Available online freely at www.isisn.org

**Bioscience Research**

**Print ISSN: 1811-9506 Online ISSN: 2218-3973**

***Journal by Innovative Scientific Information & Services Network***

**RESEARCH ARTICLE** BIOSCIENCE RESEARCH, 2024 21(4):692-697 **.OPEN ACCESS**

# Histomorphometrical measurements on the esophagus and glandular stomach of the Turtle Dove, *Streptopelia turtur* in relation to different diet

**Fatma A. Al-Nefeiy**

University of Jeddah, College of Science, Department of Biology, Jeddah, **Saudi Arabia**

***Correspondence:** faalnefaie@uj.edu.sa **Received: Sep., 12, 2024, Revised: October 12, 2024, Accepted: October 16, 2024 e-Published: October 20, 2024**

The present study carried out to investigate the effect of seasonal variations and diet quality on the structural flexibility of the esophagus and proventriculus of the turtle dove, *Streptopelia turtur* (Columbiformes). Healthy twelve specimens of the turtle dove were collected at summer and winter seasons. Histological sections of the esophagus and proventriculus were prepared and thirty section of each were measured. The wall of the esophagus and proventriculus was composed of the four main layers, tunica mucosa, submucosa, tunica muscularis and tunica serosa. Statistical analysis revealed that measurements of the esophagus were significantly difference between epithelium and muscularis thickness, but not in case of mucosa and epithelial surface magnification. In glandular stomach, there were difference between seasons in thickness of the muscle layer and superficial glands height but in case of thickness of mucosal folds and thickness of epithelium, there were no significantly difference between the winter season and summer season.

**Keywords: Morphometry, Turtle Dove, Diet quality, Esophagus, Glandular stomach.**

## INTRODUCTION

Many birds change seasonally their diet composition depending on food availability. Many authors studied earlier the flexibility of the digestive system of birds (Rensh, 1945; Leopold, 1953; Savory & Gentle, 1976a,b; Iulia Preja, et al.2023) and stated that the alimentary tract morphology and function of the birds respond to nutritional factors and changes according to the contents and amount of the food (Karasov,1996; Starck,1999, aLI). Digestion and absorption of food vary according to the quality and the amount of food digestibility and its retention time change over the seasons (Starck, 1999, Ali, et al. (2023); Shawkiet al. (2021) describe the variations of the alimentary tract of egyptian rock dove, columbalivia. Several studies mentioned that the alimentary tract is an appropriate organ to study the functional morphology and plasticity to diet change in birds. Over the year, many bird species changes their diet and accompanied by adjustment of the size of the alimentary tract (Pendergast & Boag, 1973; Moss, 1972, 1974; Walsberg& Thompson, 1990 and Piersmaet al. 1993 Al-Saffaet al. 2016, Abdellatif, et al. 2022).Babaei, et al. (2022) illustrated the morphological and histological investigation of proventriculus structure in common kestrel, steppe eagle golden eagle and imperial eagle. Shawki et al. (2022) studied seasonal variations in the digestive tract of the little owl. Many authors described the relation between the food nature and digestive tract morphology (Herrera 1984; McWilliams & Karasov, 2001). Madkourand Mohamed (2018) illustrating the glandular stomach of the Egyptian laughing dove and rock pigeon. Al-Jaborae (1980) discussed the diet switching on morphology of the alimentsry tract of European starling, under experimental conditions .Brugger (1991) demonstrating that there is significant difference in gizzard mass, thickness of muscle layers of the alimentary tract of red-winged blackbird. In Japanese quail, muscle layer thickness, epithelial surface magnification and height on intestinal villi change with diet (Starck and Kloss, 1995). Abdelnaeem, et al. 2019) discussed histological studies of the esophagus and stomach in two birds differ in their feeding behaviors were discussed by. Moss (1972) stated that there is a relationship between caeca length and diet fibrecontent in wild and captive rock ptarmigan. Several studies remember changes of the alimentary tract in relation to food quality (Lenika, 1971; Ankney, 1977; Raveling, 1979; Krapu, 1981; Tome, 1984; Halse, 1985; Heitmeyer, 1988; Moorman et al. 1992, Dyshliuk et al.2024). The aim of this study is to show the plasticity of the esophagus and glandular stomach of the turtle dove, Streptopelia turtle in relation to available and quality of food.

