FUNCTIONAL MORPHOLOGY OF THE TONGUE STRUCTURE IN SOME BIRDS DIFFERING IN FEEDING BEHAVIOUR

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ABSTRACT

The structure of the lingual epithelium and the lingual musculature were examined in the avian species (*Egretta ibis, Columb livia, Buteo buteo, Anser anser, Corvus corone* and *Tyto alba*) using light and Scanning electron microscope (SEM). These birds differ in their diet and feeding behaviour. So, the present results show many variations in between these birds in the histological structure of the lingual epithelium including papillae, glands, keratinization, and also the lingual musculature. These structural properties are adaptive features which are strongly correlated with diet and methods of intraoral food movement.

INTRODUCTION

Birds show divergent feeding behaviour which is correlated with special structural and functional adaptations of their feeding systems *(Bhattacharyya, 1990; Shawki and Al-Jalaud, 1994a, b)*. Studies on the morphological, functional and feeding behavior of the avian feeding apparatus, recently, attracted the attention of some investigators *(Bhattacharyya, 1994 and Zweers et al., 1995)*. Growing up of the results of these studies is ultimately necessary to make several valuable contributions. For example, it may help in illustrating the eco-morphology, systematic, evolution and the mechanism of the integrated components of this system in

correlation with the different patterns of feeding behaviour (*Bermejo et al., 1994 and Shawki, 1995*). Some studies have reported synchronized interactions between the jaw and the tongue during feeding and drinking in several avian species (*Zweers, 1982; Berkhoudt, 1985 and Zweers, 1991*). Some studies have reported synchronized interactions between the jaw and the tongue during feeding and drinking in several avian species (*Zweers, 1982; Berkhoudt, 1985 and Zweers, 1991*).

The aim of the present work is to study the functional morphology structure of the lingual epithelium and the lingual musculature in various avian tongue, including *E. ibis, C. livia, B. buteo, A. anser, C. corone* and *T. alba* using careful dissection, histological and SEM techniques. These birds differ in their diet and feeding behaviour. Such present study will increase the background of understanding the avian feeding mechanisms in relation to their diverse feeding behaviour.

MATERIALS AND METHODS

Adults of the birds *E. ibis* (Ciconiiformes), *C. livia* (Columbiformes), *B. buteo* (Accipitriformes), *A. anser* (Anseriformes), *C. corone* (Passeriformes) and *T. alba* (Strigiformes) were used in the present study. They were killed by decapitation and the lower jaw was removed. For general histology, tongues were dissected free, then fixed in 10% formalin solution, dehydrated, cleared and embedded in paraffin by conventional techniques. Serial sections were made at 7 um, and stained with haematoxylin and eosin. The histological structures were examined by light microscope.

For SEM, the tongue of the adult *A. anser* was fixed in 5% glutraldehyde then washed in 0.1M cacodylate buffer and post fixed in a solution of 1% osmium tetraoxide at 37°C for 2-hrs. Thereafter, the specimen were treated with 8 N hydrochloric acid at 60°C for 30 minutes to remove any extracellular mucus from their surfaces. This procedure was followed by dehydration, critical point drying and platinum-palladium ion-sputtering. The specimen

were then studied by scanning electron microscopy (Jeol, JSM-5400LV).

RESULTS

A. Lingual epithelium: (Figs. 1-33)

1. Lingual papillae: (Figs. 1-33)

The tongue of all birds show numerous "mechanical" papillae, either scattered singly or arranged in transverse rows. Generally they are directed caudally.

In *E. ibis* (Fig. 1), the large pair of postero-laterally directed spines in the posterior border of the free portion of the tongue have minute papillae on their median borders. In *C. livia* (Fig. 2), the poster-dorsal edge of the free portion of the tongue bears one row of lingual keratinized spine which are dorsally directed. In *B. buteo* and in *T. alba*, the lingual wings in the posterior portion of the tongue bears at its posterior edge a posteriorly directed row of few clube-shaped papillae (Fig. 3).

In the free portion of the tongue of the crow *C. corone* (Figs. 4, 5) many filiform papillae were observed densely distributed over the entire anterior third of the dorsal surface. In the marginal region between the anterior and posterior parts of the tongue, close array of giant concial papillae was observed and they were arranged transversely in a distinct row. All of these giant conical papillae were slightly inclined posteriorly.

In the free portion of the tongue of the goose *A. anser*, the giant conical papillae were arranged in a transverse row between the lingual body and the lingual radix (Figs. 6, 7). On both lateral sides of the lingual body, lingual hairs were compactly distributed and small numbers of cylindrical papillae were arranged between these lingual hairs.

Observations by SEM in goose *A. anser* (Fig. 8), showed that the anterior region of the lingual body was also distinguished along its forward half by a clear medium sulcus, except on the surface of the apex. Well-developed microridges were widely distributed on the cell surface of the dorsum and clearly distinguishable as cell-margin thickenings. In dorsal view the outline of each cell was polygonal (Fig. 9). Also, on both lateral sides of the lingual body, compactly distributed lingual hairs were distinguished with the presence of small numbers of cylindrical papillae that were arranged at almost regular intervals between lingual hairs. The higher magnification of SEM (Figs. 10, 11, 12) shows that the lingual hairs and the cylindrical papillae had smooth surfaces with the presence of scattered micropits and fine striations. Two curved anteroposteriorly elongated prominences were located on both sides of the median line (Fig. 13). Small dome-shaped bulges were scattered on the prominences. The epithelium of the terminal end of the lingual body has a very wrinkled surface (Fig. 14). The desquamating cells could be easily recognized on the wrinkled surface of the epithelium. Well developed significant microridges adorned the surface of all the outer epithelial cells in this area. Cell margin thickening was clearly visible, revealing the polygonal profile of each cell. The giant conical papillae are located in two transverse rows between the lingual body and the lingual radix (Figs. 15, 16). The structure of the outer most surface of these papillae was almost the same at those of lingual hairs and cylindrical papillae. The surface of giant conical papillae tended to be smooth, with scattered micropits and fine striations. However, relatively large numbers of desquamating cells were seen on the surface of the giant papillae (Fig. 17).

