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Some Comparative Anatomical and Histological Studies on the Laryngeal Cartilages of Buffaloes, Camels and Donkeys

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ABSTRACT

Comparative studies concerned the upper air ways of domestic animals are few. So this study was carried out to compare between the larynx of buffaloes, camels and donkeys. The present investigation was carried out on 39 larynxes, 13 larynxes (7 males, 6 females) of each species. Ten heads from each species were used for gross anatomical study; the remained three heads were used for the histological study. Results revealed that, the laryngeal cartilages of the three species were consisted of three single cartilages; the thyroid, the cricoid and the epiglottis, and two paired cartilages; the arytenoid and the corniculate. The cuneiform cartilages were paired cartilages present only in the larynx of the donkey. Thyroid, arytenoid and cricoid cartilages were of hyaline type, while the epiglottis, cuniform and corniculate cartilages and the vocal process of the arytenoid cartilage were of elastic type. The laryngeal epithelium of aditus laryngis, greater part of epiglottis and vocal folds was lined by non-keratinized stratified squamous epithelium. The remained parts of laryngeal epithelium from base of epiglottis and entire parts caudal to vocal folds were lined by pseudostratified columnar ciliated epithelium with goblet cells. The laryngeal glands of lamina propria were of mixed types in buffaloes and donkeys but in camels it was pure mucous glands. This study will fill a gap in the field of comparative anatomy and help other clinical investigation applied on these animals.

Introduction

Buffaloes (*Bos bubalis*), camels (*Camelus dromedarius*) and donkeys (*Equus asinus*), are the most common animals in Egypt and in other developing countries.

These animals have a significant contribution in the rural economy of Egypt. The buffaloes provide more than 5% of the world's milk supply. Their meat is very tender and palatable and is difficult to differentiate from beef. Their hides also are of significant importance in that they make superb leather products. Their dung is collected and used as fertilizer. Camels provide human with milk, meat, wool, leather, and fuel from dried manure. Dromedary husbandry is increasing today, and is being recognized as an ecologically-sound method of producing protein rich food in arid areas (Nowak, 1999; Shackleton and Harestad, 2003).

The available literature concerning the anatomical and the histological studies concerning the larynx of buffaloes, camels and donkeys are few compared with the importance of these animals. So, the present investigation was carried out in order to give the fine details about the morphological structures of the laryngeal cartilages as well as their histological structure. Therefore, this study will fill a gap in the field of comparative anatomy

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and help other clinical investigation applied on these animals.

Materials and methods

The present investigation was carried out on 39 larynxes of buffaloes, camels and donkeys, 13 (7 males, 6 females) of each species. Buffaloes and camel's heads were obtained immediately after slaughter from Toukh abbatoir (Benha, Egypt) while donkey's heads were condemned in the dissection room at the Faculty of Veterinary Medicine, Benha University, Egypt. Ten heads (5 males and 5 females) from each species were used for gross anatomical study. Three heads from each one were used for the histological study.

For gross anatomical study, 30 larynxes (10 / each species) were kept in 40°C, and then dissected to obtain the laryngeal cartilages. The different laryngeal measurements were performed according to Abdel-Rahman (1990); Moussa (1998).

For general histological structure, small specimens of 0.5 x 1 cm in thickness from different parts of mucous membrane and cartilages of the larynx were taken, immediately after slaughter (of buffaloes and camels) and condemnation (of donkeys). These samples were fixed in 10 % neutral formalin, dehydrated in ascending grades of alcohol, then embedded in paraffin wax. Sections of 5–7 um in thickness were obtained and stained with Harris Haematoxylin and Eosin and Weigert's elastic stain (Dury and Wallington, 1980; Bancroft and Stevens, 1996).

Nomenclature used in this study was adopted by Nomina Anatomica Veterinaria (2006); Schaller (1992).

Results

The laryngeal cartilages in buffaloes, camels and donkeys comprised of three single cartilages: the thyroid, cricoid and epiglottis, and two paired cartilages: the arytenoid and corniculate. In addition, the cuneiform cartilage (a paired cartilage) present only in the larynx of donkey.

The Single Cartilages

Cartilago Thyroidea

In buffaloes, camels and donkeys, the thyroid cartilage was U- shaped (Fig. 1) in cross section. It consisted of right and left laminae, which joined ventrally to form the body of thyroid cartilage.

The thyroid cartilage was the largest of the laryngeal cartilages. It was located lateral to the arytenoid cartilage and partly lateral to the cricoid and the epiglottic cartilages.

