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SOME ANATOMICAL STUDIES ON THE NASAL CAVITY OF THE DONKEY

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(B.V.Sc., 1995)

A Thesis

Presented for the Degree
of M.V.Sc. (Anatomy & Embryology)

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2000

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Date: 3/9 /2000

Approval Sheet

This is to approve that the dissertation entiteled " **Some anatomical studies on the nasal cavity of the donkey.**and presented by/ Hazem Shaker Hamoda to Tanta University for the degree of M.V. Sc.(Anatomy&Embryology) has been approved by the examining committee .

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بسم الله الرحمن الرحيم

"سبحانك لا علم لنا

إلا ما علمتنا إنك

انت العليم

الحكيم "

صدق الله العظيم

البقرة ـ آية ٣٢

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ACKNOWLEDGMENT

First of All, All greatest thanks and appreciations to ALLAH the beneficent, the merciful.

My deepest thanks and gratitudes are due to Dr. Ali A. Mansour, Professor of Anatomy & Embryology and Vice Dean of Faculty of Vet. Medicine, Kafr El-Sheikh, Tanta University for his non countable helps, greatest efforts, sincere support, fruitful advices and every valuable things he offered to me in my life and during this work.

Thanks to Dr. Mona A. Ahmed Ali Lecturer of Histology, Faculty of Vet. Medicine, Tanta University for her valuable supervision and helps during the histological study of this thesis.

Sincere thanks are also due to Dr. Farouk Abd El-Mohdy, the Head of Anatomy and Histology Department Faculty of Vet. Medicine, Kafr El-Sheikh, Tanta University for his valuable helps, sincere advices and encouragement during this work.

Thanks also to Dr. Mohamed A. Kassab Lecturer of Histology, Faculty of Vet. Medicine, Kafr El-Sheikh, Tanta University for his encouragement and valuable helps.

Lastly, I want to thank all staff members of Anatomy and Histology Department, Faculty of Vet. Medicine, Kafr El-Sheikh, Tanta University.

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To

My Lovely
Parents
And
My Sincere
Wife

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INTRODUCTION

The donkey (*Equus asinus* Africanus) is one of the equine species which is widely spread in Egypt and commonly used by the farmers in their daily work and for riding purposes.

The nasal cavity of the donkey may be exposed to many affections which need medical and/or surgical interference based upon the anatomical knowledge of these important parts of the body.

The available literature concerning the anatomical studies of the nasal cavity and paranasal sinuses of the donkey are very few compared with the importance of this animal in the daily life of the Egyptian.

Therefore this work was planned to study the detailed description of the nasal cavity with its different parts as well as the locations of the paranasal sinuses and their communications with the nasal cavity. In addition to determination of the proper seats of trephining as a treatment of the sinus affections.

This work is necessary and justified from the medicolegal and surgical points of view.

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REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Nasal cavity (Cavum nasi):

Generally, the shape and size of the nasal cavity vary according to the species. In the horse, it is less roomy than might be supposed from the exterior due to the reverse crown of the cheek teeth and the extensive development of the paranasal sinus system specially the maxillary. In the ox, it is incompletely divided by the nasal septum which does not reach the floor caudally. In the pig, it is very long, (**Hillman, 1975 and Nickel, Schummer and Seiferle, 1986** In the dog, **Evans (1993)** stated that the nasal cavity conforms the shape of the face.

Nostrils (Nares):

The nasal cavity opens to the exterior by the nostrils which vary in shape, size, supporting boundaries and motility in different species. In equines, the nostrils are crescent in form due to the deficiency of the lateral support. They are divided by the alar fold into the dorsal false nostril and the ventral true one, **Chauveau and Arloing (1891), El-Hagri (1967), Sisson and Grossman (1969), Hare (1975) and Sehummer *et al.* (1986)**.

Hare (1975) added that, the nostrils are placed obliquely, so that, they are closer together ventrally than dorsally. They are bounded by the medial and lateral wings which meet dorsally and ventrally to form the angles or commissaries. The lateral wing is thin, concave and formed from skin enclosing muscles and fibrous tissue, the medial wing is convex dorsally and concave ventrally, it has a cartilaginous base.

Schummer *et al.* (1979) in horse, reported that the nostrils are semilunar in outline during normal breathing, and become circular when

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dilated with increasing the respiratory volume. The nasolacrimal orifice can be seen when the nostril is dilated. It is located on the floor of the nasal vestibule at the junction of the skin with the mucous membrane. One or two accessory orifices further caudal.

Hare (1975) and Schummer *et al.* (1979) in the horse, stated that the skin surrounding the nostrils and between them is normal skin covered with a coat of short hair interspersed with a few tactile (sinus) hair. **Trautmann and Fiebeger (1957)** mentioned that, the external skin of nares in the horse bears hair with sebaceous and Tubular glands.

Dyce *Sack and Wensing.* (1993) stated that, the integument is extended some distance into the nasal vestibule where it meets the nasal mucosa at a sharply defined line near which several ducts may open. These ducts include the nasolacrimal duct and also the much smaller opening of the long duct of the serous lateral nasal gland.

Chauveau and Arloing (1891), Raghavan and Kachroo (1964), El-Hagri (1967), Sisson and Grossman (1969) and Schummer *et al.* (1979) in the ox mentioned that, nares are relatively small, oval in outline and capable of very little dilatation. The distance between their dorsal angles is wider than that between the ventral ones. The ventral nasal angles are rounded and wider than the dorsal nasal angles. In addition, the lateral nasal wing is concave while the medial nasal wing is convex dorsally and concave ventrally. The skin around the nostrils forms the nasolabial plate which is moist, smooth and the border of reflection is keratinized. The nasolabial plate is subdivided by superficial grooves which defined small polygonal areas contain minute central orifices of the excretory ducts of

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nasolabial glands. **Hare (1975) and Schummer *et al.* (1979)** termed the grooves extending from the central part of the nares rostral to the dorsal nasal angle, alar groove. They added that in ruminants, pig and dog, the skin of the nasal labial plate is subdivided by small grooves into areas characteristic for individual animal and remains constant with age, so that the naso prints can be used for identification purposes.

Abdel-Aziz (1983) in the buffalo recorded that, the nares are comma-shaped with rounded ventral angle and narrow dorsal one. Each naris is drawn out dorsolaterally by the alar groove which is bounded dorsolaterally by the alar cartilage which is covered by cutaneous mucous membrane.

El-Hagri (1967), Hare (1975) and Schummer *et al.* (1979) in small ruminants stated that the rostral nares are slit like and the skin between them and upper lip forms the nasal plate. **May (1970)** described nares in sheep as irregular oval to crescent-shaped openings. The medial nasal wing has a double curve that produced by the alar cartilage and covered by smooth unhairy skin. The lateral nasal wing is relatively straight and its lateral commissure is round in shape while its medial one is pointed and more acute.

In the camel, **Lesbre (1903)** described nares as being elongated ansd flaccid, moreover, **Leese (1927)** described them as thin, oblique, slit like and capable of closing at will, **George (1951)** added that each naris has the form of an oblique fissure with rounded border. **Badawi and Fath El-Bab (1974)** stated that the nares of the camel are curved slit-like cutaneous type. The ventral nasal angle is more acute than the dorsal one.

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They added that the nares are covered by a relatively thin hairy skin continued on the oral portion of the nasal vestibule and changes suddenly to cutaneous mucous membrane. The sebaceous glands are distinctly small in size and there is no sweat gland.

In carnivores, **Hare (1975) and Schummer *et al.* (1979)** reported that, the nostrils are comma-shaped and are surrounded by the nasal plate which is more extensive than in the small ruminants. This nasal plate in cat consists of small cobble stone-like elevations.

In the pig, **Hare (1975) and Schummer *et al.* (1979)** mentioned that the nostrils are rounded in shape or tend to be oval and the specialized surrounding area is called the rostral plate which fuses centrally with the upper lip and bears short tactile hair. It covers a narrow part of the snout. **Hare (1975)** added that, the surface of this area is kept moist in the pig and small ruminants by the secretion of serous glands which open in the depth of the grooves present in this area, while in carnivores, these glands are absent and the area in kept moist by the secretion of the serous glands present in the mucous membrane of the nasal cavity and the lateral nasal gland.

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Choanae:

Hare (1975) mentioned that, the nasal cavity communicates with the pharynx by the choanae "caudal nostrils". The choanae are bounded ventrally by the caudal border of the palatine processes of the palatine bones, laterally, by the perpendicular plates of the palatine bones, and medially, by the vomer bone and body of the presphenoid bone. The vomer bone in the horse and pig, divides the choana into two choanae while in the other species it is not divided. In the pig, dog, and cat, a horizontal plate of bone, the basal lamina of the ethmoid bone, separates the caudal dorsal part from the caudal ventral part of the nasal cavity.

cartilages of external nose "cartilagines nasi externi":

Bradley and Grahame (1947), El-Hagri (1967), Sisson and Grossman (1969), Hare (1975) and Schummer *et al.* (1979) in equines stated that the nasal cartilages consist of the dorsal lateral nasal cartilage "Cartilago nasi lateralis dorsalis", the ventral lateral nasal cartilage "cartilago nasi lateralis ventralis", the medial accessory nasal cartilage "Cartilage nasalis accessoria medialis" and the alar cartilage "Cartilago alaris": **Popovic (1964),** noticed only that the medial accessory nasal cartilage is fused with the ventral lateral nasal cartilage which is weakly developed and connected with the ventral border of the nasal septum.

Hare (1975), Schummer *et al.* (1979) recorded that the cartilaginous support of the nostrils, of the horse, is formed by two comma-shaped alar cartilages which are placed transversely back to back and attached to each other by connective tissue. They support the nostrils dorsally, medially and ventrally. The alar cartilage is formed from lamina

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dorsally and cornu ventrally. The connection between the alar cartilages and the rostral end of the septal cartilage may be through a strong fibrous tissue which allows a certain amount of movement. In some cases, there is an actual joint between the alar cartilage and the septal cartilage. The lamina of the alar cartilage forms the resistant base of the medial wing of the nostril and forms the prominence in the dorsal part of the wing from which the alar fold arises. While the cornu of the alar cartilage terminates in the ventral angle of the nostril. They added that the dorsal lateral nasal cartilage in the horse is narrow and extended from the dorsal border of the septal cartilage while the ventral lateral nasal cartilage is either absent or it is very narrow and covers only the palatine fissure. The medial accessory nasal cartilage is "S" shaped, connected to the ventral nasal concha and gives cartilaginous support to the alar fold.

Dyce *et al.* (1993) stated that the alar cartilage is specially large in the horse and acounts for the comma form of the nostril. The nostril is divided into ventral true nostril leading to the nasal cavity and dorsal false nostril leading to a skin lined diverticulum " Diverticulam nasi " which occupies the naso incisive notch.

Raghavan and Kachroo (1964), Sisson and Grossman (1969) in the ox, mentioned that the cartilaginous support of the rostral part of the nasal cavity includes the lateral nasal cartilages and the alar cartilages.

Popovic (1964) in the same animal reported that the lateral accessory nasal cartilage is connected with the naric part of the dorsal and ventral lateral nasal cartilage. The medial accessory nasal cartilage is connected with the ventral nasal concha and the ventral lateral nasal cartilage. **El-Hagri (1967), Hare (1975) and Schummer *et al.* (1979)**

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stated that the nasal cartilages of the ruminants are formed from the dorsal lateral nasal cartilage, the ventral lateral nasal cartilage, the medial accessory and the lateral accessory nasal cartilages in addition to the septal cartilage.

In the buffalo, **Abdel-Aziz (1983)** recorded that the nasal cartilages include the rostral part of the nasal septum, the dorsal lateral nasal cartilage, the ventral lateral nasal cartilage, the lateral accessory nasal cartilage, the medial accessory nasal cartilage and the alar cartilage. The alar cartilage is triangular in shape and has a convex lateral surface which supports the medial nasal wing and a concave medial surface which is connected to the alar fold.

Lesbre (1903) in the camel, stated that the nasal septum carries at its extremity the nasal cartilage which is comma-shaped. **Leese (1927)** in the camel, mentioned that the nasal cartilage develops only on the lower side of nares and on the upper part. **George (1951)** in the camel, observed that nares are supported by comma-shaped curved plate of cartilage. The expanded upper end of it supports the dorsal angel while the narrow end is embedded in the lateral wall of the floor of nares.

Hare (1975) and schummer et al (1979), in the pig, reported that the rostral bone is associated with the nasal cartilages and presents between the nostrils. It is attached to the rostral border of the nasal septum and supports the snout. The nasal cartilages include the septal cartilage, the dorsal lateral nasal cartilage which is divided into rostral and caudal parts by deep fissure, the ventral lateral nasal cartilage which unites with the dorsal lateral nasal cartilage along their length laterally, the lateral

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accessory cartilage which arises from the ventral part of the rostral bone and the medial accessory cartilage which connects the ventral nasal concha to the ventral lateral nasal cartilage and supports the alar fold.

