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Comparative morphological studies on the digestive system of white leghorn (*Gallus gallus domesticus*) and guinea fowl (*Numida meleagris*) birds with special reference to their cloaca.

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Abstract
The present study was carried out on six pair of White Leghorn (*Gallus gallus domesticus*) and Guinea Fowl (*Numida meleagris*) Birds. A variety of parameters of the digestive organ were estimated. The digestive system of White Leghorn and Guinea fowl birds started from their beaks then the tongue carried out the feed up to crop. The crop was an out-pocketing arrangement of the esophagus which stored swallowed feed and water until they are passed further for digestion. Proventriculus and ventriculus was collectively known as the stomach. The small intestine comprised the duodenum and lower small intestine. The caecae are two blind pouches located at the junction of small and large intestine. The large intestine was collectively shorter than the small intestine and continuous serve as a cloaca. Cloaca was the component of digestive system that located at its last terminal end which received the finishing litter of digestive, urinary and reproductive system. These three systems terminated at cloaca as the common merger chamber of thermoregulation has three different components as coprodeum, urodeum and proctodeum respectively.

Keywords: Cloaca, white leghorn, guinea fowl, coprodeum, urodeum and proctodeum

Introduction
White leghorn (*Gallus gallus domesticus*) and Guinea fowl (*Numida meleagris*) have played a very vital role for humans since 19th century. These birds are the dependable sources of income while providing nutritional support to the people living in arid, semi-arid, hilly and tribal areas. The digestive system is important while converting ingested food into nutrients to maintain the body and thereby the production. The avian digestive system begins at the mouth and ends at the cloaca. Most of the birds obtained their feed by using their beaks. The picked food enters at the flexible tube oesophagus that provides connectivity of mouth with further digestive tract. The muscular organ, tongue carries different functions as prehension, mastication and deglutination. A crop is an expanded muscular pouch segment of the alimentary tract used for the storage of food prior to digestion. The stomach made up of two parts the first part of stomach is proventriculus that secretes strong digestive juice the second part of stomach is gizzard has strong muscular wall that act like teeth to functions for grinding, mixing and mash of ingested food material also referred as the mechanical stomach. The small intestine comprises the duodenum and lower small intestine. Digestion occurs in the duodenum and the released nutrients are absorbed mainly in the lower small intestine. The caecae are two blind pouches located where the small and large intestine join. Some of the water remaining in the digested materials is reabsorbed here. The large intestine is actually shorter than the small intestine. The large intestine is the last component for water reabsorption. The cloaca is being taken after the Latin word cluo meaning ‘to cleanse’. Thus the noun cloaca implies the ‘sewer’ or ‘drain’. Cloaca is the component of digestive system that located at its last terminal end which receives the finishing litter of digestive, urinary and reproductive system. These three systems terminate at cloaca as the common merger chamber of thermoregulation has three different components as coprodeum, urodeum and proctodeum respectively. The cloaca facilitates mixing of digestive wastes with the urates *viz*. the wastes from urinary system. Peculiarly the reproductive tract of a hen when lays an egg the vagina folds over there allow the egg to leave through cloacal opening without coming into contact with faeces and urine (Joshi and Meshram, 2018) [8].

Materials and Methods

The present investigation was conducted on digestive system and cloaca of White Leghorn (*Gallus gallus domesticus*) and Guinea Fowl (*Numida meleagris*) Birds**.** The six each samples of digestive system and cloacas were collected for WLH and Guinea fowl birds at meat shops in and around City of Udaipur and carried the similar on ice at the laboratory Department of Anatomy and Histology, College of Veterinary and Animal Science, Navania, Vallabhnagar, Udaipur for evaluation of gross studies. Gross Morphological studies of different parts of the digestive system and cloaca was carried out on fresh and unfixed specimens.