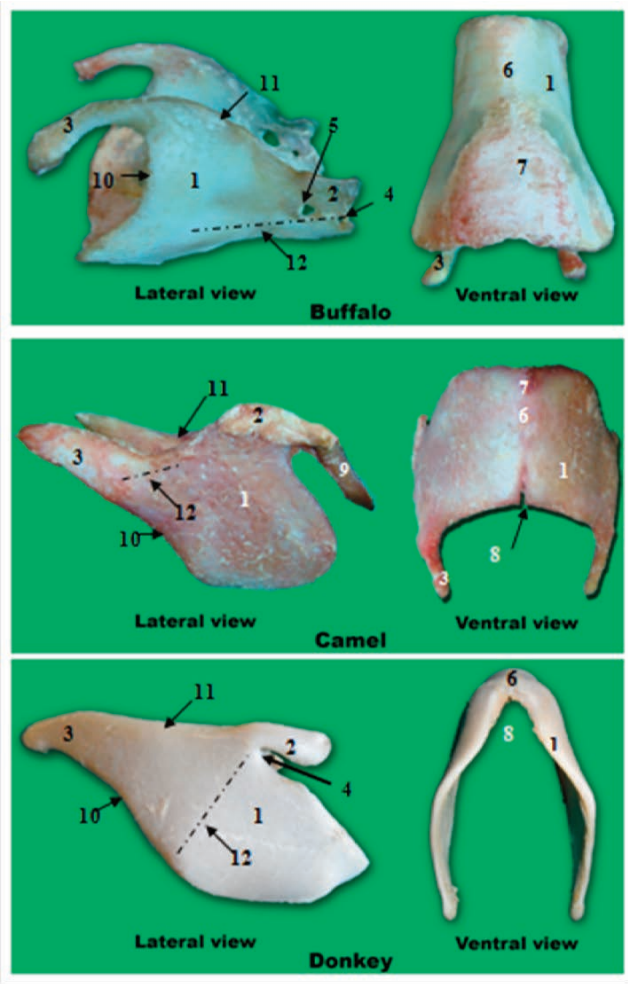

Fig. 1. A photograph of lateral and ventral views of thyroid cartilage in buffalo, camel and donkey showing: 1) Lamina dextra et sinistra. 2) Cornu rostrale (showing calcification in camel). 3) Cornu caudale. 4) Fissure thyroidea (closed in buffalo by fibrous tissue). 5) Foramen thyroideum. 6) Corpus thyroideum. 7) Prominentia laryngea. 8) Incisura thyroidea caudalis. 9) Thyrohyoideum. 10) Caudal border of thyroid cartilage. 11) Dorsal border of thyroid cartilage. 12) Linea obliqua.

In buffaloes, it was irregular quadrilateral in shape and the right and the left thyroid laminae were separated by wider space caudally. In camels and donkeys, each lamina (Fig. 1.1) resembled nearly a parallelogram.

In buffaloes the ossification appeared at the caudal part of the thyroid body (Fig. 1.6). In camels the ossification was appeared between the junction of the lamina and the rostral cornu (Fig. 1.2). But

in donkeys the ossification was appeared at the ventral prominence of the thyroid cartilage.

An oblique line (Fig. 1.12) appeared on the lateral surface of the thyroid lamina of donkeys, but in buffaloes and camels, it was horizontal in direction.

In buffaloes, it located in the rostral two thirds of the lateral surface of the thyroid lamina; it also began at the middle of the rostral border of the thyroid lamina. In camels, it was represented by a short horizontal ridge in the caudodorsal part of the lateral surface of the lamina. In donkeys, it extended between the origin of the rostral thyroid cornu and the junction between the proximal third and the distal two thirds of the caudal border of the thyroid lamina.

The lateral surface of thyroid lamina gave attachment to the thyrohyoid, the thyropharyngal and sternothyroid muscles. While it's medial surface gave attachment to the thyroarytenoideous muscle. In donkeys, it was also related to the laryngeal ventricle.

In buffaloes, the rostral border was short and relatively straight, while the caudal border was long and appeared concave at the first proximal third and convex at its distal two thirds. The rostral border of the thyroid lamina of camels was slightly convex than the caudal border which appeared straight. In donkeys, the rostral and the caudal borders of the thyroid laminae were nearly straight.

The dorsal border of thyroid lamina (Fig. 1.11) was nearly straight and extended rostrally and caudally to form the rostral and the caudal thyroid horns respectively. While the ventral borders were fused to form the body of the thyroid cartilage. The fusion of the laminae ventrally was complete in both buffaloes and camels and incomplete in donkeys resulting in a very deep thyroid notch.

The rostral cornu of the thyroid cartilage (Fig. 1.2) of buffaloes was shorter than that of donkeys and camels, while the rostral cornu of donkeys was the longest. In buffaloes and donkeys, it was relatively straight, while in camels it was slightly curved.

The caudal cornu of camels (Fig. 1.3) was the largest one; it was straight in both camels and donkeys and curved ventrally in buffaloes. In camels the caudal cornu was continued caudodorsally from the dorsal border of the thyroid lamina forming an angle of about 140^{o} with the horizontal plane. While in donkeys and buffaloes it was continued in the same line with the dorsal border of the thyroid lamina.

