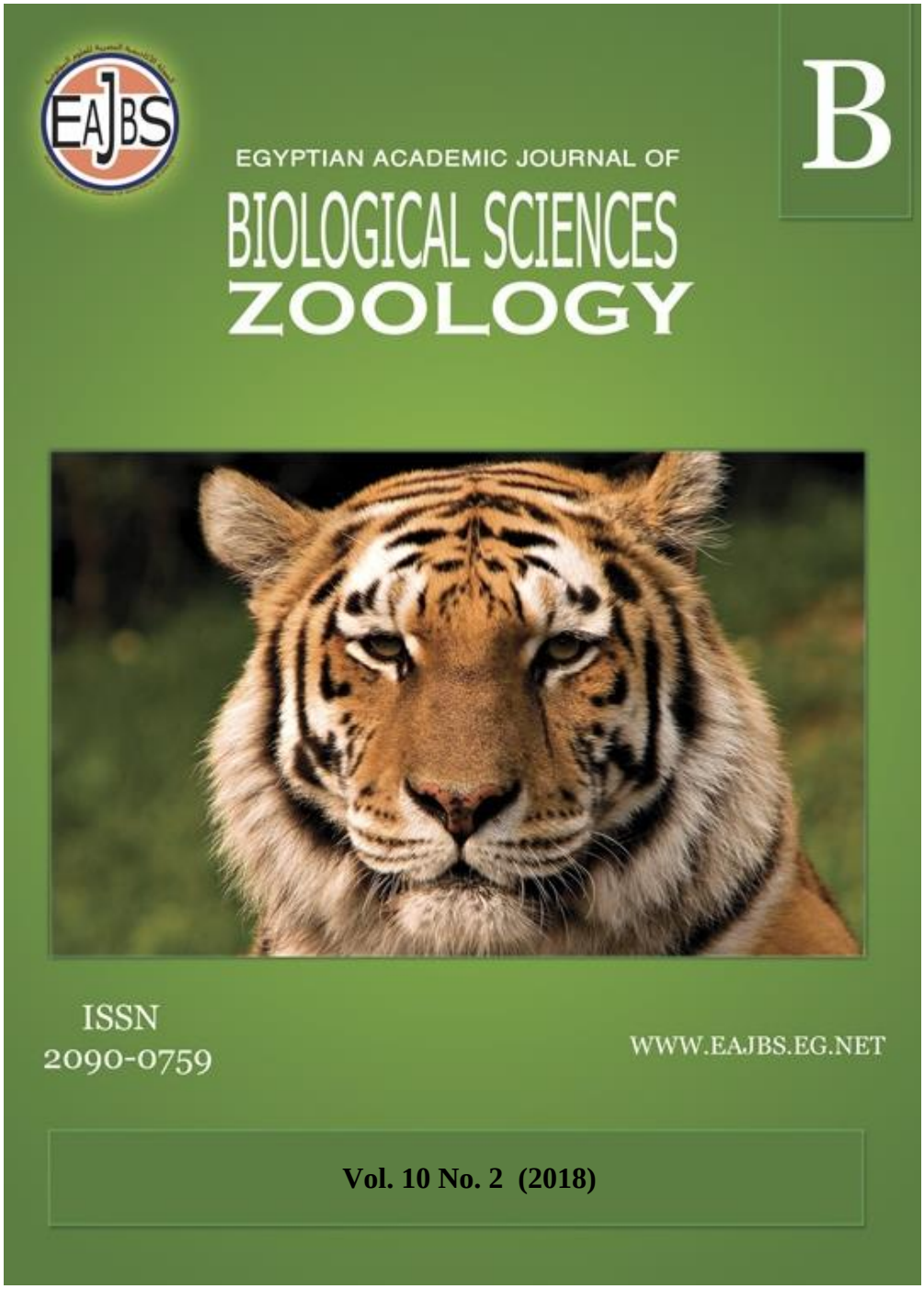

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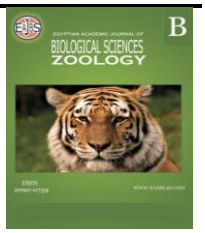

Morphometric Studies of the Esophagus and Stomach in Two Types of Birds Have Different Feeding Behaviors

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ABSTRACT

Aim of the work: The present work aims to investigate the morphometrical, aspects of the esophagus and stomach in two different Egyptian birds having different food habits.

