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SOME ANATOMICAL AND MORPHOETRIC STUDIES ON THE ESOPHAGUS AND STOMACH IN GOOSE, TURKEY, SPARROW, KESTREL, HOOPOE, OWL AND DARTER

(With 4 Tables and 23 Figures)

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دراسات طبوغرافية ومورفولوجية على المريء والمعدة في الأوز والرومي والعصفور والهدهد والعوسق المصري والبومة وطائر الغاق

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تم في هذا البحث دراسة الصفات الطبوغرافية والمورفولوجية لكل من المريء والمعدة بطريقة مقارنة في كل من الأوز والرومي والعصفور والهدهد والعوسق المصري والبومة وطائر الغاق و قد اتضح من الدراسة مايلى: أن المريء يختلف في طوله ووضعه تماما فيما بين هذه الطيور إلى جانب تكوين ووضع الحوصلة حيث يبلغ طول المريء حوالي ٢٦سم في الأوز و ١٩ سم في الغاق و١٧سم في الرومي والبومة و١١سم في العوسق المصري و٨.٥ في الهدهد و٤سم في العصفور. ويتكون المريء من جزأين أساسيين هما الجزء العنقي والجزء الصدري. كما أن الحوصلة تكون مغزلية الشكل وتمتد بطول الجزء العنقي فقط في الأوز والهدهد والعوسق المصرى والبومة . أما في طائر الغاق فهي تمتد على طول الثلث الأمامي للجزء العنقي فقط كما أنها تكون على هيئة كيس منتفخ عند قاعدة العنق في الرومي والعصفور. كما لوحظ أن الحوصلة في الأوز والعوسق المصري تمتد في الجزء الصدري للمريء ، وكما اتضح من هذه الدراسة أن المعدة تتكون من جزئيين واضحين يسهل التميز بينهما لوجود الجزء الضيق الفاصل بينهما (البرزخ) في الأوز والرومي والعوسق المصري . أما في حالة البومة والعصفور والهدهد وطائر الغاق فلا يوجد حد فاصل بين جزئي المعدة وبالتالي يصعب التميز بينهما. ويمثل وزن المعدة ١١،٨% من الوزن الكلى للطائر في الأوز ، ٥.٤% في العصفور ، ٢.٩ % في البومة و ١.٩ % في العوسق المصري و ١.٨ % في الهدهد و ١.٤ % في طائر الغاق و ١،٣% في الرومي . بينما يمثل طول المعدة ٦٥.٤٥ % من الطول الكلى لتجويف الجسم في حالة البومة و٥٢.٦ % في الهدهد و٥٠% في طائر الغاق و٤٦.٢ % في الأوز و ٤٠ % في العصفور و ٣٨.٩ % في الرومي و٢٧،٨ % في العوسق المصري . وقد اتضح أيضا من هذه الدراسة أن

حجم المعدة الفدية كبير نسبيا في البومة والعوسق المصري والهدهد وتكون صغيرة في طائر الغاق وهى كمثرية الشكل تتجه نهايتها المتسعة إلى الخلف والنهاية الضيقة للأمام . أما المعدة العضلية فهي كبيرة الحجم جدا في الأوز والرومي ومتوسطة في العصفور والهدهد وشكلها يشبه عدسة محدبة الوجهتين ويكون الجسم الجزء الرئيسي من المعدة العضلية ويفصل بين الكيسين الأعورين الصغيرين الأمامي الظهري والخلفي البطني واللذان يبرزان من نهايتي المعدة. أما في العوسق المصري والبومة والهدهد فالمعدة العضلية تشبه كيس يتكون سطحه الداخلي من تجويف واحد فقط حيث أن المعدة غير مميزة إلى جسم وكيسين أعورين. كما أتضح من هذه الدراسة أن السطح الداخلي للمعدة العضلية مبطن بطبقة متقرنة في الأوز والرومي والعصفور وهذه الطبقة مميزة إلى صفائح بينها شقوق منخفضة وتكون سميكة جدا عند جسم المعدة والكيسيين الأعورين الأمامي الظهري والخلفي البطني. أما في الهدهد وطائر الغاق فيكون هذا الغشاء المتقرن ضعيف جدا وسطحه الداخلي مغطى بطبقة متقرنة منتظمة التوزيع أما في حالة العوسق والبومة فان تجويف المعدة العضلية يمثل تجويف واحد غير مميز إلى جسم وكيسين أعورين ويحتوى على أربعة صفوف غدية بارزة من النتوءات المغطاة بطبقة متقرنة رقيقة جدا.

SUMMARY

The esophagus of birds is thin walled and distensable with relatively greater diameter than that of the mammals. It is divided into a longer cervical part and a shorter thoracic one. The length of the cervical part reaches about 20cm in goose, 15cm in darter, 14cm in owl, 12cm in turkey, 8.5cm in kestrel, 6.2cm in hoopoe and 2.5cm in sparrow. It starts from the caudal part of the oropharynx median in position dorsal to the larynx and the trachea till the level of the 2nd cervical vertebra in sparrow, hoopoe, kestrel and darter; 3rd cervical vertebra in goose and turkey and 5th cervical vertebra in owl, it curves to the right side of the neck. In goose, kestrel, hoopoe, owl and darter the cervical part of the esophagus is expanded about 2-3cm after its origin to form the elongated spindle shaped crop. In darter this expansion occupies the proximal third of the neck only where it subsides in its caliber to be very narrow along its course to open abruptly in the stomach. In turkey and sparrow the cervical part of the esophagus widens immediately cranial to the thoracic inlet between the branches of the furcula to form the sacular crop. In goose and kestrel another expansion of the esophagus was observed in the thoracic part of the esophagus. The length of the thoracic part of the esophagus reaches about 6 cm in goose, 5 cm in turkey, 4 cm in darter, 3 cm in owl, 2.5cm in kestrel, 2 cm in hoopoe and 1.5 cm in sparrow. The stomach of the examined birds can be divided into three types dependence on the nature of the diet; soft diet eating birds (kestrel and owl), hard diet eating birds (turkey and sparrow) and intermediate diet eating birds (goose, hoopoe and darter). The stomach of the

examined birds consists of cranial glandular and a caudal muscular parts, which are externally distinguishable from each other by the isthmus only in goose, turkey and kestrel, while it is not externally distinguishable in sparrow, hoopoe, owl and darter. The glandular stomach is well demarcated in goose, turkey and well-developed in kestrel. It is in the form of a spindle shaped structure in goose and turkey while it is elongated pear shape in kestrel and hoopoe; tubular in shape in sparrow and owl as well as narrow tube with the same caliber of the esophagus in darter. The muscular stomach is in the form of biconvex lens consisting of a body and two blind sacs in goose, turkey, sparrow and hoopoe, discoid in form in kestrel and owl and J like stump in darter. The relative weight of the stomach to the total body weight depends mainly upon the structure of the muscular stomach in different species of the examined birds. It represents about 11.8% in goose, 5.4% in sparrow, 2.9% in owl, 1.9% in kestrel, 1.8% in hoopoe, 1.5% in darter and 1.3% in turkey of the total body weight. On the other hand, the relative length of the stomach to the total body length reaches about 32% in owl, 20.9% in goose, 15.4% in sparrow, 14.3% in kestrel, 12.9% in darter, 10.4% in turkey and 9.2% in hoopoe. While the relative length of the stomach to the total length of the body cavity represents about 65.4% in owl, 52.6% in hoopoe, 50 % in darter, 46.2% in goose, 40% in sparrow, 38.9% in turkey and 27.8% in kestrel. In goose, turkey and sparrow the inner surface of the muscular stomach is subdivided into three portions including a cranial sac, caudal sac and a body, which is covered by the cuticle. The cuticle is well developed in the dorsal and ventral parts of the body and become thin in the cranial and caudal sacs and over the tendinous centers. In hoopoe, darter, kestrel and owl the muscular stomach is undivided internally and in hoopoe and darter the cuticle is more jell like membrane. In kestrel and owl the wall of the proventriculus contains 4 glandular folds, which extens till the isthmus to continue with the well-developed glands of the submucosa, which encircle all the contour of the muscular stomach. These glandular folds give the gizzard of kestrel and owl a glandular appearance.