The rostral thyroid notch was a depression on the middle of rostral border of body of the thyroid cartilage. It was distinct in camels, shallow in buffaloes and absent in donkeys.

The caudal thyroid notch (Fig. 1.8) was present caudally in the body of the thyroid cartilage. It was very deep in the donkey and moderately deep in camels, and shallow in buffaloes.

The thyroid fissure (Fig. 1.4) was located between the rostral cornu and the rostral border of the lamina of the thyroid cartilage. It was deep in camels and donkeys and shallow in buffaloes.

The thyroid foramen (Fig. 1.4) was found in camels, donkeys and buffaloes by closure of the thyroid fissure with connective tissue. In buffaloes, a permanent thyroid foramen found (Fig. 1.5), and located caudal to the thyroid fissure. Secondary thyroid foramen also present in buffaloes caudal to the permanent one, and may be formed by closure of the thyroid fissure. In camels and donkeys the body of the thyroid cartilage had a prominent ventral laryngeal prominence (Fig. 1.7) rostrally, while in buffaloes that prominence located caudally. The body of thyroid cartilage was ossified in its rostral portion in donkeyes and in its caudal portion in buffaloes while that of camels never ossified (Figs. 1.2 and 1.6).

Cartilago cricoidea

The cricoid cartilage (Fig. 2) it was the most caudal laryngeal cartilage; it was attached to the first tracheal ring by the cricotracheal ligament. It resembled a signet ring in buffaloes and donkeys and wristlet (short tube) like structure in camels. It was formed of a broad dorsal part, the lamina and an arch which completed the lamina laterally and ventrally.

The dorsal surface of the cricoid lamina provided attachment to the cricoarytenoideus dorsalis, while that of the arch had attachment to the cricoarytenoideus lateralis and the cricopharyngeus muscles. The inner surface of the cricoid cartilage was lined by mucous membrane.

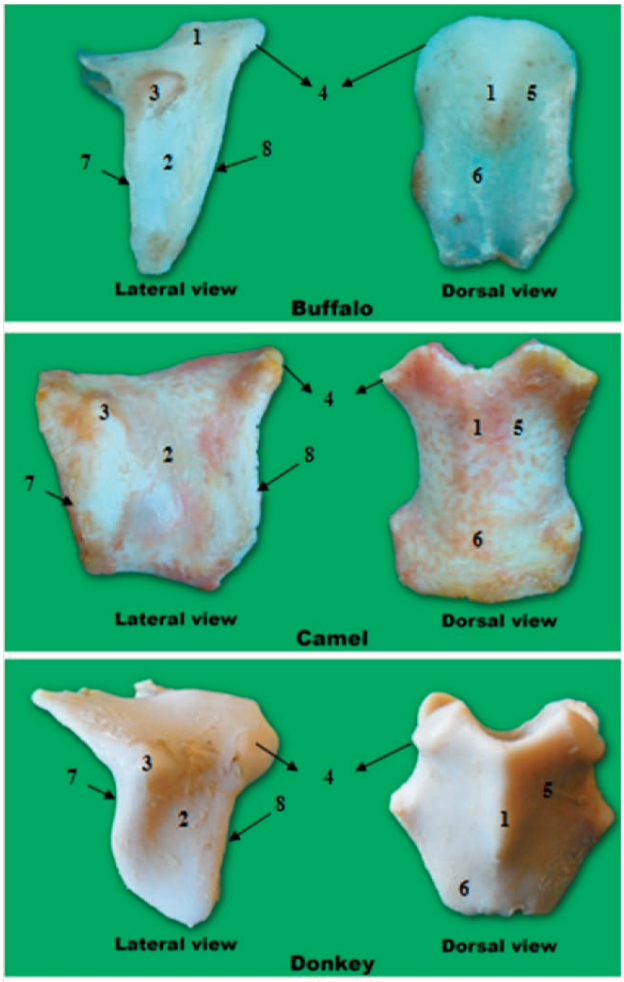

Fig. 2. A photograph of lateral view of cricoid arch and dorsal view of cricoid lamina in buffalo, camel and donkey showing: 1) Crista mediana. 2) Arcus cartilaginis cricoideae. 3) Facies articularis thyroidea. 4) Facies articularis arytenoidea. 5) Area for M. cricoarytenoideus dorsalis. 6) Lamina cartilaginis cricoideae. 7) Caudal border of cricoid cartilage. 8) Rostral border of cricoid cartilage.

In buffaloes, camels and donkeys, the lamina of the cricoid cartilage (Fig. 2.1) was the broad dorsal part, it was quadrilateral in shape, and it had a median crest. On both sides of the median crest there was a rough area for the attachment of the cricoarytenoideous dorsalis muscle (Fig. 2.5). In buffaloes, the median crest was very prominent and that of donkeys and camels was slightly distinct.