## MATERIALS AND METHODS

### Animals and food

Adult twelve turtle dove, *Streptopelia turtur* were collected at summer and winter seasons, sex bird for each season. Males only were used to avoid energy requirements for egg production in females. Birds were killed and directly dissected by cervical dislocation. Contents of the crop were examined to know the normal food contents of these birds in winter. The author found that crop contents were: parts of green plants, green seeds, small parts and integuments of small insects.

### Histological techniques

After dissection of birds, tissue samples from the esophagus and glandular stomach were fixed in neutral buffer formalin, dehydrated through ethanol (graded series) to absolute ethanol then embedded in paraffin wax. Embedded specimens were sectioned into series of thirty sections of each sample (5 µm in thickness). Five slides were prepared for each sample, six sections for each slide. Sections were stained by a routine method of haematoxylin-eosin stain. Histological sections were measured by Motic image-analysis (Motic plus, version 3.0)to obtain morph metrical data.

### Scanning electron microscopy

Suitable pieces of esophagus and glandular stomach were fixed in gluteraldehyde (5%), in cocodylate buffer (one hour) and post fixed in 37°C for two hours in buffered solution of 1% osmium tetroxide. Then, specimens were dehydrated in ethanol; and in amyl acetate for two days, dried in carbon dioxide at sputter coated with gold. JEOL scanning electron microscope (JSM-5400LV) was used foe examination.

### Morphometry

Thirty sections per tissue sample (five slides, six sections for each slide) were measured for esophagus and glandular stomach for each bird from the studied birds. For all sections of the esophagus, the following measurements were:

1- Thickness of circular and longitudinal muscles.

2- Epithelial surface magnification which was the epithelial surface over a base line defined by the inner circular muscle layer. Calculations were made by divide total length of epithelial surface by the length of the base line.

3- Thickness of mucosa and epithelium.

For glandular stomach, the following were measured:

1-Thickness of muscularis. 2- Thickness of mucosa and epithelium. 3-Superficial glands height.

### Statistics

All values were given as means ± standard deviation (S.D.). Significant difference (*P*<0.05) between measurement means of the esophagus and glandular stomach was detected by Univariate analysis of variance using SPSS (version 9.0, 1998).

## RESULTS

### The esophagus

Histological structure of the oesophagus showed that it composed of four layers: The serosa which composed of a layer of thin fibrous connective tissue with blood vessels and nerve ending. Muscularis is composed of outer thick longitudinal and inner thin smooth muscle fibers. The sub mucosa formed ofcollagenous connective tissue with and containing the oesophageal glands. Mucosa is composed of leaf-like structure mucosal folds lined by a keratinized stratified squamous epithelium. (Fig.1A ). The scanning electron microscope revealed that the inner surface of the thoracic oesophagus exhibit well and wide longitudinal folds and openings of the esophageal glands. (Fig.1B ).

Histomorphometry of the esophagus (Table1) revealed that thickness of circular muscle layer 431.52 ± 117.32 µm in winter and 288.21 ± 47.35 µm in summer while thickness of longitudinal muscle layer 205.43 ± 56.58 µm in winter and 177.65 ± 37.24 µm in summer. Thickness of mucosa was 875.54 ± 176.63 µm in winter and 665.65 ±148.68 µm in summer.

**Table 1: Winter and summer diet histomorphometry of the esophagus, (Values are means ± S.D.)**

| | Winter diet | Summer diet |
|---|---|---|
| Thickness of Circular muscle layer (µm) )* | 431.52 ± 117.32 | 288.21 ± 47.35 |
| Thickness of longitudinal muscle layer (µm)* | 205.43 ± 56.58 | 177.65 ± 37.24 |
| Thickness of mucos (µm) | 875.54 ± 176.63 | 665.65 ±148.68 |
| Thickness of epithelium (µm)* | 468.35 ± 96.42 | 275.54 ± 81.32 |
| Epithelial surface magnification | 359.98 ± 87.48 | 302.55 ± 87.52 |

Thickness of epithelium was 468.35 ± 96.42 µm in winter and 275.54 ± 81.32 µm in summer and epithelial surface magnification was 359.98 ± 87.48 µm in winter and 302.55 ± 87.52 µm in summer.