Materials and Methods: The animals under investigation are Kingfisher (*Halcyon smyrnensis*), and Hoopoes (*Upupa epops*). These birds were caught from Abou-Rawash. Constituency and the Nile Delta in Egypt. The birds were dissected the esophagus and stomach were fixed and stained for the morphometric and microscopic comparative study.

Results: From the current results, it was revealed that there are some morphometric differences between the esophagus in kingfishers and hoopoe. The esophagus of kingfishers is shorter than hoopoe, while the stomach (proventriculus length and wide) are moderately bigger than in hoopoe species. Stomach in the two studied birds is divided into two parts, glandular or true stomach (proventriculus) and the muscular stomach or gizzard (ventriculus). The glandular stomach of both kingfisher and hoopoe showing moderate differences in length and width. The relative size of these organs was variable according to the food habits and this may be the reasons of the differences between the two stomachs, so, in the birds that eat hard food items as in kingfisher proventriculus (bird species under investigation) was wide due to the high number of glands component.

INTRODUCTION

The class Aves places second in the number of species among vertebrates. There are approximately 8,600 species of birds in the world. All birds are adapted to their different environments with respect to food sources, the seashore, ponds, small rivers, fields, or mountains. Reflecting their different lifestyles, birds have different feeding habits, with corresponding differences in the structures of their digestive canal (Suzer *et al.*, 2018). The avian alimentary canal has undergone a physiological structure in apposite to other animals to accommodate physical and chemical features of a wide variety of food types (Klasing, 1999), and requirements for flight (Denbow, 2000). In addition, birds have lightweight beak and gizzard instead of heavy bone, muscular and dental structure characteristic of reptiles and mammals. The morphology of an organ system varies according to the feeding habit, habitat and nature of their lifestyle. This phenomenon is called adaptation (Tomar, 2015). Glandular stomach (proventriculus) is lined with glandular mucous layer which

secreted gastric juices such as pepsin and hydrochloric acid, by this mechanism, the ingested food with its juices passes quickly to the gizzard in which the food particles are reduced to small particles took by the intestine for more digestion and absorption (Salem, 2012). Chemically, gizzard have a keratinize nature lining that termed as keratohyalin or koilin, it was insoluble in keratinolytic solvents and resistant to pepsin (Hodges, 1974) The size of the gizzard changed according to the diet nature within the same species, when the bird eat dry seed in winter, the gizzard being thicker and larger in contrast when it eats fruits during summer (Gelis, 2013).

The current work is aimed to evaluate the measurements of the oesophagus and stomach of the carnivore Kingfisher (*Halcyon smyrnensis*), and insectivore Hoopoes (*Upupa epops*),) to illustrate the adaptions of these species to their feeding habitats.

MATERIALS AND METHODS

Animals:

A total of 20 Healthy adult alive specimens, 10 samples of White-throated kingfishers have collected from their natural environments Nile delta; On the other hand, 10 samples of Hoopoe were collected from Abu-Rawash district near Giza governorate. These specimens were trapped alive from the previously mentioned areas. In the laboratory, the specimens were anesthetized with chloroform. The experimental animals of the present work included three avian species feed on a different diet.

The anesthetized birds were weighed; the length of the body of the three species under investigation and the length of each part of the alimentary tract were measured.

Statistical Analysis:

The generated data were tabulated and expressed as mean and standard error of the mean (SEM). The weights were recorded in grams (g) and dimensions in centimeters (cm). Student t-test was used to analyze the differences between Kingfisher and Hoopoe species, test was performed using GraphPad InStat version 3.00 (GraphPad Software, San Diego, California, USA; online reference at www.graphpad. com).
Values of $P \leq 0.05$ and $P < 0.01$ were recorded and considered significant.

RESULTS

Morphometric Features:

Comparative measurements of the mean length of each component of the alimentary tract for each species are presented in table 1. The present study clarified significant differences in Esophagus and Stomach $P < 0.01$ between Kingfisher and Hoopoe species.