2. Lingual glands: (Figs. 18-33)

The glandula lingualis (sole salivary gland) are found among the lingual apparatus of *E. ibis* (Figs. 18, 19 and 20). It is a paired gland, each of which is attached to the dorso-lateral surface of the posterior half of the paraglossale through the fusion of its enveloping fibrous capsule with the perichondrium of the paraglossale. There are septa arising from a capsule dividing the

gland into lobules. A parenchyma is formed by serous acini of varying shapes and sizes, they are lined by cubical epithelium . Moreover, there are flat myoepthelial cells with flattened nuclei surrounding the acini.

In *C. livia* (Figs. 21, 22, 23), the glandula lingualis is a paired gland and is associated with the free portion of the tongue and is enveloped by a connective tissue: fascia lingualis. This fascia is anchored on the longitudinal dorsal crest of paraglossale. The lingual gland opens via many orificies on the ventral side of the free portion of the tongue.

The glandual lingualis in *B. buteo* and *T. alba* (Figs. 24, 25, 26 and 27) is a paired elongated voluminous gland and is invested in the free portion of the tongue. Each gland spreads along the dorsal and lateral surface of the OS paraglossale. The gland starts from the anterior border of the bony portion of the OS paraglossale up to the posterior end of its processus (cornua paraglossalis). Glandula lingualis is attached to the lateral surface of the OS paraglossale through the fusion of the connective tissue sheath surrounding the gland with the periosteium of the OS paraglossale. Orifices of the gland are found in the lateral sides of the free portion of the tongue.

In the free part of the tongue of crow *C. corone* (Figs. 28, 29 and 30), the paired rostral lingual glands are lateral or dorso-lateral to the paraglossal bone and their narrow rostral extremities are at the level of the middle of the cartilaginous rostral part of the bone but their narrow caudal extremities are close to the lateral part of the transverse row of lingual papillae. In transverse section the glands are triangular. The ducts of the glands open in short rostral and caudal rows on the ventro-lateral surfaces of the tongue caudal to the keratinized epithelial plate.

The lateral surface of the free portion of the tongue in *A. anser* has glandula lingualis (Figs. 31, 32 and 33).

3. Keratinization: (Figs. 18-33)

The surface of the free portion of the tongue of *E. ibis* is characterized by the presence of the cornified lingual epithelial tissue (Fig. 18-20). The cornified epithelium coating the anterior free portion of the tongue is thinner than that of the posterior part especially at its dorsal surface. As a result, the rigidity of the anterior part of the free portion of the tongue is less than that of its posterior region.

In *C. livia* (Fig. 21-23), the free portion is covered with a keratinized layer which gives the roughness appearance of its dorsal-side, while the entire ventral surface is smooth.

All surfaces of the free portion of *B. buteo* and *T. alba* (Figs. 24-27) are covered by a keratinized epithelium which differing in appearance and thickness from one area to another. Dorsally, the keratinized epithelium is firmly attached to the underlying tissues forming ridges. The ridges were arranged obliquely on both sides of the median sulcus. The keratinized layer that covers the lingual wings is smooth. The keratinized layer of the ventral surface of the free portion of the tongue is smooth, The keratinized layer is thick posteriorly and becomes very thick anteriorly to form a nail-like tough structure, the lingual nail. This nail covers the anterior ventral half of the free portion of the tongue.

In the crow *C. corone* the proximal end of the lingual body and in the lingual radix, the keratinized layer was very thin and indistinct. The keratinized epithelium found only on the lingual papillae and on the rostral parts of the ventro-lateral surfaces (Figs. 28- 30). The keratinized epithelium on the ventro-lateral surfaces undergoes a process of hard keratinization.

In *A. anser* (Figs. 31-33), the keratinized layer covering the lingual apex, the lingual body and a part from the terminal end just in front of the giant conical papillae. Penetration of the connective tissue was clearly recognizable just beneath the keratinized layer.

The epithelium of the giant conical papillae, cylindrical papillae and the lingual hair was strongly keratinized.

B. Lingual musculature: (Figs. 18-33)

The free portion of the tongue of all the present aves is supported internally by the paraglossale which is the most anterior unpaired, arrow-shaped, and longest skeletal element of the hyoid skeleton . Anteriorly, the paraglossale is extremely pointed, since it gradually tapers to a point-posteriorly, it is biforked to form a pair of processes (processus paraglossalis). Therefore, the incomplete fusion results in the existence of an elongated foramen (foramen paraglossalis) in the posterior half of the paraglossal, and is filled by a loose connective tissue. The postero-medial side of the paraglossale forms a chevron articular facet for the diarthrosis with the basihyale forming the articulo-paraglosso-basihyale. Moreover, the dorsal side possesses two lateral elongated crests on which the glandula lingualis is anchored through its enveloped fascia. OS paraglossale provides sites of attachments for muscle hypoglossus anterior, hypoglossus posterior and ceratoglossus, as well as the salivary gland glandula lingualis in the free portion of the tongue of the present aves (Figs. 18-33).

The muscle hypoglossus anterior in the free portion of the tongue of *E. ibi, C. livia, B. buteo, T. alba, C. corone* and *A. anser* is a paired muscle extending along the ventral side of the paraglossale (Figs. 20, 22, 23, 25, 26, 28-30 and 33). It arises broadly from the posterior region of the paraglossale, then it converges towards its insertion anteriorly to terminate by a short tendon. The tendons of the paired muscle are united together forming a common elongated insertion which extends anteriorly along the anterior half of the paraglossale to be attached on its anterior tip.