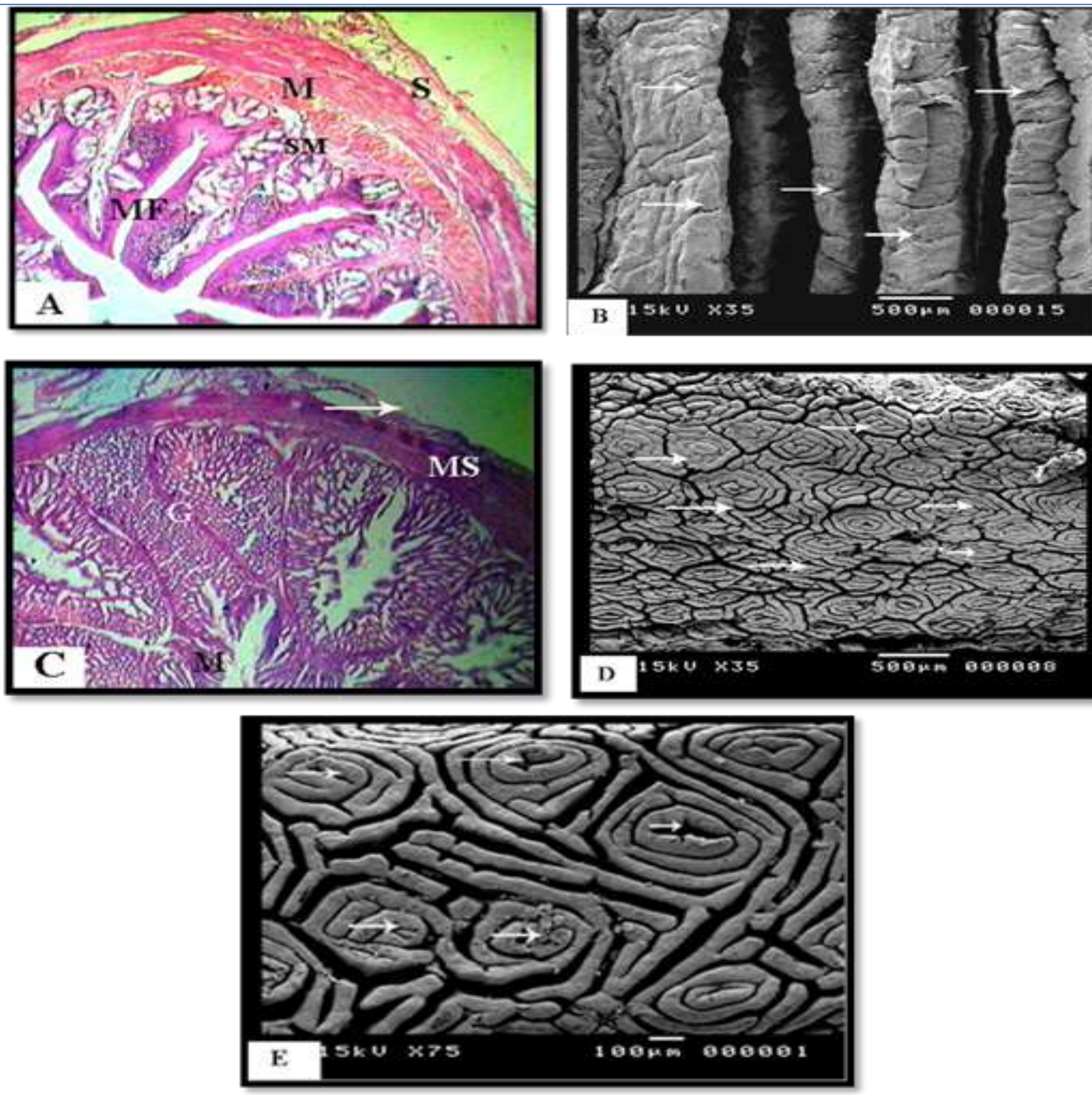


**Figure 1: A light micrograph of a transverse section of the esophagus of the turtle dove showing serosa (S), muscularis (M), submucosa (SM) and mucosal folds (MF). (H & E, X100).B. Scanning electron micrograph of the turtle dove esophagus showing the closely adjacent longitudinal folds and openings of the esophageal glands (arrows). C. A light micrograph of a transverse section of the proventriculus of the turtle dove showing Mucosa (M), mucosal glands (G) , Muscularis(MS)and serosa (arrow). (H & E, X100). D. Scanning electron micrograph of the luminal surface of the proventriculus of the turtle dove showing mucosal folds (arrows). E. Scanning electron micrograpohof enlarged portion the luminal surface of the proventriculus of the turtle dove showing openings of the proventricular glands (arrows).**

Measurements of the esophagus were significantly difference between the winter and summer seasons in thickness of epithelium and muscularis, but not in case of mucosa and epithelial surface magnification.