Schummer *et al.* (1979) stated that, the nasal cartilages of the carnivores comprise the septal cartilage, the dorsal and ventral lateral nasal cartilage which are expansive and unite with each other laterally to form two cartilaginous tubes, one for each nostril, the lateral accessory cartilage which projects forward from the ventral lateral nasal cartilage and the medial accessory cartilage which arises from the ventral nasal concha and the ventral lateral nasal cartilage and extends rostrally inside the alar fold.

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Nasal septum "Septum nasi":

In domestic animals, **Smallwood (1992)** mentioned that, there is only one nasal cavity per animal (not right and left as is often stated). The two sides are separated by a substantial nasal septum which is formed primarily of hyaline cartilage covered on each side by a highly vascular mucous membrane. The cartilaginous septum is supported ventrally by a trough provided by the vomer. It extends caudally to the level of the nasopharynx and continued by the pharyngeal septum in pig and ruminants. **Dyce *et al.* (1993)** stated that, the right and left cavities are divided by the nasal septum which is largely cartilaginous but ossified in its most caudal part (the perpendicular plate of the ethmoid bone). The septum meets the upper surface of the hard palate. In the horse and pig, the septum meets the whole length of the hard palate so that each nasal cavity communicates with the pharynx through a separate opening (choana). In other species, the caudal part of the nasal septum fails to meet the palate and there is a single opening shared by the two sides.

In the horse, **Hare (1975)** mentioned that, the caudal and ventral parts of the septum are formed by the perpendicular plate of the ethmoid bone and the vomer respectively which make up the osseous part of the septum. While the major part of the septum is formed of hyaline cartilage which is marked on its surface by faint grooves for the vessels and nerves which course over it. The dorsal border of the septal cartilage is expanded to form the narrow dorsal lateral cartilages on either sides while the ventral border is rounded and rested in the groove of the vomer and on the palatine processes of the incisive bone rostrally. The ventral border of the septal cartilage expands rostrally to form the ventral lateral cartilage which

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is very narrow, if present, and fill the palatine fissures and form the projections in the hard palate around which the greater palatine arteries curve.

Raghavan and Kachroo (1964) and Hare (1975) in the ox, reported that, the bony part of the nasal septum is formed by the perpendicular plate of the ethmoid bone and the vomer bone, while its cartilaginous part is formed by the septal cartilage. **Hare (1975) ,** added that the septal cartilage may be ossified in older ages.

Schnorr and Hegner (1967) in sheep and goat discovered the dorsal and ventral septal swelling bodies in addition to a swelling body of the naric septum. **May (1970)** mentioned that the nasal septum of the sheep is composed of nasal septal cartilage and nasal septal bone. In the young ages, the largest part of the septum is cartilaginous while the amount of bone increases with the advance of age.

Ayat ,Nawar and Osman . (1981) in the buffalo, stated that the cavernous tissue of the nasal septum is greatly thickened dorsally and ventrally to form two swelling bodies. The dorsal septal swelling body begins on a level with the third maxillary cheek tooth, while the ventral one is much larger than the dorsal and lies along the ventral part of the nasal septum. Moreover, they discovered a third swelling body present in the nasal floor. **Abdel-Aziz (1983)** in the buffalo revealed that, the nasal septum is narrow and elongated. It divides the nasal cavity into two compartments along its whole length from the nares rostrally to the choanae caudally.

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Lesbre (1903) reported that the nasal septum of the camel extends forward beyond the extremity of the nasal bone. **Leese (1927)** recorded that, the nasal cavity of the camel is divided into two similar halves by an extensive vomer bone. **Badawi and Fath El-Bab (1974)** in the same animal stated that the nasal septum is relatively short and separates the two halves completely.

Evans (1993) in the dog reported that the nasal septum is formed of the perpendicular plate of the ethmoid bone which is continued by the cartilage of the nasal septum. The cartilage of the nasal septum is divided into caudal immovable part and rostral movable part which are connected by a membranous part. **El-Sayed (1982)** in the dog pointed to the presence of two conical-like projections; one in the inferior part of the nasal septum and the other is caudally in superior position on the septum. The rostral part of the inferior swelling body is covered by thick stratified squamous epithelium, while the caudal part and the superior swelling body are covered by pseudostratified columnar ciliated epithelium with goblet cells. The subepithelial tissue contains PAS positive glands together with blood vessels and few blood spaces.

Richter (1962) in the cat, detected the presence of dorsal and ventral swelling bodies in the nasal septum.

Moller and Fahrenkrug (1971) showed that the distension of the septal swelling bodies in the rabbit and rat exhibits a cyclic alternation between the two halves of the nasal cavity.

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Taher (1976) in albino rat, found that, the venous blood spaces of the septal cavernous body join each others forming a system of erectile cavernous tissue.

Adams and Mcfarland (1972) in hamster, recorded that the lamina propria of the rostral part of the septal mucosa contains a vascular sinuses forming swelling body.

Loo (1974) observed that in the tree-shrew the superior and inferior septal swelling bodies are formed by a collection of serous glands and vascular spaces in the lamina propria. While in the gibbon, the swelling bodies contain mucous and serous glands.

Kratzing (1978) in bandicoat recorded that, there are two septal swelling bodies raised by the underlying vascular and glandular tissue and covered by non ciliated pseudostratified epithelium.

The vomero nasal organ "Organum vomeronasale"

According to **Negus (1956)**, there are four types of communication to the vomero nasal organ. The first, as in amphibia, opens into the nasal cavity. The second, as in snake and lizard, has no connection to the nasal fossa but opens directly into the oral cavity. The third, as in rabbit and guinea pig, opens into the nasal cavity which itself is connected with the mouth by the incisive duct. The fourth, as in carnivores, communicates with the nasal cavity and oral cavity by opening into the incisive duct. **Lindsay, Clayton and Pirie (1978)** observed that the vomero nasal organ in the donkey and horse consists of a pair of mucous membrane tubes enclosed totally, except their extremities, in a hyaline cartilage capsule.

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Each tube is blind caudally but opens rostrally in common with the incisive duct into a narrow recess in the floor of the ventral nasal meatus. The epithelial lining is of respiratory type except on its medial wall where , a ridge of olfactory epithelium is present. The lamina propria contains a well-developed collagenous and highly vascular tissue. In addition, there is also abundant amount of nervous tissue and glands which are mainly serous with few seromucoid glands. **Chauveau and Arloing (1891)** in the horse, mentioned that the vomero nasal organ starts at the level of the fifth cheek tooth. It is enveloped in a kind of cartilaginous sheath. It resembles the excretory duct of a gland and its wall is composed of two tunics; internal mucous membrane has longitudinal folds and external fibrous layer. **Bradley and Grahame (1947)** recorded that, the vomero nasal organ in horse is enclosed by the vomero nasal cartilage and extends to the third or fourth cheek tooth. **Hare (1975)** recorded that, the vomero nasal organ in horse consists of a pair of blind tubular, muco-membranous diverticula, lying on each side of the nasal septum and related to the palatine process of the incisive bone and to the wings of the vomer. It extends caudally to the level of the second to the third cheek tooth.

Filloto and Vigo (1957) in the ox, stated that the vomero nasal organ is covered medially by olfactory epithelium, while laterally by respiratory epithelium. **Raghavan and Kachroo (1964)** reported that, the vomero nasal organ is a canal placed on either sides of the ventral border of the nasal septum. It is lined internally with mucous membrane. The posterior end is blind while the rostral one meets the incisive duct. **El-Hagri (1967)** in ruminants recorded that, the vomero nasal organ and the incisive duct open into the oral cavity on the incisive papilla.

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Frewein (1972) using the radiological anatomy revealed that, in the most of species the rostral opening of the vomero nasal organ lies at the level of the rostral borders of the palatine fissure. Caudally, the organ extends to 2 cm rostral to the first cheek tooth in the ox, 4th cheek tooth in sheep, and at the level of the second cheek tooth in goat and dog. In the horse and cat it reaches the level of the first cheek tooth but in pig it extends only to the level of the caudal border of the third incisor. He also reported that the organ is straight in the horse, pig and cat while in the other species it forms a slight curved arch. **Kratzing (1973)** stated that the medial aspect of bovine vomero nasal tube is lined by sensory epithelium formed from sensory, supporting and basal cells. **Hare (1975)** mentioned that the vomero nasal organ in the ox consists of two bilateral mucous membrane lined blind tubes or diverticula and surrounded by the vomero nasal cartilage. **Schummer *et al.* (1979)** recorded that, the vomero nasal duct in the ox joins the incisive duct close to its oral opening.

Abdel-Aziz (1983) stated that the vomeronasal organ in the buffalo presents in the floor of the nasal cavity on either sides of the rostral part of the nasal septum and it is nearly straight while its rostral narrow part is slitghtly convex and joins the incisive duct. The main part of the vomero nasal organ is enveloped completely by the vomero nasal cartilage except the caudal part where there is only a plate of cartilage presents ventromedially.

May (1970) in sheep, recorded that the rostral end of the vomero nasal organ joins the incisive duct and it is slightly flattened transversely. **Kratzing (1971)** in sheep , stated that the vomero nasal organ consists of two epithelial tubes that open into the incisive duct. The blind caudal end

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of each tube reaches a transverse plane through the second cheek tooth. The lining epithelium is sensory on the medial aspect and non sensory ciliated laterally.

Gharib, Mossallami ,Ragab, El –sakhawy and El-shafey (1983) in the goat found that the vomero nasal organ is formed from cartilaginous tubes lined with mucous membrane and opens into the roof of the oral cavity at the incisive papilla.

Hare (1975) stated that, the vomero nasal organ in the pig is a blind tube covered externally by a thin plate of cartilage and it extends caudal to the level of the second cheek tooth. **Schummer *et al.* (1979)** mentioned that, the vomero nasal organ is relatively small in the pig. **Kratzing (1980)** in the pig, reported that, its neuro sensory epithelium resembles that of other species, is formed from sensory, supporting and basal cells.

Negus (1956) concluded that, the vomero nasal organ is well marked in carnivores and opens directly into the incisive duct. **Getty and Hadek (1964)** reported that, this organ in the dog is an isolated area of mucous membrane located in the rostral base of the nasal septum. It is largely lined with olfactory neuroepithelium on its medial wall and with a thinner cylindrical epithelium on its lateral side. **Read (1908)** stated that, the vomeronasal organ is circular in outline in the rostral portion and lined with stratified epithelium. In its middle and caudal parts, it is kidney shaped in cross section and lined with columnar and olfactory epithelium without hair. **Getty and Hadek (1964) and Evans (1993)** reported that, the hyaline cartilage of the vomero nasal organ of the dog is not a complete tube but forms a curved plate that lies at first on the lateral side. After that,

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the cartilage arches over the organ to be continued only along its medial surface. **Hare (1975)** mentioned that, the vomero nasal cartilage forms a thin plate that covers its medial and ventral aspects only. The dorsolateral surface is related to vascular spaces.

Trautmann and Fiebiger (1957) mentioned that, the vomero nasal organ in domestic animals, is formed from tubular hyaline cartilage lined internally by respiratory mucosa except a strip along the medial wall that bears an olfactory like epithelium and it is rich in blood vessels and nerves. They added that, its lamina propria contains serous glands. **Dellmann and Brown (1992)** stated that frequently, crypt like glandular invaginations containing mucous cells and ciliated cells are observed, and the propria submucosa has mucous or mixed glands.

Incisive duct "Ductus incisivus:

Bradly and Grahame (1947), El-Hagri (1967), Sisson and Grossman (1969), Hare (1975) and Schummer *et al.* (1979) in the horse reported that the incisive duct extends obliquely rostroventrally through the palatine fissure, and each duct is communicated with the nasal cavity through a slit-like opening in common with the vomero nasal organ. Its oral end communicates blindly in the submucosa of the hard palate. **Lindsay *et al.* (1978)** in the horse and donkey stated that the incisive duct is lined with stratified epithelium.

El-Hagri (1967), Sisson and Grossman (1969), Hare (1975) and Schummer *et al.* (1979) in ruminants mentioned that the incisive duct connects the ventral nasal meatus with the oral cavity. They added also

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that, the incisive duct joins the vomero nasal duct close to its oral opening.

Abdel-Aziz (1983) in the buffalo, recorded that the incisive duct is supported rostromedially by C. shaped hyaline cartilage which is an extension from the medial accessory nasal cartilage. Its dorso medial aspect present a slit-like opening of the vomero nasal organ.

Gharib *et al.*(1983), in the goat, stated that, the incisive duct is a short tube 0.75-1.0 cm long and extends obliquely between the mouth and the nasal cavity.

Badawi and Fath El-Bab (1974) in the camel stated that, the oral opening of the incisive duct has a blind end under the mucous membrane of the hard palate.

Schummer *et al.* (1979) in the pig, mentioned that the incisive duct and the vomero nasal duct are sometimes split from each other. **Hare (1975) and Dyce *et al.* (1993)** in the pig, reported that, it is a bilateral mucous tube that opens into the oral cavity on the lateral aspect of the incisive papilla and into the floor of the nasal cavity.