The rostral border of the lamina had two facets for the articulation with arytenoids cartilages. The two facets were close to each other in donkeys, widely separated in buffaloes, and surrounding a deep narrow notch in camels (Fig. 2.4). In addition, a facet for articulation with the caudal cornu of the thyroid cartilage (Fig. 2.3) was present at the junction of the lamina and the arch. In camels, it was situated caudolaterally at 0.5–1.0 cm in front of the caudal border. In donkeys, it was located at the caudal border while in buffaloes it was present only in 10 % of specimens.

The cricoid arch (Fig. 2.2) in buffaloes, camels and donkeys consisted of two lateral parts and a ventral part. The lateral parts of the cricoid arch were wide and quadrilateral in camels and narrow quadrilateral in donkeys, while those of buffaloes was triangular in shape, as it was wide dorsally and narrow ventrally. The rostral border was directed caudo-ventrally. The rostral borders of the lateral parts of the cricoid arch were thicker than that of the caudal borders.

In camels, the lateral parts of the arch and its ventral part nearly had the same width, while the ventral part in buffaloes and donkeys was narrower. In donkeys, the rostral border of the ventral part was strongly concave, which gave attachment to the cricothyroid ligament (Fig. 2.3).

Cartilago epiglottica

The epiglottis cartilage was the most rostral laryngeal cartilage. It was resembled to the petiolated plant leaves. In buffaloes, it had the shape of obovate leaf and in donkeys it had the shape of an oblanceolate leaf, while in camels it had the shape of panduriform leaf (Fig. 3). It consisted of a base, an apex, two surfaces, and two lateral borders; its base was thick and formed the stalk or the petiolus.

The lingual surface of the epiglottis was concave from the apex to the base and convex from side to side in buffaloes and donkeys. While in camels it was slightly convex. In the three species the lingual surface had attached to the hyoepiglottic muscle near the base.

In buffaloes and donkeys, the laryngeal surface of the epiglottis was convex from the apex to the base, and concave from side to side. While in camels it was slightly concave.

In buffaloes and donkeys, the base of the epiglottis had a thick fat pad ventrally, while in camels the fat pad not present, but a series of three cartilaginous projections alternated with three transverse depressions were present in the lingual surface of the base (Figs. 3.3, 4a, b and c).

The petiolus of the epiglottis was a narrow stalk like projection arose from the base (Fig. 3.4). It was more pointed in donkeys than in buffaloes and camels. It was rested on the body of the thyroid cartilage and attached to it by the thyroepiglottic ligament.

In donkeys, the cuneiform processes were two

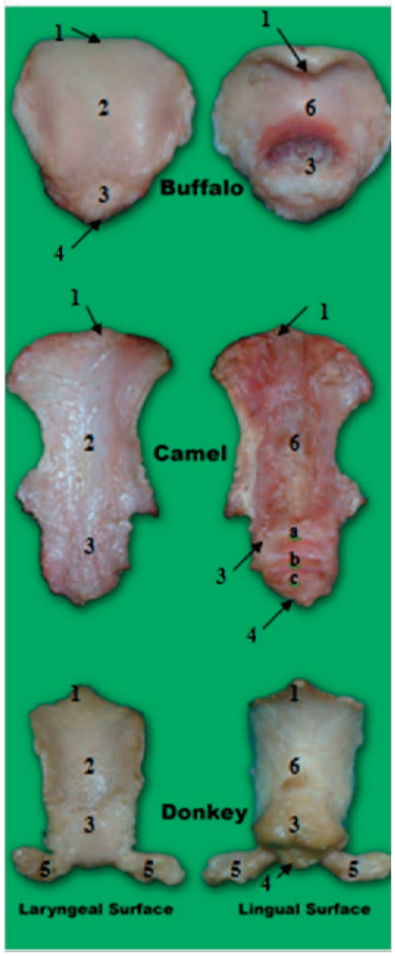

Fig. 3. A photograph of laryngeal and lingual surfaces of epiglottic cartilage in buffalo, camel and donkey showing: 1) Apex. 2) Facies laryngea. 3) Basis. 4) Petiolus epiglotticus. 5) Processus cuneiformis. 6) Facies lingualis. a-b-c – Three cartilaginous processes alternated with three transverse depressions.

cartilaginous bars aroused laterally from the base of the epiglottis (Fig. 3.5). They were extended into the vestibular fold .They were absent in both camels and the buffaloes.

The lateral borders of the epiglottis were nearly smooth. In buffaloes and donkeys the lateral borders of the epiglottis were rounded and converged at the apex. While in camels it was concave at both sides, and rounded rostrally due to the fiddle shape of the epiglottis.

In donkeys, the apex (Fig. 3.1) of the epiglottis was distinctly pointed, while that of camels was rounded. In buffaloes, the epiglottis had a blunt apex.

