusoidal capilleries in case of buffalo pancreas.

Kadhim *et al* (2010) reported that, in case of red jungle fowl, the three pancreatic duct were found to be joined together at the proximal end of ascending duodenum red jungle fowl.The exocrine part consisted of main pancreatic tissue while the endocine unit were noticed frequently in the third and splenic lobes.A single layered pyramidal cells with acidophilic zymogen granules, small centro-acinar cells were formed in the exocrine acinus. The intercalated ducts, interlobular ducts and main ducts were lined by flattened, cuboidal epithelium and simple columnar epithelium respectively. Three types of cells, such as principal, light and basal cells were recognized which exhibited short luminal projections and fuzzy surface coat.

Mobini (2013) observed that the pancreatic parenchyma of the pigeon consisted of exocrine and endocrine portions. The exocrine portion of the pancreas was arranged in the form of serous tubulo aciner glands and composed of many secretory acini and duct systems. The pancreatic islands were composed of varoius shapes of large alpha and small beta islets. Alpha islets consisted of alpha and beta cells while beta islets containing beta and delta cells.

Al-Agele and Mohammed (2012) described that, the pancreas of golden eagle was covered by a capsule of very thin layer of connective tissue. The glandular tissue of exocrine parenchyma was formed by single layered triangular cells which were observed as pyramidal shape.

Gulmez (2003) noticed that the pancreatic glands of goose containing centro-acinar cells were observed intermittently inside the connective tissue of the ducts which extended from the interlobular ducts to the emptying point of the pancreas. The intercalated ducts and intralobular ducts were lined with simple flattened and tall columnar epithelium respectively.

Saadatfar and Asadian (2009) studied that the exocrine part of was consisted of round to oval shaped acini and ducts in case of pancreas of mynah. The endocrine parts were scattered as islets with different sized and shaped small groups of cells. The A islets and B islets were more in dorsal and ventral surface respectively.

2.2.6.The Liver:

Trautmann *et al.* (1960) narrated liver lobules that made up the parenchyma of liver were the smallest functional units. Each lobule contained a central vein and the surrounding parenchyma, whose sinusoids were all drained by the central vein. The lobules were larger in adult than the young and growing animals. The covering of the liver was a thin coat of peritoneum, the capsula serosa, below which there was another loose connective tissue layer usually very thin, the capsula fibrosa (Glisson's capsule).

Dellman (1971) described that the histological section of liver which showed more or less homogeneous distribution of liver cords which contained liver parenchyma were absence of typical lobulation. Irregular arrangement of interlobular veins, vessels were there throughout the parenchyma. A dense connective tissue covering which looked like that of glission capsule was identified at the outermost layer of liver just beneath the messothelium. A small number of elastic fibres were identified within the connective tissue fibres. The hepatocytes containe large spherical nucleus with lined basale.There was a network of blood sinusoids in close proximity to the hepatic plate.

Hodges (1974) narrated that the cells of the liver parenchyma were arranged in a series of anastomosing hepatic plates, each plate being consisted of double layered polygonal cells. The mean thickness of the hepatic plate was about 23μm and the longest dimension of the component cells, which was normally that from the vascular pole to

the biliary pole was approximately 12μm making these cells rather smaller than hepatocytes of the mammals.

Nickle *et al* (1977) depicted that the liver of birds was found to be a tubular gland. The liver parenchyma was composed of tubes of cells connected together in a net-like fashion. The axial lumina of such tubules were the bile capillaries. The wall of the tubules was consisted of cells of liver, in between which the intercellular bile canaliculi were located. In cross section, these tubules were observed in between two or six cells.

Chapter - 3

Materials and Methods

MATERIALS AND METHODS

Any scientific technique consists of systemic observations, classification and evaluation of data. It is characterized by careful and accurate classification of facts and their observations, inventions of scientific law by creative imagination and self-criticism to attain the final goal. Thus, the scientific law has two important bases; one of which deals with the method employed and the other with the result achieved. In this chapter the attempt has been directed towards elucidation different aspects of methodology adopted and the tools employed to accomplish the present investigation.

The present study was carried out at the department of Veterinary Anatomy, Histology and Embryology, Faculty of *Veterinary and Animal Sciences*, West Bengal University of Animal and Fishery Sciences, Kolkata-37.

3.1. THE OBJECTIVES OF THE STUDY:

- To study the gross anatomy of gastro-intestinal tract of Vanaraja chicken.
- To study the morphometry of different parts and organs of gastro-intestinal tract of Vanaraja chicken.
- To study the histomorphology of Gastro-intestinal tract of Vanaraja chicken.

3.2. COLLECTION OF SPECIMEN:

To undertake the present investigations, the three of each sex of adult Vanaraja poultry birds were collected from Instructional Livestock Farm Complex of West Bengal University of Animal and Fishery Sciences and from the poultry farm of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith, South 24 Parganas (Fig-1). The birds were sacrificed under general anaesthesia and the organs of the gastrointestinal tracts were harvested immediately (Fig-2).

3.3. GROSS ANATOMICAL AND MORPHOMETRICAL STUDIES:

Immediately after collection, gross anatomical observation was done by naked eye. The gross appearance, length, breadth, colour of different parts of the gastrointestinal tract was noted by naked eye and electronic slide calipers. Digital cameras were used to record the location of the organs. The weights of the different organs were taken by weighing balance.

3.4. PROCESSING AND STAINING OF TISSUES FOR HISTOLOGICAL OBSERVATION:

All the tissues were subjected to the standard procedures of processing before proceeding for sectioning. All the sections were taken at 5 µm thickness with the help of Leica rotary microtome.

3.5. PROCESSING OF TISSUE FOR HISTOLOGICAL STUDY:

For preparation of histological slide, different parts and organs of the Vanaraja chicken were collected.

3.5.1. FIXATION:

The samples were fixed for histological studies in 10% neutral buffered formalin solution.

3.5.2. STAINING METHOD:

3.5.2.1. HAEMOTOXYLIN AND EOSIN STAINING (LUNA, 1968):

The slides were passed in Xylene three times for 15 minutes gradually. Afterwards those slides were kept in pure alcohol three times gradually for 2 minutes. Then the sectioning slides were passed in ascending grades of ethyle alcohol for 2 minutes. Then the slides were washed in distilled water for 2 minutes. After that dipped it in Mayer's Haemotoxylin for 15 minutes and then washed it under running tap water for 20 minutes. After washing the slides were kept

in 2% Eosin for 40 seconds. After rinsing the slides were kept in 90% ethyl alcohol for 1 minute. Then the slides were passed in Xylene solutions gradually in three times for 15 minutes each. After that the slides were ready to observe under microscope.

3.6. MICROSCOPY:

Microscopy was done by using Leica Qwin Image Analyser software in Lecia DM 2000 Microscope. The images were taken from the stained sections.

3.7.STATISTICAL ANALYSIS:

All metric parameters were calculated by observing standard statistical protocol and were expressed as mean ± standard error.

Chapter - 4

Results

RESULTS

4.1.GROSS ANATOMICAL STRUCTURE:

4.1.1.The Crop and esophagus:

The esophagus was found to be a long, narrow, and highly distensible tube that extended from the glottis to at the posterior end of the pharynx, to join with the glandular stomach (proventriculus) in the abdominal cavity. The esopahagus was composed of cervical and thoracic part. The crop was a thin walled distensible diverticulum of the esophagus which was found just before the esophagus entered the thorax. The average length of the cervical part and thoracic part was recorded as 20.47±0.34 cm and 10.47±0.84 cm respectively. The cervical esophagus was longer than the thoracic esophagus (Fig-3). Towards the anterior part of the neck region the cervical part of the esophagus was located in the midline and dorsal to the trachea. In the posterior part of the neck the esophagus was placed to the right of the midline between trachea laterally and jugular vein dorsally. The esophagus was wider in diameter in its initial portion. The thoracic esophagus was dorsal to the bronchi and later on it was situated between the heart and lungs and was closely associated to the Cervical, clavicular, and anterior thoracic air sacs. The esophagus was dilated and opened into the proventriculus, there was no clear demarcations between this organ. The internal surface of the esophagus was cream colored and the lumen showed cream colored with number of longitudinal folds (Fig-4).

4.1.2.The Proventriculus and gizzard:

The proventriculus was thick walled, short, spindle shaped organ that was located above the liver and between the esophagus and the gizzard. The lumen of the proventriculus was narrow and thick and was composed of number of compound tubular glands (Fig-3). On the other hand, the gizzard was a biconvex lens shaped large muscular organ that was suspended in the postero-ventral part of the abdominal cavity and was laid between the lobes of the liver (Fig-3). The proventriculus was opened into the gizzard on the antero-dorsal

middle part was wider and its luminal wall was thinner. The expanded distal part possessed a pointed extremity (Fig-3). The average length of each cecum was 22.81±2.59 cm.

4.1.4.2.The Colo-rectum:

Light red colored, short colo-rectum lying below the lumbo-sacral vertebrae was continued with the the ileum cranially and was extended caudally to the cloaca as a straight tube (Fig-3). It was suspended from the dorsal wall of the abdominal cavity by a small portion of the mesentery. The average length of the colo-rectum was reported as 13.00±0.04 cm.