Getty and Hadek (1964), El-Hagri (1967), Schummer *et al.* (1979) and Evans (1993) in the dog, stated that the incisive duct connects the nasal cavity with the oral cavity and receives the vomero nasal duct.

The lateral nasal gland(Glandula nasalis Lateralis):

In this concern, **Sisson and Grossman (1969), Nickel *et al.* (1973)** mentioned that the lateral nasal gland is absent in ox while it presents in other domesticated animals, it is of microscopic dimensions and of serous

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nature. In the pig and carnivores it is present in the maxillary sinus (recess) while in the horse, sheep and goat, it is present close to the naso maxillary opening in its mucous membrane. They added that, the duct of the lateral nasal gland is lined with stratified epithelium and runs along the middle nasal meatus to open close to the straight fold or at the end of it except in horse, where it opens further caudal on the lateral aspect of the ventral part of the straight fold at the level of the first or second cheek tooth. The latter authors added that, the secretion of the lateral nasal gland passes through the incisive duct to the oral cavity except in the horse. It runs caudodorsally forming an angle of 45° with the hard palate to open in each nasal fessa **Negus (1956)** found that, the incisive duct in dog, cat, rabbit and guinea pig is lined by a thick squamous epithelium.

Traumann and Fiebeger (1957) and Hare (1975) stated that, the mucosa of the incisive duct in the domestic animals is partially surrounded by a trough of hyaline cartilage and lined by stratified non ciliated epithelium. It contains tubular serous and mixed glands and it is characterized by the presence of many leucocytes and lymphaic nodules.

The nasal acrimal duct "Ductus nasolacrimal":

Regarding the osseous part of the nasal acrimal duct among domestic animals, **Taha (1990)** stated that this part extends along the lacrimal bone in the buffalo and camel, in addition to the maxilla in the donkey. The rostrocaudal portion of the lacrimal bone is short in the camel and long in the buffalo and donkey. Therefore, the osseous part of the nasal acrimal duct is the longest in the donkey and shortest in the camel and intermediate in the buffalo. In this concern, the absolute length of the osseous part of the nasolacrimal duct measures about 9.4,7.2and2.6cm

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in the donkey, buffalo and camel respectively. It measures about 7-8 cm in the horse (**Latimar *Wyman and Diesem,* (1984)**, 5.9 cm in the buffalo (**Abdel-Aziz, 1983)**, 4.5-4.8 cm long in the sheep (**Gilanpour 1979)** and 4 cm in the camel. (**Saber and Makady ,1987).** Moreover, **Hagras (1991)** in the goat added that, the initial part of the osseous nasal acrimal duct is divided by an osseous partition into two channels. The nasal acrimal duct coursed rostroventrally and deviated slightly medially as mentioned in the mule (**Ebeid, 1985)**, in the horse (**Hare , 1975)**, in the buffalo (**Shokry, *Ahmed andEl-keiey* , 1985, and Taha, 1990)**, in the camel (**Saber and Makady, 1987)**, in the dog (**Yakely and Alexander, 1971)** and in the cat (**Küpper, 1973)**. However, (**Kirshnameurthy *,peshin , Nigam , Sharma and Kurar* 1981)** in the horse, **Heider *et al.* (1975)** in cattle and **Gilanpour (1979)** in sheep, stated that, the osseous part of the nasal acrimal duct runs in a straight line rostrally. While, **Said *,shokry , Saleh and Hegazi* (1977)** in the donkey and **Diesem (1975)** in the horse reported that the osseous part of the duct has a well marked curve with dorsally directed convexity. The osseous part of the nasal acrimal duct runs on the inner surface of the external lamina of the lacrimal bone and the maxilla in the donkey, (**Fouad *Ewais Abdel Aziz ,and Mobarak ,* 1984)** and horse (**Taylor, 1965)**. This part of the duct runs in the maxillary sinus bordering the concofrontal sinus ventrolaterally in the donkey (**Taha, 1990)** while in the horse, it runs in the frontal sinus (**Diesem, 1975)**.

Chauveau and Arloing (1891) in the ass and mule reported that the nasal acrimal opening (Ostium nasolacrimale) passes to the inner wall of the lateral wing near the dorsal nasal angle. **Diesem (1975)** recorded that the nasal acrimal duct in equines passes rostral and a little ventral along the lateral wall of the frontal sinus and nasal cavity. It opens near the ventral commissure of the nostril and its length is about 25-30 cm. **Chauveau and Arloing (1891), Bradley and Grahame (1947), El hagri**

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(1967) , **Sisson and Grossman (1969), Hare (1975) and Schummer *et al.* (1979)** in the horse, mentioned that, the opening of the nasal acrimal duct presents in the floor of the ventral commissure at the mucocutaneous junction. This opening is located about 5 cm caudal to the ventral nasal angle. There is one or two accessory openings present further caudal.

Smallwood (1992) reported that, the rostral orifice of the nasal acrimal duct presents near the lateral margin of the nostril in the donkey, and in the floor of the nasal vestibule in the horse, while in ruminants, it is located around the corner on the ventromedial aspect of the alar fold, so it is not easily accessible for back flushing.

Raghavan and Kachroo (1964) and Sisson and Grossman (1969) recorded that, the nasal acrimal opening in the ox is not visible as it is concealed by a cartilaginous prolongation from the ventral turbinate bone. **El-Hagri (1967), Hare (1975) and Schummer *et al.* (1979)** mentioned that the nasal acrimal duct of the ox opens close to the nostril on the medial surface of the alar fold. **El-Hagri (1967)** added that the opening of the duct in the ox can be seen through the nostril. **Habel (1975)** reported that the nasal acrimal opening presents at the rostroventral part of the alar fold in ruminants. **Diesem (1975)** stated that the duct in bovines measures about 12-15 cm in length and usually has a straight course. The rostral part of the duct passes under the mucosa of the medial surface of the alar fold. However, in ovines, the nasal acrimal duct terminates into the dorsal aspect of the nostrils.

George (1951) in the camel, reported that, the nasal acrimal duct opens about 1 cm above the lower commissure of the nostril at the junction of the skin and the mucous membrane. **Badawi and Fath El-Bab (1974)** mentioned that, the duct in the camel runs cranioventrally and medially under cover the mucous membrane lining the ventral nasal meatus. There

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is a slight dilatation before its opening. The duct is lined by two layers of cuboidal cells which change into stratified squamous near its orifice at the medial wall of the nasal vestibule.

Bojsen-Moller (1967) in the pig stated that the nasal acrimal duct enters into the nasal cavity just in front of the orifice of the maxillary sinus and runs in the inferior aspect of the root of the ventral nasal concha and then it proceeds to open in the lateral wall of the vestibule. **El-Hagri (1967)** mentioned that there is a second opening lateral to the caudal end of the ventral nasal concha in the pig. While **Sisson and Grossman (1969)** stated that this second opening is situated in the caudal part of the ventral nasal meatus. **Hare (1975) and Schummer *et al.* (1979)** added that the functional opening presents at the caudal end of the ventral nasal concha and a second orifice with a rudimentary duct may be present in the nasal vestibule on the lateral aspect of the alar fold. Moreover, **Diesem (1975)** recorded that, the nasal acrimal duct of the pig is incomplete in its middle part. Therefore the duct is divided into a caudal tear carrying part and a rostral non functional part.

Smallwood (1992) in the pig, reported that, there is one opening of the nasal acrimal duct near the nostril in the young piglets and after birth, a second opening typically develops on the lateral surface of the ventral concha near its caudal end. Subsequently, the more rostral opening and the rostral part of the duct typically degenerate leaving only the more caudal opening.

Getty and Hadek (1964) in the dog, stated that the nasal acrimal duct lies initially within an osseous canal which opens in the lacrimal bone at the lacrimal sac fossa, passes rostroventrally and continues in a groove on the medial surface of the maxilla. It opens ventral to the basal lamella of the ventral nasal concha.

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Evans (1993) in the dog, mentioned that the opening of the nasal acrimal duct is located in the rostral end of the alar fold and it is visible at the ventral part of the vestibule. **El-Hagri (1967) and Schummer *et al.* (1979)** in canines, recorded that the nasal acrimal opening is present in the floor of the nostril with the presence of a second opening lateral to the ventral nasal concha at the level of the canine tooth. The main orifice is located ventral to the alar fold and the second one in the ventral nasal meatus at the caudal end of the ventral nasal concha. **El-Sayed (1982)** concluded that the nasal acrimal duct in the dog is present at the ventral aspect of the alar fold and it is lined by a stratified squamous epithelium. He added that, in the rabbit, the nasal acrimal duct is located at the rostral part of the alar fold towards the nasal septum and it is lined by stratified cuboidal epithelium infiltrated with lymphocytes. **Diesem (1975)** reported that, the nasal acrimal duct in the dog consists of three portions; the caudal part lies in a bony canal of the lacrimal bone, then in the lacrimal groove of the maxilla; the middle part lies in the medial wall of the maxilla and covered with the nasal mucosa; and the rostral portion is free after passing between the cartilages that form the ventral and lateral aspects of the nares.

Dellmann and Brown (1992) in different domestic mammals mentioned that the nasal acrimal duct is lined with either stratified columnar epithelium with goblet cells or transitional epithelium. The lamina propria is rich in lymphoreticular tissue and contains cavernous plexuses. Rostrally, simple branched tubulo-acinar glands are present. These glands are mixed in sheep and goat. **Bloom and Fawcet (1975)** in man, reported that the nasolacrimal duct is lined with pseudostratified tall columnar epithelium. While **Ham and Cormack (1979)** described the epithelium as being formed of two layers of columnar epithelium containing goblet cells.

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Nasal conchae "Conchae nasalis":

In this concern, **El-Hagri (1967), Hare (1975) and Shively (1987)** in the domestic animals; **May (1972)** in sheep and **Smuts and Bezuidenhaut (1987)** in the camel, mentioned that there are dorsal, ventral, middle nasal conchae in the middle part of the nasal cavity and ethmoidal conchae (in caudal part). In this concern, **Smallwood (1992)** stated that, each half of the nasal cavity is filled mostly with the delicate shell-like nasal conchae which are covered with a highly vascular mucous membrane. **Dyce *et al.* (1993)** mentioned that, the nasal conchae divided into caudal system (ethmoidal) which consisting the lateral mass or labyrinth of the ethmoid bone and rostral (nasal) system including the large dorsal, ventral and much smaller middle conchae. Moreover, **Nickel *et al.* (1986)** in domestic mammals and **Evans and De-Lahunta (1988)** in the dog stated that the dorsal nasal concha (naso turbinate) is called endoturbinate I but the middle nasal concha is known as endoturbinate II and represents the largest one among the ethmoidal conchae (ethmoturbinates) while the ventral nasal conchae is referred to as maxilloturbinate.

In the horse, **Dyce *et al.* (1993)** reported that, the space enclosed within both the dorsal and ventral nasal conchae is divided into two compartments by internal septum. The dorsal conchal sinus combine with the frontal sinus to form the conchofrontal sinus. The ventral conchal sinus communicate with the rostral maxillary sinus. The middle conchal sinus connects with the caudal maxillary sinus. **Bradely and Grahame (1947)** in equines, reported that, the dorsal nasal concha is broader caudaly and tapered rostrally **El-Hagri (1967), Sisson and Grossman (1969), Hillman (1975) and Schummer *et al.* (1979)** stated that, the dorsal nasal concha forms a spiral lamella rostrally which encloses a recess and has a subdivided bulla, while caudally it encloses the dorsal conchal sinus which

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combines with the frontal sinus forming the concho frontal sinus. They also added that, the ventral nasal concha is similar to the dorsal one, the rostral part encloses a recess and subdivided bulla rostrally and the caudal part forms the ventral conchal sinus which communicated with the rostral maxillary sinus. Concerning the middle nasal concha, it is small and forms the middle conchal sinus. The ethmoidal conchae are arranged in two rows (three in horse) the larger ones extend far into the interior of the nasal cavity so it known as endoturbinates, while the smaller ones remain externally and is termed ectoturbinates. In the horse , the ectoturbinates form double row, but in the other domestic mammals it form a single row. **Hillman (1975) and Nickel *et al.* (1986)** in the horse stated that the number of endoturbinates and ectoturbinates on each side are 6+25 or 6 endoturbinates and (21-31) ectoturbinates.

El-Hagri (1967), Sisson and Grossman (1969), Schummer *et al.* (1979) in ox mentioned that, the dorsal concha formed from a porous basal lamina in its rostral third and dorsal conchal sinus in the rest of the length which extends a distance into the rostral end of the frontal bone. **Sisson and Grossman (1969) and Hare (1969)** in ox added that, the dorsal nasal concha is widest in its middle and tapered towards either ends, and the dorsal conchal sinus is separated from frontal sinus by mucous membrane. **El-Hagri (1969) and Schummer *et al.* (1979)** recorded that the rostral part of the ventral nasal concha is formed from a basal lamellae and dorsal and ventral spiral lamellae. Rostrally the dorsal and ventral spiral lamellae form a recesses and their free borders form subdivided bullae while caudally the two form the ventral conchal sinuses which has three recesses in its lateral wall. However, **Sisson and Grossman (1969) and Hare (1975)** in ox recorded that the ventral nasal concha splits into two plates. These plats are rolled in opposite directions enclosing two separate cavities which are subdivided by several septa, the dorsal one

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opens into the middle nasal meatus while the ventral opens into the ventral nasal meatus. **El-Hagri (1967) and Schummer *et al.* (1979)** in ox reported that the middle nasal concha consist of basal lamina which gives dorsal and ventral spiral lamellae. The dorsal lamella forms the middle conchal sinus while the ventral lamella forms a recess **Paulli (1900)**, stated that the ethmoturbinates in ox consist of 5 endoturbinates and 18 ectoturbinates or 4 + 18 (**Nickel *et al.*, 1986**).

