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DEVELOPMENTAL STUDIES ON THE FLOOR OF THE OROPHARYNX OF THE POST-HATCHING QUAIL (With 21 Figures)

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دراسات تطورية على أرضية البلعوم الفموي للسمان بعد الفقس

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أجرى هذا البحث على السمان من عمر 1 - 45 يوم بعد الفقس. وقد تم دراسة التغيرات المورفولوجية ظاهريا وبالإستعانة بالميكروسكوب الإلكتروني الماسح. أظهرت النتائج أن أرضية الفم تزداد في الطول بتقدم العمر ولكن بمعدل أقل من اللسان. لم يملأ اللسان أرضية الفم تماما في جميع الأعمار لذلك توجد مسافة بين طرف قمة اللسان والنهية الأمامية لأرضية الفم. طول هذه المسافة يختلف في الأعمار المختلفة. لتوضح من الدراسة أيضا أن العلاقة بين موقع الشكال اللساني والصف المستعرض للحلمات اللسانية وزاوية الفم تتوقف على عمر الطائر. يغطي السطح الظهري لقمة والجزء الأمامي لجسم اللسان حلمات خيطية تصبح أكثر سمكا وطولا وتأخذ شكلا اسطوانيا بتقدم العمر. وباستخدام التكبيرات العليا تبين أن الخلايا ذات الشكل الحرشفي عند عمر يوم تغطي بنظام معقد من الطيات المجهرية والتي توجد بكثرة عند عمر 45 يوم حيث تأخذ نظام المتاهة. الشكل العام للحلمات اللسانية مخروطي ولها قواعد عريضة وقمم مدببة عند عمر يوم. ولكن في السمان الأكبر عمرا تزداد هذه الحلمات في الحجم وتصبح أكثر استطالة وذات قواعد ضيقة وقمم إكليلية نسبيا. وقد لوحظ كذلك أن موقع وطول وشكل الفتحة الحنجرية وكذلك اتساع الميزاب الحنجري يختلف وفقا لعمر الطائر. ومع تقدم العمر تبين أن الحلمات البلعومية تزداد في الحجم والصف الأمامي منها يأخذ شكلا منحنيا قليلا. علاوة على انتشار بعض الحرشيف على سطح هذه الحلمات عند عمر يوم حيث تزداد في العدد لتغطي كل السطح عند عمر 45 يوم.

SUMMARY

The morphological changes of the floor of the oropharynx of the quail from 1-45 days old were studied grossly and by scanning electron microscope. The oral floor increases in length with the advancement of

the age but at a slower rate than the tongue. In all studied ages the tongue does not fill the oral floor completely. Therefore there is a distance between the tip of the tongue and the rostral end of the oral floor, the length of this distance varies in different ages. The relation between the position of the frenulum linguae, the transverse row of the lingual papillae and the angle of the mouth depends upon the age of the bird. The dorsum of the apex and the rostral part of the body of the tongue are covered by filiform papillae which become thicker, longer and cylindrical with the advancing age. At high magnification the scale-shaped cells of the body of the tongue are covered, at one day old, by complex pattern of microplicae which are extensively present at 45 days old showing labyrinthine pattern. The lingual papillae in general are cone-shaped, they have wide bases and pointed apices at one day old. In older quails the papillae increase in size and become elongated with relatively narrower bases and blunt apices. The position, length and shape of the laryngeal inlet as well as the width of the laryngeal sulcus vary according to the age of the bird. With the advancement of the age, the pharyngeal papillae increase in size and the rostral row attains a slightly curved appearance, moreover the few scales distributed on the papillary surface at one day old increase in number and size till covering the entire surface at 45 days old.

Key words: Developmental studies on oropharynx of quail.

INTRODUCTION

The quails have many advantages compared with other birds because they do not eat a lot, their food conversion is high and their space requirements are small. The quails are not only considered as a source of meat and egg production but they also became as standard laboratory birds. Although the morphology of the oropharynx in different adult avian species has received a considerable attention of several investigators, the information about the development of the oropharynx in birds is meagre. Therefore, the present work aims to give a quantitative data about the development of the floor of the oropharynx in the post-hatching quail concerning its gross anatomical and scanning electron microscopical structures.