4.1.5.The Pancreas:

The pancreas was a long, narrow gland and was situated within the duodenal loop (Fig-3). It was mainly consisted of dorsal and ventral lobe. Smaller splenic lobe was extended from the head of the pancreas towards the spleen. The ducts of both dorsal and ventral lobes were extended almost the full length of their course. The pancreatic ducts and the bile ducts were opened into the limb of duodenum. The average weight of the pancreas was 3.70 ±0.07 gm.

4.1.6.The Liver:

Reddish brown colored liver of Vanaraja chicken was having left and right lobes in which the lobes were connected ventrally by a fold of peritoneum. The right lobe was heart shaped and showed a large gall bladder while the prism shaped left lobe was smaller and it had no gall bladder (Fig-6). The hepato enteric duct from the left lobe and the hepato cysytic duct from the right lobe were opened into the ascending limb of the duodenum separately. The weight of the liver was 54.54±12.30 gm.

4.2.HISTOLOGICAL STRUCTURE:

4.2.1.The Esophagus and crop:

The innermost layer tunica mucosa of the esophagus was lined with stratified squamous epithelium. The thickness of the layer was almost equal in cervical and thoracic part of the esophagus. The mucosal folds were numerous all along the length of the esophagus. The cells of the stratum basale were round to spherical in shape and in the subsequent layers, the cells became flattened. There was no cornification and the nuclei of the subsequent layers revealed no complete degenerative changes.

The tunica propria (lamina propria) was composed of loose connective tissue, fibroblast and areas of lymphocytic infiltrations and aggregation. The tunica propria was lined by numerous mucous glands. The numbers of the glands were more in cervical region than that in thoracic region. The gland was composed of masses of compound tubular glands. The glands were lined by single layer of columnar cells with small, round basal nuclei and eosinophilic cytoplasm. Each gland was formed from a varying number of units and each unit comprised of many tubules which were opened into a common cavity and then was opened into the lumen through a common duct. The duct of the gland passed through the lining epithelium and opened into the lumen. In some of these glands were associated with lymph nodules and in some cases the glands were infiltrated by lymphoid tissue (Fig-8).

The internal edge of the tunica propria was formed into a series of deep papillae and it was revealed the capillary loops, passed into the layers of lining epithelium.

The muscularis mucosae was well developed throughout the length of the esophagus and was composed of smooth muscle fibers.

The tunica submucosa of esophagus was poorly developed and was composed of loose connective tissue with large blood vessels, lymphatics and nerve fibers.

The tunica muscularis of esophagus was composed of two distinct layers; an inner circular and outer longitudinal layer. The inner circular layer was thicker than the latter one. These two layers were separated by connective tissue, fibers within which nerve plexus was revealed.

The tunica adventitia was consisted of loosely arranged connective tissue which formed the external boundary of the

part of the circumference. The duodenum was originated from the gizzard. The average longitudinal and transverse diameter of gizzard was recorded as 6.38±0.02 cm and 5.21±0.01 cm respectively.)

4.1.3.The Small intestine:

4.1.3.1.The Duodenum:

The duodenum was U shaped structure and it was light red in color (fig-3). It arose from the cranial part of the gizzard and exhibited a proximal descending and a distal ascending limb. The ascending limb of the duodenum extended caudally to connect the jejunum. Both limbs of duodenum enclosed the pancreas (Fig-3). The average length of the duodenum was 30.15±0.11 cm.

4.1.3.2.The Jejunum and ileum:

The jejunum was organized in a number of short garland like coils at the edge of the long dorsal mesentery (Fig-3). The proximal part of the jejunum was continued with the duodenum and extended caudally to connect the ileum. On the other hand, the ileum was reddish gray in color and was continued with jejunum in the midline ventral to the rectum and cloaca caudally. But no gross demarcation was identified between the terminal part of jejunum and beginning of ileum (Fig-3). The average entire length of the jejunum and ileum was 131.67±3.45 cm.

4.1.4.The Large Intestine:

The large intestine of the Vanaraja chicken was identified as it was composed of a pair of ceca and a short straight intestine which was continued with the ileum and cloaca.

4.1.4.1.The Ceca:

Each cecum was divided into three parts. The proximal part of the cecum was light red in color and it was having narrow lumen. The

esophagus. Blood vessels, nerve fibers were found within this layer (Fig-7).

4.2.2.The Stomach (proventriculus and gizzard):

4.2.2.1.The Proventriculus:

The proventricular wall revealed four tunics of digestive organ; tunica mucosa, tunica submucosa, tunica muscularis and the outermost tunica serosa. The surface mucosa of the proventriculus was invaginated at regular interval forming mucosal plicae and sulci. The lining epithelium was simple columnar. Few goblet cells were identified in this layer. From the base of the sulci, short, compound tubular glands extended into the lamina propria. Lamina propria was formed by loose connective tissue with lymphocytic infiltration and lymphatic nodules of different sizes. Lymphatic nodules were frequently found especially close to the mucosal papillae. The proventricular glands were compound tubular and formed the greatest thickness of the proventricular wall (Fig-9). The shape of the gland varied round, oval, hexagonal or polymorphic lobules separated from each other by thin perilobular connective tissue sheath. The wall of the each lobule was composed of numerous secretory tubules which opened together into a wide cavity. The central cavity was communicated by duct which opened within the lumen. The tubules and the ducts of the proventricular glands were lined by simple cuboidal and simple columnar respectively (Fig-10). The submucosa was poorly developed and was formed by loose connective tissue. The muscular layer was formed by thin inner circular and thick outer longitudinal smooth muscle fibers. The outermost covering of proventriculus was consisted of flattened mesothelial cells within the network of submesothelial connective tissue.

4.2.2.2.The Gizzard:

Outwardly peritoneal coat lined the gizzard. Tunica muscularis was composed of a very thin outer longitudinal layer, a massive circular layer and an internal oblique layer. Well developed myenteric plexus was found in regular intervals between the outer and middle muscular layer. The tunica submucosa was thin and composed of loose connective tissue, blood vessels, nerve fibers. The muscularis

mucosa was absent in case of gizzard. The tunica propria was glandular and composed of loose connective tissue fibers (Fig-11). The glands were branched tubular, simple glandular tubular and single tubular. The lining epithelium of the gland was simple cuboidal (Fig-12). The tunica mucosa was invaginated within the tunica propria and formed different size gizzard pits. The pits were extended into the glandular layer.

4.2.3.The Small intestine:

4.2.3.1.The Duodenum:

The tunica mucosa was formed into large number of tall, finger like villi arranged in a zigzag pattern. However the shape, size of villi varied within the different regions of duodenum. The villi were lined by simple columnar epithelium. Goblet cells were found within the epithelial lining.

The tunica propria was composed of loose connecting fibers, glands, connective tissue cells and lymphocytes. Towards the apical and basal region of the villi multiple capillaries were observed. Tunica propria was glandular. The crypts of Liberkuhn were lined by cuboidal epithelia cells with some goblet cells (Fig-14). Tunica muscularis was thin and composed of smooth muscle fibers. The submucosa was poorly developed and composed of very thin layer of connective tissue without any gland. The muscularis mucosa consisted of outer longitudinal and inner circular layer. The latter was thicker. Myenteric plexus were found in between two muscular layers. Externally a thin layer of loose connective tissues observed (Fig-13).

4.2.3.2.The Jejunum and ileum:

Similar histological structure of duodenum was observed in jejunum and ileum. However the height of the villi shortened gradually from duodenum to ileum. The frequency of distribution of intestinal glands revealed no differences in both the areas. Only the numbers of goblet cells increased in both areas (Fig-15 & 16).

4.2.4.The Large intestine:

4.2.4.1.The Ceca:

Histologically the Cecum was identified into three parts viz. proximal , middle and distal parts. It revealed four layers (mucosa, submucosa, muscularis and serosa).

Small villi were found in the proximal part and the heights were almost similar to that of the ileum (Fig- 16 &17). In the middle part, typical villi were absent. Instead of that numerous folds were protruded within the lumen (Fig-18). However the folds were not so deep like that of the middle portion in case of distal part. Frequency of crypts of Lieberkuhns and mucus secreting cells gradually decreased from proximal to distal cecum (Fig-19). Within the tunica propria, many lymphoid cells and lymphoid nodules were found.

4.2.4.2.The Colo-rectum:

The mucosa of the colo-rectum was formed by villi which was line by simple columnar epithelium with tubular gland, lined by cuboidal epithelium with goblet cells. The shapes of the villi were short, thick and blunt ended. Tunica propria was invaded with lymphoid cells and lymphoid nodules. The submucosa was thin and the orientations of the muscular and serosa layer were almost similar to that of the cecum (Fig-20).

4.2.5.The Pancreas:

A thin fibrous capsule encircled peripherally the whole gland. In some areas, indistinct interlobular septa merged towards the peripheral covering. The lobulations were indistinct and incomplete.

The exocrine tissue of the pancreas revealed the structure of the numerous acini. The acinus was lined by pyramidal acinar cells surrounding a very narrow lumen. The cells were strongly basophilic basale and contained numerous coarse eosinophilic granules at the apex. The nucleus of the pyramidal cell was large, round and basale. Collecting ducts from the glandular acini were hardly distinguishable.