The mean body weight (BW) sample (99.25±1.9 gm) and digestive canal weights (DCW) (9.4±0.20 gm) of kingfishers (*Halcyon smyrnensis*) were higher than those in Hoopoe *(Upupa epops)* (59.8±1.07 gm; and 5.45±0.17 gm respectively; $P < 0.01$). The mean of digestive canal length (DCL) in kingfishers (61.2±0.29 cm) were higher than those in Hoopoe (37.1±0.06 cm; $P < 0.01$). In contrast the oesophagus length (OL) in kingfishers (7.3±0.07 cm) were slightly less than in Hoopoe (7.8±0.13 cm; $P > 0.05$). The proventriculus width (PrW) (0.52±0.009 cm) and proventriculus length (PrL) (1.91±0.04 cm) of kingfishers were higher than those in Hoopoe (0.47±0.021 cm and .46±0.01 cm; respectively; $P < 0.01$). The present study also observed that, the gizzard length (GL) (1.73±0.05 cm) and gizzard width (GW)

(1.51±0.02 cm) of kingfishers were higher than those in Hoopoe (1.51±0.00 cm and 1.04±0.03 cm; respectively; $P < 0.01$).

Table (1): Summarize the morphometric characters of the internal body structure of *H. smyrnensis* and *Upupa epops*. Mean±SEM

No.	character	*H. smyrnensis*		*Upupa epops*	
		Min-Max	Mean±SEM	Min-Max	Mean±SEM
1	**B.W**(gm)	91.0-104.0	99.25±1.9	56.0-63.0	59.8±1.07
2	**D.C.W**(gm)	8.7-10	9.4±0.20	5.1-6.0	5.45±0.17
3	**D.C.L**(Cm^2)	60.20-62.0	61.2±0.29	37-37.5	37.1±0.06
4	**O.L**(Cm^2)	7.6-7.10	7.3±0.07	7.4-8.2	7.8±0.13
5	**Pr.W**(Cm^2)	0.49-0.55	0.52±0.009	0.42-0.54	0.47±0.021
6	**Pr.L**(Cm^2)	1.80-2.10	1.91±0.04	1.4-1.52	1.46±0.01
7	**G.L**(Cm^2)	1.57-1.96	1.73±0.05	1.49-1.54	1.51±0.00
8	**G.W**(Cm^2)	1.44-1.59	1.51±0.02	0.97-1.2	1.04±0.03

Mean ± SEM; Standard Error of Mean, **gm**: gram, **Cm:** Centimeter **B.W:** Body weight**, D.C.W**: Digestive canal weight, **D.C.L**: Digestive canal length, **O.L:** Oesophagus length, **Pr.W**: Proventriculus width, **Pr.L:** Proventriculus length, **G.L:** Gizzard length, **GW:** Gizzard width.

Anatomical Features:-

The digestive system in birds composed of buccal cavity, pharynx, esophagus, proventriculus, gizzard, small intestine, large intestine and cloaca.

The esophagus and trachea are hollow organs for conveying food and air into the stomach, intestines and lungs respectively. The trachea runs ventral to the esophagus through the cervical region and bifurcates shortly into the thoracic inlet. The esophagus exits between the points of bifurcation of the bronchi. The present data clarified that the exclusively fish diet of the kingfishers (*Halcyon smyrnensis*) requires a relatively specialized alimentary tract for digestion. The long esophagus leads into short proventriculus. The food passes from the oesophagus to a simple muscular stomach (proventriculus and ventriculus), which is highly distensible. In the proventriculus, chemical digestion commences and the food is passed as a yellowish chyme past the pyloric sphincter into the small intestine (consisting of duodenum and ileum), which leads into the large intestine. The large intestine is short and terminates in the cloaca, which opens to the outside by the cloacal opening (Figs. 1&2).

On the other hand, photographs of the dissection and layout of the alimentary tract within the body cavity of the Hoopoe *(Upupa epops)* are presented in figures 3&4. The oesophagus leads into proventriculus, gizzard, pyloric sphincter into the small intestine (consisting of duodenum and ileum), which leads into the large intestine. The large intestine is long and terminates in the cloaca, which opens to the outside by the cloacal opening (Figs. 3&4).

Fig 1: A photograph of the dissection of the alimentary canal of Kingfisher *Halcyon smyrnensis* showing I= Intestine, R= rectum, H= heart, T= trachea, G.B= gall

Fig. 2: A photomicrograph of the alimentary canal of *Halcyon smyrnensis* Scale bar: 1cm

Fig 3: A photograph of the dissection of the alimentary canal of *Upupa epops* showing I= Intestine, R= rectum, H= heart, T= trachea, G.B= gall bladder, L.L= Lobes of liver.