MATERIAL and METHODS

The present work was carried out on forty apparently healthy post-hatching Japanese quails (*Coturnix coturnix japonica*) of both sexes ranging from 1-45 days old. They were divided into 5 groups (1,7,15,30 and 45 days old). The birds were anesthetized with dimethyl ether. For the gross anatomical examination five birds of each group were used. The oropharynx was opened, its floor was dissected and fixed in 10% formalin then examined. The scanning electron microscopical examination was carried out on three birds of each group. The floor of the oropharynx was washed with normal saline then fixed in paraformaldehyde 2.5% and glutaraldehyde 2.5% solution in 0.1M phosphate buffer. After washing in the same buffer, the specimens were postfixated in osmium tetroxide 1% in phosphate buffer followed by washing in the same buffer. Then they were dehydrated in ascending graded ethanol followed by critical point drying in carbon dioxide. The samples were finally sputter-coated with gold and examined with a JEOL-5400LV scanning electron microscope.

RESULTS

The floor of the oropharynx extends from the rostral end of the mandible to the pharyngeoesophageal junction. It includes the oral and pharyngeal floors. The oral floor contains most of the tongue which can be divided into three parts; apex, body and root (Figs.1,2). The transition between the apex (free part) and the body is marked by the attachment of the frenulum linguae and that between the body and the root by the transverse row of caudally directed lingual papillae. The pharyngeal floor can be divided into rostral part which is occupied by the root of the tongue and caudal part which contains the laryngeal mound.

The tongue of one day old quails is small with triangular dorsal surface and sharp edges which converge toward the apex. It is fixed by a short connective tissue band representing the beginning of the frenulum linguae. The total length of the tongue at one day old is 8.83 mm while it becomes 16.82 mm at 45 days old. On the other hand, the total length of the oral floor at one day old is 10.02 mm and it reaches 17.91 mm at 45 days old. Consequently the length percentage of the tongue between the two ages is 190.48 %, while this percentage in case of the oral floor is 178.74 %. The aforementioned result proves that the oral floor develops at a slower rate than the tongue.

In all studied ages the tongue does not fill the oral floor completely (Fig.1), therefore there is a distance between the tip of the apex of the tongue and the rostral end of the oral floor which varies in the different ages. This distance represents nearly half the total length of the oral floor at the age of 1-15 days, one third at 30 days and one fourth at 45 days.

Concerning the relation between the frenulum linguae, transverse row of the lingual papillae to the angle of the mouth, it is found that at the age of 1-15 days they are located nearly at the same level. But at the age of 30-45 days both the frenulum linguae and the papillary row are situated rostral to the level of the angle of the mouth, with the frenulum linguae in front of the papillary row.

A median groove; at one day old, is demonstrated on the rostral third of the dorsum of the tongue (Fig.3), but does not reach to the tip of the apex as revealed by scanning electron microscope. At 15 days old the groove occupies the rostral half of the tongue including the tip. At the age of 30-45 days the median groove (Fig.1) extends along the dorsal surface from the tip rostrally to the papillary transverse row caudally. It is deeper in the quails of 45 days old than of 30 days old.

The scanning electron microscope indicates generally that the dorsum of the apex and the rostral part of the body of the tongue at different ages are covered by caudally directed filiform papillae (Figs.3,4,5). The height and thickness of these papillae increase caudalwards, but decrease toward the free edges of the tongue. At one day old the papillae are short with blunt free ends, they were not observed at the tip of the apex. Moreover, the filiform papillae on both sides of the median sulcus are mostly seen placed obliquely. At 7 days old the papillae cover all the lingual apex including the tip. With the advancement of age the papillae become longer and cylindrical, they have mostly pointed free ends as shown at 45 days old (Fig.6).