The intralobular ducts were very short and were found at the entry level of the lobules. The intermediate tubules were lined by simple flattened epithelium with a large oval nucleus. In the larger duct, lining epithelial cells became cuboidal.

Small roughly spherical islets of the cells were found within the glandular acini covered by a layer of connective tissue fibers. Two types of islets were identified; alpha islets and beta islets on the basis of the staining. Alpha islets were darker than the beta islets. Populations of the alpha islets were more in splenic lobe. The alpha cells were columnar and the alpha cells cords were resembled columnar epithelium. The nucleus of the cell was oval to round containing one or two nucleoli. Beta islets were found in all the lobes of pancreas. The sizes of the islets were smaller than that of the alpha. The polygonal beta cells were arranged in a strand. The nuclei were round to ovoid in outline with one or two nucleoli. Delta cells were found in both the islets (Fig-21).

4.2.6.The Liver:

Histological section of liver of Vanaraja chicken revealed more or less homogeneous arrangement of liver cords which were consisted of liver parenchyma without typical lobulations. Interlobular veins, vessels were arranged irregularly throughout the liver parenchyma. A dense connective tissue covering which resembled like Glisson's capsule was identified at the outermost layer of the liver just below the mesothelium.

Hepatocytes were large and having spherical nucleus with lined basale. There was a network of blood sinusoids in close proximity to the hepatic plate. The hepatic plate was two cells thick.

The liver was composed of tubules of cells, which were attached with each other in a net-like orientation. These were the bile capillaries. The wall of the tubule was composed of liver cells, in between which the intercellular bile canaliculi were situated. The tubules were observed in between two or six cells (Fig-22).

Figure 4: Photograph showing internal surface of the crop (c)

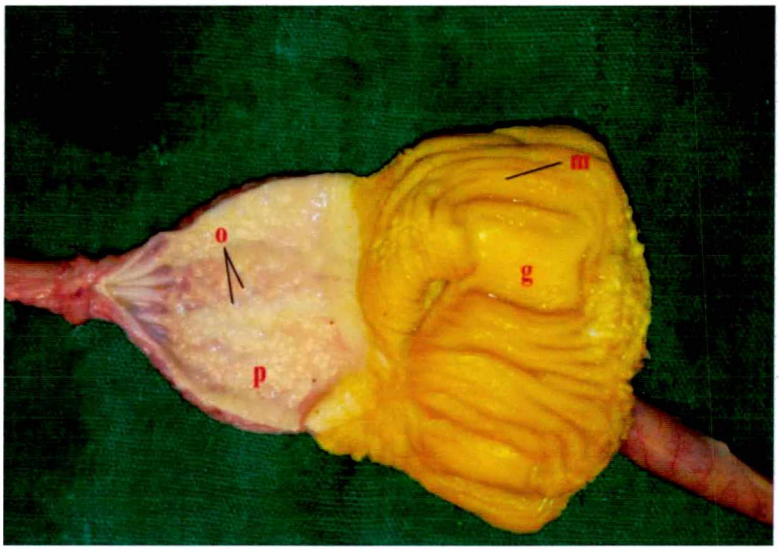


Figure 5: Photograph showing proventriculus (p) with opening of gland on papillae (o) and gizzard (g) with yellow colored hard membrane

Figure 1: Photograph showing live Vanaraja chicken.

Figure 2: Photograph showing anaesthetized Vanaraja bird.

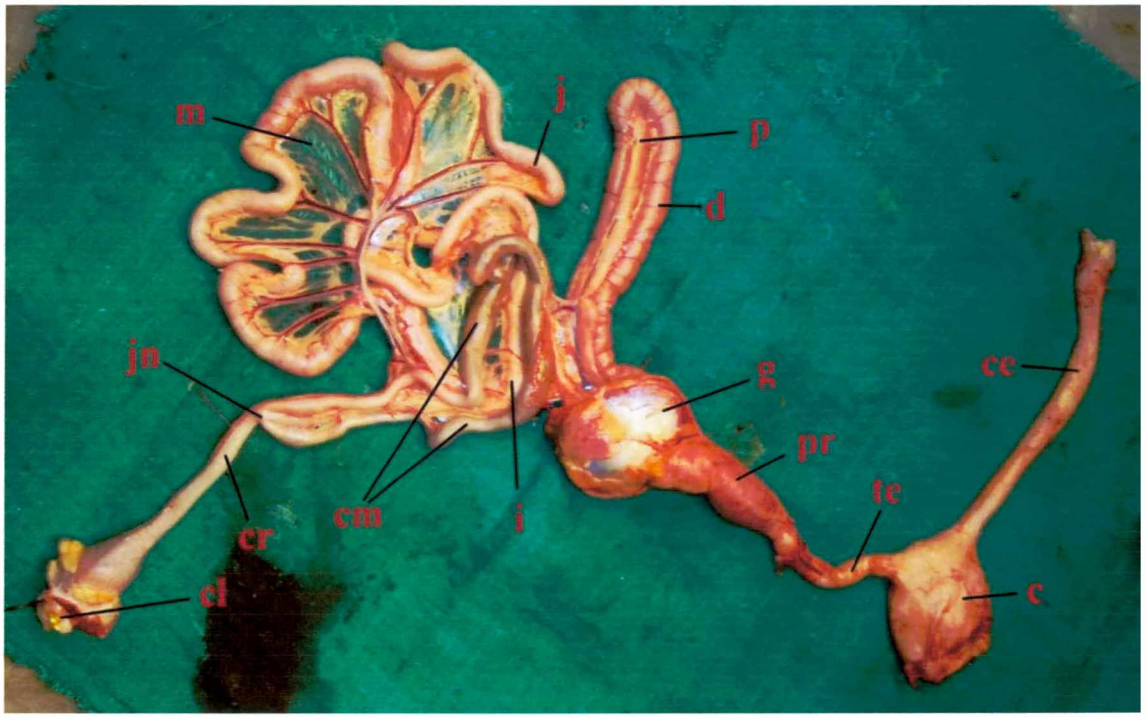


Figure 3: Photograph of digestive tract of Vanaraja poultry bird showing cervical part of esophagus (ce), crop (c), thoracic part of esophagus (te), proventriculus (pr), gizzard (g), duodenum (d), pancreas (p), jejunum (j), mesentery (m), ileum (i), ceca (cm), ileo-cecal junction (jn) colo-rectum (cr) and cloaca (cl)

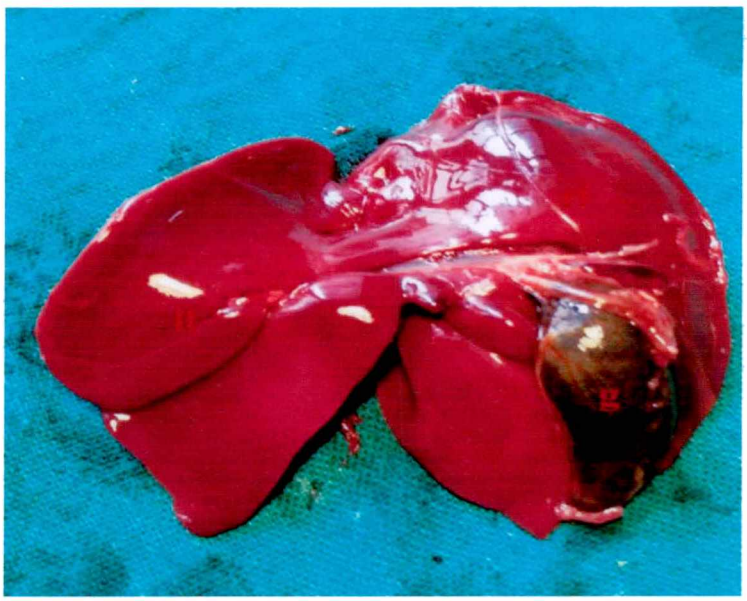


Figure 6: Photograph showing gross liver structure with its right and left lobe (rl &ll), gall bladder (g)

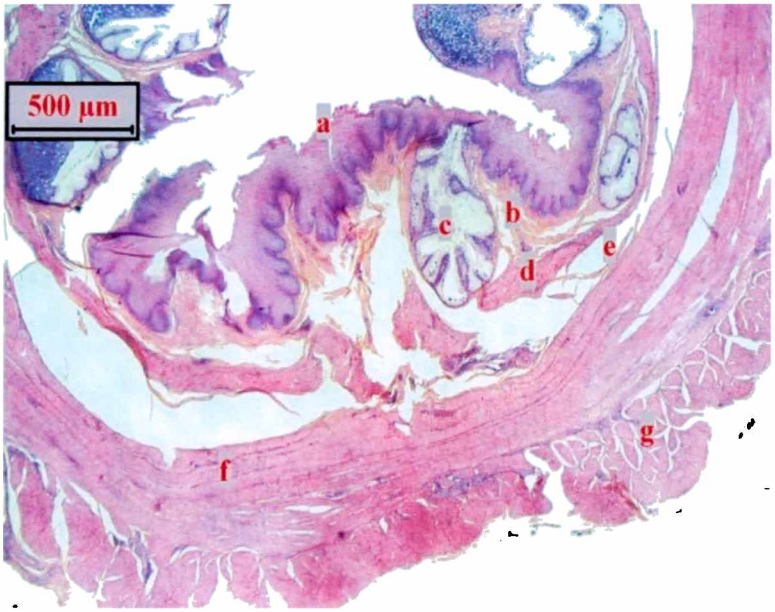


Figure 7: Photomicrograph showing esophagus having stratified squamous epithelium (a), tunica propria (b), mucous gland (c), muscularis mucosae (d), submucosa (e), circular muscle layer (f), longitudinal muscle layer(g). H&E, X4.