Result and Discussion

Gross Studies of Digestive System Digestive system of both the species of birds *viz*. Guinea fowl (*Numida meleagris*) and White leghorn (*Gallus gallus domesticus*) has an equal and essential importance in dealing the food which they take-in to have the source of energy. The different organ of digestive system in both the birds has shown similarity with the similar sequence. The alimentary tract was started at the beak or mouth and other prime organs including tongue, oesophagus, crop, proventriculus, gizzard, small intestine, large intestine were observed there which finishing at the cloaca (fig.1). The small intestine has shown duodenum, jejunum and ileum as its organ components and large intestine also has three organ components *viz*. right and left caeca and colorectum. Birds use their beak to take the feed in mouth cavity, the cavum oris and push forward to esophagus. The esophagus in both the breeds was found to be thin, straight long cylindrical tube extended from the pharynx to proventriculus. It was lying down, locating dorsal and right to the trachea. The food stuff was to be carried from mouth to the proventriculus via crop. Oesophagus was observed in both the sections of cervical and throacic part which was divided by saccular diverticulum called the crop. The expandable esophageal pouch named after crop was located in front of thoracic inlet at right ventero-lateral aspect to the esophagus. As it was located caudal to cervical region it was considered as the thoracic region, however, no clear division for thoracic and abdominal region was observed there in any of the species of birds. The crop serves as the short-term storage place for food which was containing longitudinal folds at the mucosal level. A similar finding was reported by Aizawa *et al*. (2013) [1] in Blue and Yellow macaws, Hamdi *et al*. (2013) [6] in Black-winged kite and Saran *et al*. (2019) [13] in Guinea fowl. The proventriculus in Guinea fowl (*Numida meleagris*) and White leghorn (*Gallus gallus domesticus*) was small, stretched thick walled tube, situated between the crop and gizzard responsible for primary digestion wherein the digestive enzyme and hydrochloric acid mixed with ingested food. There was constricted area between the proventriculus and gizzard called isthmus. This outcome of present revelations was in close accordance to mentioning of Aizawa *et al*. (2013) [1] in Blue and Yellow macaws and Saran *et al*. (2019) [13] in Guinea fowl, however Hamdi *et al*. (2013) [6] in Black-winged kite and Hussein and Rezk (2016) [7] in Cattle Egret were not mentioned such observance. The gizzard was biconvex in shape situated in the left caudo-dorsal region of the thoraco-abdominal cavity made up of a pair of strong muscles with a protective membrane for grinding and mixing the ingested food material. The gizzard was much larger and more muscular than the proventriculus. The present findings were similarly mentioned by Chaplin *et al*. (1992) [3] in domestic Turkey, Moore (1998) [11] in domestic Goose, Aizawa *et al*. (2013) [1] in blue and yellow macaws, Hussein and Rezk (2016) [7] in Cattle Egret and Saran *et al*. (2019) [13] in Guinea fowl. The small intestine had three segments *viz*. duodenum, jejunum and ileum. The Duodenum appeared as a 'U' shaped loop of intestine right desending part and left asending part separated by the pancreas within the loop. Jejunum was the longest segment among the entire intestine and arranged in the form of coils and floating in the common mesentery. The ileum was extended from the meckel's diverticulum of jejunum to the ileoceco-colic junction. The clear demarcation between jejunum and ilium was devoid in both the species undertaken for studies. The two blind pockets, caeca were there at the ileo-caecal junction where the small intestine ends and large intestine get originated. These were comparatively wide, short, straight tubes and continued upto colo-rectum which was the terminal end of large intestine, which further ceased into the most cloacal chamber *viz*. coprodeum. These findings were in agreement with the descriptions given by Hamdi *et al*. (2013) [6] in Black-winged kite and Saran *et al*. (2019) [13] in Guinea fowl and dissimilar to Aizawa *et al*. (2013) [1], as they had observed the caeca was missing in Blue and Yellow macaws.

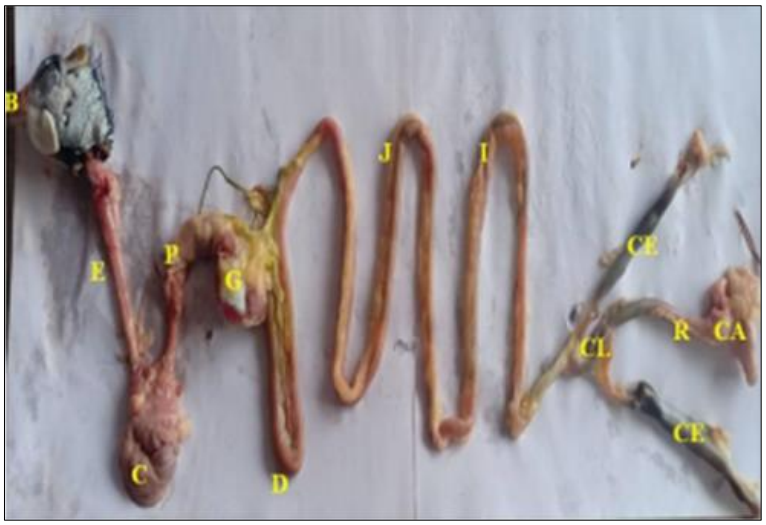

Fig 1: Digestive tract of Guinea Fowl showing Beak (B), Esophagous (E), Crop (C), Proventriculus (P), Gizzard (G), Duodenal loop (D), Jejunum (J), Ilium (I), Caecum (CE), Colon (CL), Retum (R) and Cloaca (CA).