The scanning electron microscope reveals that the dorsum of the caudal part of the body of the tongue in all studied ages is covered by caudally directed flattened scale-shaped cells (Fig.7), which increase in number and size in older quails. At higher magnification, in the quails of one day old, these cells display a complex pattern of microplicae which run in different directions surrounding micropits (Fig.8). The microplicae increase in number with advancing age, thus they are extensively present at 45 days old showing a labyrinthine pattern (Fig.9). Moreover at this age the micropits become deeper.

A single transverse row of caudally directed lingual papillae separates the body from the root of the tongue. The number of these papillae is about 14 -16 in the quails at 1- 15 days old (Fig.10) and becomes about 18-24 in the quails at 30-45 days old (Fig.11). In all ages, the papillae of this row are shortest close to the midline and increase in length lateralwards. At 15 days old a second short row of small papillae appears caudal to the previous row. They are also directed caudally and demonstrated as two groups lying on both sides of the root of the tongue partially undercovered by the peripherally situating papillae of the first row.

In general and as shown by the scanning electron microscope the lingual papillae are cone-shaped. At one day old they are short having wide bases and pointed apices (Fig.14). In addition a few small scales are irregularly distributed on the surface of these papillae. In older quails the lingual papillae increase in size and become elongated with relatively narrower bases and blunt apices. Moreover the scales become numerous and larger, they cover the entire surface of the papillae, but concentrate at the bases in the quails of 45 days old (Fig.15).

The rostral part of the pharyngeal floor which is occupied by the root of the tongue is characterised, at one day old, by transversely oriented thread like mucosal microfolds representing the future folds and separated by very narrow furrows (Fig.10). They concentrate at the apical part of this region. At 45 days the mucosal folds become well developed and distribute all over the root of the tongue (Figs.11,13). They run in a wavy manner, separated by wide deep furrows and get thickened caudally.

The caudal part of the pharyngeal floor contains the laryngeal mound with its laryngeal inlet (cleft) which varies in position, length and shape at different ages. At the age of 1-15 days the laryngeal inlet lies opposite to the infundibular cleft intum caudal to the choanal slit, and at 30 days old the caudal part of the inlet lies opposite to the rostral part of the cleft. At 45 days old the laryngeal inlet becomes in front to the infundibular cleft and related to the caudal part of the choanal slit. The laryngeal inlet measures 1.45, 2.54, 3.34 and 4.18 mm long at 1, 15, 30 and 45 days old respectively. Therefore, the length at 45 days old is about three folds that at one day old.

Concerning the shape, the laryngeal inlet at one day old is in the form of a short longitudinal opening with a slightly wider caudal end (Fig.10). It becomes elongated at 7 days old, but from 15-30 days old it has an elliptical outline (Fig.12). At 45 days old the laryngeal inlet has

triangular shape with the base directed caudally (Fig.13). The rostral end of the inlet at the age from 1-30 days communicates with both sides of the laryngeal mound through crescentic-shaped caudally directed groove. The quails of 45 days old have large distinct deep groove which receives rostrally very narrow parallel sagittal furrows (Figs.11,13). At this age an additional 1-2 small grooves are demonstrated caudal to the previous groove. The caudal end of the laryngeal inlet continues caudally by the laryngeal sulcus. At the age of 1-15 days, the sulcus has the same width along its length. But at the age of 30-45 days, it becomes wider caudally than rostrally.

On both sides of the laryngeal mound one sagittal row of 5-6 small caudally directed papillae is demonstrated at one day old (Figs.10,16). The papillae of this row are parallel to the rim of the laryngeal inlet, they converge caudally bordering the beginning of the laryngeal sulcus. The papillae become larger in size and are encircled at their bases by small scales at 45 days old.