In the free portion of the tongue of *C. livia, B. buteo* and *C. corone*, the M. hypoglossus posterior is a paired fan-shaped muscle that lies posterior to hypoglossus anterior (Figs. 22, 23, 27, 29 and 30). The muscle fibers are antero-laterally and obliquely extended

from the origin on the basihyale towards its site of insertion. It originate along the lateral surface of a processus basihyale ventrale; it insert on the ventral surface of processus paraglossale.

The muscle ceratoglossus in the free portion of the tongue in *C. livia* (Figs. 21-23), is a paired pinnate and well developed muscle, each of which extends along the latero-ventral side of the hyoid skeleton. It originate from the lateral and ventro-dorsal surface of the OS cerato-bronchiale. The fibers of ceratoglossus terminate anteriorly with an elongated and stout tendon to be inserted on the lateral tuberosity of the OS paraglossale. It extends between the OS ceratobranchiale posteriorly and the OS paraglossale anteriorly.

DISSCUSION

The tongue of the present birds shows numerous variability in form and size which may be related to feeding habits. The characteristic of the tongue adapted to collect food is the developed hypobranchial apparatus, which permit large protrusions of organ as the present species. Also, the present results confined that tongue adapted to manipulate food is not protrude organ with numerous sharp caudally-directed papillae.

The present cattel egret *E. ibis* has a reduced and protrusible tongue. this bird exhibits divergent feeding habits and minute papillae were observed in the posterior border of the free portion of the tongue. This characteristic may classified this bird in the third type of the classification of Harrison. The same results were observed in *Bubulcus ibis* **(Shawki and Abdel Rahman, 1998).**

The tongue of the present columba *C. livia* is specified by the presence on one row of spines like papillae at the posterior end of its free portion. These spines are directed postero-dorsally that facilitate the transport of food items in one direction from the tip of the beak to the oesophagus. The same results observed by *Bhattacharyya (1980, 1990)* in domestic and Imperial Pigeons and in collard dove. *Streptopelia decaoto* as a seed pecker bird *Shawki and Al-Jalaud (1994a)*.

In the present study. *B. butes* and *T. alba* are a good examples of the lingual feeding type. the posterior region of the dorsal surface of the free portion possesses several rows of well-developed club-shaped papillae that curved posteriorly.

The same results obtained in *Milvus migrans aegyptius (Shawki, 1995)*. These papillae are considered as special adaptive feature for procuring and swallowing the food.

The present bird. *C. corone*, inhabits cultivated land and feeds on seeds, plant matter, worms and small vertebrates. In this bird the anterior third of the free portion of the tongue contain many filiform papillae and the marginal region between the anterior and posterior areas of the free portion, gaint conical papillae were arranged in row. As other birds. these papillae help in controlling the movements of the food during the deglutition process and pushing it into the oesophagus *(Shawki and Al-Jalaud, 1994b)*. In the chicken tongue *(Iwasaki and Kobayashi, 1986)*, filiform papillae, which are distinct protrusions of the desquamating epithelial cells, are widely distributed over the anterior region. While there were few papillae on the surface of the posterior region. In view of the way chickens feed, the fluffy surface of the lingual dorsum. coated with mucous fluid, seems to be suitable for retaining various foods. On the tongue of the little tern *(Iwasaki, 1992b)*, median papillae are located in the anterior region, and protrusions of desquamating epithelial cells are prominent. The notched surface of the lingual dorsum seems to be suitable for retaining small fishes, which the birds usually catch with their tapering bills.

The present goose *A. anser* have two types of papilla, the first one, lingual hairs and cylindrical papillae located on both side of the anterior region of the tongue. The second one is the giant conical papillae found in the dorsal surface between the body and the radix of the tongue. This result agree with that perform on the Middendorff's bean goose that have cylindrical and giant conical papillae *(Iwasaki et al., 1997a)*. These structures might cooperate with the cornified teeth in biting off parts of plants. Strong keratinization of the epithelium of these papillae suggests good adaptation with respect to performance of these functions.

Salivary glands are adapted to the type of food. The present bird *E. ibis* shows only mucus cells since the lingual salivary glands act as hydraulic structures, when it filled with secretion, can be considered as a rigid structure. *Shawki and Abdel Rahman (1998)* showed that, the salivary glands of the egret *Bululcus ibis* secret saliva through ultra-minute pores. If these pores were larger as in other birds then the surface of the free portion of the tongue will be rough which may decrease the efficiency of sliding process of small food preys by falling of the small food items into the preglottal region, the slide and fall phases of the mechanism are terminated.

The present seed-eater columba have relatively large and well developed glands. These glands are essential to get large quantities of mucus which are highly required for contact with dry grains of different size. It is interested to mention that *McLelland (1979)* devided the subsalivary gland of galliformes and columbiformes into rostral and caudal glands. The present study confirmed that such a division was not recorded in the seed-eater columba or in the carnivorous herring gull birds *(Al-Jalaud, 1992)*.

The glandula lingualis of the present *B. buteo* and *T. alba*, located in the free portion spread along the dorsal and lateral surfaces of OS paraglossale. Discharge of the salivary glands acting as hydraulic structures in the tongue of *Milvus* needs to change its configuration to move to food items backwards inside the buccal cavity *(Fung, 1981 and Homberger, 1982)*.

There is a pair of lingual salivary glands in the free portion of the tongue of *C. corone*. In the quails, the lingual salivary glands

were paired and they were present on the right and left of the paraglossal (*Liman et al. (2001)*. They secret mucins that make protection to the mucosal surface of the tongue against pathogenic microorganisms and play a role in the moistening and lubrication of boli.