Figure 8: Photomicrograph showing glands of the esophagus (g). H&E, X10

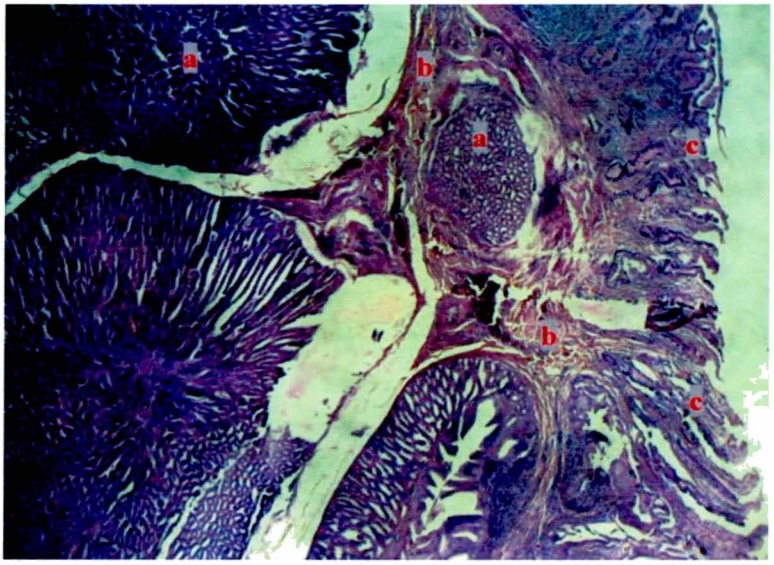


Figure 9: Photomicrograph showing transverse section of part of proventricular wall: Proventricular glands (a), tunica propria (b) and mucosa (c). H&E, X4

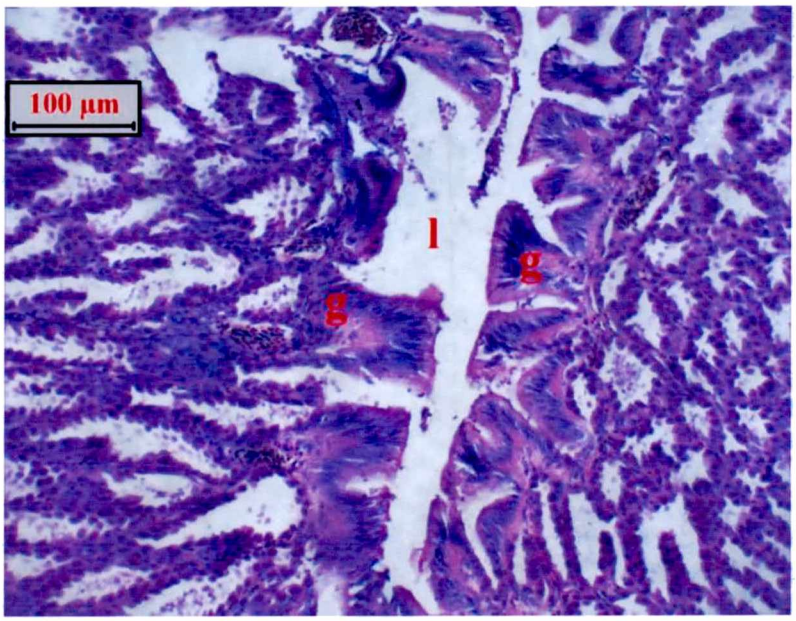


Figure 10: Photomicrograph showing Proventricular glands (g) and lumen of organ (l). H&E, X20

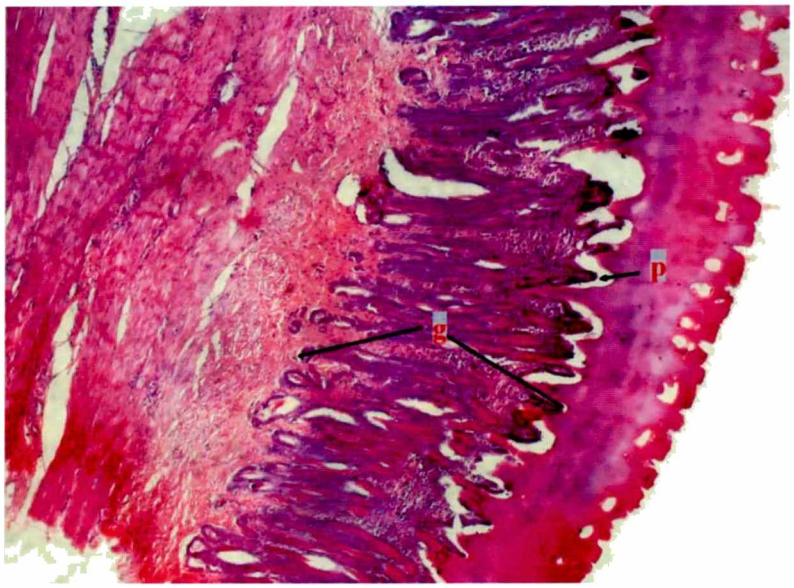


Figure 11: Photomicrograph of normal gizzard showing glands (g) and pits (p). H&E, X4

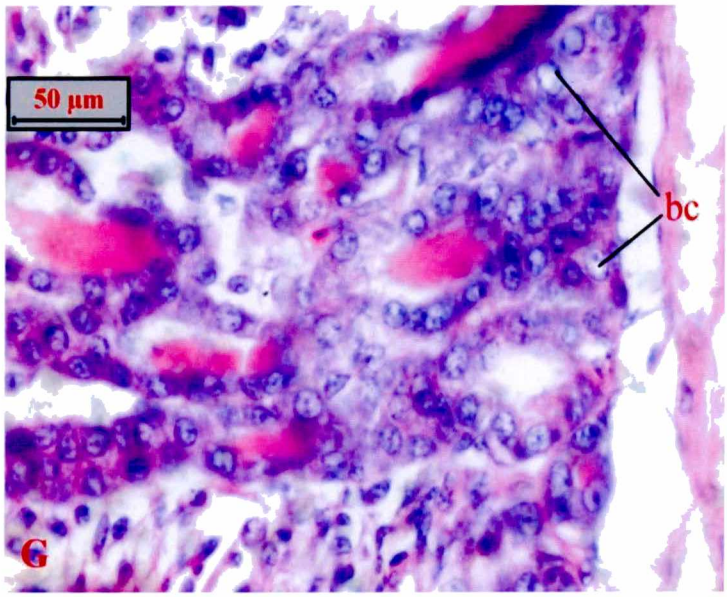


Figure 12: Photomicrograph showing gizzard glands with basal cells (bc). H&E, X100

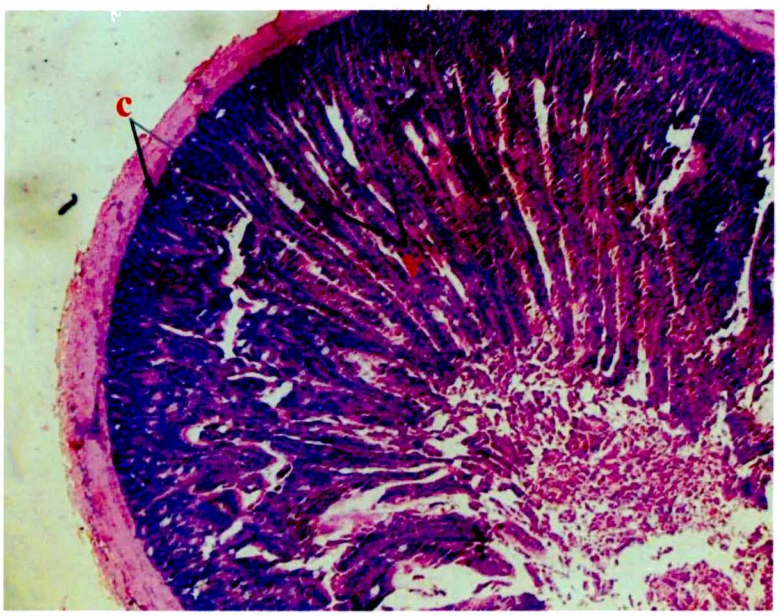


Figure 13: Photomicrograph showing normal duodenum with villi (v) and crypts (c). H&E, X4