The paired cartilages

Cartilago arytenoidea

The arytenoid cartilages were situated on either side rostral to the cricoid cartilage and partly medial to the laminae of the thyroid cartilage .They were slightly pyramidal in shape. They consisted of three surfaces, three borders, a base and an apex.

The medial surface of the arytenoid cartilages in buffaloes was concave from the base to the apex, and convex from up to down. While in donkeys and camels, it was slightly concave.

In donkeys and buffaloes, the lateral surface of the arytenoid cartilage was concave. While it was slightly concave in camels and separated from the lamina of the thyroid cartilage by the M. cricoarytenoideus lateralis, which also had attachment to it. In donkeys, it was separated from the thyroid lamina by M. vocalis of the thyroarytenoideus muscle and the laryngeal ventricle, while in camels and buffaloes, M. thyroarytenoideus and a fat pad were in between it and the thyroid lamina.

The dorsal surface of the arytenoid cartilage was concave, and attached to the arytenoideus transversus muscle. In the three species, the dorsal and the lateral surfaces were separated by a ridge which increased in size toward the lateral angle and formed the muscular process of the arytenoid cartilage (Fig. 4.6). The muscular process was more prominent in camels than in others. The dorsal border of the arytenoid cartilage formed a wide notch with the apex in buffaloes and a narrow and a deep one in donkeys, while in camels that notch was not present.

The rostral and the caudal borders of the arytenoid cartilage were converged ventrally to form the vocal process (Fig. 4.2), which was large in buffaloes, small in donkeys and camels. The base of the arytenoid cartilage was faced caudally. In donkeys and buffaloes, it had an oval facet for the articulation with the cricoid cartilage, while in camels that facet formed of two shallow concave areas separated by a ridge.

The apex of the arytenoid cartilage in buffaloes was nearly straight, while that of donkeys was slightly convex. There was no clear demarcation between it and the adjoining corniculate process. It was slightly convex in camels, with a clear demarcation between it and the attached corniculate process.

Processus corniculatus

In buffaloes, camels and donkeys, the corniculate processes were two cartilages fused with the

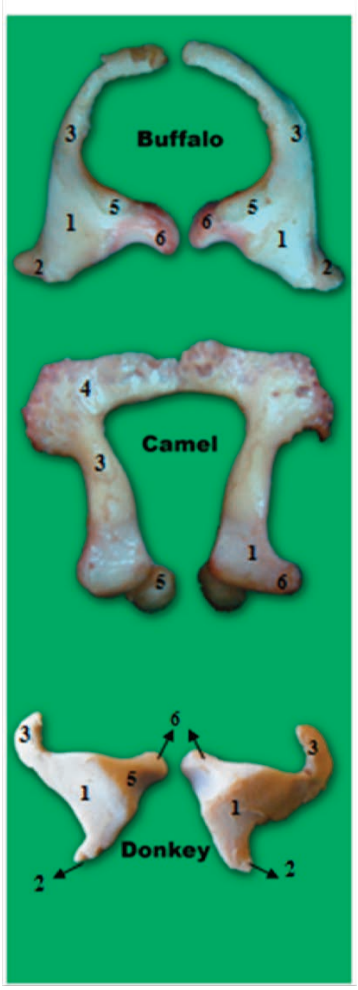

Fig. 4. A photograph of medial surface of arytenoid cartilages in buffalo, camel and donkey showing: 1) Facies medialis. 2) Processus Vocalis. 3) Processus corniculatus. 4) Semilunar appendix of Processus corniculatus. 5) Facies articularis. 6) Processus muscularis.

apices of the arytenoid cartilage.

In buffaloes and donkeys, the arytenoid cartilages with the fused corniculate processes were resembled the shape of the pitcher, while in camels they were resembled an anchor.

In buffaloes, the corniculate process (Fig. 4.3) was long and curved caudally. In donkeys, the corniculate processes were relatively shorter than those of buffaloes and curved caudodorsally.

In both buffaloes and donkeys, the corniculate processes were fused to the apices of the arytenoid cartilages with no clear demarcation between them, and the corniculate process attached to crista arcuata of the arytenoid cartilage by the arycorniculate ligament.

In camels, the arytenoid cartilages had large corniculate processes, these processes were fused dorsomedially and on each side they have a large semilunar appendage (Fig. 4.3 and 4). Clear demarcation between the apex of the arytenoid and the corniculate process was seen in the same animals. Its length was measured 2.5-3 cm in buffaloes, 3.5-4.5 cm in camels and 1.5-2 cm in donkeys.

Processus cuneiformis

In donkeys, the cuneiform processes (Fig. 3.5) were two cartilaginous bars arose laterally from the base of the epiglottis. They were extended into the vestibular fold .They were not observed in buffaloes and camels. It was measured 2-2.5 cm in length.