Key words: Comparative Anatomy, Esophagus and *Stomach Birds.*

INTRODUCTION

Only little information was given by King and McClelland (1984), Nickel, Shummer and Seiferle (1977), McClelland (1975) about

the topography and morphology of the esophagus and stomach in fowl, duck and pigeon. Ibrahim (1992) give a detailed study on the topography and morphology of the esophagus and stomach in fowl, duck, pigeon, dove, quail, heron and jackdaw.

The main aim of the present study is to throw light on the topography and morphology of the esophagus and stomach of different species of birds (goose, turkey, sparrow, hoopoe, kestrel, owl and darter.) differ in the nature of food intake, including soft diet eating birds (kestrel, owl); hard diet eating birds (turkey, sparrow), intermediate diet eating birds (goose, hoopoe and darter).

MATERIALS and METHODS

The present investigation was carried out on the esophagus and stomach of ten adults (males and females) birds of each of Goose *(Anser domestica)*, Turkey *((Meleagris gallopavo)*, Sparrow *(Prunella modularis)*, Buff- headed wood-hoopoe *(Phoeniculus bollei)*, Kestrel *(Flaco tinnunculus)*, owl *(Asio otus)* and Darter *(Anhinger rufa)* of both sexes and of different ages. Certain measurements were taken including, length and weight of the esophagus and stomach as well as that of the body and the length of the body cavity. The birds were weighted then slaughtered and dissected for topographic study of the esophagus and stomach. After that, the stomach of each bird was removed and weighted, then preserved in 10% formalin solution before morphological study. The nomenclature used is that adopted by the NOMINA ANATOMICA AVIUM (1979) as if it was possible.

RESULTS

Esophagus:

The esophagus of birds is thin walled and distensable with relatively greater diameter than that of mammals, as well as within the avian species where there is a clear close relation-ship between its caliber and the size of the diet of the food, which they fed on. The esophagus connects the oropharynx with the glandular stomach (proventriculus). It is divided into the longer cervical part and the shorter thoracic part.

The cervical part:

In situ when the neck is unexpended, the cervical part of the esophagus is shorter than the s-shaped cervical region of the vertebral column. Mostly, the cranial third of it lies ventral to the vertebral column

in all examined bird species except in darter which passes ventrolateral to the vertebral column till the level of the 4th cervical vertebra where it becomes dorsal to the level of the 11th cervical vertebra; then return again lateral to the vertebral column. The caudal two thirds lie to the right of the column in sparrow, hoopoe, kestrel and owl (Fig. 14, 15,16,17/1) and dorsal in goose, turkey and darter (Fig. 12, 13,18/1). The cervical part of the esophagus reaches about 20cm in length in goose, 15 cm in darter, 14cm in owl, 12cm in turkey, 8.5cm in kestrel, 6.2cm in hoopoe and 2.5cm in sparrow. It lies in the midline at first dorsal to the larynx and trachea till the level of the 2nd cervical vertebra in sparrow, hoopoe, kestrel and darter, 3rd cervical vertebra in goose & turkey and 5th cervical vertebra in owl. As the esophagus courses to the right side of the neck it is covered only by the skin and accompanied by the right jugular vein and vagus nerve. In goose, hoopoe, kestrel, owl and darter (Fig. 12, 15,16,17,18 /2) the cervical part of the esophagus is expanded about 3 cm after its origin to form the elongated spindle shaped crop. In turkey and sparrow, the cervical part of the esophagus widens immediately cranial to the inlet of the body cavity between the branches of the furcula to form the crop (Fig. 13, 14/2).

The crop:

The crop functions as a highly dispensable storage chamber for food especially in hard diet eating bird and is closely, adhere to the covering skin. In goose, hoopoe kestrel and owl the crop is in the form of elongated spindle-shaped dilatation with distinct cranial middle and caudal regions (Fig. 12, 15,16,17,19/2). Moreover, in goose & kestrel the crop extends about 2-3 cm within the body cavity. In turkey and sparrow (Fig. 13,14,19/2) the crop has the form of a sacular ventral diverticulum from the caudal part of the cervical esophagus. It lies on the right side of the neck and rests on the furcula when it is full. In darter (Fig. 18) the crop is represented by spindle shaped dilatation occupies only the cranial third of the cervical esophagus. Generally, the inner surface of the esophagus and the crop is characterized by the presence of parallel longitudinal folds (Fig. 20). The size and number of these folds depend upon the size of the swallowed pieces of food. It is observed that, these folds are greater in number and well developed in owl, kestrel, hoopoe and darter where the birds swallow very large pieces of food; and that of goose as the bird store the food through out the whole length of the esophagus.

In turkey as it produce a very characteristic voice either for showing off or for mating call, the circular muscles of the cervical esophagus just caudal to the crop are well developed. In addition, there

is an elastic bar area of skin attached with the adventitia of the crop at its ventral median part and the scapula (Fig. 20), which help in the mechanism of the production of the voice. These mechanism as, when the cervical part of the esophagus is inflated with the air from the air sacs and lungs via the trachea and the glottis; this air is prevented from escaping rostrally by the tongue and close apposition of the floor and roof of the pharynx and caudally the trachea, sternohyoid muscle and the most important is the inelastic bar of skin of the ventral median part of the crop and the well developed circular muscle of the esophagus caudal to the expanded crop

The thoracic esophagus:

The thoracic part of the esophagus (Fig. 12-18 /3) is shorter than the cervical part but its diameter is wider except in darter. It extends caudally in a straight course dorsal to the syrinx, trachea and between the extrapulmonary primary bronchi. It is pushed between the syrinx and the ventral surface of the lung to reach the base of the heart and the dorsal surface of the liver. At the level of the 2nd intercostal space or the third rib in goose, kestrel and darter; third intercostal space or the fourth rib in turkey, hoopoe and owl and fourth intercostal space or the fifth rib in sparrow, the esophagus turns to the left and ends in the glandular stomach without any line of demarcation in sparrow, hoopoe, owl and darter (Fig. 7, 8, 10, 11), while in goose, turkey and kestrel it can be easily distinguished externally (Fig. 5,6,9). During its course the thoracic part of the esophagus is related to the right and left common carotid arteries as well as jugular veins. It is closely related to the cervical, clavicular and cranial thoracic air sacs. This part of the esophagus is relatively long in goose, turkey and darter where it reaches about 6cm, 5cm, and 4cm respectively. While it is relatively short in owl about 3cm, kestrel about 2.5 cm, hoopoe about 2 cm and in sparrow about 1.5 cm (Table 1).