Abdel-Aziz (1983) in buffalo reported that, the dorsal conchal sinus is separated from the frontal sinus by a double layer of mucous membrane and does not communicate with the nasal cavity. The dorsal part of ventral nasal concha encloses a recess rostrally and subdivided bulla caudally while the ventral part of the ventral nasal concha encloses the ventral recess and the ventral conchal sinus in the free border. The caudal narrow part of the ventral nasal concha does not contain basal lamina or any bony support and it is purely vascular. The middle nasal concha is excavated by middle conchal sinus. The ethmoidal conchae include the endoturbinates I, II, III and IV in addition to about 11-18 ectoturbinates.

El-Hagri (1967) and Schummer *et al.* (1979) in the small ruminant reported that, the dorsal nasal concha resembles that of the ox except its basal lamina is compact. They added also that, the ventral nasal concha has a dorsal and ventral spiral lamellae. In the goat both spiral lamellae form recesses and bullae, while in the sheep the ventral one only which form a recess and bullae. They described the middle nasal concha to be formed from dorsal spiral lamella which forms the middle conchal sinus and the ventral one forms short ventral conchal sinus rostrally and a recess caudally.

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Gharib et al . (1983) in the goat, stated that, the middle nasal concha is supported by a weak basal lamella which bifurcates into a dorsal and a ventral spiral lamellae.

Badawi and Fath El-Bab (1974) in camel reported that the dorsal nasal concha is narrow rostrally and wide caudally and is formed from the basal lamina rostrally and the conchal sinus dorsocaudally, the ventral nasal concha splits into dorsal and ventral spiral lamellae which encloses a recess and having bulla on each side. The middle nasal concha encloses the middle conchal sinus. The ethmoidal conchae are 5 to 6 in number arranged as two middle, two to three intermediate and one lateral.

El-Hagri (1967), Hillman (1975) and Schummer *et al.* (1979) in swines mentioned that the dorsal nasal concha is formed only from basal lamina in the rostral and caudal parts, while in the middle part it encloses the dorsal conchal sinus. The ventral nasal concha has a dorsal spiral lamella which encloses a recess and ventral lamella forms a recess rostrally and ventral conchal sinus caudally. And the middle nasal concha is small and has a dorsal and a ventral spiral lamellae which form recesses **Hillman (1975)** reported that the ethmoidal conchae in swines are 7 endoturbinates and 13 intervening ectoturbinates.

Boumi and Zietzchmann (1936) in canines stated that the first endoturbinate is the dorsal nasal concha. **Getty and Hadek (1964)** reported that the dorsal nasal concha is composed of a thin shelf of bone and a scroll of the first endoturbinate **El-Hagri (1967) and Schummer *et al.* (1979)** mentioned that the rostral and the short caudal parts of the dorsal nasal concha are formed only from basal lamina while the middle part is formed from basal lamina which gives a spiral lamella enclosing a recess. **Hare (1975)** reported that the dorsal nasal concha is relatively long, narrow and has a smooth surface. **Getty and Hadek (1964)** stated

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that, the ventral nasal concha extends from the level of the first to the third premolar tooth. **El-Hagri (1967) and Schummer *et al.* (1979)** recorded that the ventral nasal concha is large, well developed and has several secondary lamellae which arise from the spiral lamella creating multiple narrow recesses . **Hare (1975)** stated that the ventral nasal concha is shorter and broader than the dorsal one and has irregular surface. **Evans and De-Lahunta (1988)** reported that, the ventral nasal conchae in dog consist of several elongated scrolls. **Getty and Hadek (1964) and Hare (1975)** reported that, the ethmoidal conchae in dog are four endoturbinates and six ectoturbinates. **El-Hagri (1967) and Schummer *et al.* (1979)** recorded that, the middle nasal concha is long and has many secondary lamellae internally. **Dyce *et al.* (1993)** in carnivores added that the ethmoidal conchae collectively are larger than the nasal conchae, an indication of dog's keen sense of smell. Moreover, **Hare (1975) and Evans and De-Lahunta (1988)**, mentioned that the third and fourth endoturbinates are large in both dog and cat. In the cat the fourth endoturbinate extends caudally into the sphenoid sinus, while the dorsal nasal concha and endoturbinate II project into the frontal sinus (Fronto nasal sinus in cat).

Nasal meatus: (meatus nasi)

The nasal meatus in all domestic animal are dorsal (olfactory) middle (sinus), ventral and common nasal meatus. **Chauveau and Arloing (1891), Bradly and Graham (1947), El-Hagri (1967), Sisson & Grossman (1969) and Hare (1975)** in the horse mentioned that the dorsal nasal meatus is narrow, the middle nasal meatus is somewhat larger than the dorsal one , while the ventral nasal meatus is the largest.

Sisson and Grossman (1969), Hare (1975) in ox , mentioned that, the dorsal nasal meatus is small and extends caudally as far the junction of inner plate of the frontal bone with the cribriform plate of the ethmoidal

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bone. **Raghavan and Kachroo (1964) and El-Hagri (1967), Sisson and Grossman (1969), Hare (1975) and Schummer *et al.* (1979)** in ox described the middle nasal meatus as a narrow air space, divided caudally into two channels by the middle nasal concha. The ventral nasal meatus is is the largest of the three meatuses and communicates with the ventral recess and bulla of the ventral nasal concha. The common nasal meatus in ox is wide below and narrow above.

May (1970) in sheep mentioned that, the middle nasal meatus is deeper than the dorsal one and divided caudally into a dorsal and ventral branches while the ventral nasal meatus is the largest passage and the common nasal meatus is slit like passage.

George (1951) in camel, reported that, the dorsal nasal meatus is narrow behind and gradually widens in front. The middle nasal meatus is much narrower than the previous one and divided caudally into two narrow spaces. The ventral nasal meatus in camel is wider than the other two and it gradually widens rostrally. **Badawi and Fath El-Bab (1974)** in camel, confirmed that the dorsal and middle nasal meatuses are narrow and the latter is divided caudally , while the ventral nasal meatus is relatively capacious.

El-Hagri (1967), Sisson and Grossman (1969) and Hare (1975) in swines reported that the dorsal nasal meatus is extremely small while the middle meatus is represented by a deep fissure. **Sisson and Grossman (1969)** stated that the middle nasal meatus is divided caudally into two branches and the ventral nasal meatus is relatively wider than the other two.

In canines, **Hare (1975)** recorded that the dorsal nasal meatus is narrow and shallow . **Evans (1993)** mentioned that the middle nasal meatus has dilatation (antrum) at its anterior end.

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Trautmann and Fiebiger (1957) stated that the mucosa of the respiratory region of the nasal cavity in domestic animals is covered by stratified columnar epithelium rostrally and changes gradually into pseudostratified epithelium with goblet cell , the basement membrane of the epithelium contains network of reticular fibers. The lamina propria has many elastic fibers in deeper layers and contains tubuloalveolar glands and the submucosa carries vascular trunks and in certain areas sizable venous erectile tissue. **Dellmann and Brown (1992)** reported that the epithelium of the respiratory mucosa is ciliated pseudostratified columnar with goblet cells, but most of the respiratory mucosa has a smooth surface, papilla-like elevation and occasional ridges were not common. The propria submucosa consists of loose connective tissue separated from the epithelium by a thick basal lamina contains mixed branched tubuloalveolar glands . The erectile tissue consists of large veins with smooth muscle sphincters.

Nogueira, Alves and Godinho (1976) in zebu (*Bos indicus*) showed that the nasal conchae are lined by pseudostratified ciliated columnar epithelium with goblet cells. The goblet cells are very frequent on the caudal part of the ventral nasal concha, abundant on the ventral surface of the ethmoidal conchae and rare on the roof of the nasal cavity. The lamina propria of the middle part of the ventral nasal concha and ethmoidal conchae, contains only serous glands, while the dorsal nasal concha and the rostral and caudal parts of the ventral nasal concha contain both serous and mucous gland.

Khamas (1980) in sheep, found large number of mucous glands on the medial surface of the nasal conchae. While glands are fewer or even absent in some areas on the surfaces facing the conchal sinuses. **Gharib *et al.* (1983)** in goat, reported that, the respiratory part of the nasal cavity is lined by pseudostratified columnar ciliated epithelium with goblet cells

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and this epithelium shows intraepithelial glands as well as crypts of different shapes and sizes. The olfactory epithelium is formed of olfactory receptors, supporting cell, basal cell and intermediate cells.

Badawi and Fath El-Bab (1974) in camel recorded that the straight fold and the alar fold are covered rostrally by non-cornified stratified squamous epithelium and caudally by pseudostratified ciliated columnar epithelium with few goblet cells. The nasal conchae are lined by low pseudostratified ciliated columnar epithelium with goblet cell which increase toward the middle portion. The mucosae in both folds contain numerous compound tubular seromucous gland which disappear gradually toward the middle portion of the nasal conchae. The glands at the caudal part of the nasal cavity are relatively few simple tubular mucous secreting.

Trautman and Fiebiger (1957) in carnivores, reported that, the glands were small in size and few in numbers. **Abbass *et al.* (1981) and El-Sayed (1982)** in dog, found that, the straight fold is covered with cuboidal epithelium, while the free end of the alar fold is covered by thick stratified squamous epithelium and their subepithelial tissue contains only PAS positive glands with blood vessels and few blood spaces. The respiratory part is lined by pseudostratified ciliated columnar epithelium with goblet cell. The latter aggregate at certain area to constitute the intra epithelial glands. The lining epithelium rests on an indistinct basement membrane. The respiratory epithelium shows crypt or flask-shaped depression and the subepithelial tissue is made up of fibro elastic connective tissue containing numerous blood spaces, capillaries and nerve fibers with numerous group of glandular acini.

Paranasal sinuses (sinus paranasalis)

General considerations:

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In domestic animals , the paranasal sinuses are air filled cavities within the bones of the skull which develop at foetal life as diverticula of the nasal cavity. They are lined with respiratory mucous membrane and communicate with the nasal cavity the pneumatization of the bones of the skull reduce the weight of the head which requires large surface areas for the attachment of muscles and a lot of space to accommodate the teeth.(**Schummer *et al.*, 1979; Budras and Sack, 1994 and Ashdown and Done, 1996**). However, **Ommar and Harshan (1995)** stated that in horse and cat they extend into the sphenoidal sinus and are covered by an olfactory type of mucous membrane while in the dog, cat and pig, the ethmoturbinate bones project into the frontal sinus and lined by the olfactory epithelium. Moreover, **Schummer *et al.* (1979)** in domestic animals described that the paranasal sinuses are paired cavities and they are the maxillary, frontal, palatine and sphenoidal sinuses which are present in all domestic mammals. The lacrimal sinus is found only in pig and ruminants. In addition, there are also dorsal and ventral conchal sinus. The ventral conchal sinuses presents only in equines, pig and ruminants. Finally and also confined to the pig and ruminants, there are cavities known as ethmoidal cellulae. On the other hand, **Gourely and Vasseur (1985)** in the dog and cat added that, it has been suggested that the sinses amplify sounds as the glottis. However, there is probably no relationship between the presence of sinuses and voice. The sinuses are thought to be insulators. Preventing the heat loss from adjacent turbinate structures, as well as they may also protect the brain from the impact of cold air in arctic climates.

Maxillary sinus (Sinus maxillaris):

Regarding the maxillary sinus in equine. **Omar, Khidr, Kamel, Abdel-Maboud and Elseddawy (1986)** in the donkey, **Youssef and El-sayed (1997)** in the mule and **Rooney, Sack and Habel (1969), Nickel**

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et al. **(1986), Budras and Sack (1994) and Ashdown and Done (1996).** in the horse, recorded that it excavates in the maxillary, lacrimal, zygomatic and in part the ethmoid bones. **Omar *et al.* (1986)** in the donkey reported that the paranasal sinses are small in size in young age and reach their maximal development at 8 years old. This result supports the reports of **Cook (1966)** in equines and **El-Hagri (1967)** in the domestic animals.