### The glandular stomach

Histological structure revealed that the proventricular wall of the turtle dove composed of four main layers: the mucosa which composed of regular intervals mucosal folds, submucosa which consists of connective tissue contains well blood vessels and numerous deep proventricular glands, muscular is is composed of two layers of outer longitudinal and inner circular smooth muscle fibers and serosa of connective tissue with blood vessels and nerves (Fig.1C). Proventriculus scanning electron microscopy of the lumen of turtle dove showed that mucosal folds arranged in circles (Fig.1D). The openings of the proventricular glands with a an irregular shapes which rounded or in a rosette shape (Fig.1E).

**Table 2: Winter and summer diet histomorphometry of the glandular stomach. (Values are means ± S.D.)**

| | Winter diet | Summer diet |
|---|---|---|
| Thickness of muscular is (μm)* | 269.87 ± 43.51 | 156.32 ± 37.58 |
| Thickness of mucosa (μm))* | 3865.32 ± 329.78 | 3469.45 ± 295.34 |
| Thickness of Epithelium (μm) | 16.35 ± 3.85 | 25.35 ± 4.12 |
| Superficial glands height (μm) | 465.85± 102.65 | 378.35 ± 98.85 |

Histomorphometry of the glandular stomach (Table 2) revealed that thickness of the muscle layer was 269.87 ± 43.51 μm in winter and 156.32 ± 37.58 μm in summer. Thickness of mucosa was 3865.32 ± 329.78 μm in winter and 3469.45 ± 295.34 μm in summer. Thickness of epithelium was 16.35± 3.85 μm in winter and 25.35 ± 4.12 μm in summer. Superficial glands height was 465.85 ± 102.65 μm in winter and 378.35 ± 98.85 μm in summer. Measurements of the glandular stomach were significantly difference between the winter season and summer season in thickness of the muscle layer and superficial glands height but in case of thickness of mucosal folds and thickness of epithelium, there were no significantly difference between the winter season and summer season.

## DISCUSSION

High fiber diet of wild birds in winter has low quality in comparison with low fiber diet, thus, birds tend to consume large amount of food to compensate low digestible food by increasing amount intake. As a consequence, the esophagus volume and its layers increase in their size to provide a high capacity to process food with low digestibility. Also, different histological layers of the glandular stomach become greater in their size to start digestion of food which with low digestibility and pass it to the muscular stomach. Thickness of circular and longitudinal muscle of both esophagus and glandular stomach were greater in winter diet birds than those of summer diet ones. This observation is in accordance with (Miller, 1975 and Kehoe, *et.al.*, 1988) who stated that high fiber diet resulted in an increase of food intake and also in accordance with Shawki et al. (2021) who discussed the hisomorphometrical studies of the esophagus of the rock dove during the summer and winter seasons. Umar et al. (2021) revealed a significant increase in the thickness of the different tunics of the digestive organs in *Struthio camelus* and added that these findings may be of importance for the strategic manipulation of feed and nutrition. The digestive system of birds shows different adaptations to particular nutritional needs (Savory and Gentle, 1976b; Walsberg&Thompson,1990, Barton& Houston,1994) and Starck, and Abdel-Rahman,, 2003). Results of this study also is agreements with Lenka (1971) who stated the development of longitudinal and circular muscles is necessary for consuming and passing large amount of food. Results of the present work is Compatible with Elshaer, F. M. 2018, who discussed the anatomy of the alimentary canal of Kingfisher and Hoopoes who have characteristics of functional adaptation towards the mode of feeding. Lenka (1971) reported that birds which their food contain dry sharp plants, have a protective function, squalors stratified epithelium. Also, AbdEl naeem et al. 2019revealed that, there are some morph metric differences between kingfisher and hoopoe in both esophagus and stomach. Kehoe et al. (1988) discussed responses of gut morphology of mallard after diet switching. Shawki et al. 2022) stated that histomorphometrical measurements exhibit changes between summer and winter in the esophagus and glandular stomach. Hume, 2002 reported that increase the thickness of muscular layer of the birds alimentary tract resulting in increasing digestive load, as in this study.