Stomach:

The stomach of all examined birds consists of two chambers the glandular stomach cranially (proventriculus) which secrete the gastric juice and the muscular stomach caudally (gizzard) which functions as the site of gastric proteolysis or mechanical digestion the two chambers cotinue with each other through an intermediate zone (isthmus). Depending on the nature of the diet the present study can divides the stomach of the examined birds into three

types: *Soft diet eating birds* (meat): as in kestrel and owl in which the stomach appears as sac like structure oval to round in shape; with thin wall and composed internally from one part lined by

uniformally semithin layer of cuticle. The main function of this type of gizzard is storage the food only. The proventriculus is well developed (Fig. 9, 10).

Hard diet eating birds (grains): as that in turkey and sparrow in which the stomach appear as a biconvex lens with very thick muscular wall, oval or rhomboid in shape and consists internally of three parts; 2 blind sacs and body; lined by the cuticle of different thickness. The main function of this type is mechanical treatment of the food. The proventriculus is somewhat small and of spindle shape. In these birds the esophagus is responsible for the storage of food (Fig. 6,7,19).

*Intermediate diet eating birds (*worms, fishes, fruit, plant) as in goose, hoopoe and darter in this type of birds the shape of the stomach is somewhat between that of the two proceeding types depending upon which the role of the gizzard is either that of a storage or as an organ concerned with the physical digestion Its internal surface covered with jell like cuticle (Fig. 6,8,11,23).

The relative weight of the stomach depends upon the nature of the diet; generally much of the total weight of the stomach is related to the weight of the gizzard. As recorded in (Table 2) and (Fig1); the relative weight of the stomach to the total body weight represents nearly about 11.8% in goose, 5.4% in sparrow, 2.9% in owl, 1.9% in kestrel, 1.8% in hoopoe, 1.5% in darter and 1.3% in turkey. On the other hand, the relative length of the stomach to the total body length is about 32% in owl, 20.9% in goose 15.4% in sparrow, 14.3% in kestrel, 12.9% in darter, 10.4% in turkey and 9.2% in hoopoe (Table 4 & Fig.1). However the relative length of the stomach to the total length of the body cavity is about 65.4% in owl, 52.6% in hoopoe, 50% in darter, 46.2% in goose, 40% in sparrow, 38.9% in turkey and 27.8% in kestrel as recorded in (Table 4 & Fig. 2). This result explain that; the stomach occupies more than the half the length of the body cavity in owl and hoopoe, half length of the body cavity in darter, more than one third of the body cavity length in goose, sparrow & turkey and slightly more than one quarter in kestrel.

The glandular stomach (proventriculus):

The glandular stomach is well developed in kestrel and well demarkated in goose and turkey. It is spindle shaped in goose, turkey and elongated pear shaped in kestrel and hoopoe (Fig. 5,6,8,9/ a, á). Its cranial pole is connected with the esophagus and can be easily detected externaly by the presence of a constriction at their connection (Fig. 5,6.9/1). Its caudal pole is rounded in shape and represents the base of the proventriculuds. In sparrow and owl it is tubular form (Fig. 7,10.

11a, á). In darter the proventriculus is ill developed and has the same width of the esophagus (Fig. 11 a, á). The proventriculus extends cranio-ventrally somewhat ventrally and to the left on the left side of the body cavity. Dependence on its length; the extension of the glandular stomach differs in the different examined bird species; in goose the proventriculus begins at the level of the 2nd intercostal space and extends caudally to the level of the 5th rib (Fig. 12). In turkey and owl the glandular stomach extends from the level of the 3rd intercostal space till to the level of the fifth rib (Fig. 13,17/b). However, in kestrel the well-developed glandular stomach extends from the level of the 2nd intercostal space till the level of the 4th rib (Fig. 16/b). In sparrow & hoopoe the glandular stomach extends from the level of the 4th intercostal space to the level of the last rib (Fig. 14, 15/b). In owl the proventriculus extends from the level of the 3rd intercostal space to the 6th rib (Fig. 17). In darter the proventriculus extends from the level of the 2nd rib to the level of the 6th rib (Fig. 18).

The relative weight of the glandular stomach to the total stomach weight represents about 40.9% in sparrow, 27.3% in kestrel & owl, 13.8% in darter, 13.4% in hoopoe, 11.6% in turkey and 8.9% in goose. (Fig.4) and (Table 2). In goose the glandular stomach measures about 6 cm in length & 1.9 cm in width, in turkey 3.5 cm in length and 1.5 cm in width, in kestrel is about 1.1 cm in length and 0.9 cm in width, in sparrow 0.7 cm in length and 0.2 cm in width, in hoopoe 1.6 cm in length and 0.5 cm in width, in owl 3.5 cm in length and 1.1 cm in width and in darter 2.3 cm in length and 0.4 cm in width. The relative length of the glandular stomach to the total body length is 13.2% in owl, 10.4% in goose, 7.1% in hoopoe, 6.3% in kestrel, 5.4% in sparrow and 6.6 % in darter 5.2% in turkey. On the other hand, the relative length of the glandular stomach to the total length of the body cavity represents about 28.1% in hoopoe, 26.9% in owl, 25,6% in darter, 23.1% in goose, 19.4% in turkey, 14% in sparrow and 12.2% in kestrel. However, the relative length of the glandular stomach to the total length of the stomach is about 53.3% in hoopoe, 51.1% in darter, 50% in goose and turkey, 44% in kestrel, 41.2% in owl and 39% in sparrow (Fig.1, 4) & (Table 4).

In all examined birds the proventriculus is completely conceald by the left lobe of the liver of which it makes a deep gastric impression, the spleen on the medial side and coverd dorsally by the thoracic and abdominal air sacs, the left testis, ovary& oviduct, caeca and ileum. Dependence on the nature of the diet the inner surface of the proventriculus in meat eating birds contains well developed glands which appear in the form of 4 rows on its sides appear the opening of the

excretory ducts of the glands of the lamina propria. (Fig. 22), However, in hard diet eating birds a number of low and wide papillae are projecting into the lumen of the glandular stomach, at the apex of each papilla opens the excretory duct of one of the glands of the lamina propria (Fig. 21).