In this respect **Schummer *et al.* (1979)** stated that in young horses, the maxillary sinuses are dorsal to the facial crest and a considerable distance caudal to the infraorbital foramen as the skull matures and the cheek teeth are gradually pushed from their sockets, the maxillary sinus expands ventrally below the facial crest and in old horses may reach the infraorbital foramen and extend caudally to the level of the lateral angel of the eye. Moreover, **Denoix, Guillemot, Sanaa, Denoix and Druelle (1996)** in the horse stated that the rostral approach to the rostral maxillary sinus seems contra-indicated in young horses, since the endoscope would inevitably hit the dental alveoli. They added that the oblique radiographic views proved very useful for locating the exact position of the rostral maxillary sinus (especially prior to the trephination of the sinus), as well as for the identification of the teeth present in each maxillary sinus often difficult endoscopically since the alveoli are not easily distinguishable from one another.

Shively (1987), Freeman, Orsini, Ross and Madison (1990) and Ommar and Harshan (1995) in the horse stated that the maxillary sinus is divided by an oblique bony septum (*Septum sinuum* maxillarium) into a small rostral and a large caudal parts, which is not observed in the donkey (**Omar *et al.*, 1986**) and mule (**Youssef and El-sayed ,1997**). The aforementioned authors in the horse added that the septum is usually located about 5 cm caudal to the rostral end of the facial crest as well as its

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dorsal border is delicate and cribriform. According to the **El-Hagri (1967) and Nickel *et al.* (1986) and Shively (1987)** in the horse, all paranasal sinuses, communicate with the middle nasal meatus through the maxillary sinus. They added that the maxillary sinus communicates with the nasal cavity through the naso-maxillary opening (apaertura nasomaxillaris) which is located at the level of the last cheek tooth which leads to the caudal part of the middle nasal meatus. However, **Bradley and Grahame (1947)**, **Rooney *et al.*(1969) and Ommar and Harshan (1995)** in the horse described that, both the rostral and caudal maxillary sinuses are partially divided into lateral and medial parts by the infraorbital canal. On the other hand, **Selim (1982)** in the donkey and mule stated that the latter division is not observed. **De-Lahunta and Habel (1986), Budras and Sack (1994) and Ashdown and Done (1996)** in the horse revealed that the rostral maxillary sinus communicates over the infra orbital canal with the ventral conchal sinus while the caudal maxillary sinus communicates caudoventrally with the sphenopalatine sinus and dorsomedially with the concofrontal sinus. Regarding the boundaries of the maxillary sinus in the horse, the previous authors described that its dorsal boundary isrepresented by a line drawn from the infraorbital foramen backwards parallel to the facial crest, the ventral boundary is the facial crest, while the rostral limit is a line from the rostral end of the facial crest to the infraorbital foramen as well as the caudal limit by a transverse line rostral to the root of the zygomatic arch. **Selim (1982)**, mentioned that the facial crest appears to divide the maxillary sinus externally into a dorsal and a ventral parts in the horse and mule. However, the facial crest forms the ventral boundary of the sinus in the donkey. **De-Lahunta and Habel (1986)**, added that the roots of the last three or four cheek teeth are associated with the lateral compartment of the sinus. **El-Hagri (1967), Sisson and Grossman (1969), Selim (1982), Shively (1987) and Ommar and Harshan (1995)** in the buffalo, mentioned that the maxillary sinus, is

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excavated in the maxilla, the zyogmatic bone and the lacrimal bulla of the lacrimal bone. It extends rostrally as far as the facial tuberosity, and a little further in old animals. They added that , it continues into the lacrimal bulla to a point opposite the biforcation of the zygomatic process of the zygomatic bone. According to **El-Hagri (1967), Habel (1975) and Ommar and Harshan (1995)** in the ox, the maxillary sinus communicates freely with the palatine sinus over the infraorbital canal through an oval opening. Dorsal to this, it communicates by a shorter and narrower opening with the middle nasal meatus. They added that the floor of the maxillary sinus is irregular and the roots of the last three or four cheek teeth project up into it, and covered by a plate of bone. However, **Dyce *et al.* (1993)** in the ox recorded that the maxillary sinus communicates with the nasal cavity via a large naso maxillary opening but natural drainage of pus or other fluid is hindered by its location high in the medial wall. **Shively (1987)** in the ox, added that the palatine and maxillary sinuses open directly into the middle nasal meatus through a common naso maxillary opening. The lacrimal sinus communicates with the maxillary sinus, and the frontal, sphenoid and conchal sinuses open independently into the ethmoidal meatuses. On the other hand **Smallwood (1992)** in the same animal reported that the maxillary sinus is not divided into rostral and caudal compartments but has a clinically important diverticulum that extends caudally under the eye. This is lacrimal bulla, which is an extremely thin-walled (egg shell) extension of the maxillary sinus. The author added that, it is vulnerable to damage during radical enucleation ozf the bovine eye.

May (1970) in sheep, and **Sleim (1982)** in sheep and goat reported that the dorsal limit of maxillary sinus is approximately in a line from the infraorbital foramen to a point below the medial canthus of the eye. The outlet extends upward, backward and inward from its upper part reaching

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the middle meatus beneath the rostral free end of the great ethmoturbinate bone which partially block the orifice. On the other hand **El-Hagri (1967), Sisson and Grossman (1969) and Dyce *et al.* (1993)** in sheep stated that the maxillary sinus is relatively small, other wise it resembles that of large ruminants. The aforementioned authors added that the maxillary sinus of sheep does not communicate with the lacrimal sinus, which may open into the nasal fundus separately or via the lateral frontal sinus.

According to **Moustafa and Kamel (1964)**, in the camel, the maxillary sinus is confined totally to the maxillary bone. However, it excavates a small part of the maxilla as well as the rostral part of the zygomatic bone, (**Badawi and Fath El-Bab, 1974; Selim, 1982 and Smuts and Bezuidenhout, 1987)** in addition to the lacrimal bone in the ox (**Kanan, 1990)**. They stated that the area of sinus extends from a line joining the infraorbital foramen into the upper margin of the orbit. They also added that the maxillary sinus is divided into irregular spaces by septa, and there is no extensions of the roots of the molar teeth into the maxillary sinus. However, **Tyagi and Singh (1993)** in the camel reported that the maxillary sinus communicates freely dorsally with the lacrimal sinus. The two maxillary sinuses are partly separated by the osseous lacrimal duct and communicate with the dorsal limb of the caudal extension of the middle nasal meatus. The latter authors added that the naso maxilly opening is partly occluded by the pointed lateral extension of the dorsal conchal sinus.

According to **Sisson and Grossman (1969) and Nickel *et al.* (1986)**, in the pig the maxillary sinus is situated entirely within the maxilla and the lacrimal bone and in older animals it also extends into the zygomatic bone. **Hillman (1975)** added that it also excavates in the ethmoid bone and ventral nasal concha. The maxillary sinus in the pig is divided into lateral and medial extensions by a substantial bony lamella

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(**Hillman, 1975 and Nickel** ***et al.*****1979**). However **Shively (1987)** stated that the sinus is divided into a rostral and a caudal parts. In this respect, **Sisson and Grossman (1969)** mentioned that the maxillary sinus in the pig does not communicate with the frontal and sphenoidal sinuses, but with the middle nasal meatus by means of a considerable orifice (naso maxillary opening), which presents at the level of the 6th cheek tooth. The naso lacrimal canal courses within the roof of the maxillary sinus of the pig, being separated from it by a thin bony plate (**Hillman 1975**), while the infraorbital canal runs along its floor (**El-Hagri, (1967)**. **Sisson and Grossman (1969) and Clayton, Flood Mandeville and Farrow (1996)** added that the roots of the molar teeth do not project up into it.

Regarding to the maxillary sinus **Nickel** ***et al.*** **(1986)**, **Shively (1987), Hudson and Hamilton (1993) and Ommar and Harshan (1995)** in carnivores stated that it is different from those of the other animals in that it does not lie between the external and internal plates of the limiting bones, but merely forms a hollow in these bone known as the maxillary recess. They added that the recess is bounded laterally by the maxilla, lacrimal and palatine bones and medially by the orbital lamina of the ethmoid bone. **Nickel** ***et al.*** **(1986)** in the cat recorded that the lacrimal bone does not participate.

On the other hand, **Evans and De-Lahunta (1988) and Done, Goody, Evans and Stickland (1996)** in the dog said that, the walls of the maxillary recess are formed laterally and ventrally by the maxilla and medially by the orbital lamina of the ethmoid bone. Moreover, **El-Hagri (1967) and Nickel** ***et al.*** **(1986)**, in carnivores mentioned that the entrance to the maxillary recess, the naso maxillary opening, is reduced by the uncinate process of the dorsal nasal concha (endoturbinate I). This process enters the recess and divides it into a large rostral and a small caudal parts. **Nickel** ***et al.(1986),*** added that the size of the maxillary recess is relatively

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constant and does not vary with the increasing age of the animals. However, **El-Hagri (1967), and Kanan (1990)** stated that the lateral wall of the recess is crossed obliquely by the naso lacrimal canal as well as the root of the molar teeth do not project up into it. In this respect, **Evans (1993) and Anderson (1994)** in the dog added also that the lateral nasal gland occupies this recess.

Frontal sinus (Sinus frontalis):

In equines, **Mansmann, McAllister and Pratt (1982), Constantinescu (1991), Nickels and Tulleners (1992), Budras and Sack (1994), Ommar and Harshan (1995), Selim (1982)** in the donkey and mule **and Ashdown and Done (1996)** in the horse mentioned that the frontal sinus is formed in the frontal, lacrimal, ethmoid and dorsal turbinate bones. It extends forwards to the rostral margin of the orbit, backwards to the temporal condyles and outwards into the roots of the zygomatic process of the frontal bone. **Omar *et al.* (1986)** in the donkey and **Hillman (1975)** in the horse, described that the sinus is roughly triangular with the base on the middle line separated from the opposite side by a complete septum. Its apex is directed laterally into the zygomatic process of the frontal bone. They added that in contrast to other domestic animals, in the horse, the frontal sinus is extensively communicated with the dorsal conchal sinus (Sinus conchae dorsalis) in a rostromedial direction to form (Sinus concofrontalis). The frontomaxillary opening (Apertura frontomaxillaries) is a large oval opening that lies in the floor of the conco frontal sinus, rostolateral to the ethmoidal labyrinth. In this concern, **De-Lahunta and Habel (1986)** revealed that there is no frontomaxillary opening in any of domestic animals except in equines. Moreover, **El-Hagri (1967) and Schummer *et al.* (1979)** in the horse observed that, the frontal sinus is divided by a transverse crest into three parts; cranial, medial and caudal , but according to **Selim (1982)** it is divided into a

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medial, middle and lateral parts. All three divisions are communicated to each other. On the other hand, **Shively (1987)** stated that the frontal sinus is undivided in the horse.

According to **McFarland (1970), Schummer *et al.* (1979), Shively (1987); Constantinescu (1991) and Ommar and Harshan (1995)** in the ox and **Ahmed (1944), Saigal and Khatra (1977) and Selim (1982)** in the buffalo described that the frontal sinus excavates the frontal, parietal, interparietal and in part also the temporal and occipital bones in ox, but in the frontal, parietal and supraoccipital bones in the buffalo (**Moustafa and Kamel 1971**). Thus they completely surround the cranial cavity except ventrally. The right and left frontal sinuses are separated from each other by a medium septum. The aforementioned authors added also that a transverse septum separates the large caudal frontal sinus from the smaller rostral sinuses. The medial, in constant intermediate and the lateral rostral frontal sinus, each of which opens separately into one of the ethmoid meatuses.

Habel (1975) and Schummer *et al.* (1979) in the ox added also that the caudal frontal sinus is divided by an incomplete septum into a caudal and rostromedial parts which communicate with each other. However, **Selim,(1982)** in cattle revealed that the frontal sinus is divided into a middle, caudomedial and caudolateral parts. In this concern **Schummer *et al.*, (1979)** in the ox and **Moustafa and Kamel**, **(1964)** in the buffalo observed that the caudal frontal sinus contains three diverticula namely, cornual nuchal and postorbital diverticula. **Selim (1982)** in the buffalo and goat observed also another two diverticula namely, a rostral and post. cornual diverticula. The cornual diverticulum is commonly opened by dehorning procedures in cattle (except) those performed in young animals). **McNutt, Aitken and Murphey (1922), Tyagi and Singh (1993)** in the ox added also that there is a thin plate of bone separating the

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post orbital diverticulum from the temporal fossa, therefore, when this portion breaks, infection can easily reach the eye. In this concern, **De-Lahunta and Habel (1986) and Constantinescu (1991)** in the ox stated that the supraorbital canal conducts the supraorbital vein which joins the ophthalmic venous plexus within the periorbita. The canal passes through the caudal sinus in an incomplete septum extending from the internal lamina of the frontal bone to the wall of the orbit.