Histological findings

In buffaloes, camels and donkeys, the thyroid, arytenoid and cricoid cartilages were hyaline in type (Fig. 8A). While the epiglottis, cuniform and corniculate cartilages and vocal process of arytenoid cartilage were elastic in type.

The epiglottis and corniculate processes of arytenoid cartilages were formed mainly of aggregation of chondrocytes separated by elastic connective tissue. Perichondarium of all cartilages was formed of dense irregular connective tissue rich in blood capillaries and continued with deep layer of lamina propria. The perichondrium of camels was highly vascular than that of buffaloes and donkeys.

In buffaloes, camels and donkeys, the laryngeal epithelium of aditus laryngis, greater part of epiglottis and vocal folds was lined by non-keratinized stratified squamous epithelium (Figs. 5a and 6A) .The remained parts of laryngeal epithelium from base of epiglottis and entire parts caudal to vocal folds were lined by pseudostratified columnar ciliated epithelium with goblet cells. Narrow transitional zone of stratified columnar epithelium was located directly caudal to vocal folds. In buffaloes, numerous taste buds were located in the non keratinized stratified squamous epithelium that lined base of epiglottis. In camels and donkeys, no taste buds were found.

In buffaloes, camels and donkeys, the lamina propria (Fig. 7B) of laryngeal mucousa was formed of dense irregular connective tissue. While that of respiratory region (caudal to vocal folds) was formed of loose connective tissue. The lamina propria was continued with perichondrium of laryngeal cartilages elastic fibers also present in the form of meshes especially at apex of epiglottic cartilage

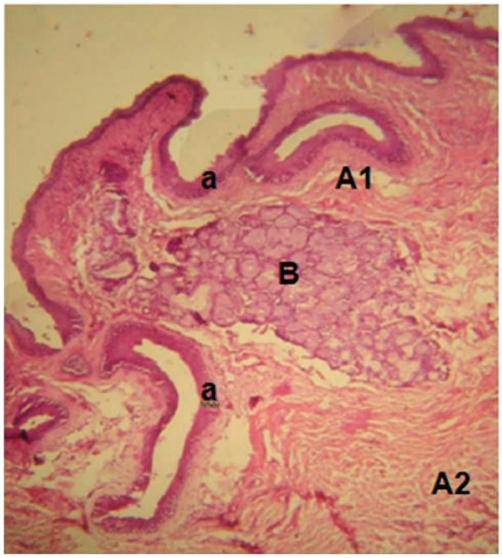

Fig. 5. A photomicrograph of epiglottic cartilage of camel, (H&E stain, 10 X), showing: a) None keratinized stratified squamous epithelium. A 1) Superficial layer of lamina propria. A 2) Deep layer of lamina propria. B) Mucous glands aggregations.

Fig. 6. A photomicrograph of epiglottic cartilage of camel, (H&E stain, 20 X), showing: A) Mucous glands aggregations. B) Interlobular connective tissue. C) Fat cells.

and corniculate process of arytenoid cartilage.

In buffaloes, the lamina propria was thick at vocal fold while in camels and donkeys; it was thick at vocal and ventricular folds.

In the three species, the lamina propria covered epiglottis and corniculate were highly vascular and thick, particularly in camels. Numerous capillaries were located at superficial layer of propria (Fig. 5.A1). While deep layers (Fig. 5.A2) of propria especially at middle ventricle had numerous thin walled veins.

In buffaloes and donkeys, the laryngeal glands of lamina propria were of mixed types, mainly mucous secreting glands with serous demilunes. These glands were absent in the vocal folds of buffaloes and in the vocal and ventricular folds of camels and donkeys.

In camels, the laryngeal glands were scares except at the base of epiglottis where it has a characteristic arrangement as it appeared as lobules separated from each other by connective tissue rich in fat cells. These glands (Fig. 5B) were mainly mucous secreting glands divided by interlobular loose connective tissue, many clusters of fat cells were found in between these glandular aggregations (Fig. 6A).

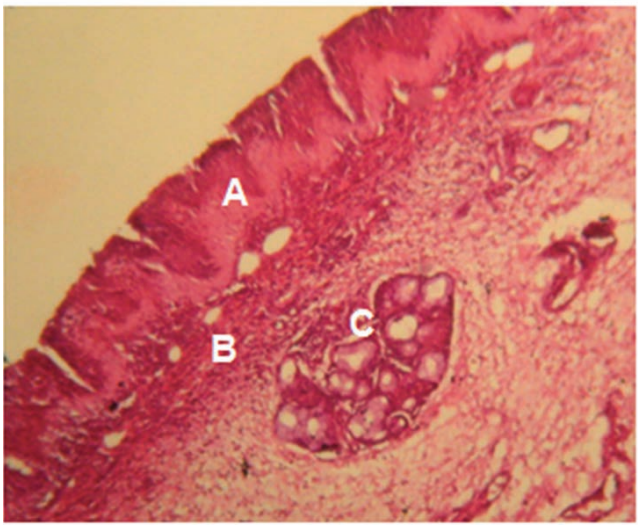

Fig 7. A photomicrograph of corniculate process of arytenoid cartilage of camel, (H&E stain, X 10), showing: A) None keratinized stratified squamous epithelium. B) Lamina propria (dense irregular connective tissue). C) Mucous secreting acini.