The free portion of the tongue of the present goose *A. anser* have an anterior lingual salivary glands lateral or dorso-lateral to the paraglossal bone. Similar observation is recorded in the chicken tongue. The anterior lingual glands of the chicken are composed of masses of compound tubular glands *(Gargiulo et al., 1991)*. The main functions of the anterior lingual gland are the lubrication of boli and protection of the cells from pathogenic organisms, functions similar to those suggested for the salivary and oesophageal glands *(Suprasert et al., 1986)*

Keratinization of the lingual epithelium is a common feature in the present birds and confirmed the previous studies *(Iwasaki, 1992b, Iwasaki et al., 1997a and Kobayashi et al., 1998)*, in particular on the ventral side of the tongue, where the so-called "lingual nail" *(Homberger, Brush, 1986, Carver and Sawer, 1989)*. In the ancestors of birds, the lingual epithelium might have become adapted to dry conditions. Animal keratins are special structures found at the interfacing surfaces to confront the environmental stress factors: e. g mechanical protection, abrasive. grasping, eating and digging.

The tongue of the present egret *E. ibis, C. livia, C. corone and A. anser* show that the dorsal surface of its free portion has a thick cornified epithelium, while the ventral one is soft. So, the different types of surface covering keratin of the tongue reflect the demand placed on the lingual surface *(Homberger and Brush, 1986)*.

The thick keratinized layer in *B. ibis* may enable the bird to manipulate the food items by the anterior portion of the tongue from the tip of the beak and draw it backward toward the buccal cavity *(Shawki and Abdel-Rahman, 1998)*. Also, the abrasive stress of the food items will be more noticed on the posterior region of the free portion of the tongue, since the large items like hard shelled animals (molluscs) and frogs may cause damage to that part of the tongue during deglutition process. Nevertheless, deglutition

of these food items using the tongue inside the buccal cavity needs less rigidity.

The dorsal surface of the free portion of the tongue in the present seed-eater and sometimes a fruit-eater is covered with keratinized layer that give the roughness appearance but the ventral surface is smooth. This feature enable the transport of food items into the oesophagus and make protection to lingual epithelium *(Shawki and AL-Jalaud, 1994a)*. The lateral edges of the present pigeon is smooth while that on Imperial pigeon *(Bhattacharyya, 1980, 1990)*, and collared dove *(Shawki and AL-Jalaud, 1994a)* are rather rough and not smooth ones.

Spiny keratinized papillae in *Larus argentatus* may help in controlling the movements of the prey during the deglutition process. The presence of backward directed spines on the posterior edge of the free portion of the tongue help in pushing the prey to the oesophagus *(Shawki and AL-Jalaud, 1994b)*.

Examination of the dorsal lingual epithelium of the tongue of Middendorff's bean goose is composed of stratified squamous epithelium on its anterior and posterior regions *(Iwasaki et al., 1997a)*. In the present goose, the observations by SEM show that the surface of the cylindrical and giant conical papillae have micropits. These results are also observed on the surface of strongly keratinized epithelium of the lingual papillae of mammals *(Iwasaki et al., 1987a)*. The striations observed on the surface of the cylindrical papillae of the present goose might be generated by hard food during feeding. Similar observation is recorded in the Middendorff bean goose *(Iwasaki et al., 1997a)*. The surface of the posterior region of the present goose is smoothed. Similar observations are recorded in Middendorff's bean goose, the little tern *(Iwasaki, 1992b)* and the chicken *(Iwasaki and Kobayashi, 1986)*. The present SEM studies have shown that the dorsal surface of the posterior end of the tongue is relatively smooth. This structure seems to be adapted to the smooth swallowing of food. The ultra structure of the dorsal lingual surface and tongue shape are quite suitable to the feeding habits of each species. The similarities in keratinization of the lingual epithelium in the present

goose and the little tern seem to be strongly related to the similarities in the habitats of the two species At the same time, the differences in the degree of keratinization of the lingual epithelium between the present investigated specie and the chiken seem to be based on difference in habitat. The chicken lives in a habitat much drier than that of the goose and the little tern.

Elevation, depression and bending of the free portion of the tongue in birds are essential movements for the success of manipulating the food parts *(Skawki, 1995)*. The presence of the M. hypoglossus anterior, M. hypoglossus posterior and M. ceratoglossus are responsible for these movements respectively in the present studied birds. The paraglossale is the anterior unpaired element which represents the main support of the free portion of the tongue in the present aves. As shown by *Skawki (1995)* in *Milvus migrans aegytius*, the presence of an anterior cartilaginous paraglossal process in carnivorous bird permits for the ventral bending process of the anterior tip of the tongue during picking up the food pieces from the prey, also, the presence of an oval foramen paraglossale increases the mobility of this element during the deglutition process.

The OS paraglossale is a complete cartilaginous element without any bony structure in domestic and Imperial pigeons the rostral part of the tongue of these pigeons must be highly elastic and flexible so that it can be bent into the extreme curves *(Bhattacharyya, 1980, 1990 and Zweers, 1982)*. This observation on pigeon is disagree with that on the *Collard dove* because the OS paraglossale in *C. dove* is completely bony structure without any foramina or cartilaginous process that prevents the flexibility of the free portion of the tongue, regarding the presence of the origin and insertion of muscle the rigidity of the OS paraglossal *(Shawki and Al-Jalaud 1994a)* .

The muscle M. hypoglossal anterior in the free portion of the tongue of the present birds is located along the ventral side of the paraglossal. *Shawki and Abdel Rahmaan (1998)* concluded that the contraction of the M. hypoglossus anterior in the free portion of the tongue of *B. ibis* generates a force along the ventro-medial surface of the paraglossale through its insertion tendon. Thus, it flexes the free portion of the tongue as well as depressing it by the

contraction of the lateral muscle fibers which may affect the flexible articulatio-paraglosso-basoihyalis. This developed muscle is characterized by its lateral additional origin on the lateral surface of the insertion tendon of muscle ceratoglossus lateralis. The same pattern is recorded in *Grus Americana (Fischer and Goodman, 1955).*

The contraction of M. hypoglossal anterior in the free portion of the tongue may increase the rigidity of the Os paraglossa *(Homberger 1986 and Shawki and Al-Jalaud, 1994a).* It was noticed that muscle hypoglossus anterior has pinnate character and different sites of attachements that reflect its powerfull action.