Regarding the frontal sinuses in small ruminants, **May (1970)** in sheep, **Schummer *et al.* (1979) and Shively (1987)** in sheep and goat, mentioned that the sinuses occupy only the frontal bone and consist of a small medial and large lateral sinus. The medial frontal sinuses are rather asymmetrical in sheep and don't always reach the median plane. On the other hand, **El-Hagri (1967) and Schummer *et al.* (1979)** in the goat, described that the right and left medial sinuses lie against the median septum. The aforementioned authors added also that the lateral frontal sinus extends caudally to the level of the caudal border of the zygomatic process and extends in horned animal into the cornual processes. In this concern **Moustafa (1961)** in the goat recorded that the rostral limit of the frontal sinus is on a level with a line drawn between the lacrimal tubercles. While the caudal limit corresponds to a line drawn from the middle of the frontal suture to the root of the supra orbital process. He added also that the course of the supra orbital canal which is enclosed by one of the septa of the sinus, is backward and downward for a distance of about 1 cm, then directed forward and laterally at an almost right angle to open on the orbital surface of the frontal bone. Moreover, **Schummer *et al.* (1979)** in the goat, asserted that, the apertures of the lateral and medial frontal sinuses open into the dorsolateral ethmoidal meatuses. Clinically **Vitums (1959), Case (1957) and Garret (1988)** in the goat reported that the frontal sinus is very shallow in the area of the base of the horn. The caudal

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part of the base of the horn may rest directly on the plate of bone covering the brain, for this reason, extreme care must be used in dehorning adult goat to avoid damaging the bone which covers the brain.

According to, **Moustafa and Kamel (1964), Badawi and Fateh El-Bab (1973), Selim (1982), Smuts and Benzuidenhout (1987), Kanan (1990) and Tyagi and Singh (1993)** in the camel, the frontal sinus is not so extensive as in other domestic ruminants. It is confined to the frontal bone. The right and left sinuses are separated by an irregular septa.

Badawi and Fateh El-Bab (1973) and Selim (1982) in the camel added also that the frontal sinus is divided into medial and lateral portions. The sinus communicates with the middle nasal meatus by a small aperture, while, **Tyagi and Singh (1993)** in the same animal, recorded that the sinus communicates with the dorsal nasal meatus of the nasal cavity by a curved slit near the midline.

In the pig, **Shively (1987), Smallwood (1992) , Dyce *et al.* (1993), and Ommar and Harshan (1995)** recorded that there are three frontal sinuses on each side, the large caudal, the smaller medial and lateral rostral sinuses. The frontal sinuses are usually not present at birth. In fully grown pigs they constitute large air spaces which occupy several of the dorsal and lateral cranial bones. The right and left frontal sinus are separated from each other by a sagittal septum. They stated that the caudal frontal sinus is the largest sinus in the pig. It occupies frontal, parietal, occipital and temporal bones, thus surrounding the cranial cavity dorsally, laterally and caudally.

In this respect , **Dyce *et al.* (1993)** in the pig stated that the brain is situated about 5 cm below the overlying skin and well protected by two plates of bone. The authors added that the deep location of the brain has

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consequences at slaughter since pigs can not be stunned reliably, hence humanly, by mechanical means (hummer or captive bolt).

Moreover, **De-Lahunta and Habel ,(1986)** in the pig added also that, the internal and external plates of the frontal bone are widely separated over the brain rendering mechanical means of stunning for slaughter in effective.

According to **De-Lahunta and Habel (1986), Evans (1993) and Ommar and Harshan (1995)** in the dog, there are three frontal sinuses in each side in the dog (lateral, medial and rostral), each with its own opening into the ethmoidal meatuses.

The frontal sinuses in the right side are separated from those of the left side by a median septum. However **El-Hagri (1967)** in the same animal named them as lateral, medial and nasal frontal sinuses. On the other hand, **Hillman (1975)** in the dog added that there are two frontal sinuses lateral and medial in each side. The authors agreed that the lateral frontal sinus is the largest one and occupies much of the frontal bone, including its zygomatic process, and may extend to the level of tempromandibular joint in large animals. On the other hand , **Gourely and Vasseur (1985) and Boyd, Paterson and May (1991)** in the dog and cat mentioned that the size of the frontal sinuses varies according to the breed. Some Brach cephalic dogs and Persian cats have very small frontal sinuses and in some animals they are absent. However, **Walker (1982), Nickel *et al.* (1986) and Hudson and Hamilton (1993)** in the cat, recorded that there is only one frontal sinus on each side. It is undivided and located in the frontal bone and communicates rostrally with the nasal cavity

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Lacrimal sinus (sinus lacrimalis):

Shively (1987) and Shummer *et al.* (1979) reported that it is found only in the pig and ruminants.The latter authors in the ox, stated that the lacrimal sinus is small being excavated in the lacrimal and frontal bones and lies rostromedial to the orbit. They considered it as a caudo dorsal diverticulum of the maxillary sinus.

In this concern, **Hillman (1975) and Schummer *et al.* (1979)** in the ox reported that the lacrimal sinus opens in the maxillary sinus. In this concern, **Moustafa (1961)** in goat revealed that, the lacrimal sinus is an independent cavity.

On the other hand, **Loeffler (1958)** in the same animal, **May (1970)** in sheep and **Hillman (1975) and Schummer *et al.* (1979)** in small ruminants revealed that the lacrimal sinus is not associated with the maxillary sinus but it existes either as an independent cavity which opens separately into one of the ethmoidal meatuses or it is occasionally a lateral diverticulum of the lateral frontal sinus.

Moreover, **El-Hagri (1967), Hillman (1975) and Ommar and Harshan (1955)** in the pig revealed that the lacrimal sinus is usually an independent sinus, but occasionally it is a diverticulum of the lateral rostral frontal sinus \and is related ventrally to the maxillary sinus, medially and rostrally to the rostral frontal sinus and caudally to the orbit. The aperture of the lacrimal sinus opens into a lateral ethmoidal meatus.

On the other hand, **Hillman (1975) and Schummer *et al.* (1979)** in the pig added that the sinus starts to develop when the pig is about 6 month old or it may be greatly reduced or absent.

Palatine sinus (Sinus palatinus):

In the concern of the palatine sinus, **Shively (1987), Kanan (1990), Tyagi and Singh (1993) and Ommar and Harshan (1995)** in the ox ,

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observed that the sinus is contained mainly within the palatine process of the maxilla and in the horizontal plate of the palatine bone (in side the hard plate). The right and left palatine sinuses are separated from each other by a bony median septum. All, added also that the palatine sinus extends from the caudal border of the palate to a point slightly rostral to the first maxillary cheek tooth. It communicates with the maxillary sinus over the infraorbital canal by a wide maxillopalatine opening (Apertura maxillopalatine) and communicates with the nasal cavity by the common naso maxillary aperture. Owing to the presence of several foramina in the bony roof of the palatine sinus, they stated that it is separated from the nasal cavity by mucous membrane in fresh state.

However, **May (1970)** in sheep and **Schummer *et al.* (1979)** in sheep and goat, observed that the palatine sinus don't reach as a far medially and the bony defects of its roof are quiet small. Moreover, **May (1970)** in Sheep, added that the palatine and maxillary sinus open into the middle nasal meatus by a common opening. The common orifice forms a canal about 2-5 cm long and 1 cm wide in sheep, but it is shorter in the goat (1.5 cm x 0.5 cm). He added that, this opening is rostral to the openings of the frontal sinus and faces rostrally in sheep and dorsally in goat.

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Sphenoid sinus(sinus sphenoidal):

Concerning the sphenoid sinus in ruminants, **El-Hagri (1967), Schummer *et al.* (1979) and Shively (1987)** stated that, the sphenoid sinus is absent in sheep and goat. The latter author, added also that the same sinus may be absent in ox. The aforementioned authors reported that the sphenoid sinus in ox excavates the body and the orbital wing of the presphenoid bone. The right and left sphenoid sinuses are separated by a septum which seldom coincides with the median plane. They added that each sinus consists of a tube like rostral part and a wider caudal part. Both parts widely communicate with each other and open into the nasal fundus by anaso sphenoidal opening.

However, **Kanan (1990) and Smuts and Bezuidenhout (1987)** in the camel, revealed that the sphenoid sinus is found in the body of the presphenoid bone. It is the smallest one of the paranasal sinuses and communicates with the ethmoidal meatues.

In the pig, **El-Hagri (1967), Hillman (1975) and Schummer *et al.*, (1979)**, mentioned that, the sphenoid sinus consists of a central cavity and three recesses. The central cavity lies in the bodies of the presphenoid and basisphenoid. The caudal recess extends to the basilar part of the occipital bone. The rostral recess extends to the pterygoid process of the basisphenoid and into the pterygoid process of the palatine bone, while the lateral recess is the largest of the three, occupies the squamous part of temporal bone. The sphenoid sinus opens into a ventral ethmoidal meatus. According to **Walker (1982); Boyd *et al.* (1991); Hudson and Hamilton (1993); and Ommar and Harshan (1995)** in the cat, the sphenoid sinus occupies the presphenoid and contains a part of endoturbinate IV which projects into it from the nasal cavity.

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They added that it excavates the body of the presphenoid and in older animals extends into the body of the basisphenoid. The part of the sinus which is contained in the body of the presphenoid is related dorsally to the optic canal and schismatic groove. All agreed of the absence of the sphenoid sinus in dog. On the other hand, **Negus (1958) an Evans (1993)** in the dog reported that the sphenoid sinus is present and lies within the presphenoid bone and is occupied largely by endoturbinate IV.

Spheno palatine sinus (Sinus sphenopalatinus):

Regarding to the spheno palatine sinus, **Omar *et al.* (1986)** in the donkey and **Budras and Sack (1994), Ommar and Harshan (1995)** and **Ashdown and Done(1996) ,** in the horse reported that this sinus is formed by the union of the palatine sinus within the perpendicular plate of the palatine bone and the sphenoid sinus which situated behind it .The sphenoid sinus is enclosed within the presphenoid and with advanced age extended within the basisphenoid. On the other hand, **Omar *et al.* (1986)** stated that the sphenopalatine sinus does not divided in the donkey while **El-Hagri (1967)** in the horse recorded that the spheno palatine sinus divides into the sphenoidal and palatine sinuses. On the other hand, **Shively (1987)** in the horse reported that the sphenoid sinus may be absent. **Omar *et al.* (1986)** in the donkey reported that, the sphenopalatine sinus opens in the caudomedial part of the maxillary sinus.

Paraethmoid sinuses (ethmoidal cells):

According to **El-Hagri (1967) and Schummer *et al.* (1979)** in ruminants reported that in addition to the paranasal sinuses, there are ethmoidal cells (medial paraorbital sinus) comprise some cavities in the neighborhood of the medial wall of the orbit. These cavities may number up to ten in bovines and two or three in small ruminants , they vary greatly in form and size in different individuals. They are related to the frontal, palatine and orbital wings of presphenoid and open into the nasal fundus.

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In the pig, they are named paraethmoidal sinuses which are not limited to the orbital but extend further in the cranial part of the skull and all of the m begin in the sphenoid recess. They communicate with the nasal fundus and vary in number, size, and form in different individuals.

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MATERIALS AND METHODS

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MATERIALS AND METHODS

This work was carried out on 30 apparently healthy adult donkeys of both sexes and of different ages. These animals were grouped according to the pattern of study into:

→ 20 donkeys were used for gross anatomical study.

→ 5 donkeys were used for radiographical study.

→ 2 donkeys were used for computed tomographical study.

→ 3 donkeys were used for histological study.

The animals were bled by incision of the common carotid artery and the histological samples were taken just after bleeding.

The bled animals were injected through the common carotid artery by formalin solution 10% for preservation.

For gross anatomical study, cross sections at different levels of the heads as well as sagittal sections were carried out to study the different parts of the nasal cavity and the paranasal sinuses.

Cast preparation of the paranasal sinuses was used by injection of silicon material through an artificial opening at the roof of the frontal sinus(medial to the supraorbital peramen by about 3 cm)

To prepare the heads for radiographical study, median longitudinal sections of the heads were done to show the positions and extensions of the paranasal sinuses and other related structures.

Computed tomographical study by using two heads to obtain a cross sections of the nasal cavity at different levels and compared these sections with that of dissected sections .

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For histological study, small pieces from different parts of the nasal cavity were taken and fixed in Bouine's solution for 24 hr and 10% neutral buffered formalin. After proper fixation, the specimens were dehydrated, in ascending grades of alcohol then some specimens decal cifeied in formic acid 5% for 3 – 4 days . Then cleared in mettyl benzoat and embeded in paraffin. Sections were obtained at 5-7 μm thickness and stained with haematoxylin and Eosin, Periodic acid Schiff techmique , Crossmon's Trichrome, and Verhoeff's method for elastic fibers.

All stain techniques were adopted to that reported by **Bancroft and Stevans (1990)**.

The nomenclatures used in this work were adopted to **N.A.V. (1994)** as possible.

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RESULTS AND DISCUSSION

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RESULTS

The nasal cavity in the donkey extended from the nares rostrally to the choana caudally. The bony boundaries of the nasal cavity were; the nasal bones and the rostral part of the frontal bones dorsally, the horizontal processes of the palatine bones and the palatine processes of the maxillary and incisive bones ventrally, the maxillary, zygomatic, lacrimal, perpendicular plates of palatine bones and ethmoid bones laterally, the cribriform plate of the ethmoid bones caudally.

Our results delt with the different components of the nasal cavity which included; nares, cartilagines nasi externi, septum nasi, choana, organum vomeronasale, ductus incisivus, ductus nasolacrimale and conchae nasalis. Moreover, sinus paranasalis were also studied.