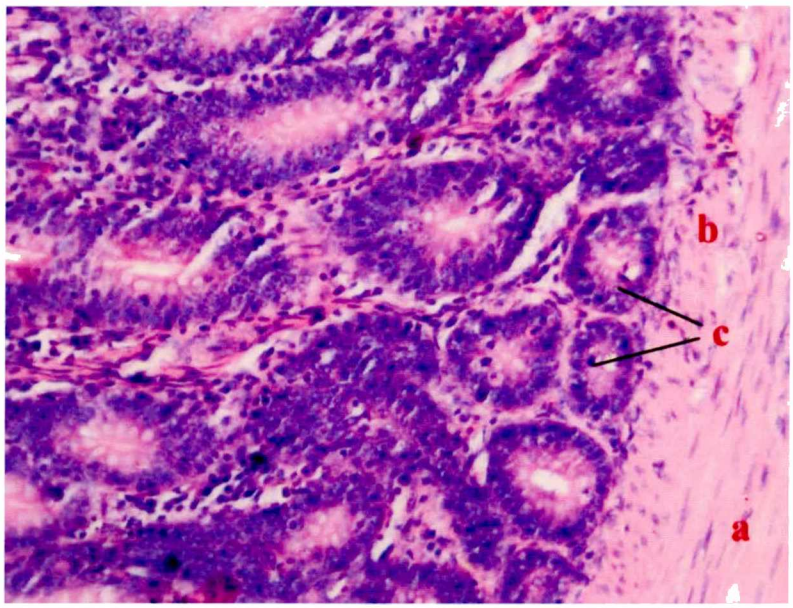


Figure 14: Photomicrograph showing normal duodenum with crypts (c), circular muscle layer (a) and muscular mucosae (b). H&E, X40

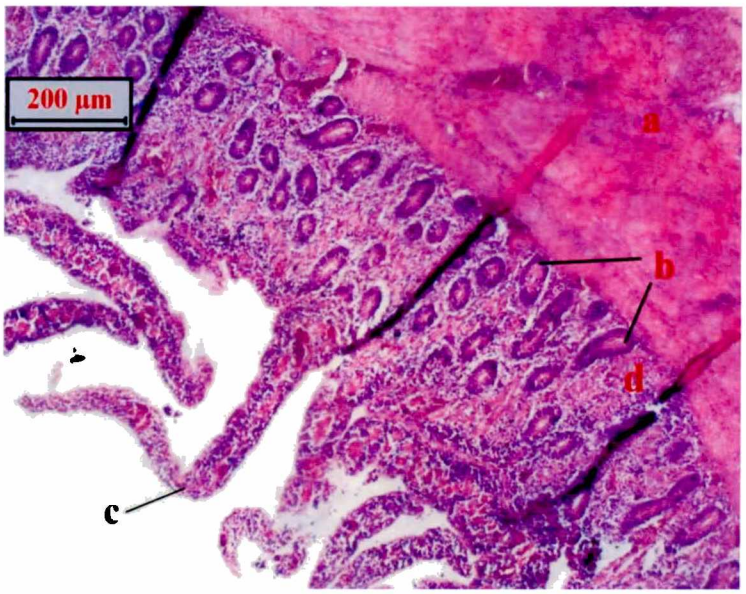


Figure 15: Photomicrograph showing normal jejunum with circular muscle (a), crypts (b), villi (c) and tunica propria (d). H&E, X10

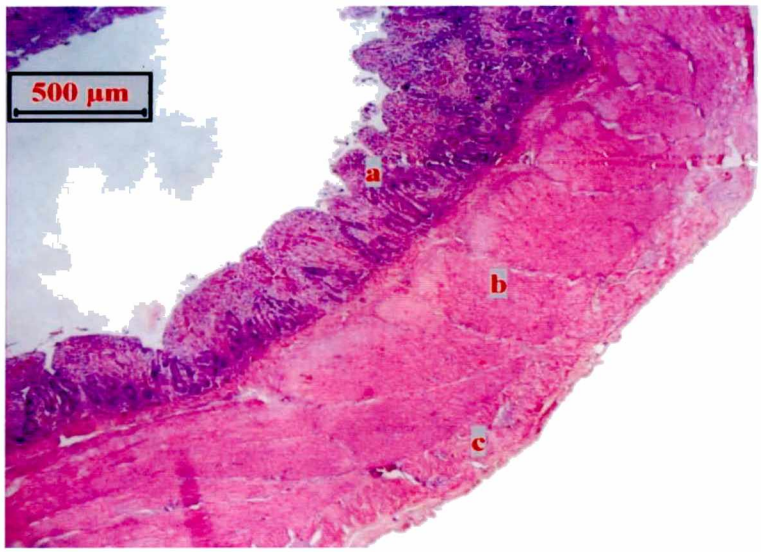


Figure 16: Photomicrograph of ileum showing villi (a), circular muscle (b), outer longitudinal muscle (c). H&E, X4

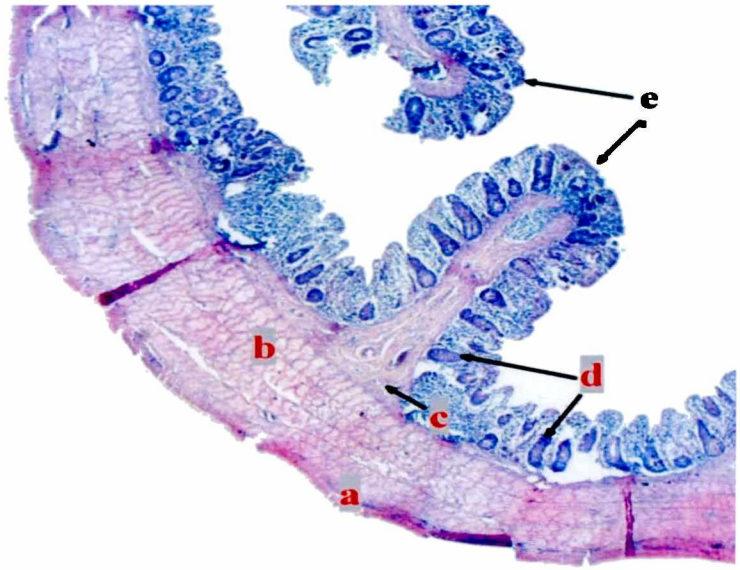
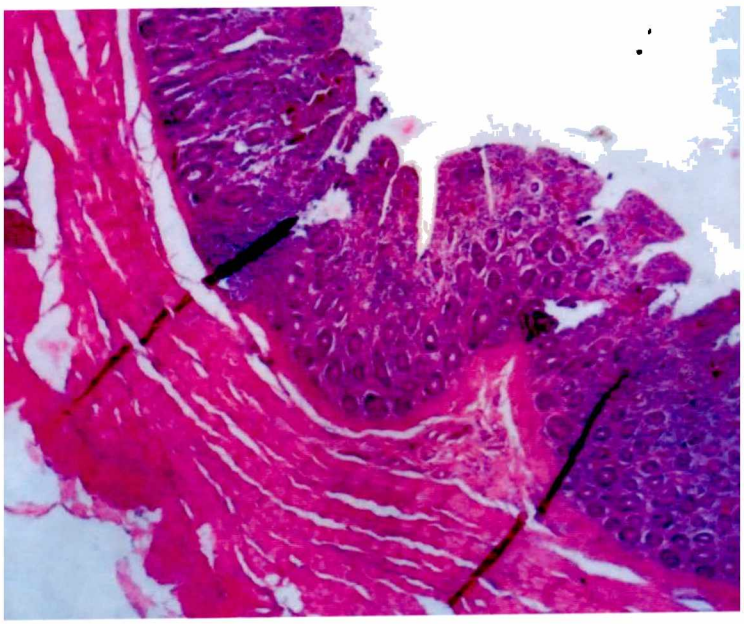
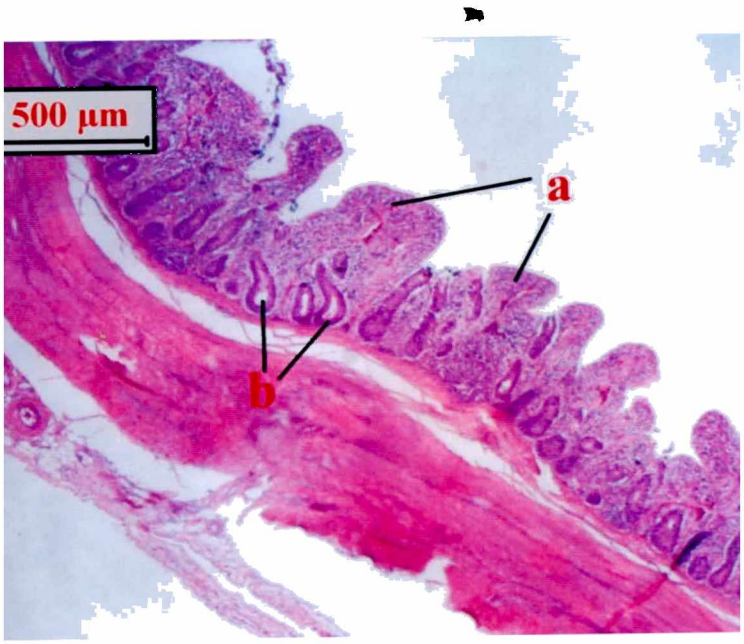