In the free portion of the tongue of *C. livia, B. buteo* and *C. corone,* the muscle hypoglossus posterior is a paired muscle lies posterior to hypoglossus anterior. In *C. livia,* **Bhattacharyya (1980)** considered that the hypoglossus posterior is a derived part from the muscle ceratoglossus. In the herring gull it is an unpaired muscle that is attached from origin to insertion *(Al-Jalaud, 1992).* In the chicken, M. hypoglossus posterior is a paired muscle and its anatomical relations were subjected to some confusion *(Yamada, 1964 and Nickel et al., 1977).* In the *C. dove* the hypoglossus posterior is paired muscleand it is attached on the basihyale. It affects articulatio-paraglossale-basihyale resulting in the depression of the posterior portion of the Os paraglossale and consequently elevating its anterior tip *(Shawki and Al-Jalaud, 1994a).*

The M. hypoglossus posterior in the free portion of the tongue of *Larus argentatus* reveals that it plays an important mechanical role during the feeding process *(Shawki and Al-Jalaud, 1994b).* The contraction of this muscle results in the fixation of articulatio-paraglossal-basihyale. Then, the two bony elements behave as one single skeletal component such a transfiguration increases the resistance of the tongue to overcome the upper pressure coming from the heavy preys during the deglutition process.

The M. ceratoglossus in the free portion of the tongue in *C. livia* is a well developed muscle. The anatomical relations of the muscle ceratoglossus of the Imperial pigeon are different from those of the *C. dove (Shawki and Al-Jalaud, 1994a)* and form those of the herring gull *(Al-Jalaud, 1992).* In *C. dove,* muscle ceratoglossus crosses articulatio-paraglosso-basihyale and

articulatio-basihyale-ceratobranchiale. This muscle acts on both articulations and causes the depression of the free portion of the tongue *(Shawki and Al-Jalaud, 1994a). Shawki (1995)* Showed that the M. ceratoglossus in the free portion of the tongue of *M. migrans* is the main depressor of the entire free portion of the tongue. Consequently, due to the deficiency of accurate information dealing with the anatomical relations of the components of the lingual apparatus of different birds, it is difficult to compare the function of one particular muscle in different avian species.