The muscular stomach (gizzard):

The muscular stomach (Gizzard) is a large organ. Its cranio-caudal diameter is greater than its dorsoventral one except in kestrel in which it is circular in shape. In goose, turkey, sparrow and hoopoe the muscular stomach (Fig. 5,6,7,8) is shaped like a biconvex lens which is firm to touch and of red colour with a rhomboidal circumferance in case of goose and turkey; oval in shape in hoopoe, semicircular in sparrow. In kestrel and owl the muscular stomach is in the form of a sac like structure (Fig. 9,10). The craniocaudal axis of the gizzard extends ventrally and to the right in the left ventral part of the body cavity, cranially the gizzard related to the left and right lobes of the liver, dorsally to the left air sac, ovary, oviduct, rectum and left caecum. The rgiht ventral part of the gizzard is related to the duodenum and pancreas. The muscular stomach almost fills the left lower quadrant of the caudal part of the body cavity and even extends beyond the midline to the right in hoopoe, kestrel and owl where its ventral contour reaches the ventral abdominal wall. In goose and turkey it extends from the level of the 5^{th} rib to about 0.3 & 0.5 cm caudal to the caudal border of the last one respectively. In sparrow the muscular stomach extends about 3cm more caudally from the level of the last rib.In hoopoe the muscular stomach extends from the level of the 6^{th} rib till the level of the caudal border of the last rib. In kestrel and owl the muscular stomach extends from the level of the 4^{th}& 5^{th} rib to a level caudal to the caudal border of the last rib for about 0.5 & 0.9 cm respectively. However, in darter the muscular stomach extends from the level of the 6^{th} rib till to the level caudal to the caudal border of the last rib for about 2 cm.

The weight of the muscular stomach depends upon to which extend the role of the muscular stomach for the physical preparation of the food among the examined bird species. As recorded in (Table 2) and (Fig. 1) the weight of the muscular stomach represents about 10.8% of the total body weight in goose, 5.1% in sparrow, 2.1% in owl, 1.4% in hoopoe & kestrel, 1.3% in darter and 1.1% in turkey. On the other hand, the weight of the muscular stomach represents about 94.3% of the total weight of the stomach in sparrow, 91% in goose, 88.3% in turkey, 86% in darter, 81.2% in hoopoe, 72.8% in owl and 72.7% in kestrel (Table 2 & Fig. 4). In comparison the weight of the muscular stomach in soft diet

eating birds with that of hard diet eating birds; the gizzard of the owl to that of the goose represents about {0.16: 1}, that of the owl to turkey represented [0.83: 1]; more over the gizzard of kestrel represents [0.05:1] times that of the turkey and [(9.7)-3:1] in goose. This means that the weight of the gizzard in birds feed on diet of soft food is much less developed than in birds feed on hard items. (Table 2 &Fig. 4). As recorded in (Table 4) that the relative length of the muscular stomach to the total length of the body about 18.9% in owl, 17.4% in goose, 10% in sparrow, 8.2% in turkey, 8% in kestrel, 6.3% in darter and 6.2% in hoopoe. On the other hand, the relative length of the muscular stomach to the total length of the body cavity reaches about 38.5% in goose &owl, 30.5% in turkey, 26% in sparrow, 24.4% in darter, 24.3% in hoopoe and 15.6% in kestrel. However, it forms about 83.3% of the total length of the stomach in goose, 78.6% in turkey, 65% in sparrow, 58.8% in owl, 56% in kestrel, 48.9% in darter and 46.7% in hoopoe (Table 4 and Fig. 4). The muscular stomach of goose, turkey, sparrow and hoopoe in which the diet consists of predomintly of tough food, requiring mechanical treatment before the action of the gastric juice, consists of body and a small cranial blind sac and a small caudal blind sac. The extensive right and left tendinous surface of the body usually united dorsally and ventrally by much narrow annular surfaces. The intermediate zone opens into the cranial sac, the junction between the muscular and glandular stomach usually being marked externally by an isthmus (Fig. 5,6,7,8).

The interior of the gizarrd in meat eater birds (kestrel, owl) is internally undivided, the inner surface is lined by a thin continuous layer of cuticle is uniformly thick and of semi-firm consisting jelly like its function is probably mainly to protect the underlying mucosa from the effects of the gastric juice secreted by the proventriculus (Fig 22). In grains eater birds (turkey, goose, sparrow) the interior of the gizzard is subdivided into three portions including cranial sac, caudal sac and a body, which can be divided into dorsal and ventral parts. The cranial sac opens in the dorsal part and the caudal into the ventral part. The cuticle varies extensively in thickness between the different regions of the gizzard and it's of extremely hard consistency (Fig. 21). It is best developed in the dorsal and ventral parts of the body and thinnest in the cranial and caudal sacs and over the tendineus centers. The cuticle covers the dorsal and a ventral part of the body is especially thick and forms the so-called dorsal and ventral griding plates. As with the muscle of the gizzard the thickness of the griding plates is also asymetrical. The dorsal grinding plate and the ventral griding plate is thickest cranially

opposite to the cranio-ventral thick muscle and this arrangement enable the griding plates to fit very closely together and reduce the lumen of the gizzard to a cleft. In the intermediate type of stomach depends upon the function of the gizzard, if it is for storage the cavity then is undivided and lined with soft uniform thickness cuticle (hoopoe, darters) however, when it is for mechanical preparation of the food the cavity is subdivided and lined by hardish cuticle of unequal thickness spallow (Fig. 24).

DISCUSSION

According to Das and Biswac (1967), King and McClelland (1984) as well as Ibrahim (1992) and as described in this investigation that the esophagus consists of a long cervical and short thoracic parts. Also the position of the esophagus in goose and different studied birds is similar to that of fowl. From the account of Malewitz and Calhoun (1958) few differences exist between the esophagus of turkey and that of fowl. In this study, the length of the esophagus is about 26 cm in goose, 19 cm in darter, 17 cm in turkey and owl, 11cm in kestrel, 8.5 cm in hoopoe and 4 cm in sparrow. According to Ibrahim (1992) the length of the esophagus is about 22.5 cm in heron, 18 cm in fowl, 15 cm in duck, 14 cm in jackdaw. 10.5 cm in pigeon and dove and 9.5 cm in quail. On the other hand, Latimer and Rosenbaum (1926) stated that the length of the esophagus in turkey is 22.5-33.5 cm. In these concern measurements by Marsden (1940) in young turkeys demonstrated that the cervical esophagus excluding the width of the crop is approximately twice the length of the thoracic esophagus.

Gadaw (1891), Niethammer (1933) and Ziswiler (1967 a, b) have described the great diversity in the form, size and complexity of the crop. According to the above-mentioned authors, the simplest form of the crop is basically a spindle shaped enlargement of the cranial, middle and caudal regions of the cervical esophagus. This type was observed in this study in goose, hoopoe, kestrel and owl. In the darter the enlargement was only found in the cranial part of the cervical esophagus. Only in goose and kestrel, the crop extends about 2-3 cm within the body cavity; this is in agreement with that described in duck and jackdaw (Ibrahim, 1992). However, Boker (1929) mentioned that the thoracic esophagus in Strigops is short straight with no crop like expansion. In turkey and sparrow the best-developed forms of the crop are highly differentiated sac- like structure, which arise as ventral or lateral diverticulum of the caudal part of the cervical esophagus. This is

in agreement with that mentioned by Ibrahim (1992) in fowl, pigeon dove and quail as well as by Boker (1929) in birds. The present study is in agreement with that of King and McClelland (1984) who mentioned that the internal surface of the esophagus and crop contain longitudinal folds that differ in number and thickness according to the size of the swallowed food. The present study agrees also with that described by Clark et al. (1942); Honesss and Allred (1942); Garod (1874 a&b); Niethammer (1937, 1961 & 1966); Lehmann (1941) and Sick (1954) that the adventitia of the crop connects ventrally with inelastic skin and the circular muscle layer of the cervical part of the esophagus caudal to the crop is very thick which help in production of voice in different species of birds.