Figure 17: Photomicrograph of proximal cecum showing outer longitudinal muscle layer (a), inner circular muscle layer (b), muscularis mucosae (c), crypts (d), villi (e). H&E, X4



ure 18: Photomicrograph showing the wall of mid cecum
owing one of the plicae. H&E, X10



igure 19: Photomicrograph showing villi (a), crypts (b) of
istal cecum. H&E, X4

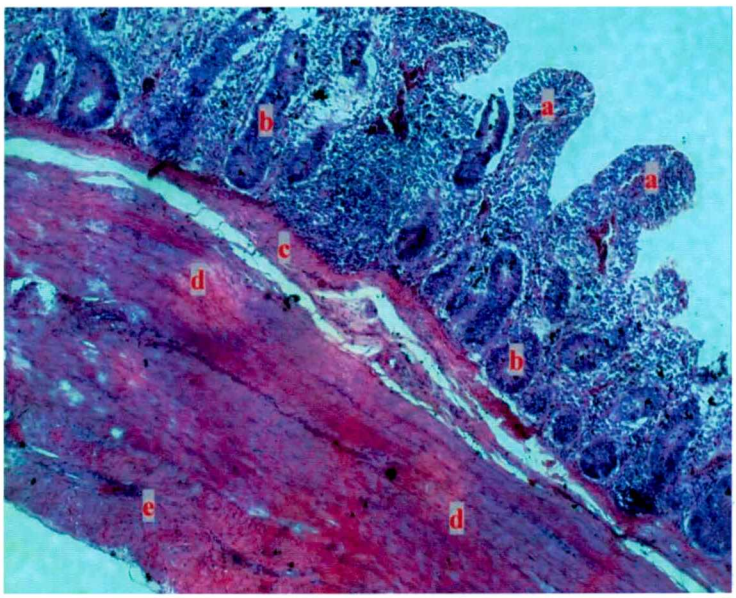


Figure 20: Photomicrograph showing normal structure of colo-rectum with villi (a), crypts (b), muscularis mucosae (c), circular muscle (d), longitudinal muscle (e). H&E, X10

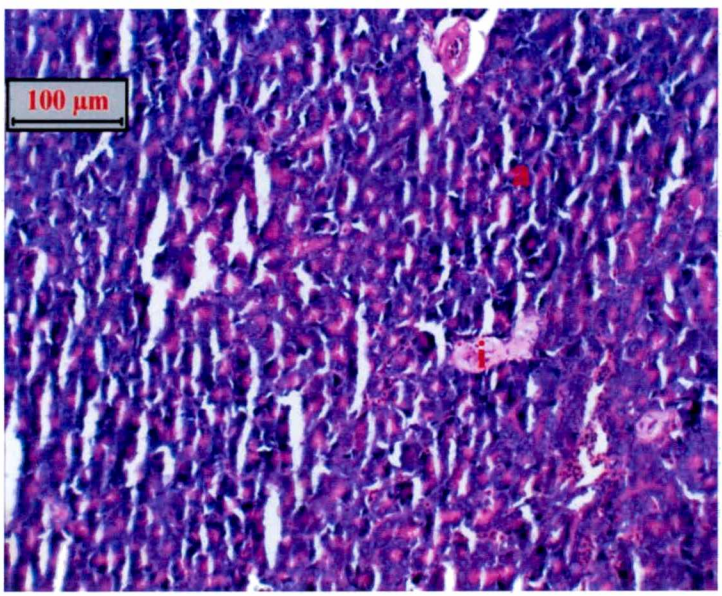


Figure 21: Photomicrograph showing normal pancreatic islet (i) surrounded by pancreatic acini (a). H&E, X20

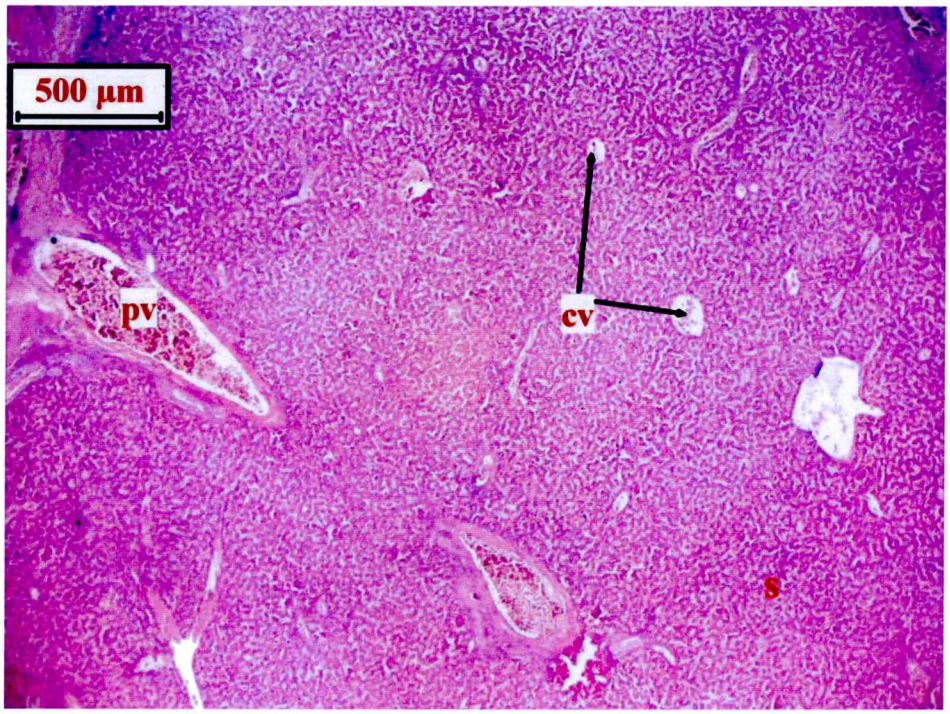


Figure 22: Photomicrograph of liver showing mass of anastomising sinusoids (s), portal vein (pv) and central hepatic vein (cv). H&E, X4

❖ **Table-1: Showing lengths and diameters of different parts and organs of digestive tract of Vanaraja poultry birds.**

Length (cm)	**Bird 1**	**Bird 2**	**Bird 3**	**Bird 4**	**Bird 5**	**Bird 6**	**Avg.**
Cervical esophagus	18.5	22.2	21.00	21.00	19.80	20.60	**20.47±0.34**
Thoracic esophagus	7.5	12.10	10.50	11.50	10.30	9.60	**10.47±0.84**
Duodenal loop	30.00	28.70	30.50	30.50	30.15	29.8	**30.15±0.11**
Jejunum and ileum	126	130.7	132.5	133.8	130	131.2	**131.67±3.45**
Cecum	21.50	20.32	23.40	23.00	22.60	24.35	**23.32±0.77**
Colo-rectum	13.00	11.43	11.00	13.00	13.20	12.80	**13.00± 0.04**
Longitudinal diameter of gizzard	6.32	6.52	6.43	6.50	6.39	6.24	**6.38±0.02**
Transverse diameter of gizzard	5.23	5.46	5.40	5.30	5.18	5.16	**5.21±0.01**

❖ **Table- 2: Showing weights of the pancreas and liver of Vanaraja Birds.**

Weight (gm)	**Bird 1**	**Bird 2**	**Bird 3**	**Bird 4**	**Bird 5**	**Bird 6**	**Avg.**
Pancreas	3.15	4.10	4.26	4.00	3.60	3.49	3.70±0.07
Liver	54.40	54.29	64.60	51.47	53.54	58.60	54.54±12.30

Chapter - 5

Discussion

DISCUSSION

In the present study, an attempt has been made to find out the gross anatomy and histological structure of the digestive tract of Vanaraja chicken.

The result have been studied correlated with the observations and findings of the previous workers and finally has been discussed in this chapter.

5.1.GROSS ANATOMICAL STRUCTURE:

5.1.1.The Esophagus and Crop:

The esophagus was found to be a long, narrow, and highly distensible tube that extended from the glottis to at the posterior end of the pharynx, to join with the glandular stomach (proventriculus) in the abdominal cavity. Similar observations were recorded by Shehan (2012) in goose, Ali (2014) in sea gull and Madhu *et al.*(2015) in emu bird.

The esophagus was composed of cervical and thoracic part. Similar observation was cited by Shehan (2012) in goose and Madhu *et al* (2015) in emu bird. The cervical esophagus was longer than the thoracic esophagus. This is in accordance with Shehan (2012) in goose. In the posterior part of the neck the esophagus was placed to the right of the midline between trachea laterally and jugular vein dorsally. Similar observation was documented by Evans (1996) in budgerigar. The internal surface of the esophagus was cream colored and the lumen showed cream colored with number of longitudinal folds. This is in accordance with Madhu *et al* (2015) in emu bird. Although Ghosh and Hegde (1991) described that in pigeon, the mucosal folding were short and broad in oesophagus while it was long and narrow in case of crop, which is not in accordance with the present findings. Grazal (1995) narrated that the crop of the hoatzin was folded into two interconnected chambers whereas the lower esophagus was multi chambered structure. Both the crop and the esophagus were possessed muscular structure between chambers. However this observation was not found in the present study.

The crop was a oesophageal enlargement present just before the thoracic inlet. This finding was similar to the description of Shehan (2012) in goose, Grazal (1995) in hoatzin. Although Bailey *et al* (1997) depicted that crop or any other oesophageal enlargement was absent in case of captive bustards while this finding was not in accordance with present findings.