It is concluded that the feeding mechanism and, in particular, the way in which the lingual apparatus interacts with the food items are the main determinants of the tongue morphology, anatomy, as well as the related structures. Finally, more comparative anatomical, functional and ecological investigations are urgently needed to enrich the interest of this important area.
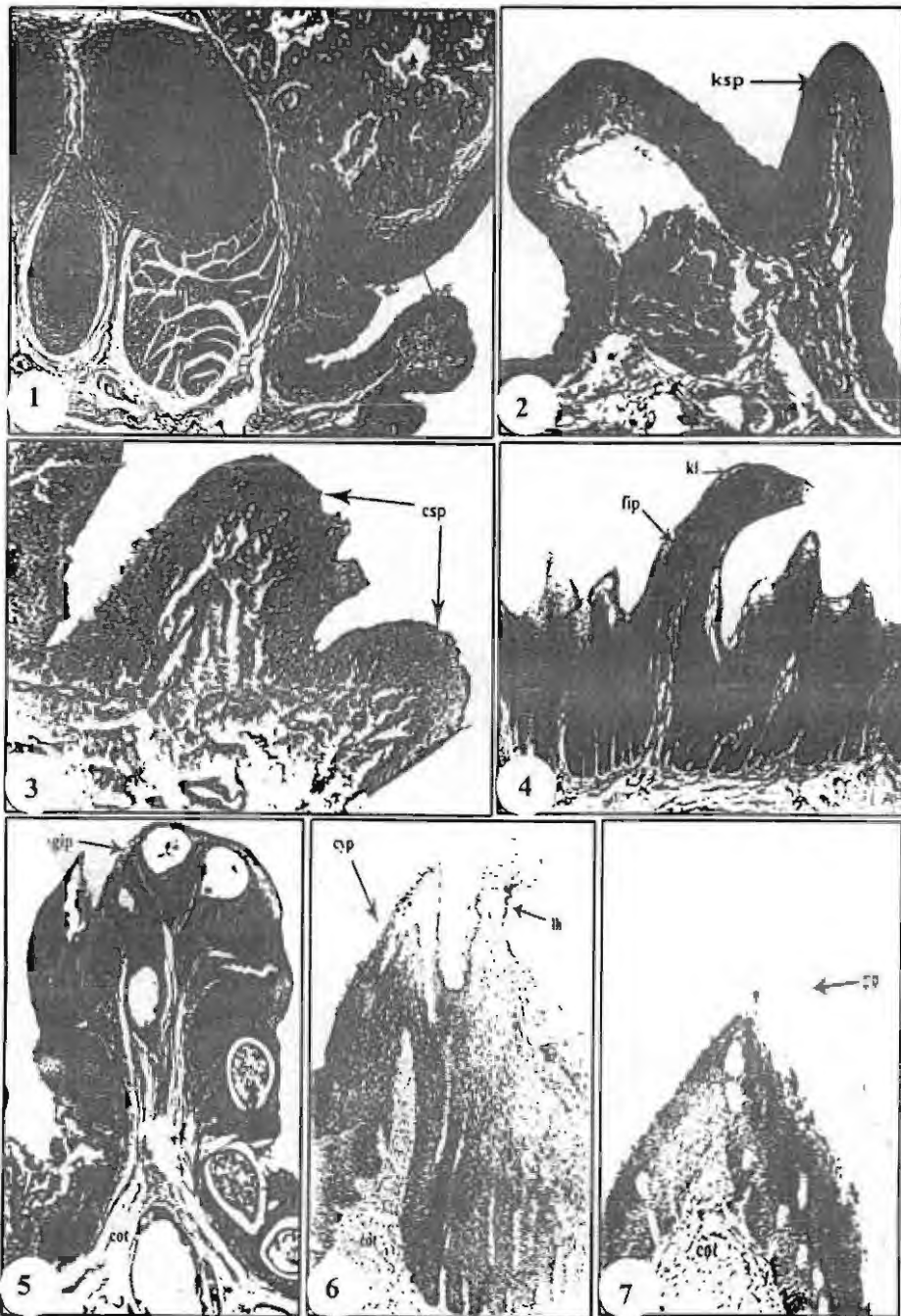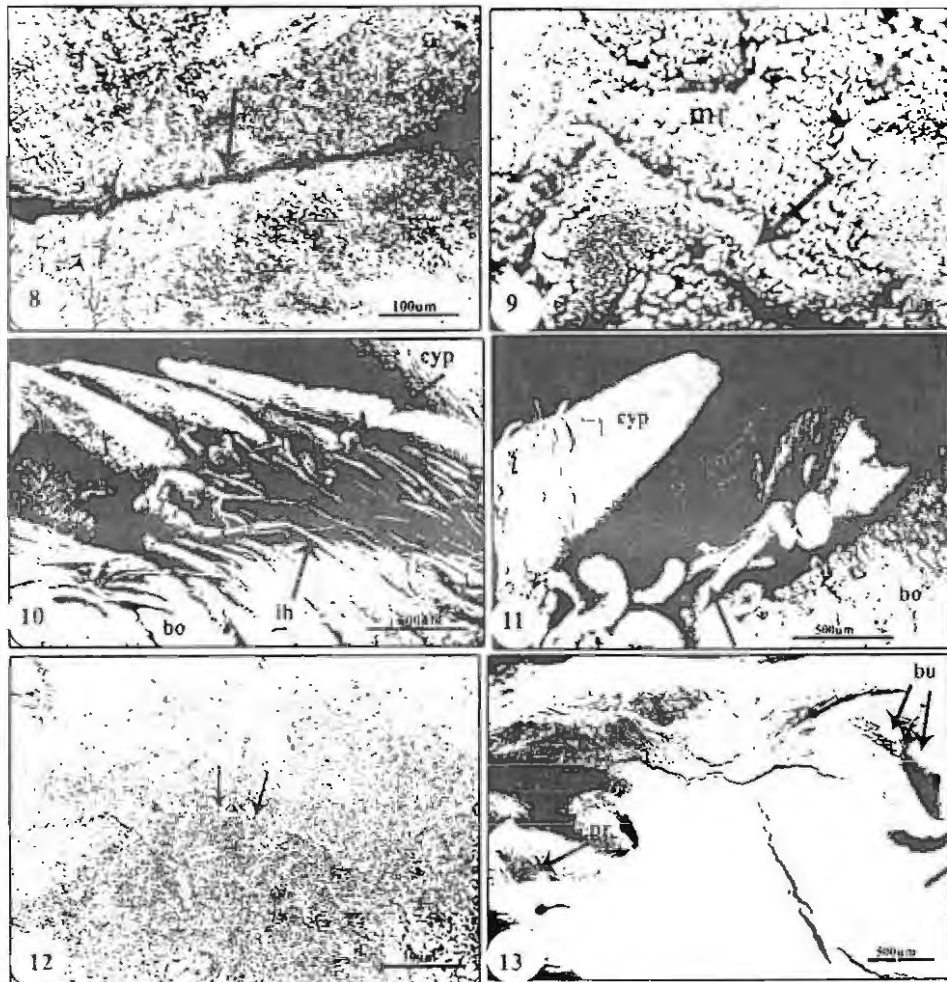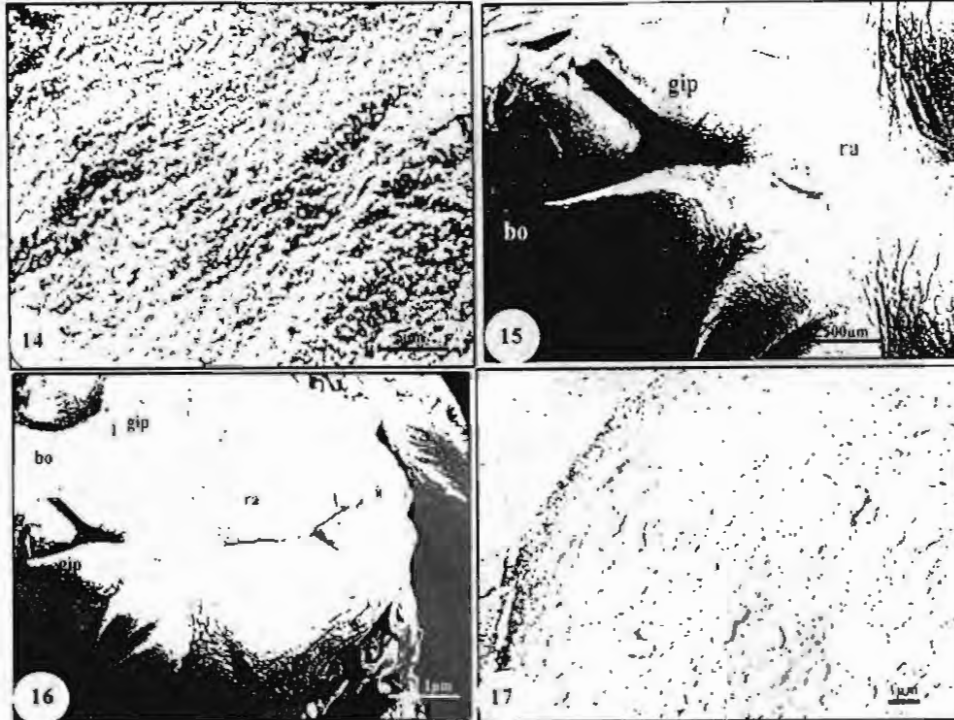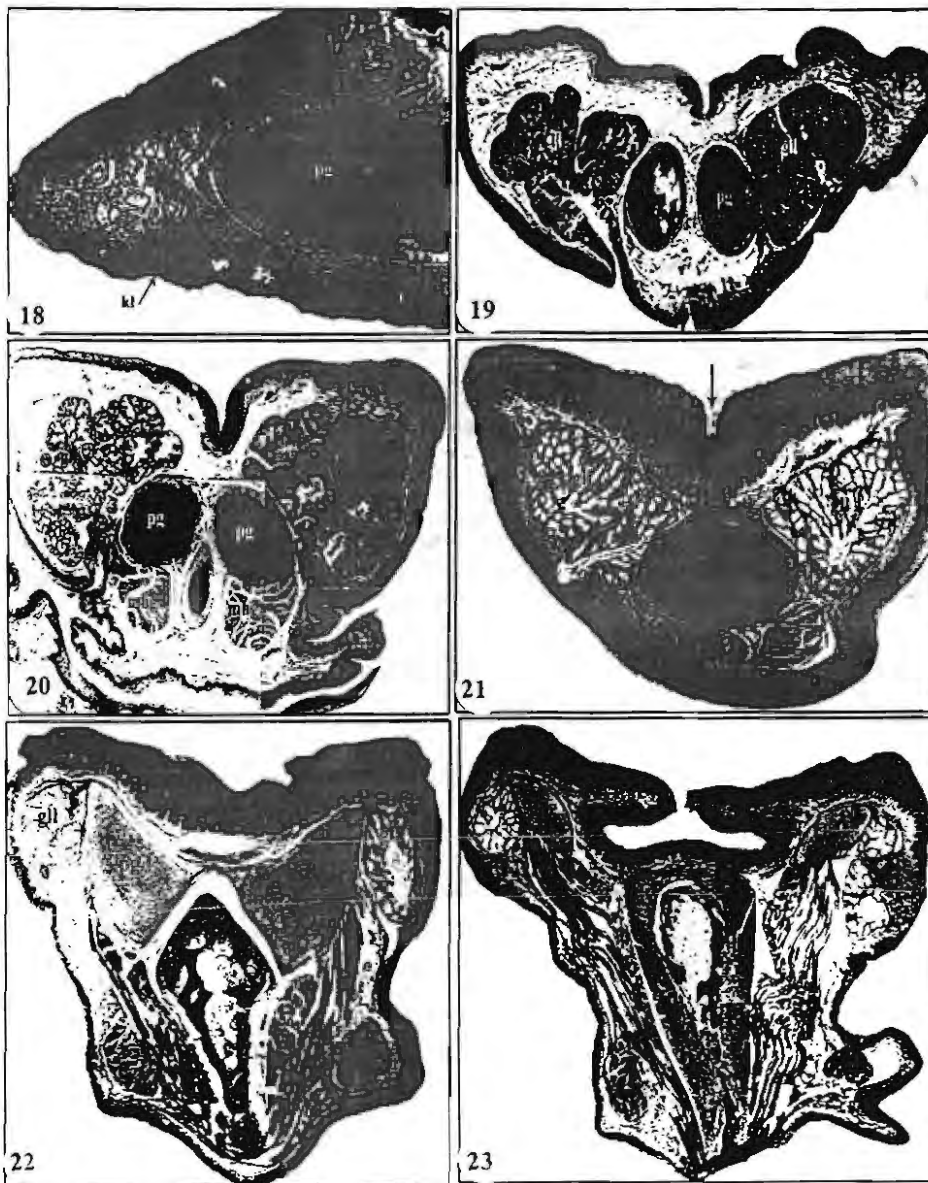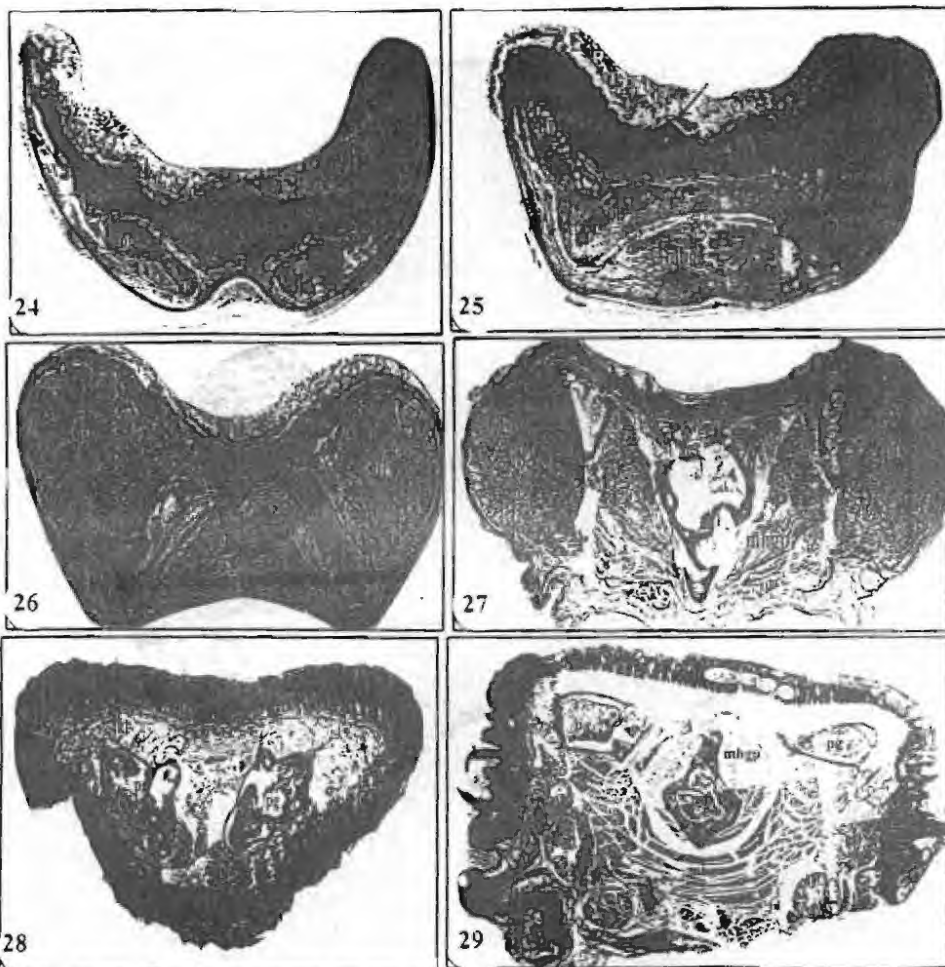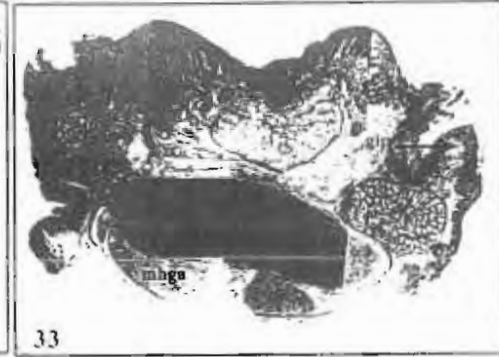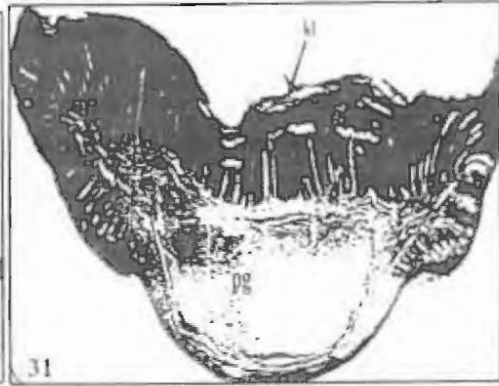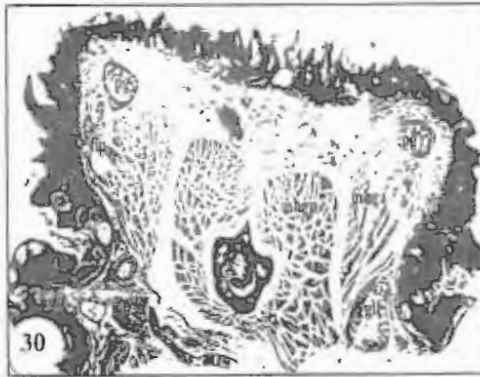
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Fig. 12. Higher magnification scanning electron micrograph of the surface of a cylindrical papillae located on the lateral