The general appearance of the stomach varies considerably between different groups of birds and seems to be determined mainly by diet as mentioned by Swenander (1902). In this respect, the present study divides the stomach of the examined birds into three types; soft diet eating birds as in kestrel and owl; the main function of gizzard in this type is storage of food only. Hard diet eating birds as in turkey and sparrow; the main function of this type is mechanical treatment of the food. The proventriculus is somewhat small spindle shape. In these birds the esophagus is responsible for the storage of food. In the intermediate diet eating birds; as in goose, hoopoe and darter, the role of this gizzard is either storage or as an organ concerned with the physical digestion. More or less similar results concerning this aspect in accordance with that mentioned by Swenander (1902). McClelland (1975), Nickel et al (1997) and King and McClelland (1984) where the general appearance of the stomach varies considerably between different groups of birds and seems to be determined mainly by diet.

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LEGENDS OF FIGURES

Fig. 1: A histogram showing the relation between the weight & length of the stomach to the total body weight & length respectivelly.

Fig. 2: A histogram showing the relation between the length and position of the stomach and length of the body cavity in different examined bird species.

Fig. 3: A histogram showing the relation between the mean percentage of the weight of the proventriculus and the gizzard of the total weight of the stomach in the examined birds.

Fig. 4: A histogram showing the relation between the mean percentage of the length of the proventriculus and the gizzard of the total length of the stomach in the examined birds.

Fig. 5-11: A photograph showing the stomach of:

5- Goose 6- Turkey 7- Sparrow 8- Hoopoe

9-Kestrel 10- Owl 11-Darter

(a) Right view (á) Left view

a- Esophagus b- Proventriculus c- Gizzard

d- Pylorus with the origin of the duodenum

1- Isthmus 2- Body

3- Cranial blind sac with craniodorsal thin muscle

(3) 4- Caudal blind sac with caudoventral thin muscle.

(4) 5- Dorsal and 6- ventral parts of the muscular stomach with the cranioventral

(6) and caudodorsal (5) thick muscles.

7- Tendinous aponeurosis

8- Caudal transverse groove

9- Cranial transverse groove.

Fig12-18: Diagrammatic illustration of the esophagus and stomach in:

12- Goose 13- Turkey 14- Sparrow

15- Hoopoe 16- Kestrel 17- Owl

18-Darter (Right view) showing:

a- Trachea b-Scapula c-First rib d-Last rib

1- Cervical part of the esophagus 2- Crop

3- Thoracic part of the esophagus 4-Proventriculus

5- Gizzard 6- Duodenum.

Fig. 19: Diagram showing the shape of the crop in different examined bird species.

A- Turkey B- Sparrow

C- Goose, Hoopoe, Kestrel, Owl and Darter.

Fig. 20: A photograph showing in turkey:

o- Oesophagus T-trachea S- shoulder joint

-The longitudinal folds of the inner surface of the crop. (arrow)

-The elastic skin at the ventral aspect of the crop. (*)

Fig. 21: A photograph of opened stomach of turkey (grain eating bird) showing:

o- Esophagus p- Proventriculus i- Isthmus

g- Gizzard y - Pylorus.

with the origin of the duodenum.

• - Mucous membrane of the esophagus.

M.M of the proventriculus with the orifice of the glands. (arrow)

e- Mucosa of the cranial & caudal blind sacs (cuticle).

h- Mucosa of the body

k- Cranio-ventral thick muscle

u- Caudo-dorsal thick muscle.

Fig. 22: A photograph of opened stomach of kestrel (meat eating bird) showing:

o- Esophagus p- Proventriculus i- Isthmus

g- Gizzard y- Pylorus

with the origin of the duodenum.

• - Mucous membrane of the esophagus (arrow) longitudinal glandular folds of the mucosa of the proventriculus.

(*) Four raw of mucosal folds of the gizzard encircles the all of its counter.

Fig. 23: A photograph of opened stomach of darter (fish eating bird) showing: The interior of the gizzard one compartment.

o- Esophagus p- Proventriculus i- Isthmus

g- Gizzard y- Pylorus

with the origin of the duodenum.

• - Mucous membrane of the esophagus

g- Jill likes cuticle membrane with the same thickness.

Table (1): Showing the length of the oesophagus and its parts (in cm) in the examined birds.

Bird	Total length	Cervical part (absolute length)	Cervical part (relative to total)	Thoracic part (absolute length)	Thoracic part (relative to total)
Goose	26.0 ± 1.17	20.0 ± 1.32	76.9 ± 5.73	6.0 ± 0.28	23.1 ± 1.27
Turkey	17.0 ± 1.12	12.0 ± 1.12	70.6 ± 1.37	5.0 ± 0.37	29.4 ± 1.07
Sparrow	4.0 ± 0.3	2.5 ± 0.16	26.5 ± 2.1	1.5 ± 0.14	37.5 ± 2.18
Hoopoe	8.5 ± 0.62	6.2 ± 0.36	72.9 ± 5.12	2.0 ± 0.15	23.5 ± 1.08
Kestrel	11.0 ± 0.84	8.5 ± 0.61	77.3 ± 5.84	2.5 ± 0.19	22.7 ± 2.31
Owl	17.0 ± 0.92	14 ± 0.12	82.4 ± 6.07	3.0 ± 0.11	17.6 ± 1.11
Darter	19.0 ± 1.6	15.0 ± 1.21	78.95 ± 6.40	4.0 ± 0.32	21.1 ± 1.2

Table (2): Absolute and relative values of the body weight, weight of the stomach as well as its proventricular and ventricular parts in examined birds.

Bird	Total body weight	Absolute stomach weight	Stomach/ body percentage	Absolute weight of proventriculus	Proventriculus/body percentage	Proventriculus/stomach percentage	Absolute gizzard weight	Gizzard/ body percentage	Gizzard/ Stomach percentage
Goose	1500 ± 50.3	177.3±7.69	11.82 ± 1.4	15.9 ± 0.6	1.06 ± 0.11	8.97 ± 0.29	161.4 ± 9.4	10.76 ± 1.0	91.0 ± 6.1
Turkey	2588 ± 90.5	33.55 ± 2.3	1.30 ± 0.07	3.9 ± 0.18	0.15 ± 0.01	11.62 ± 0.70	29.63 ± 2.7	1.14 ± 0.1	88.3 ± 5.7
Sparrow	22.5 ± 2.5	1.22 ± 0.07	5.42 ± 0.11	0.5 ± 0.08	2.2 ± 0.15	40.98 ± 0.43	1.15 ± 0.08	5.11 ± 0.1	94.26 ± 7.1
Hoopoe	85 ± 6.2	1.49 ± 0.08	1.75 ± 0.07	0.2 ± 0.01	0.24 ± 0.02	13.42 ± 0.7	1.21 ± 0.11	1.42 ± 0.0	81.21 ± 5.2
Kestrel	89.5 ± 7.5	1.72 ± 0.12	1.92 ± 0.11	0.47 ± 0.11	0.53 ± 0.21	27.33 ± 0.47	1.25 ± 0.07	1.4 ± 0.1	72.67 ± 4.3
Owl	950.0 ± 25	27.97 ± 2.7	2.94 ± 0.11	7.63 ± 0.20	0.80 ± 0.03	27.30 ± 0.47	20.36 ± 1.2	2.14 ± 0.3	72.8 ± 5.3
Darter	110 ± 9.5	1.59 ± 0.12	1.45 ± 0.13	0.22 ± 0.02	0.20 ± 0.01	13.84 ± 1.2	1.37 ± 0.12	1.25 ± 0.1	86.0 ± 7.6

Table (3): Showing the mean values of the absolute lengths of the bird, body cavity (with its pregastric, gastric and postgastric regions), stomach with its glandular and muscular parts.