Nares:

The nostrils **Fig. (1)** of the donkey were found to be crescent shaped with medially located concavity. They became ovoid when dilated during forcible respiration. The ventral nasal angle was narrower than the dorsal nasal angel the long axis of both nostrils was oblique rostroventrally. The distance between the two dorsal angles was wider (about 6.3 cm) than that between the ventral ones (about 4.0 cm). The average thickness of the dorsal and ventral nasal angels was 0.22 cm and 0.34 cm respectively. The medial nasal wing (ala nasi medialis) was convex dorsally and concave ventrally and it was supported by the lamina of the alar cartilage. the lateral nasal wing (ala nasi lateralis) was concave medially and it was more thinner than the medial one. The average thickness of the medial and lateral nasal wings was about 0.51 cm and 0.36 cm respectively. The medial and lateral nasal wings, in addition to the area between the two nostrils, were covered by a normal skin with short

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hair and interspersed by many tactile hairs. The skin was reflected on the rostral margin of the nostril to be extended inside the nasal cavity to a varying degree, at the floor, it extended about 4 cm, at the lateral side about 3 cm while at the medial side bout 2 cm. This skin carried fine short hairs which disappeared at the mucocutaneous junction. The mucocutaneous junction was defined by a sharp line. The nostril was supported dorsomedially by the septal cartilage and the lamina of the alar cartilage, and ventrally by the cornu of the alar cartilage, while the lateral wall had not any support. The alar fold extended caudally from the lamina of the alar cartilage in a horizontal manner to divide the nostril into two parts; dorsolateral narrower part leading to a blind cutaneous pouch (diverticulum nasi), this opening was called false nostril which was about 0.7 cm in diameter, and ventromedial wider part leading to the nasal cavity. The opening of the nasolacrimal duct was situated dorsally on the medial surface of the lateral wall of the nostril about 0.5 cm below the dorsal nasal angle, and about 1.5 cm from the margin of the lateral nasal wing, this orifice was located in the cutaneous area.

The microscopic study of the mucocutaneous junction revealed that there were three portions, cutaneous, transitional zones and the mucous membrane (from outside to inside) Fig. (2).

The cutaneous zone was formed from epidermis and dermis Fig. (3). The epidermis was stratified squamous keratinized epithelium from 7-10 layers of cells covered with a prominant amount of keratine. The basal cell layer contained melanin pigment Fig. (4). Epidermal pegs extended toward the dermis to a varying depth and alternated with the dermal papillae Fig. (4). The epidermal cells rest on basement membrane. The dermis was formed of dense irregular connective tissue contained hair follicles with their errector pili muscles, sebaceous glands, apocrine sweat

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glands Fig. (5). The connective tissue under the epidermis was less denser and less cellular. The main cell elements were fibroblasts. Fig. (4), While the fibrous elements were collagen and elastic fibers. The amount of elastic fibers was condensed in the deep part of the dermis.

The transitional zone of mucocutaneous junction was characterized by thick layers of stratified squamous epithelium keratinized at the junction with the skin, then the amount of keratine decreased toward the mucous part Fig. (7). The amount of pigment granules in the basal cell layer decreased. The hair follicles and sweat glands disappeared, but the sebaceous glands which remain in little amount under the epithelium. The serous glands appeared deep in this part contained irregular duct Fig. (6).

At the beginning of the mucous membrane, the epithelium decreased in the number of layers and became stratified columnar (2-3) cells thick with large number of PAS +ve goblet cells Fig. (8). Then the epithelium changed to Pseudostratified ciliated columnar with PAS +ve goblet cells. Fig. (9). The duct of the serous glands opened on the surface of the epithelium Fig. (10).

The lamina propria-tela submucosa was formed from dense irregular connective tissue that separated from the epithelium by a thick glassy non cellular membrane Figs. (9&10). The serous glands were grouped into lobules by a connective tissue septa. Each lobule contained the secretory acini and a number of striated ducts that lined with columnar epithelium. The hair follicle, sebaceous and sweat glands disappeared. A highly vascular connective tissue was found under the previous structures Fig. (10).

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Diverticulum nasi Fig. (12):-

The nasal diverticulum was a blind cutaneous pouch occupying the naso incisive notch and extended caudally beyond the notch by about 2.5 cm. It was divided by the nasal process of the incisive bone into a rostrodorsal part which occupied the nasoincisive notch and a caudoventral part which extended caudal to the notch and rested on the lateral wall of the maxilla. The rostrodorsal part was divided by a cutaneous fold into dorsal pouch and ventral one. The ventral pouch lead to the nostril by an opening of about 0.7 cm in diameter. This opening called false nostril.

The microscopic picture of the nasal diverticulum resembled that of the cutaneous portion of the nasal vestibule except that the keratine decreased in amount in the epidermis and the hair follicles and sebaceous glands decreased in the dermis. While the sweat glands showed no noticeable difference from that in the skin Fig. (13).

Cartilagines nasi externi" : Fig. (15&16):

The cartilages of the external nose of the donkey included; cartilago septi nasi, cartilago nasi lateralis dorsalis, cartilago nasi lateralis ventralis, cartilago nasalis accessoria medialis and cartilago alaris.

1. Cartilago nasi lateralis dorsalis:

The dorsal lateral nasal cartilage was narrow and illdeveloped. It was represented by a slight horizontal extension from the dorsal border of the rostral part of the septal cartilage. The rostral part of the dorsal lateral nasal cartilage was uncovered by the nasal bone and its average length was about 8 cm while its average width was about 0.7 cm and its thickness 0.15 cm. Its free border was curved ventrally. It was connected with the medial border of the lamina of the alar cartilage by a fibrous tissue. The caudal part of the dorsal lateral nasal cartilage was overlapped dorsally by

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the nasal bone. In the old age, this caudal part underwent ossification. At the median plane, the cartilages of both sides were forming a shallow median depression dorsally.

2. **Cartilago nasi lateralis ventralis:**

The ventral lateral nasal cartilage was ill developed and represented by a thick narrow ventrolateral extension from the ventral border of the rostral part of the septal cartilage at the area of the palatine processes of the incisive bone. It filled the palatine fissure. It was projected rostrally forming, with its fellow, two converging pointed cartilaginous rods around the incisive foramen, the greater palatine artery curved medially dorsal to this rode to join its fellow forming the palatolabial artery.

3. **Cartilago nasalis accessoria medialis:**

The medial accessory nasal cartilage was well developed hock-shaped cartilage. It considered the rostral extension of the cartilaginous basal lamella of the basal fold of the ventral nasal concha. It was directed dorsally for about 2 cm, then rostrally for about 2 cm where it embedded inside the alar fold to which it gave support.

4. **Cartilago alaris:**

The alar cartilage was well developed comma-shaped cartilage. It was formed from two parts; the cornu and the lamina . The cornu was a narrow long and curved bar extended ventrolaterally from the lamina and supported the ventral wall of the nostril. The lamina was a flattened quadrilateral plate of cartilage located dorsally and supported the medial wing of the nostril. The two alar cartilages were located back to back at the rostral end of the septal cartilage and attached to each other by a fibrous tissue. They were united to the rostral end of the septal cartilage by a synovial joint which facilitates a slight movement helping in dilatation

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of the nostril during forcible respiration. The lamina of the alar cartilage gave a rostral support to the alar fold.

Septum nasi: Fig. (17 &18):

The present study revealed that the nasal septum was a median partition which divided the nasal cavity longitudinally into two similar halves from the nostrils rostrally to the choanae caudally. It was formed from cartilagenous part (cartilago septi nasi) and an osseous part "pars ossea". The cartilagenous part was fixed dorsally into the nasal and frontal bones and ventrally, it was lodged in the septal groove of the vomer bone and between the two palatine processes of the incisive bone. Caudally, the septal cartialge joined the rostral end of the perpendicular plate of the ethmoid bone. Rostrally, the septal cartilage extended between the two nostrils forming the naric septum which supported the nostrils medially and articulated with the alar cartialge. The septal cartilage underwent ossification in old age and the ossification process is directed from the caudal part and extended rostrally. In older animals, the caudal extension of the nasal septal cartilage presented a bifurcation into dorsal and ventral parts. The dorsal part was tapered and joins the rostral end of the perpendicular plate of the ethmoid bone. The ventral part was joined with the vomer bone ventrally and with the perpendicular plate of the ethmoid bone caudally.

The osseous part of the nasal septum formed the ventrocaudal part of the septum and consists of the vomer bone and perpendicular plate of ethmoid bone. The vomer bone was joined with the palatine processes of the maxillary bones throughout its entire length and its rostral end became cartilagenous and fixed between the caudal parts of the palatine processes of the incisive bone. The dorsal surface of the vomer formed the vomeral "septal" groove which received the septal cartilage and the perpendicular

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plate of the ethmoid bone. The vomer bone divided the (choana) into two openings.

The perpendicular plate of the ethmoid bone was small in young aged animals. In old aged animals the caudomiddle part of the septal cartilage became mostly osseous and the ossification appeared caudally as an extension from the perpendicular plate of the ethmoid bone.

The nasopharyngeal opening “choana” Fig. (19&20) was found to be oval in shape and divided by the vomer bone into two pyramidal halves “choanae”. The choanae were bounded medially by the vomer, laterally by the lateral walls of the nasopharynx. The average mediolateral diameter of each half at its widest part was about 2 cm while the average rostrocaudal diameter was about 5 cm. The choanae of the donkey were located horizontally.

Microscopically the rostral part of the nasal septum was formed from lamina epithelialis of pseudostratified columnar ciliated epithelium with PAS +ve goblet cell Fig. (21&22). Under the epithelium, the lamina propria-tela submucosa was dense irregular connective tissue contained seromucoid glands which presented as a separate lobules surrounded by connective tissue capsule contained inside striated duct Fig. (22). A muscular large blood vessels were observed in the lamina propria submucosa. The elastic fibers appeared as a discreat bundles under the epithelium and between the gland lobules Fig. (23).

In the lamina propria submucosa there was a fibro cartilaginous layer, this layer was formed of hyaline cartilage contained very few amount of elastic fibers, the cartilage covered externally with a thick layer of dense regular C.T. contained fibroblasts.

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Organum vomeronasale: Fig. (24, 25&26):

The vomeronasal organ was a tubulo-cartilaginous organ presented in the floor of the nasal cavity under the mucous membrane on either sides of the ventral border of the nasal septum. It was formed from two parts; the vomeronasal duct and the vomeronasal cartilage. The duct was enclosed by the cartilage and supported by the vomer bone. The cartilage enclosed the duct along its whole length except at its extremities, the vomeronasal duct was nearly straight except at its opening into the incisive duct rostrally where the vomeronasal organ became convex laterally. The rostral end of this organ passed through the palatine fissure to join the incisive duct just before its rostral end under the mucous membrane of the hard palate. Since, the incisive duct did not open into the oral cavity, the vomeronasal organ was not communicated with the oral cavity but opened indirectly into the nasal cavity through the incisive duct. The caudal end of the vomeronasal organ was blind and leveled with the second cheek tooth. The length of this organ was about 9-13 cm.

Microscopically, the vomeronasal organ was formed from the vomeronasal duct, the vomeronasal cartilage, nerve fibers, blood vessels and glands. The vomeronasal duct was lined on the medial side by an olfactory epithelium Fig.(27) while the lateral side was lined with stratified columnar ciliated epithelium rostrally and pseudostratified ciliated columnar epithelium caudally. The lamina propria submucosa was consisted of loose connective tissue with large blood vessels and very rich in serous or seromucoid glands laterally Fig. (28) while medially, the glands were very few and the majority of the vomeronasal nerve fibers presented Fig. (28). The vomeronasal cartilage was elastic in type Fig. (29) and enclosed the vomeronasal duct completely except at a small dorsal opening from which the large nerves emerged. Fig.

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(28). In the cross section of this organ, the lumen of the vomeronasal duct appeared elliptical and the organ appeared semi circular or half moon shaped owing to the lateral thick connective tissue area.

Ductus incisivus: Fig. (25):

The present study revealed that, the incisive duct was very small ill developed duct. It had a nasal opening, which was slit like, at the floor of the nasal cavity at the level of about 0.5 cm rostral to the canine tooth. The incisive duct passed through the palatine fissure to join the rostral end of the vomeronasal duct under the mucous membrane of the hard palate then the incisive duct ended blindly. This duct was enclosed by a cartilaginous prolongation from the ventral lateral nasal cartilage. The average length of the incisive duct was about 0.5 cm.