Caudal to the laryngeal mound, at one day old, a rostral transverse row of caudally directed pharyngeal papillae (Fig.16) extending from the laryngeal sulcus medially to the lateral wall of the pharynx laterally. The most medial papillae of each side bordering the laryngeal sulcus. Behind this row a number of small sized caudomedially pointing papillae are demonstrated and forming the future caudal row, they demarcate the junction between the pharynx and esophagus. With the advancement of age the pharyngeal papillae (Fig.17) increase in size, the rostral row attains a slightly curved appearance with convexity directed rostrally, while the caudal row becomes transverse.

The pharyngeal papillae at one day old are cone-shaped with wide bases, pointed apices and a few scales scattered on their surfaces. In older quails the papillae become longer with narrower bases, the scales increase in number and size till covering the entire papillary surface at 45 days old. At this age the rostral row have a cylindrical-shaped papillae some of them are bifurcated (Fig.19), while the caudal row has a cone-shaped ones.

The scanning electron microscope reveals that at one day old a numerous nearly circular openings of the lingual salivary glands (Fig.20) are demonstrated in the rostral part of the pharyngeal floor. Moreover at 7 days old a few small longitudinally arranged openings of the cricoarytenoid salivary glands (Fig.21) are shown lateral to the laryngeal mound.

DISCUSSION

In all studied ages the tongue does not fill the oral floor completely. Therefore, there is a distance between the tip of the tongue and the rostral end of the oral floor. Similar observation was reported in chicken and pigeon by Nickel *et al* (1977), in duck by Abdalla (1994) and in fish eaters birds by Koch (1973). However, Nickel *et al* (1977) added that the tongue in lamellirosses (duck and goose) fills the oral cavity completely. This distance varies in the different ages. The variation is due to that the oral floor develops at a slower rate than the tongue. Consequently it is concluded that there is a correlation between the length of aforementioned distance and the age of the quail. In this respect, Abdalla (1994) mentioned that the ratio between the area of the oral floor free from the tongue and that occupied by it differs in chicken, pigeon and duck.

The present study shows that at one day old a median groove is demonstrated on the rostral third of the dorsum of the tongue, but does not reach to its tip. It occupies the rostral half including the tip at 15 days old, and extends caudally along the dorsum till the papillary transverse row of the lingual papillae at the age of 30-45 days old. Similar result was obtained in the adult quail (Ghattas, 2003), in duck (Abdalla, 1994; Abd-Elmohdy and Ghattas, 1995) and in turkey (Abd-Elfatah *et al*, 2000). This groove terminates in front the papillary row in chicken and pigeon (Abdalla, 1994), but present only in the rostral part of the tongue in chicken, duck and goose (Nickel *et al*, 1977). When the mouth is closed the median groove contains the median longitudinal mucosal ridge of the palate (McLelland, 1975).

The recent investigation reveals that the dorsum of the apex and the rostral part of the body of the tongue are generally covered at different ages by filiform papillae. But the tip of the tongue is devoid of these papillae at one day old, on reaching 7 days old the papillae appear in this area. The papillary height and thickness increase with advancing age. Within the same age, they increase caudalwards, but decrease toward the free edges of the tongue. The filiform papillae are distributed all over the dorsum of the free part of the tongue in chicken, but present only in the mid-region of this part in pigeon (Abdalla, 1994). In turkey the filiform papillae are demonstrated in the body of the tongue, but in the tip and root of the tongue the papillae could not be observed (Abd-Elfatah *et al*, 2000). In this connection, the surface of the epithelium is smooth along the ventral surface of the tongue in adult quail but reveals

exfoliation on the dorsal one (Ghattas, 2003). The filiform papillae serve a mechanical functions (Banks, 1993), they impart the velvety appearance to the dorsal surface of the tongue (Gartner and Hiatt, 1997).