5.1.2.The Stomach (the Proventriculus and Gizzard):

Thick walled, short, spindle shaped proventriculus was situated above the liver and between the oesophagus and the gizzard. Narrow, thick proventricular lumen was composed of number of compound tubular glands. Biconvex lens shaped muscular gizzard was suspended in the postero-ventral part of the abdominal cavity and was lied between the lobes of the liver. The proventriculus was opened into the the gizzard on the antero-dorsal part of the circumference. The duodenum was originated from the gizzard. Similar findings was observed by Al-Saffar *et al* (2016) in striated scope owl, Catroxo *et al* (1997) in red-cappede cardinal, Hassan & Mossa (2012) in pigeon and Abumadour (2013) in falcon. Although Bailey *et al* (1997) described that the proventriculus and the gizzard was cone shaped and oval shaped respectively in case of captive bustards which were not in accordance with present observations.

5.1.3.The small Intestine:

5.1.3.1.The Duodenum:

U shaped light red colored duodenum arose from the right aspect of the gizzard cranio-dorsally and was having a proximal descending and a distal ascending limb. The ascending limb extended caudally to connect the jejunum. Both limbs of duodenum enclosed the pancreas. Pancreatic and bile ducts were opened into the distal ascending limb of duodenum. The present findings were similar to the observations of Jain *et al* (2016) in case of CARI shyama chicks and Vanaraja growers, Ahmad *et al* (2012) in case of Japanese quail and Igwebuike & Eze (2010) in case of African pied crow.

5.1.3.2.The Jejunum and Ileum:

The jejunum was oriented in a number of short garlands like coils at the edge of the long dorsal mesentery. The proximal part of the jejunum was continued with the duodenum and extended caudally to connect the ileum. On the other hand, the ileum was continued with jejunum from the ceco-colic junction. The anatomical findings of this part had similarity with the descriptions of Ahmad *et al* (2012) for Japanese quail and Indu *et al* (2011) for peafowl. However the anatomical observation of jejunum was dissimilar with the findings of Igwebuike and Eze (2010) who narrated that the jejunum was arranged in the form of cone shaped spiral coils which had centripetal, a sigmoid flexure and centrifugal coils in case of African pied crow.

5.1.4.The large Intestine:

5.1.4.1.The Ceca:

Vanaraja chicken had a pair of ceca; right cecum and left cecum. Right and left cecum extended laterally at the junction of small and large intestine. The observations were in accordance with the description of McLelland (1989) for most birds, Ghosh (2015) for domestic fowl. The light red colored proximal part of the cecum was having narrow lumen. The middle part was wider and its luminal wall was thinner. The expanded distal part possessed a pointed extremity. These findings were similar to that of the description of Ghosh (2015) while these were not identical with the observation of McLelland (1989) who stated that many herons and bitterns possessed only one cecum. In addition to these, Ince *et al* observed a pair of ceca as rudimentary organs in case of Marmara region sea gulls which was not similar to present findings.

5.1.4.2.The Colo-rectum:

Light red colored, short colo-rectum lying below the lumbo-sacral vertebrae was continued with the ileum cranially and was extended caudally to the cloaca as a straight tube. It was suspended

from the dorsal wall of the abdominal cavity by a small segment of mesentery. Similar observations were done by Indu *et al* (2011) in peafowl, Getty (1975) and Ghosh (2015) in domestic birds.

5.1.5.The Pancreas:

Long, narrow, grey white coloured pancreas was lying in the mesentery connected to the limbs of the duodenum. Dorsal, ventral and splenic lobes were extended from the apex of the duodenal loop to the point where the pancreatic ducts entered into the distal ascending loop of the duodenum. Similar findings were observed by Clara (1924) and Getty (1975) who stated that in case of pancreas of fowl, a smaller lobe, other than dorsal and ventral lobe, was extended from head of the pancreas towards the spleen which had been termed as 'splenic lobe'. Although, Mikami and Ono (1962) depicted that the further subdivision of lobes of pancreas in case fowl and divided the ventral lobe into ventral lobe proper, the third lobe on the basis of independent form and peculiar distribution of islets. Identical findings were documented by Getty (1975), Guha & Ghosh (1978), Al-Agele & Mohammed (2012) And Al-Sharoot & Ali (2016) who described that the pale yellowish and reddish pancreas was consisted of dorsal, ventral and splenic lobe in which these lobes were long, thin and were extended longitudinally in the dorsal mesentery, joining the two limbs of duodenum. The gland exhibited three main excretory ducts that opened into the distal ascending limb of duodenum.

5.1.6.The Liver:

Reddish brown colored liver was located in ventral part of the abdominal cavity and it had two lobes: right lobe and left lobe. Identical observation was recorded by Selman (2013) in coot bird, Stornelli *et al* (2006) in ostrich and Moslem (2015) in ostrich and poultry. The right lobe was larger than that of the left lobe. The right lobe had a large gall bladder while the left lobe did not have any as observed by Moslem (2015) in poultry bird and Ghosh (2015) in domestic fowl. Although Moslem (2015) and Stornelli *et al* (2006) documented that the gallbladder was absent in case of ostrich, which is not accordance with present findings. Hepato-cystic duct and hepato-enteric duct were originated from the right and left lobe

respectively and were drained into ascending loop of duodenum. This finding was corroborated with the description of Ghosh (2015).

5.2.HISTOLOGICAL STRUCTURE:

5.2.1.The Esophagus and Crop:

The esophagus and the crop were composed of four tunics from inward; tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa. The tunica mucosa was lined by non keratinized stratified squamous epithelium. The poorly developed tunica submocosa layer was consisted of loose connective tissue and was contained vessels, lymphatics and nerves. The tunica muscularis was composed of thick inner circular and thin outer longitudinal layers. The tunica serosa was consisted of loose connective tissue fibers and it formed the boundary of tunica muscularis layer. The present histological findings were in accordance with the observation of Shehan (2012) in geese, Rossi *et al* (2006) in partridge, Madhu *et al* (2015) in emu, Kadhim and Mohamed (2013) Ghosh and Hegde (1991) in pigeon.

The lamina propria contained numerous mucous glands which were consisted of masses of compound tubular glands every gland formed a varying number of units. The mucous glands were less developed in cervical region than in the thoracic region. However the numbers of glands were more in cervical part. The present observations were similar to that of Kadhim & Mohamed (2013) in homing pigeon, Parchami *et al* (2011) in common quail.

5.2.2.The Stomach (the Proventriculus and Gizzard):

The histological observation of the Vanaraja chicken demonstrated that the wall of the proventriculus and the gizzard consisted of four tunics and this was in consistent with the findings of Kadhim *et al* (2011) in Red Jungle fowl, Al-Saffar *et al* (2016) in striated scope owl and Ahmed *et al* (2011) in Japanese quail. However Zhu (2015) established three layers in stomach of black tailed crake. The lining of the tunica mucosa of the stomach was of simple columnar epithelium that was described by Zhu (2015) and Hassan & Moussa (2012) in case of black tailed crake and duck respectively.

This finding was similar to the present observation. But it was not in accordance with the description of Kadhim *et al* (2011) in case of Red Jungle fowl and of Cartroxo *et al* (1997) in case of Red Capped Cardinal. This observation was also dissimilar to that of Hassan & Moussa (2012) in pigeon and of Rossi *et al* (2005) in Partridge who stated that the mucosal layer was lined by cuboidal epithelium.

Ahmed *et al* (2011) commented that the muscularis mucosa possessed compound tubule-alveolar glandular lobules. The gizzard mucosa formed the tubular glands in the lamina propria and each gland was lined by cuboidal cells. The muscularis mucosa was absent in case of gizzard of Japanese quail. The similar observation was documented in present study. However the simple tubular gastric glands were noticed by Kadhim *et al* (2011), Cartroxo *et al* (1997) and Toner (1964) in case of Red Jungle fowl, red capped cardinal and domestic fowl respectively. Also Glerean & Katchburian (1964) observed the prismatic cells lining of the glands which was not in accordance with the current study.

5.2.3.The small Intestine:

5.2.3.1.The Duodenum:

The mucosal surface of the duodenum was studded with large number of tall finger like villi that were arranged in a zigzag pattern which might be attributed for slow passage of food materials to enhance absorption. The observation was supported the findings of Dellman (1971), Jain *et al* (2016) in Vanaraja & CARI Shyama chicken and Ahmad *et al* (2012) in domestic bird. Although Hodges (1974) stated that the presence of leaf shaped villi in case of fowl. According to Jain *et al* (2016), Igwebuike *et al* (2010), Ahmad *et al* (2012) and Kachave *et al* (2009), the lining of the villus was composed of simple columnar epithelium containing goblet cells and entrochromaffin cells in case of Vanaraja & CARI Shyama chicken, African pied crow, Japanese quail and Poultry & broiler chicken respectively. It confirmed the findings of the present study. The present data was dissimilar to that of Rodrigues *et al* (2012) who stated that the villi were lined by pseudostratified squamous epithelium in case of Rhea. The glands (Crypts) were situated in lamina propria and were borderd by cuboidal epithelial cells with some goblet cells. This finding was not in agreement with the observation of Kachave *et al* (2009) who noticed

the columnar cells lining of crypts in case of broiler and layer poultry bird.