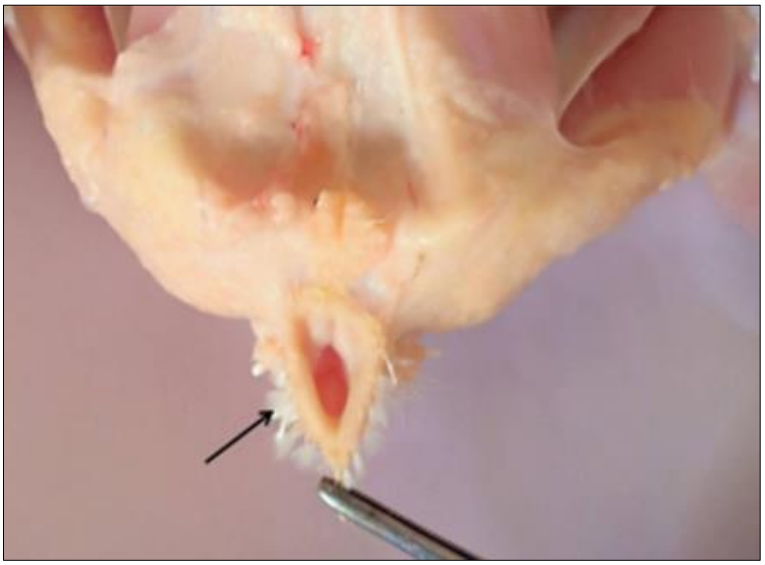

Fig 2: Photo showing Cloaca of White Leghorn birds.

Fig 3: Photo showing Caecum (CE), Rectum (R), Cloaca (CA), Kidney (K), Ureters (U), I (Intestine) and Vas deference (V).

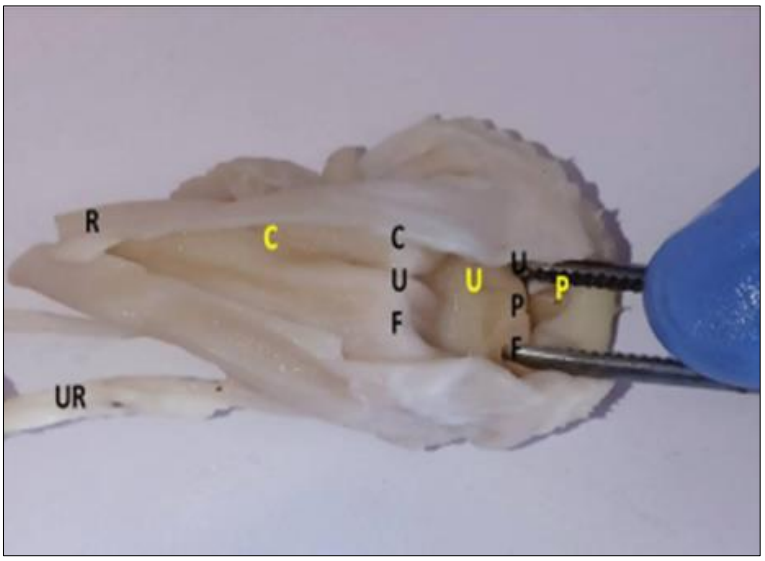

Fig 4: Photo showing Cloaca of White Leghorn Rectum (R), Coprodeum (C), Coprourodeal fold (CUF), Urodeum (U) , Uroproctodeum fold (UPF), Proctodeum (P) and Ureters (UR)

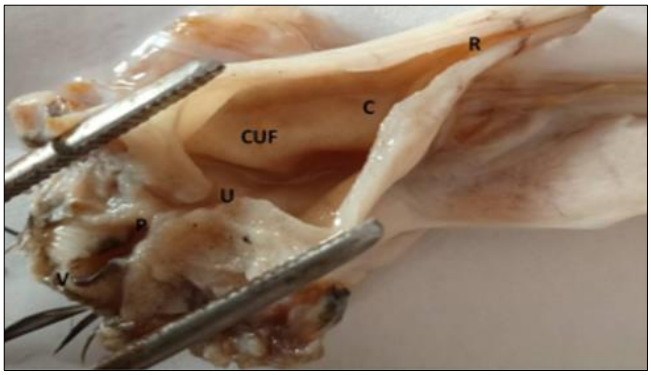

Fig 5: Photo showing Cloaca of Guinea Fowl Rectum (R), Coprodeum (C), Coprourodeal fold (CUF), Urodeum (U), Proctodeum (P) and Vent (V)