By scanning electron microscope the present work indicates that the dorsum of the caudal part of the body of the tongue is generally covered by flattened scale-shaped cells, which increase in number and size with advancing age. At higher magnification these cells show microplicae and micropits. The microplicae display a complex pattern at one day old and labyrinthine pattern at 45 days. This morphological feature (microplicae and micropits) of the post-hatching quail could not be observed in the other birds species corresponding to the available literature. However, this feature is demonstrated in the tongue of the mouse, goat and donkey (Utiyama *et al*, 1995; Kumar *et al*, 1998; Abd-Elneaim *et al*, 2002). Utiyama *et al* (1995) mentioned that the microplicae surround the taste pores in mouse tongue. The microplicae appear to provide a structure to make even spreading easier and give adhesion to a mucous coat (Sperry and Wassersug, 1976). They have been suggested to play a mechanical and protective roles (Kumar *et al*, 1998; Abd-Elneaim *et al*, 2002).

The scanning electron microscopical observation reveals that at 1-15 days old the tongue has a single transverse row of about 14-16 caudally directed lingual papillae. They increase in number to become about 18-24 at 30-45 days old. A second caudal short row of papillae appears at 15 days old. Concerning the lingual papillae a considerable species variations were obtained from available literature. Two transverse rows of the lingual papillae were described in duck (Abdalla, 1994) and in hawk (Abd-Elmohdy, 1993), but 1-2 rows were observed in duck (Hassouna, 2002). However one row was reported in chicken (Hodges, 1974; Homborger, 1982; Homborger and Meyers, 1989), in pigeon (Koch, 1973), in turkey (Abd-Elfatah *et al*, 2000) and in quail (Ghattas, 2003). In ostrich the lingual papillae are absent (Elmorsi *et al*, 2002). This variation in the lingual papillae in different species of birds may be due to nutritional behaviour of different birds species (Abd-Elmohdy, 1993). The caudally directed lingual papillae are the feature of the tongue of most species including those with major adaptations for procuring food or eating, and serve to assist swallowing, they help to propel the food caudally and to prevent its regurgitation (McLelland, 1979; King and McLelland, 1984).

The examined post-hatching quails have in general cone-shaped lingual papillae. Similar finding was given in the duck (Abdalla, 1994)

and in the turkey (Abd-Elfatah *et al.*, 2000). In the chicken the papillae are finger-shaped, however in the pigeon the centrally-situated papillae are nearly conical in shape but the lateral ones are dome in shape (Abdalla, 1994). At one day old a few small scales are irregularly distributed on the papillary surface. With the advancement of age the scales become numerous and larger covering the entire surface of the papillae but concentrate at the bases in the quails of 45 days old. In this respect Abdalla (1994) mentioned that the lingual papillae carry secondary scale-like papillae which are more in duck than in chicken and pigeon. Moreover, in chicken the secondary papillae increase in number basalwards. These scales were also observed in turkey by Abd-Elfatah *et al.* (2000), they are small and directed toward the apical ends of the lingual papillae.

The present work reveals that there is a correlation between the position, length and shape of the laryngeal inlet on one hand and different ages of the examined quails on the other hand. At the age from 1-15 days the inlet lies opposite to the infundibular cleft and at 30 days old the caudal part of the inlet lies opposite to the rostral part of the cleft. At 45 days old the laryngeal inlet becomes in front to the infundibular cleft and related to the caudal part of the choanal slit. In this respect, in female chicken the rostral part of the inlet lies under the caudal part of the choanal slit, whereas in male the whole inlet lies substantially caudal to the choanal opening during eupnea (White, 1975).

The recent investigation indicates that the length of the laryngeal inlet increases with the advancement of age. Therefore, the length at 45 days old is about three folds at one day old. The length of the inlet in duck and goose is 1.3 cm (White, 1975). The laryngeal inlet of one day old examined quails is in the form of a short longitudinal opening with slightly wider caudal end. It becomes elongated at 7 days, elliptical at 15-30 days and triangular at 45 days old. This inlet is a narrow slit-like opening in birds (Nickel *et al.*, 1977; King and Mclelland, 1984; Dyce *et al.*, 1996). The laryngeal inlet (glottis), formed by arytenoids, closes the entrance to the larynx by reflex muscular action, preventing food particles and other foreign matter from reaching the lower air passage. Despite the narrowness of the glottis it is possible to intubate the trachea in large cage birds (Dyce *et al.*, 1996). Slight widening of the inlet sometimes accompanies inspiration during resting breathing, wide dilatation of the inlet and marked rostral movement of the whole mound occur with each inspiration during gasping (White and Clubb, 1967).