Bird	Total body length	Body cavity	Stomach length	Pregastric region	Gastric region	Postgastric region	Proventriculus length	Gizzard length
Goose	57.5 ± 4.08	26.0 ± 1.21	12.0 ± 0.16	7.5 ± 0.21	10.5 ± 0.13	8.0 ± 0.18	6.0 ± 0.18	10.0 ± 1.0
Turkey	67.5 ± 5.07	18.0 ± 1.48	7.0 ± 0.32	7.2 ± 0.34	7.0 ± 0.27	3.8 ± 0.05	3.5 ± 0.10	5.5 ± 0.19
Sparrow	13.0 ± 1.29	5.0 ± 0.75	2.0 ± 0.11	2.3 ± 0.09	2.0 ± 0.08	0.7 ± 0.03	0.7 ± 0.16	1.3 ± 0.08
Hoopoe	22.5 ± 1.16	5.7 ± 0.67	3.0 ± 0.07	2.5 ± 0.13	1.5 ± 0.11	1.7 ± 0.15	1.6 ± 0.12	1.4 ± 0.07
Kestrel	17.5 ± 1.40	9.0 ± 0.85	2.5 ± 0.19	4.5 ± 0.12	2.5 ± 0.09	2.0 ± 0.12	1.1 ± 0.08	1.4 ± 0.07
Owl	26.5 ± 1.59	13.0 ± 0.11	8.5 ± 0.07	6.0 ± 0.08	4.0 ± 0.32	3.0 ± 0.12	3.5 ± 0.11	5.0 ± 0.07
Darter	35.0 ± 2.8	9.0 ± 0.90	4.5 ± 0.32	4.5 ± 0.22	3.0 ± 0.32	1.5 ± 0.11	2.3 ± 0.21	2.2 ± 0.01

N.B.: The total length of the stomach is less than the sum of the length of its glandular and muscular parts because the total length is taken along the longitudinal axis of the whole stomach and the proventriculus is sometimes bent on the gizzard (Fig 5, 6).

Table (4): Showing the mean length percentages of the stomach and its glandular and muscular parts to the total body length, length of body cavity, as well as its position within the body cavity in examined birds.

Bird	Stomach/ Body	Stomach/ body cavity	Pregastric region/ body cavity	Gastric region/ body cavity	Postgastric region/ body cavity	Pro-ventriculus/ Body	Pro-ventriculus/body cavity	Pro-ventriculus/stomach	Gizzard/ body	Gizzard/ body cavity	Gizzard/ stomach
Goose	20.9 ± 1.5	46.2 ± 3.07	28.8 ± 1.57	40.4 ± 0.07	30.8 ± 0.28	10.4 ± 0.08	23.08 ± 2.8	50.0 ± 3.38	17.39 ± 0.2	38.5 ± 2.7	83.3 ± 5.1
Turkey	10.4 ± 1.1	38.9 ± 3.12	40.0 ± 2.43	38.9 ± 2.11	21.3 ± 1.18	5.18 ± 0.17	19.44 ± 1.1	50.0 ± 3.52	8.15 ± 0.42	30.5 ± 2.2	78.6 ± 4.8
Sparrow	15.4 ± 0.9	40.0 ± 2.84	46.0 ± 2.47	40.0 ± 3.31	14.0 ± 1.29	5.38 ± 0.18	14.0 ± 0.91	35.0 ± 2.52	10.0 ± 0.82	26.0 ± 2.3	65.0 ± 4.9
Hoopoe	9.2 ± 0.8	32.6 ± 3.28	43.9 ± 3.43	26.3 ± 2.42	29.8 ± 2.21	7.11 ± 0.35	28.07 ± 2.2	53.3 ± 4.97	6.22 ± 0.1	24.3 ± 1.8	46.7 ± 3.5
Kestrel	14.3 ± 1.2	27.81 ± 2.1	50.0 ± 3.29	27.8 ± 1.51	22.2 ± 1.27	6.29 ± 0.74	12.22 ± 1.1	41.0 ± 3.82	8.11 ± 0.79	15.6 ± 1.2	56.0 ± 3.9
Owl	32.1 ± 2.1	65.4 ± 4.72	46.2 ± 2.39	30.8 ± 2.52	23.1 ± 1.09	13.21 ± 0.1	26.92 ± 1.2	41.2 ± 3.40	18.87 ± 0.3	38.5 ± 2.2	58.8 ± 4.3
Darter	12.9 ± 1.2	50 ± 4.2	50 ± 3.9	33.3 ± 2.7	16.7 ± 1.1	6.57 ± 0.3	25.56 ± 2.2	51.1 ± 4.1	6.29 ± 0.3	24.4 ± 2.1	48.9 ± 4.3

Fig (1): Histogram showing The mean percentage of the stomach weight length to the total body weight and total body length in studied birds..

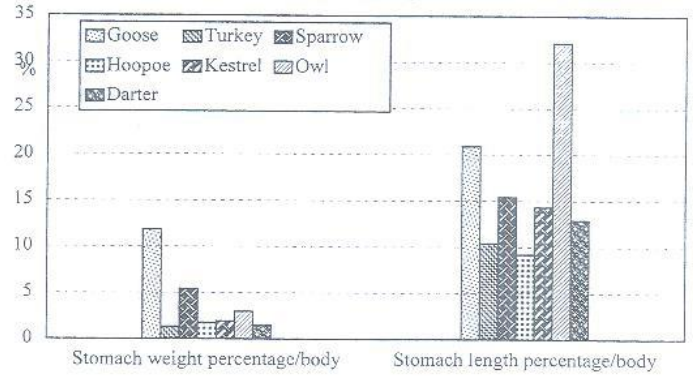


Fig (2): Histogram showing the relation between the length and position of the stomach and body cavity in studied birds.

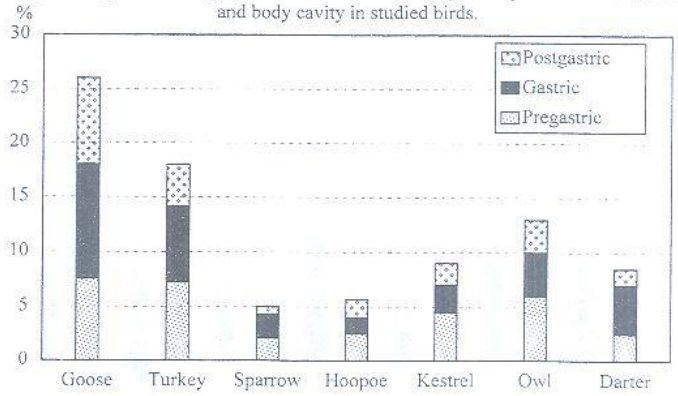


Fig (3): Histogram showing the relation between the mean percentage of the weight of the proventriculus and gizzard to the total stomach weight in studied birds.