Gross Studies of Cloaca The cloaca of Guinea fowl (*Numida meleagris*) and White leghorn (*Gallus gallus domesticus*) was into cylindrical pipe shaped structure which was lying into the ventero-posterior portion of celomic cavity (fig.2). It was observed as the portion where intestinal, genital and urinary tracts got opened. This end portion was projected caudally beyond the body cavity and pelvic bone. The cloaca of both the species was divided into three major parts that started from cranial coprodeum then urodeum and the last caudal protodeum which was in confirmation with the report of De-oliveira and Mahecha (1996) [4] in Nothura maculosa, Kuchel and Franklin (2000) [9] in Estuarine crocodile, Sanchez-Martinez *et al*. (2007) [12] in Squamata, Elbrond *et al*. (2008) [5] in Rhea americana, Yang and Jiang (2011) [15] in African ostrich, Taylor (2016) [14] in Green-winged macaw and Rock pigeon, Joshi and Meshram (2018) [8] in White leghorn fowl. In between these three parts two folds were there as to copro-urodeal connecting coprodeum and urodeum and uro-proctodeal which was connecting urodeum and proctodeum (fig.4 and 5) these findings were in accordance with the description of Bakst and Cecil (1983) [2] in Turkey, DeOliveira and Mahecha (1996) [4] in Nothura maculosa, Yang and Jiang (2011) [15] in African ostrich, Taylor (2016) [14] in Green-winged macaw and Rock pigeon and Joshi and Meshram (2018) [8] in White leghorn fowl. The most cranial coprodeum was the largest of cloaca that acquiring feces from the rectum. No differentiating line was there between rectum and coprodeum, but the junction of rectum and coprodeum had an immediate increase in luminal diameter that was constantly advancing towards the vent (fig.4). The copro-urodeal fold was somewhat a barrier of fold of mucous membrane which separates the coprodeum from urodeum and might be serving to avoid the contamination of egg with faeces and also it provide passage for urine to mix with faeces. The present finding was parallel to the findings of Bakst and Cecil (1983) [2] in Turkey, Oliveira and Mahecha (1996) [4] in Nothura maculosa, Taylor (2016) [14] in Green-winged macaw and Rock pigeon, Mohammed (2017) [10] in Turkey hen and Joshi and Meshram (2018) [8] in White leghorn fowl. The copro-urodeal fold in female was more developed just prior to the oviposition. Urodeum was the smallest and second chamber of the cloaca. It was connected cranially to the coprodeum via copro-urodeal fold and caudally to the proctodeum via uro-proctodeal fold. It was the lodgment for left and right ureters in birds of either sex, also it has provided the lodgement for the left oviduct in females and paired ductus deferens in males. These findings were supported by the conclusion mentioned by Kuchel and Franklin (2000) [9] in Estuarine crocodile, Sanchez-martinez *et al*. (2007) [12] in Squamata, Elbrond *et al*. (2009) [5] in Rhea Americana and Mohammed (2017) [10] in Turkey hen. In the Guinea fowl (*Numida meleagris*) birds, the ureters and left oviduct in female and both left and right ductus deferens in males were opened dorsolaterally, however, in the White leghorn (*Gallus gallus domesticus*) birds the ureters were opened dorsally and left oviduct and the ductus deference were opened laterally (fig.3). which confirmed the findings of Bakst and Cecil (1983) [2] in Turkey, Kuchel and Franklin (2000) [9] in Estuarine crocodile, Martinez *et al*. (2007) [12] in Squamata, Elbrond *et al*. (2008) [5] in Rhea americana Taylor (2016) [14] in Green-winged macaw and Rock pigeon, Mohammed (2017) [10] in Turkey hen and Joshi and Meshram (2018) [8] in White leghorn fowl. The proctodeum was final and second largest division observed in both the species of birds. Cranially it was connected to the urodeum via uroproctodeal fold and caudally with horizontal external opening of the cloaca which was named as the vent. The uro-proctodeal fold was appeared clear in both birds (fig.4 and 5). The present reports were also confirmed by the reports of De-oliveira and Mahecha (1996) [4] in Nothura maculosa, Yang and Jiang (2011) [15] in African ostrich, Taylor (2016) [14] in Greenwinged macaw and Rock pigeon, Mohammed (2017) [10] in Turkey hen and Joshi and Meshram (2018) [8] in White leghorn fowl.

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