5.2.3.2.The Jejunum and Ileum:

Almost similar observations were found in case of jejunum and ileum as in duodenum. However the heights of the villi became shorter gradually from duodenum to ileum. This finding was similar to that of Igwbuike *et al* (2010) in case of African pied crow. Indu *et al* (2011), Kachave *et al* (2009) reported that, as in duodenum, the villi of jejunum and ileum lining was composed of simple columnar cells in case of pea fowl, broiler & layer poultry bird respectively. Although Rodrigues *et al* (2012) observed pseudo stratified squamous epithelial lining of villi in jejunum in case of Rhea. As observed by Kachave *et al* (2009) in broiler and layer poultry fowl, present findings also revealed that the glands or crypts were of bulged base tubular type and they were opened into the lumen between the bases of the villi. The crypts were lined by cuboidal epithelium with more numbers of goblet cells. But this observation was not akin to the finding of Ahmad *et al* (2012) in Japanese quail, who stated that, the crypts were lined by columnar cells.

5.2.4.The large Intestine:

5.2.4.1.The Ceca:

Each cecum was identified with three parts and the wall of the cecum was composed of four tunics; tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa. Identical observations were done by Rodrigues *et al* (2012) in rhea and Udoumoh *et al* (2016) in common pigeon. The proximal and distal cecum possessed typical and saw shaped structure of villi respectively. But the mid cecum did not show any typical villi structure; instead of that, numerous parallel folds were found. Similar observations were documented by Chen *et al* (2002) in domestic goose. Many lymphoid cells and lymphoid nodules were found in the lamina propria as observed by Udoumoh *et al* (2016) in common pigeon and by Calhoun (1954) in chicken. However Calhoun (1954) did not agree with the presence of lymphoid nodules in lamina propria.

5.2.4.2.The Colo-rectum:

Histological arrangement of the wall of the colo-rectum was almost similar to that of the cecum. Short, thick, blunt ended villi were observed in colo-rectum. Simple columnar cells lined the tunica mucosa layer. The lamina propria was invaded with lymphoid cells and lymph nodules. The present findings were almost in accordance with the description of Rodrigues *et al* (2012) and of Indu *et al* (2011) in case of rhea and pea fowl respectively.

5.2.5.The Pancreas:

The pancreas of Vanaraja was covered by a distinct connective tissue capsule. This finding was in accordance with Batt (1926) in poultry, Ham (1969) in domestic fowl and Al-Agele & Mohammed (2012) in golden eagle.

In H&E section, pale staining clusters of small roughly spherical or oval, highly vascularised islets of cells were noticed in different lobes which were identified as Islets of Langerhans. Similar descriptions were narrated by Dellman (1971), Ladukar *et al* (1996) in buffalo, Mobini (2013) in pigeon, Saadatfar & Asadian (2009) in mynah.

Batt (1926) described that in case of fowl pancreas, the intralobular ducts were found in the entry level of the tubules. The intermediate tubules were lined by simple flattened epithelium. The cells of epithelium lining were gradually become cuboidal in further ducts. The present findings were in accordance with the description.

5.2.6.The Liver:

Histological section of liver showed that the liver was covered with the capsula serosa, a thin coat of peritoneum. Below the capsula serosa, a thin, loose connective tissue layer capsula fibrosa (Glisson's capsule) was present. Identical findings were documented by Trautmann *et al* (1960).

The observations were in accordance with that of Dellman (1971) who depicted that the histology of liver revealed homogeneous

distribution of liver cords in the parenchyma without lobulations. The hepatocytes were spherical and large in size. The nuclei were lined basale.

Two single layer of hepatocytes were arranged together to form hepatic plate. Blood sinusoids network was located in close proximity to the hepatic plate. This finding was akin to that of Hodges (1974).

The tubule of bile capillaries was consisted of liver cells. The intercellular bile canaliculi were placed in between the tubules. The tubules were seen in between two or six cells as described by Nickel *et al* (1977).

Chapter - 6

Summary

SUMMARY

By studying the detailed anatomical and histomorphological speciality of this breed, we can have better understanding of this poultry and can also understand that it can be record successfully in backyard poultry farming in rural West Bengal as well as India for egg purpose or for meat purpose. It, thereby, can strengthen the socio-economic status of the people and also can strengthen the rural economy of our country. As a layer bird vanaraja is superior to other desi backyard poultry breeds.

The esopahagus was composed of cervical and thoracic part. The crop was a thin walled distensible diverticulum of the esophagus which was found just before the esophagus entered the thorax. The cervical esophagus was longer than the thoracic esophagus. Esophagus was dilated and opened into the proventriculus, although there was no clear demarcation between these organs.

The lumen of the proventriculus was narrow and thick and was composed of number of compound tubular glands. On the other hand, the gizzard was a biconvex lens shaped large muscular organ that was suspended in the postero-ventral part of the abdominal cavity and was laid between the lobes of the liver.

The duodenum arose from the cranial part of the gizzard and exhibited a proximal descending and a distal ascending limb. The ascending limb of the duodenum extended caudally to connect the jejunum. Both limbs of duodenum enclosed the pancreas.

The proximal part of the jejunum was continued with the duodenum and extended caudally to connect the ileum. On the other hand, the ileum was reddish gray in color and was continued with jejunum in the midline ventral to the rectum and cloaca caudally. But no gross demarcation was identified between the terminal part of jejunum and beginning of ileum.

The large intestine of the Vanaraja chicken was composed of a pair of ceca and a short straight intestine which was continued with the ileum and cloaca. Each cecum was divided into three parts.

Light red coloured, short colo-rectum was lying below the lumbo-sacral vertebrae.

The pancreas was consisted of dorsal, ventral and splenic lobe. The pancreatic ducts and the bile ducts were opened into the limb of duodenum.

The liver was composed of left and right lobes. The gall bladder was situated in the right lobe. The hepato enteric duct from the left lobe and the hepato cystic duct from the right lobe were opened into the ascending limb of the duodenum separately.

Histologically, the mucous membrane of the oesophagus had irregular folds which were lined by thick non keratinised stratified squamous epithelium with numerous openings of the glands occupied on the sides of the folds. Diffuse and aggregation of lymphocytes also observed in the lamina propria. The oesophageal glands were lined by single layer of columnar cells with small, round basal nuclei, eosinophilic cytoplasm and clear marked borders. The numbers of the glands were more in cervical region than that in thoracic region.

The lining epithelium of proventriculus was simple columnar. Few goblet cells were identified in this layer. From the base of the sulci, short, compound tubular glands extended into the lamina propria.

The muscularis mucosa was absent in case of gizzard.The tunica propria was glandular and the glands were branched tubular, simple glandular tubular and single tubular. The lining epithelium of the gland was simple cuboidal. The tunica mucosa was invaginated within the tunica propria and formed different size gizzard pits.

The small and large intestine were lined by simple columnar epithelium revealing villi with different shape and size. Histologically the cecum was identified into three parts viz. proximal, middle and distal parts. Within the tunica propria of the cecum, many lymphoid cells and lymphoid nodules were found.

Chapter - 7

Conclusion

CONCLUSION

As in others birds the cervical part of esophagus of Vanaraja was larger than the thoracic part. Thin walled crop was a distensible diverticulum with number of longitudinal folds in which food materials were stored for a while.

The compound tubular glands formed the narrow, thick proventricular lumen. Muscular stomach gizzard was suspended in the postero-ventral part of the abdominal cavity and was located in between lobes of the liver.

Descending and ascending duodenal limbs enclosed the pancreas. The descending limb connected with jejunum caudally. The jejunum was continued with duodenum cranially and with ileum caudally.

Both cecum of large intestine had three parts. Short, straight colo-rectum, was continued with ileum cranially and was located below the lumbo-sacral vertebrae.

Histologically, the non keratinized stratified squamous epithelium lined the esophageal mucous membrane foldings. Lamina propria of esophageal glands showed diffused lymphocytic aggregations. Availabilities of oesophageal glands were more in cervical part and these glands were lined by columnar cells. Proventricular epithelial lining was simple columnar with numbers of goblet cells. Gizzard wall was devoid of muscularis mucosae. Invaginations of tunica muscularis into the glandular lamina propria formed the gizzard pits.

The morphology of the ceca of the Vanaraja chicken supports the idea that the ceca are important in the digestion of food materials and immunological response of the birds to antigens.

Numerous alpha islets were found in splenic lobe of pancreas.

No major gross anatomical and microscopical differences between Vanaraja and other birds were observed, however, the differences may be due to age, breed or inherent in eating habits. This analysis will contribute to a better understanding of the physiological processes related to the nutrition and management of Vanaraja chicken during their growth.

Chapter - 8

Future Scope of

FUTURE SCOPE OF RESEARCH

In the present work entitled "Study Of Gross Anatomical and Histological Architecture of Gastro-Intestinal Tract in Vanaraja Breed of Poultry", the study demands further investigation more elaborately in the following aspects:

- Further electron microscopic identifications of different parts and organs of gastro-intestinal tract.
- Study of pre and post natal development of the digestive system should be carried out to evaluate the digestive efficacy in adult bird.
- Identifications and characterisations of different glands by immuno-histochemistry and enzyme-histochemistry.

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