The present work shows one sagittal row of papillae lying on both sides of the laryngeal mound. Moreover, two transverse rows of pharyngeal papillae are generally arranged caudal to the mound. These papillae are directed mainly caudally and differ according to the age of the quail. In chicken each side of the laryngeal mound bears four rows of caudally pointing papillae, two transverse and two sagittal, in turkey there is no sagittal line of papillae on the edge of the inlet (White, 1975). In cage and aviary birds a few filiform papillae are distributed over the laryngeal prominence and caudal floor of the pharynx (Petra, 1982). In nearly all the species of the bird the mound has several rows of strong backward-pointing cornified papillae, which help in the raking movements of the larynx during swallowing (King and Mclelland, 1984).

LEGENDS

- Fig.(1):** Photograph showing the tongue and the oral floor at one day old (left), 15 days old (middle) and 45 days old (right).
- Fig.(2):** Scanning electron micrograph of the tongue at one day old showing the apex (1), body (2), root (3) and the transverse row of lingual papillae (4). Note that the median groove (arrow) demonstrated on the rostral third of the lingual dorsum. (X15).
- Fig.(3):** Scanning electron micrograph of the apex of the tongue at one day old showing the filiform papillae and the median groove. (X150).
- Figs.(4,5):** Scanning electron micrographs of the apex of the tongue showing the filiform papillae at 7 days old (Fig.4) and at 45 days old (Fig.5). (X350).
- Fig.(6):** Scanning electron micrograph showing a higher magnification of the filiform papillae at 45 days old. Note that the papillae are cylindrical in shape. (X1500).
- Fig.(7):** Scanning electron micrograph of the caudal part of the body of the tongue at 45 days old showing the scale-shaped cells. (X1500).
- Figs.(8,9):** Scanning electron micrographs at higher magnification showing the microplicae on the surface of the scale-shaped cells at one day old (Fig.8) and at 45 days old (Fig.9). Note that the microplicae display a complex pattern at one day but a labyrinthine pattern at 45 days. (X5000).

- Fig.(10):** Scanning electron micrograph at one day old showing one transverse row of lingual papillae (arrow), thread like mucosal projections (two arrows) on the root of the tongue, the laryngeal inlet (I) and crescentic shaped groove (G) extends from it, row of papillae (P) parallel to the rim of the inlet and the laryngeal sulcus (S). (X35).
- Fig.(11):** Scanning electron micrograph at 45 days old showing two rows of lingual papillae (arrow) and well developed mucosal folds (two arrows) separated by wide deep furrows. (X35).
- Figs.(12,13):** Scanning electron micrographs showing the shape and size of the laryngeal inlet (I) at 30 days old (Fig.12) and at 45 days old (Fig.13). Note that more than one groove (G) extend from the laryngeal inlet at 45 days old. (X35).
- Figs.(14,15):** Scanning electron micrographs showing the lingual papillae at one day old (Fig.14) and at 45 days old (Fig.15). (X150).
- Figs.(16,17):** Scanning electron micrographs showing the pharyngeal papillae at one day old (Fig.16) and at 45 days old (Fig.17). Note that the papillae arrange into two rows in both ages but differ in shape. (X35).
- Figs.(18,19):** Scanning electron micrographs showing the pharyngeal papillae at one day old (Fig.18) and at 45 days old (Fig.19). Note the size, shape of the papillae and number of scales on their surface at both ages, some papillae are bifurcated at 45 days old. (X150).
- Fig.(20):** Scanning electron micrograph showing the openings of the lingual salivary glands at one day old. (X350).
- Fig.(21):** Scanning electron micrograph showing the openings of the cricoarytenoid salivary glands are demonstrated lateral to the laryngeal mound at 7 days old. (X100).

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