Fig. 4: A photomicrograph of the alimentary canal of *Upupa epops* showing I= Intestine, D= Duodenum, Oes= Oesophagus, Pro= Proventriculus, Giz= Gizzard, L= liver.Co= Colaca.Scale bar: 1cm

DISCUSSION

Eosophagus:

The morphology of an organ system varies according to the feeding habit, habitat and nature of their lifestyle. This phenomenon is called adaptation (Tomar, 2015). The present data clarified that the exclusively fish diet of the kingfishers (*Halcyon smyrnensis*) requires a relatively specialized alimentary tract for digestion.

From the current results, it was revealed that there are slightly significant morphometric differences between the esophagus in kingfishers (*Halcyon smyrnensis*) and hoopoe (*Upupa epops*). The esophagus of kingfishers (*Halcyon smyrnensis*) is shorter than hoopoe, while the stomach (proventriculus length and wide) are moderately bigger than in hoopoe species.

The anatomical studies of the present investigation revealed that the esophagus is a muscular tube located in the right side of the neck between the orophalanx and proventriculus, and also not crop structure were observed. The esophagus of kingfishers did not need the crop to store the food because their mode of feeding, this species mainly hunts large crustaceans (Raza, 1995), insects, earthworms (Yahya, and Shahla 1991), rodents, snakes, fish and frogs (Roberts and Priddy, 1965). Furthermore, the young are fed mostly on invertebrates (Burton 1998), and these results agree with (Ali, 2014.; Rodrigues *et al,* 2012, and Bailey *et al,* 1997), While disagreement with (Lei, 2015), who has found that it expended to form the crop in Grey-Backed Shrike.

Also, no crop was observed in the esophagus of hoopoes species, the absent of crop may be due to the food may be stored throughout the length of the oesophagus of avian species which have no crop (Ziswiler & Farner, 1972; McLelland, 1979a)

Stomach:

The avian stomach consists of two chambers: the cranial chamber the proventriculus or glandular part, and the caudal chamber, the gizzard (ventriculus).

Bird's stomach is a dynamic organ and is subject to continuous morphological changes in time (Strack, 1999; Barboz and Jorde, 2002 and Szcepanczyk, 2007). The glandular stomach of both kingfisher and *Upupa epops* showing a significant differences in length and width, the difference between stomach of under investigation birds are probably due to the feeding habits or perhaps the amount of food engulfed by birds under investigation (King and Mclelland 1984.; Kent and car 2001, and Kardong 1998). The relative size of these organs was variable according to the food habits and this may be the reasons of the differences between the two stomachs, so, in the birds that eat hard food items as in kingfisher proventriculus (bird species under investigation) was wide due to the high number of glands component. These results were conformable with what has been found by (Abumandour, 2014) developed glands organized into lobules, separated by scarce dense connective tissue (lamina propria). The weight and size of the stomach in different species of birds varies even within the same species may due to the dietary habits.

This study was based on providing some basic morphological data on some organs of the alimentary canal of both Kingfisher and hoopoe species. Finally, thus, it is obvious that the anatomy of the alimentary canal of both birds demonstrates certain specific characteristics of functional adaptation as a reflection mode of feeding of all birds.

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ARABIC SUMMARY

دراسات مورفومترية مقارنة على مرئ ومعدة نوعين من الطيور ذات طبيعة غذائية مختلفة

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تهدف الدراسة الحالية الى معرفة الفروق المورفومترية بين المريء والمعدة في نوعين من الطيور ذات طبيعة غذائية مختلفة وهم صياد السمك (*Halcyon smyrnensis*) والهدهد , و*Upupa epops*). القاطنين بجمهورية مصر العربية.

وقد أظهرت النتائج ان هناك اختلافات جوهرية بين طول وحجم المرئ والمعدة فى الطائرين محل الدراسة ويرجع ذلك الى نوع وطريقة التغذية المختلفة بينهم مما يبين على أن هناك علاقة وأرتباط وثيق بين نوع وطريقة التغذية وشكل وحجم المرئ والمعدة.