side of the lingual body of the free portion of the tongue of goose *A. anser.* Arrows: micropits. X2000.

Fig.13. SEM image of two curved antero posteriorly elongated prominences (pr) that are located on both sides of the median line of the free portion of the tongue of goose *A. anser.* Double arrows: small bulg (bu). X35.

Fig. 14. SEM image of the epithelial surface of the proximal end of the lingual body of the free portion of the tongue of goose *A. anser.* X3500.

Fig. 15. SEM image of giant conical papillae located between the lingual body (bo) and the lingual radix (ra) of the free portion of the tongue of goose *A. anser.* X15.

Fig. 16. SEM image of the proximal end of the lingual body (bo) of the free portion of the tongue of goose *A. anser.* X15.

Fig. 17. Higher magnification SEM image of the epithelial surface of giant conical papillae located between the lingual body and the lingual radix of the free portion of the tongue of goose *A. anser.* X7500.

Fig. 18. T. S. through the anterior tip of the free portion of the tongue in bird *E. ibis* showing the keratinized layer surrounding it. X40.

Fig. 19. T. S. through of the median part of the free portion of the tongue in bird *E. ibis* showing its shallow dorsal groove and the surrounding keratinized layer and the glandula lingualis.X40.

Fig. 20. T. S. through the posterior part of the free portion of the tongue in bird *E. ibis* showing that the dorsal groove becomes deeper than that of the previous median part, the keratinized layer and the glandula lingualis. X40.

Figs. 21, 22, 23. T. S. through the anterior tip, median region and posterior region of the free portion of the tongue in bird *C. livia* respectively. Arrow: dorsal surface. X40.

Figs. 24, 25, 26, 27. T. S. through the anterior region, median region and posterior region of the free portion of the tongue in bird *B. buteo* respectively. X40.

Figs. 28, 29, 30. T. S. through the anterior region, median region and posterior region of the free portion of the tongue in bird *C. corone* respectively. X40.

Figs. 31, 32, 33. T. S. through the anterior region, median region and posterior region of the free portion of the tongue of bird *A. anser* respectively. X40.

Abbreviations

cot   Connective tissue core of papillae
csp   Club shaped papillae
cyp   Cylindrical papillae
fip   Filiform papillae
gip   Giant conical papillae
gll   Glandulla lingualis
kl   Keratinized layer
ksp   Keratinized spine- like papillae
mcg   Muscle ceratoglossus
mhg   Muscle hypoglossus
mhga   Muscle hypoglossus anterior
mhgp   Muscle hypoglossus posterior
mr   Microridge
P   Paraglossal

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المورفولوجياالوظيفية لتركيب اللسان فى بعض الطيور المختلفة فى السلوك الغذائى

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تم دراسة تركيب الطلائية اللسانية وايضا العضلات اللسانية فى كل من طائر ابى قردان- الحمامة المنزلية - البط - الصقر- البومة وايضا الغراب باستخدام الميكرسكوب الضوئى والميكرسكوب الماسح . وحيث ان هذه الطيور تختلف فى غذائها وفى الطريقة التى تتغذى بها فقد اظهرت النتائج ان هناك اختلافات بين هذه الطيور فى التركيب النسيجى للطلائية اللسانية متضمنة الحلمات-الغدد وعملية التقرن وايضا العضلات اللسانية ويكون هذا الاختلاف مرتبطا بالغذاءوحركته.