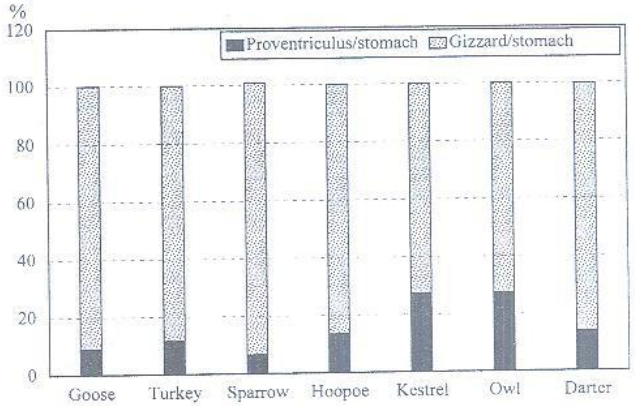
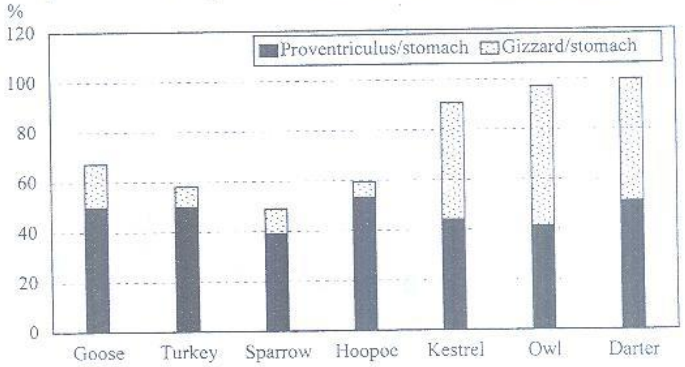
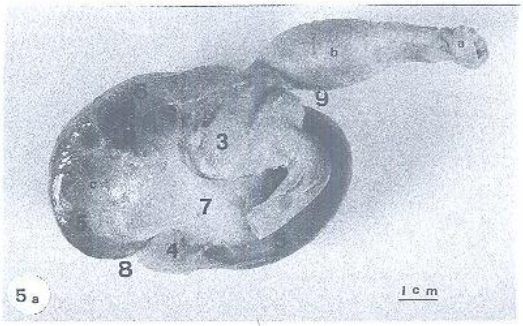


Fig (4): Histogram showing the relation between the mean percentage of the length of the proventriculus and gizzard to the total stomach length in studied birds.





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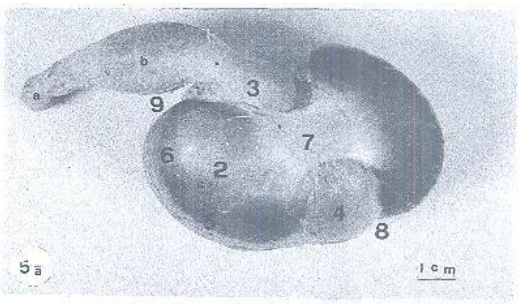

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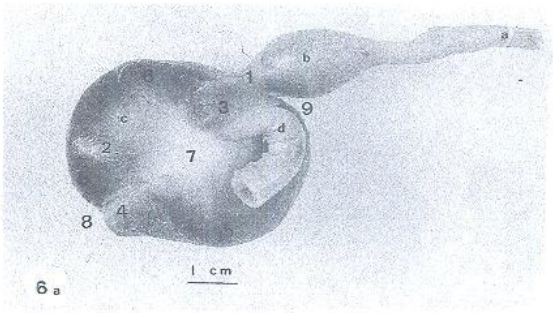

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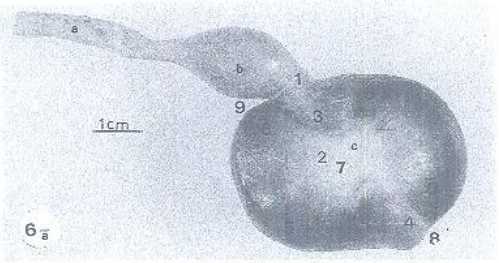

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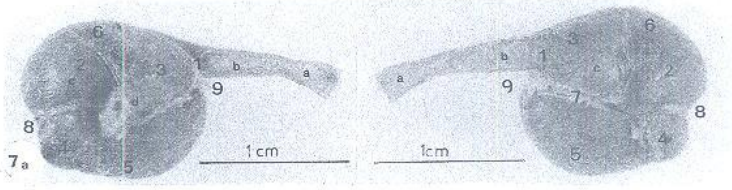

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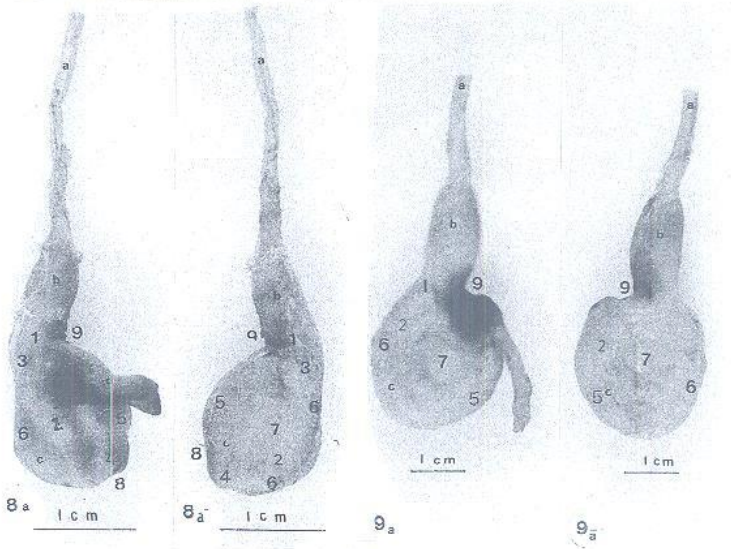

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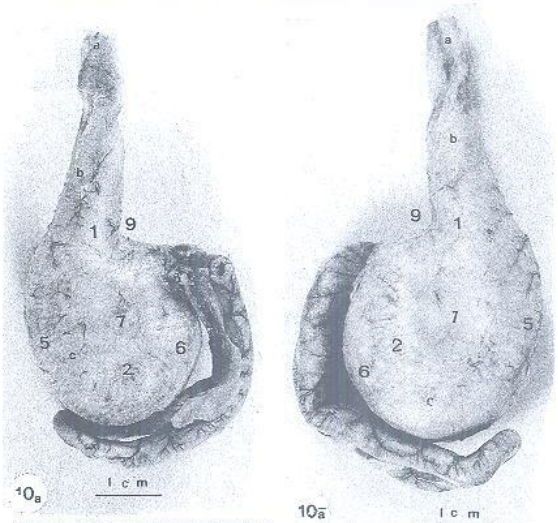