## CONCLUSION

In conclusion when data obtained from this study and by different authors on the effect of diet quality on the histomorphometry of the upper part of the alimentary canal of birds, it has been concluded that there is a responses and structural flexibility of the alimentary tract of birds to different diet.

### Supplementary materials

The supplementary material / supporting for this article can be found online and downloaded at: https://www.isisn.org/article/

### Author contributions

The author, Fatma A. Al-Nefeiy contributed in all parts of this study.

### Funding statement

There are no funding sources.

### Informed Consent Statement

Not applicable.

### Data Availability Statement

All of the data is included in the article/Supplementary Material.

### Acknowledgments

The author gratefully acknowledge Deanship of

Scientific Research, University of Jeddah for their assistance and kind help to achieve this study.

### Conflict of interest

The authors declared that present study was performed in absence of any conflict of interest.



### REFERENCES

Abdellatif A. M.; Farag A.; Metwally E. (2022). Anatomical, histochemical, and immunohistochemical observations on the gastrointestinal tract of *Gallinula chloropus* (Aves: Rallidae). BMC Zoology. 7(61).

AbdElnaeem A. H.; Elshaer, F. M.; Rady M.(2019). Histological and histochemical studies of the esophagus and stomach in two types of birds with different feeding behaviors. International Journal of Development. 8(1):23-42.

Ali H. M.; Ali K. A.; Taha A.M. (2023). Comparative Anatomical, Histological, and Electron Microscopical Studies on the Cervical Region of the Esophagus in Some Birds with Different Diet Habits. Journal of Advanced Veterinary Research. 13(2).

Al-Jaborae F. F. (1980). The influence of diet of the gut morphology of the starling *(Sturnus vulgaris).* Ph D thesis, Uni.Oxford, England.

Al-Saffar F. J.; Al-Samawy E. R. (2016). Histomorphological and histochemical study of stomach of domestic pigeon (*Columba liviadomestica*). The Iraqi Journal of Veterinary Medicine, 40(1):89-96.

AnkneyC. D. (1977). Feeding and digestive organ size in breeding leeser snow geese. Auk 94: 275-282.

Babaei1, M. ;Hesari, A. Esfandiyari, k ; Morovvati, H. (2022). Morphological and histological investigation of proventriculus structure in common kestrel (Falco tinnunculus), steppe eagle (*Aquila nipalensis*), golden eagle (*Aquila chrysaetos*), and imperial eagle (*Aquila heliacal*). Spring, 18(1): 5-17.

Barton N. W. ; Houston, D. C. (1994). Morphological adaptation of the digestive tract in relation to feeding ecology of raptors. Journal of Zoology. 232: 133-150.

Brugger K. E. (1991). Anatomical adaptation of the gut to diet in red-winged blackbirds (*Agelaiusphoeniceus*). Auk 198: 562-567.

Dyshliuk N., Huralska S, Kot T., Mazurkevych T., Stehnei Z., Usenko S. (2024). Morphology of the Gastrointestinal Tract and its Lymphoid Tissuein the Common Blackbird (Turdusmerula). Acta fytotechnzootechn, 27, (1): 35–45.

Halse S. A. (1985). Diet and size of the digestive organs of Spru-winged geese . Wildflow,36: 129-134.

Heitmeyer M. E. (1988). Changen in the visceral morphology of wintering female mallards (*Anas platyrhynchos*). Canadian Journal of Zoology,66: 2015-2018.

Herrera C. M. (1984). Adaptation to frugivory of Mediterranean avian seed dispersers. Ecology**,** 65: 609-617.

Iulia P. A.; Cipou M. F.; Martonos C. O.; SterminA. N.; DamianA. (2023). The Comparative Anatomy of the Upper Digestive System in26 Species of Zoophagous-Polyphagous Palearctic Birds. International Journal of Morphology. 41(5):1336-1342.

Karasov W.H. (1996). Digestive plasticity in avian energetics and feeding ecology. In avian Energetics and nutritional ecology (ed. C. Carey), 61-84. New York: Chapman and hall.