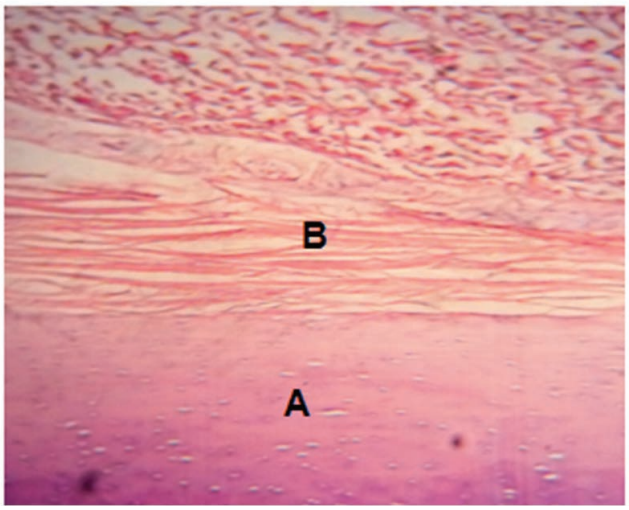

Fig. 8. A photomicrograph of arytenoid cartilage of donkey, (H&E stain, X 40), showing: A) Hyaline cartilage. B) Striated muscle fibers.

Discussion

Based on the results of the present investigation, the laryngeal cartilages in buffaloes and camels consisted of three single cartilages: the thyroid, the cricoid and the epiglottis, and two paired cartilages: the arytenoid and the corniculate. Similar findings were reported by El- Hagri (1967), Hare (1975); Nickel *et al*. (1979) in ruminants, and Smuts and Bezuidenhout (1987) in camels. In addition to the previously mentioned cartilages, the cuneiform cartilages were present in donkeys, which come in agreement with that observed in horses by El-Hagri (1967), Hare (1975) and Nickel *et al*. (1979) and in donkeys by Abdel-Rahman (1990) and Badawy (2005).

Results showed that, in buffaloes, camels and donkeys, the laminae of the thyroid cartilage were quadrilateral in shape, similar to that recorded by Hare (1975) and Nickel *et al*. (1979), in ruminants and equines, and Smuts and Bezuidenhout (1987) in camels. But in buffaloes, these laminae separated by wider space caudally, so the cavity they surround is nearly funnel shaped.

The present study revealed that the rostral thyroid cornu in buffaloes and donkeys was relatively straight, similar to that observed by Hare (1975) and Nickel *et al*. (1979) in ruminants and equines, but that of camels was slightly curved. We also observed that the rostral thyroid cornu of donkeys was the longest one and that may provide a mechanical aid in the movement of the thyrohyoid joint, which found to be synovial only in donkeys. The caudal thyroid cornu was straight in donkeys similar findings were given by Hare (1975) and Nickel *et al*. (1979) in equines, curved ventrally in buffaloes as mentioned by Hare (1975) and Nickel *et al*. (1979) in ruminants, and Ibrahim and Yousif (1992) in sheep and goat. Whereas, the rostral thyroid notch was present only in buffaloes and camels; this was accepted by El- Hagri (1967), Hare (1975), Nickel *et al*. (1979) and Schaller (1992).

El-Hagri (1967), Hare (1975) and Nickel *et al*. (1979) mentioned that the caudal thyroid notch in ruminants was a shallow notch and that agree with our observation in buffaloes. While in camels, we found that notch slightly deeper than that of buffaloes. Our results also revealed that the caudal thyroid notch was very deep in donkeys. This was in agreement with that described by El- Hagri (1967), Hare (1975) and Nickel *et al*. (1979) in horses and Abdel-Rahman (1990) and Badawy (2005) in donkeys. This notch in donkeys gives wide attachment for cricothyroid membrane, which was the site for surgical interference in equines in case of roaring (Badawy, 2005).

The thyroid foramen was formed in the three species by closure of thyroid fissure with connective tissue .This was accepted by El- Hagri (1967), Hare (1975) and Nickel *et al*. (1979) in ruminants and equines. But we also found a permanent thyroid foramen in buffaloes caudal to the thyroid fissure.

The cricoid cartilage in buffaloes and the donkeys was resembled a signet ring, similar to that mentioned in ruminants and equines by El- Hagri (1967), Hare (1975), and Nickel *et al*. (1979). In camels, it was a short tube like structure, which in agreement with that mentioned by Smuts and Bezuidenhout (1987) in the same animal. The two large foramina, which present near the caudal border of lamina of cricoid cartilage that reported by Abdel-Rahman (1990) in donkeys are not observed in the present work.