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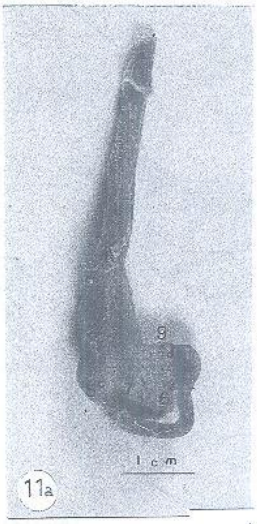

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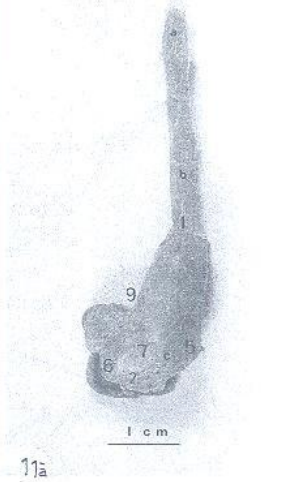

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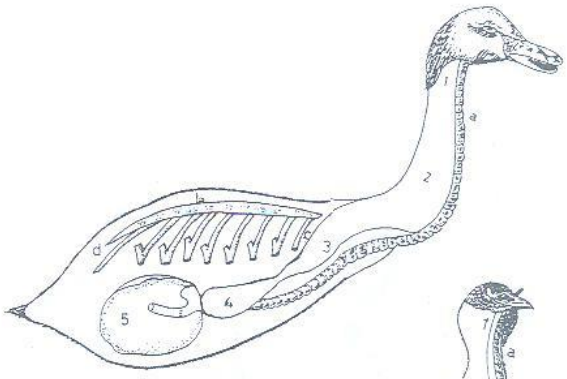
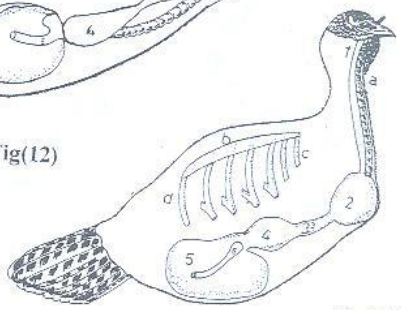
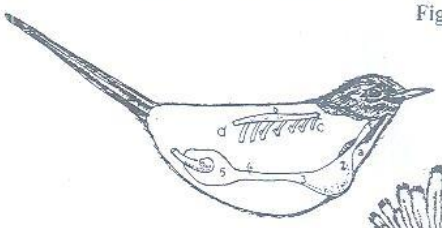


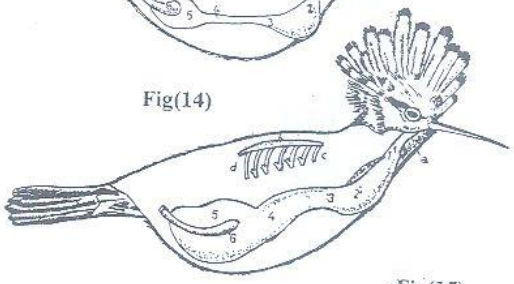
Fig(12)



Fig(13)

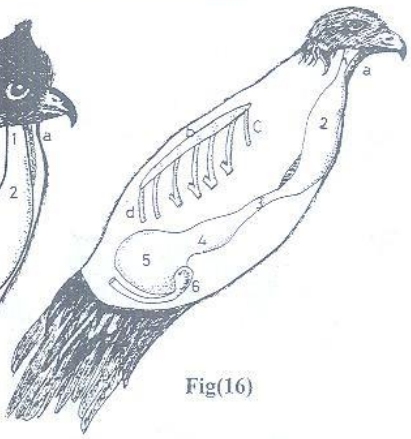


Fig(14)

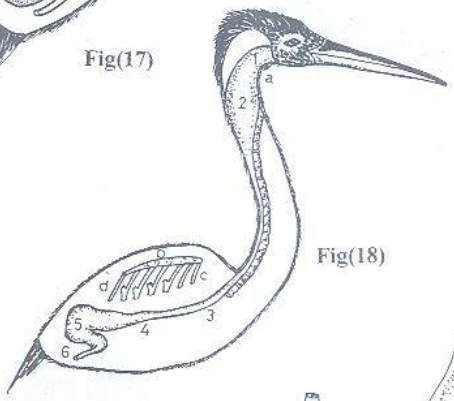


Fig(15)

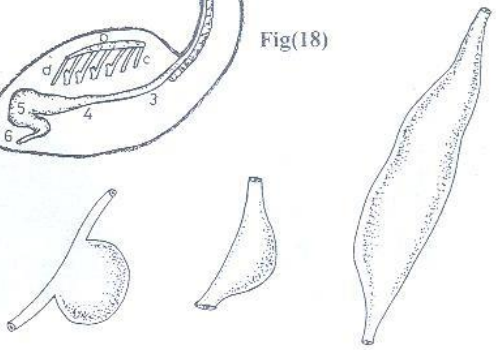
Fig(16)



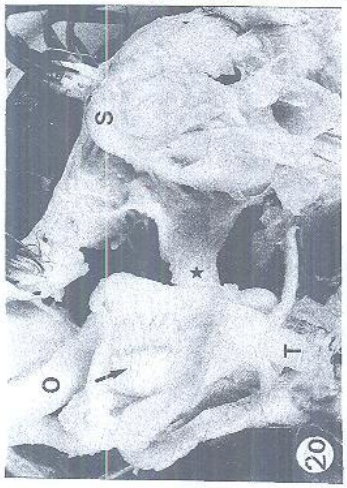
Fig(17)

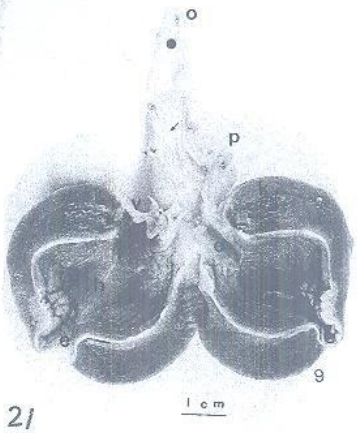


Fig(18)



Fig(19) A: Turkey B: Sparrow C: Goose, hoopoe, kestrel, owl & darter





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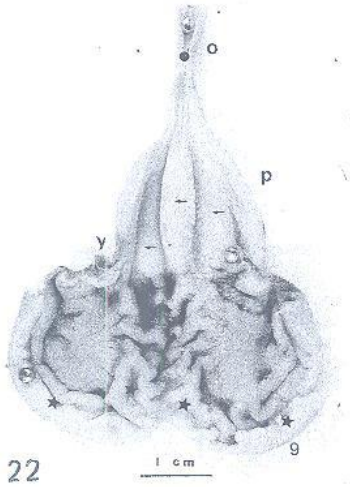

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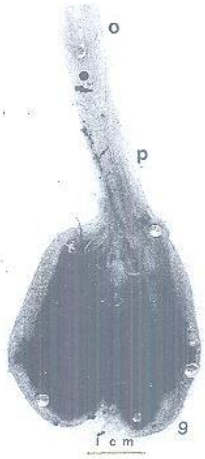

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