Kehoe F. B. ;Ankney, C. D. (1988). Variation in digestive organ size among five species of diving ducks. *(Aythyaspp.)*CanadianJoural of Zoology.63: 2339-2342.

Kehoe F. B.; Ankney C. D. ;Alisauskas R. T. (1988). Effects of dietryfibre and diet diversity on digestive organs of captive mallards ( *Anas platyrhynchos*). Canadian Joural of Zoology..66: 1597-1602.

KrapuG. L.(1981) .The role of nutrient reserves in mallard reproduction. Auk98: 29-38.

LenikaB. (1971). The effect of diet in the histological structure of the esophagus and glandular stomach of the coot ( *Fulicaatra* L.) Zoological Pollonia. 21: 263-280.

Leopold A. S. (1953). Intestinal morphology of gallinaceous bird in relation to food habits. Journal of Wild Managment 17: 197-203.

Madkour F.M.; MohamedA. A (2018). Comparative anatomical studies on the glandular stomach of the rock pigeon (*Columba liviatargia*) and the Egyptian laughing dove (*Streptopelia senegalensis aegyptiaca).* Anatomia Histology Embryologia *48(3).*

McWilliamsS. R. ;Karasov, W. H. (2001).Phenotypic flexibility in the digestive system structure and function in migratory birds and its ecological significance. Comp. Biochem.. physiol. 128A: 579-593.

Miller M. R. (1975). Gut morphology of mallards in relation to diet quality. Journal of WildlManagment. 39: 168-173.

Moss R. (1972). Effect on captivity on gut length in red grouse. JJournalof WildlManagment. 36: 99-104.

Moss R. (1974). Winter diets, gut length and interspecific competition in Alaskan ptarmigan. Auk 91: 737-746.

Pendergast B. A.; Boag, D. A. (1973). Seasonal changes in the internal anatomy of spruce grouse in Alberta. Auk90: 307-317.

Piersma T.; Koolhaas A. ;Dekinga A. (1973). Interaction between stomach structure and diet choice in shore-birds. Auk 110: 552-564.

Raveling D. G. (1979). The annual cycle of body composition of Canada geese with special reference to control of reproduction. Auk 96: 234-252.

SavoryC. J. ; Gentle M.J. (1976a). Effect of dietary dilution with fibre on the food intake and gut dimensions of Japanese quail. Br. Poult. Sci. 17: 561-570.

Savory C. J. ; Gentle M.J. (1976b). Changes in food intake and gut size of Japanese quail in response to manipulation of dietary fibre content. British Poultry Science. 17: 571-580.

Shawki N. A.; Mahmoud F.A. ; Mohamed M.Y.(2021). Seasonal variations of the digestive tract of egyptian rock dove, *columbalivia*: anatomical, histological and scanning electron microscopical studies. Assiut university journal of zoology. 50(1) :60-97.

ShawkiN. A.; Mahmoud F.A. ; Mohamed M.Y.(2022).Seasonal Variations in the Digestive Tract of the Little Owl, *Athene noctua*: Anatomical, Histological, and Scanning Electron Microscopical Studies. Microscopy and Microanalysis, 28, 844–857.

Starck J.M.; Abdel-Rahman G.H. (2003). Phenotypic flexibility of structure and function of the digestive system of Japanese quail. Journal of Experimental Biology.206: 1887-1897.

StarckJ.M. ; Kloss E. (1995). Structural response of Japanese qual intestine to different diets. Deutsche TierarztlicheWochenschrift. 102:146-150.

StarckJ. M. (1999). Structural flexibility of the gastro-intestinal tract of vertebrates. Implicationsfor evolutionary morphology. Zoology Anzghiger.238: 87-101.

Tome M.W. (1984). Changes in nutrient reserves and organ size in female ruddy ducks breeding in Manitoba. Auk 101: 830-837.

Umar *Z.; Qureshi S.; Shahi, R.* (2021). Histological and histomorphometric study of the cranial digestive tract of ostriches (*Struthio camelus*) with advancing age. *VeterinarniMedicina,* 66, 2021 (04): 127–139

WalsbergM. J.; Thompson C. W. (1990). Annual changes in gizzard size and function in a frugivorous bird. Condor92: 794-796