The epiglottis in camels had a pandoriform leaf shape. But it resembled to an obovate leaf in buffaloes, these findings similar to that mentioned by Hare (1975) in ox and by Ibrahim and Yousif (1992) in sheep and goat. While it resembled to an oblanceolate leaf in donkeys, similar findings were observed by Hare (1975) in horses and dogs and by Yadam (1992) in cats.

The base of epiglottis had a thick fat pad ventrally in buffaloes and donkeys. This is similar to that mentioned by Hare (1975) and Nickel *et al*. (1979) in ruminants and equines. While in camels, the fat pad not present, but a series of three cartilaginous projections alternated with three transverse depressions were present in the lingual surface of the base. That condition not common in the domestic animals and may be similar to that found in man as mentioned by Gray (2000) at which the base of the epiglottis is projected back ward as an elevation called tubercle or cushion.

In buffaloes, camels and donkeys, the petiolus was a narrow stalk like projection aroused from the base of epiglottis; these findings are similar to that reported by Hare (1975) and Nickel *et al*. (1979) in ruminants and equines.

In donkeys, the cuniform processes are two cartilaginous bars aroused laterally from the base of epiglottis and extended into the vestibular fold,

these findings were in agreement with that recorded by Hare (1975) and Nickel *et al*. (1979) in horses, Abdel-Rahman (1990) and Badawy (2005) in donkeys, While differ from that observed by Nickel *et al*. (1979) in carnivores and Gray (2000) in man, who stated that, the cuneiform processes are embedded in the aryepiglottic folds.

The arytenoid cartilage in buffaloes, camels and donkeys was pyramidal in shape, these findings disagree with Hare (1975) in ruminants, who mentioned that the arytenoid is slender in shape and Nickel *et al*. (1979) in pig and Smuts and Bezuidenhout (1987) in camel, who said that the arytenoid is shaped like an anchor.

Results in buffaloes, camels and donkeys revealed that, the corniculate processes fused with apex of arytenoid with no clear demarcation, these observations come in agreement with that mentioned by El- Hagri (1967), Hare (1975); Nickel *et al*. (1979) in ruminants, equines, swines and carnivores. While in camels, our results showed that there was a rod-like connection between apices of arytenoid cartilage with its extensive corniculate processes. These later findings resembled to that recorded in camels by Smuts and Bezuidenhout (1987).

The arytenoid cartilages in camels had a large corniculate processes,which fused dorsomedially and on each side they have a large semilunar appendage similar to that observed in pig by (Nickel *et al*., 1979).

Based on the results of the present investigations, the laryngeal epithelium in buffaloes, camels and donkeys, which lined aditus laryngis, greater part of epiglottis and vocal folds, was non-keratinized stratified squamous epithelium. The remained parts of laryngeal epithelium from base of epiglottis and entire parts caudal to vocal folds were lined by pseudostratified columnar ciliated epithelium with goblet cells. Narrow transitional zone of stratified columnar epithelium was located directly caudal to vocal folds. That recorded by Fathel-Bab (1970) in camels, Dellmann and Brown (1987) in ruminants and equines, Attia and Moustafa (1989) in buffaloes, Borysenko and Beringer (1984), Fawcett and Jensh (1997) and Stevens and Lowe (1997) in man.

In buffaloes, numerous taste buds were located in the non keratinized stratified squamous epithelium that lined the base of epiglottis. In camels and donkeys no taste buds were found, this was in agreement with that described by Georgi (1951) in camels, Attia and Moustafa (1989) in buffaloes and Abdel-Rhaman (1990) in donkeys.

The lamina propria of the camel's larynx was highly vascular than in donkeys and buffaloes. Numerous capillaries were located at superficial layer of propria. While deep layers of propria especially at middle ventricle had numerous thin walled veins, similar findings were observed by Fathel-Bab (1970) in the same animals.

In buffaloes and donkeys, the laryngeal glands of lamina propria were of mixed types, mainly mucous secreting glands with serous demilunes; these results similar to that recorded by Dellmann and Brown (1987) in ruminants and equines. The authors also observed that the laryngeal glands of camels were scares except at the base of epiglottis where it has a characteristic arrangement as it appeared as lobules separated from each other by connective tissue rich in fat cells. These glands were mainly mucous secreting glands divided by interlobular loose connective tissue, many clusters of fat cells were found in between these glandular aggregations. Similar findings were reported by Fathel-Bab (1970) in the same animal.

The thyroid, arytenoid and cricoid cartilages in buffaloes, camels and donkeys were hyaline in type. While the epiglottis, cuniform and corniculate cartilages and vocal process of arytenoid cartilage were elastic in type. This was in agreement with that recorded by Fathel-Bab (1970) in camels and by Dellmann and Brown (1987) in ruminants and equines.

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