Ductus nasaolacrimalis: Fig. (30,31,32&33):

The nasolacrimal duct in the donkey was extended from the lacrimal sac at the medial angle of the eye to open rostrally at the lateral wall of the nostril. Its average length was about 24 cm. The caudal part of the naso lacrimal duct passed through the osseous lacrimal canal which present at the medial surface of the lacrimal and maxillary bone. This osseaus lacrimal canal formed the lateral boundary of the fronto maxillary opening and separated between the frontal sinus and the maxillary sinus laterally. This osseous lacrimal canal had a gentle curve with its convexity directed dorsally at the initial part and then directed rostrally with a little ventral direction. The osseous lacrimal canal was measured about 9 cm in length in the adult cases. This osseous part was ended at the level of the 3rd cheek tooth (dorsal to the infraorbital foramen). Then the nasaolacrimal duct passed rostroventrally in the lacrimal groove at the medial surface of the maxillary bone. In the groove, the duct was firstly covered by a small plate of cartilage for about 5 cm, then became covered

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by a mucous membrane for about 10 cm and ran on the lateral surface of the ventral nasal concha and its basal fold. Lastly, the duct coursed rostrodorsally on the nasal process of incisive bone to open at the medial surface of the lateral wall just below the dorsal angle of the nostril. It was found that, the first and last parts of the duct were wider than the rest of the duct.

Conchae nasalis: Fig. (34,35 &36):

The nasal conchae in the donkey comprised; concha nasalis dorsalis, concha nasalis ventralis and concha nasalis medi and and choncae ethmoidalis. The nasal conchae were generally formed from scroll like bone " covered with mucous membrane.

Chonca nasalis dorsalis:

The dorsal nasal concha occupied the dorsal part of the nasal cavity and extended rostrally from the most dorsal part of the cribriform plate of the ethmoid bone till about 2 cm rostral to the first cheek tooth. It was the longest one of the nasal conchae (about 23.5 cm) and considered as the first endoturbinate of the ethmoidal conchae. Its caudal end was splitted into two limbs, the dorsal limb was fixed to the most dorstal part of the cribiriform plate and the tectorial lamina of the ethmoidal bone while the ventral limb was fixed to the medial surface of the maxillary bone at the point of the rostral attachment of the ethmoidal conchae (at the level of the caudal end of the last cheek tooth). The dorsal nasal concha was continued rostrally as a straight fold “plica recta” which splitted into two branches, the dorsal branch, was supported by the cartilaginous basal lamella only without spiral lamella while the ventral branch was supported by the ventral branch of the cartilaginous basal lamella. The two branches rejoined again to form one straight fold which had no any support and extended to about 2 cm caudal to the dorsal nasal angle.

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The basal lamella of the dorsal nasal concha was attached to the dorsal ethmoidal crest of the nasal bone. The spiral lamella was curved toward the middle nasal meatus, (ventrally, laterally then dorsally) and varied in pattern according to position. It formed the dorsal conchal sinus caudally, a recess with subdivided bulla at the middle part and a recess only rostrally. The dorsal conchal sinus was separated from the bulla by an oblique bony septum at the level of the rostral end of the fifth cheek tooth. The average length of the dorsal conchal sinus was about 8 cm. This sinus was opened freely with the rostral lateral part of the frontal sinus forming the conchofrontal sinus. The average length of the subdivided bulla was about 7 cm while the recess was about 4.2 cm, the straight fold was about 4.3 cm. The concha widened gradually by the caudal direction to reach its maximum breadth 3.1 cm at the level of the caudal end of the last cheek tooth and it took the triangular shape. The covering mucosa was rich in cavernous plexuses and it was thinner than that of the ventral nasal concha.

The caudal part of the dorsal nasal concha and the most caudal part of the nasal septum was covered with brown pigmented mucous membrane which simulated the caudal portions of the ethmoidal conchae, this represented the olfactory mucous membrane.

Concha nasalis ventralis:

The ventral nasal concha was broader and shorter than the dorsal nasal concha. It was extended from the level of the caudal end of the last cheek tooth caudally to the nostril rostrally. It was fixed to the conchal crest of the maxilla. The rostral continuation of the ventral nasal concha was diverged into two folds, the alar fold dorsally and the basal fold ventrally. The basal fold was supported by a basal lamella which was cartilagenous and extended to form the medial accessory nasal cartilage

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which directed dorsally and rostrally to be embedded within the alar fold which was supported by the medial accessory nasal cartilage only. The ventral nasal concha formed the ventral conchal sinus caudally and a recess with subdivided bulla at the middle and a recess rostrally. The ventral conchal sinus was extended from the caudal end of the third cheek tooth rostrally to the caudal end of the last cheek tooth caudally. In about 90% of the cases, the ventral conchal sinus was subdivided completely by a thin bony septum into a small rostral sinus and a larger caudal one. While in 10% of cases, there was a partial or no division. In cases of divided sinus, the rostral ventral conchal sinus opned into the middle nasal meatus by a small round or oval opening, while the caudal ventral conchal sinus opened into the maxillary sinus above the infra orbital canal. On the other hand, in case of not divided sinus, it was opened only into the maxillary sinus. The average length of the ventral conchal sinus was about 6 cm, the caudal sinus was about 4 cm and the rostral one was about 2 cm in length. The maximum height of the ventral conchal sinus was about 2.5 cm at the level of the fifth cheek tooth. The bulla was separated from the ventral conchal sinus by an oblique septum which was located at the level of the caudal end of the third cheek tooth the bulla was divided by small septae into numerous small cells. The average length of the subdivided bulla of the ventral nasal concha was about 5 cm, and the average length of the recess without bulla was about 5 cm, while the average length of the basal fold was about 3 cm and that of the alar fold was about 5 cm. The average length of the ventral nasal concha was about 21 cm. The most caudal part of the ventral nasal concha was formed from a thick mucous membrane only which was highly vascular and contained the beginning of the sphenopalatine blood vessels and the caudal nasal nerve. The ventral nasal concha was covered by a very thick mucous membrane which was very rich in cavernous plexuses.

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The dorssal and ventral nasal conchae divided the nasal cavity into three meatuses; meatus nasi dorsalis, meatus nasi medius and meatus nasi ventralis.

The dorsal nasal meatus was a narrow passage extended from the dorsal nasal angle to the cribriform plate of the ethmoid bone. It was present between the roof of the nasal cavity and the dorsal nasal concha. Its average length was about 25 cm while its average width was about 0.5 cm.

The middle nasal meatus was extended from the dorsal nasal angle to the ethmoidal conchae. It was present between the dorsal nasal concha and the ventral nasal concha. It was wider than the dorsal nasal meatus specially at its middle part where its average width was about 1.4 cm while at the rostral and caudal parts it was narrow "average width was about 0.5 cm". It was shorter than the dorsal nasal meatus and its average length was about 20 cm. The maxillary sinus opened into this meatus through the nasomaxillary opening which was situated between the dorsal and the ventral nasal conchae at the level of the fifth cheek tooth.

The ventral nasal meatus was wider than the other two meatuses "average width was about 2 cm". It extended between the ventral nasal angle and the choana. Its average length was about 24 cm. It was present between the ventral nasal concha and the floor of the nasal cavity. All the previous meatuses opened freely into the common nasal meatus which located paramedian between the conchae laterally and the nasal septum medially and extended from the roof to the floor of the nasal cavity.

Ethmoidal conchae: "Conchae ethmoidaleis"Fig.(36,37,38&39)

They were formed from 6-7 endoturbinates and 12-20 ectoturbinates. The ethmoidal conchae were attached caudally to the

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cribriform plate of the ethmoid bone and to the papyraceous lamina.

A. Endoturbinalia:

The endoturbinates were arranged dorsoventraly in the form of:

1. **Endoturbinate I**: It formed the dorsal nasal concha and attached to the dorsal part of the papyraceous lamina (Tectorial lamina) of the ethmoid bone. There were also about four small secondary lamella projected from it under the most caudal part of the dorsal conchal sinus at the connection with the cribriform plate of the ethmoid bone but they did not reach the nasal septum.
2. **Endoturbinate II**: It was attached to the lateral part of the papyraceous lamina (orbital lamina) and formed the middle nasal concha which was small. At its connection to the cribriform plate caudally, it gave about 6 secondary lamellae, "4" of which are smaller than the rest. The other two larger secondary lamellae reached medially the level of the nasal septum The dorsal one was excavated by the middle conchal sinus which opened into the caudomedial part of the maxillary sinus.
3. **Endotrubinate III, IV, V, VI** were similar in form and shape and each one was formed from a primary lamella originated from the orbital lamina of ethmoid bone, Each primary lamella was divided into a dorsal and a ventral secondary lamella, both of them reached the level of the nasal septum medially. Each secondary lamella was excavated by a small sinus which opened into an ethmoidal meatus. Each primary lamella gave also about (4-6) small secondary lamellae which did not reach the nasal septum. The endotrubinate III was present in about 90% of cases and absent in about 10% of cases.
4. **Endoturbinate VII:** It was attached to the basal lamina of the

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ethmoid bone. The primary lamina gave two secondary lamellae, one of them was large, reaching the level of the nasal septum medially and enclosed by a small sinus which opened into an ethmoidal meatus. The other lamella was very small and did not reach the nasal septum. The caudal part of this endoturbinate was contained inside the sphenopalatine sinus.

B. Ectoturbinalia:

The ectoturbinates were represented by (12-20) ones with different sizes and lengths. They did not reach the level of the nasal septum. They were arranged in a lateromedial sequence two rows ventrally and three rows dorsally.

The ethmoidal conchae with their papyraceous lamina were bulged into the floor of the frontal sinus and formed the medial boundary of the frontomaxillary opening.

Microscopically, the nasal concha was lined on each side with lamina epithelialis. The outer side of the conch was covered with respiratory epithelium (pseudostratified ciliated columnar) with high number of goblet cells that contained numerous PAS +ve mucigenous globules Fig. (40). The inner side of the concha was lined with stratified cuboidal epithelium with two rows of spherical nuclei. In between the two laminae epithelialis, the propria-submucosa was formed from loose connective tissue with many cavernous spaces under the respiratory epithelium while, under the lamina epithelialis of inner side, the propria was formed from dense irregular connective tissue with small blood spaces. In between the two propria submucosae, there was a layer of bone blended with the propria submucosa on either side Fig. (40&41).

The microscopic structure of the rostral part of each ethmoidal

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concha resembled that of the nasal concha Fig. (42). While the caudal part was differed and was covered at its outer wall by olfactory epithelium while the inner wall was lined with respiratory epithelium Fig. (43). The olfactory epithelium was thick pseudostratified ciliated columnar epithelium rested on a well developed basal lamina Fig. (44). It contained light brown pigmented granules in the basal cell layer of the epithelium and carried sensory hair on the a pieces of the cells. Under the olfactory epithelium, the propria-submucosa was formed of loose connective tissue contained serous glands that opened through the epithelium on the surface. These glands contained also pigment granules Fig. (45). Under the respiratory epithelium, the propria-submucosa was formed of dense irregular connective tissue. In between the propria-submucosae of both sides, a thin layer of bone was found with large cavernous spaces Fig. (42).

Sinus paranasales: Fig. (46,47&48):

The paranasal sinuses in the donkey included: Sinus maxillaris, Sinus frontalis and Sinus sphenopalatinus.

Sinus maxillaris: Fig. (49,50&51):

In the present work, the maxillary sinus is the largest one of the paranasal sinuses. It was nearly quadrilateral, its long axis paralleled to the facial crest. Its average length was about 11.5 cm while the average width varied according to the location; at the level of the medial angle of the eye, it measured about 7.5 cm, while at the level of the rostral end of the facial crest it was about 4.5 cm. The average depth of the maxillary sinus was about 6.5 cm. It was extended from the caudal end of the maxillary tuberosity caudally to about 0.5-1.5 cm caudal to the infra-orbital foramen rostrally. In some cases, it extended rostral to the level of infra-orbital foramen by about 0.5-1.5 cm.

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Regarding the divisions of the maxillary sinus in the donkey there was a variation between the examined cases and even in the same animal from right to left side. In 5 cases there was an oblique septum "septum sinuum maxillarium" divided the maxillary sinus into rostral and caudal portions. In one case the septum was well developed and divided the sinus completely into rostral and caudal maxillary sinuses while in the other four cases the septum was reduced and appeared as a low ventral ridge dividing the sinus incompletely into rostral and caudal parts. This septum was extended from about the middle of the facial crest laterally to about the level of the caudal end of the last cheek tooth medially. In all other cases there was no any septum. The infraorbital canal was divided the caudal part of the maxillary sinus into small medial part and larg lateral one. In ten cases there was a sagittal bony lamella dividing the rostral part of the maxillary sinus into smaller medial part and large lateral one. In some cases, this sagittal asseous lamella extended along the whole length of the maxillary sinus resulting in the division of the caudal part of the maxillary sinus into three portions (medial, intermediate and lateral)" by the infraorbital canal as well as this sagittal bony lamella. Also, there were short transverse and oblique osseous lamellae dividing the maxillary sinus into several cellulae ranging from 18-25 in number. The maxillary sinus was communicated with the middle nasal meatus by the naso maxillary opening «apertura nasomaxillaris » which was located between the sinus parts of the dorsal and ventral nasal conchae. This opening was slit-like and measured bout 2.5 cm length. The rostral part of the maxillary sinus was communicated above the infraorbital canal with the ventral conchal sinus. Also the maxillary sinus was communicated with the frontal sinus caudo dorsally by the frontomaxillary opening "apertura frontomaxillaris" which was round to oval in shape and present in the roof of the caudal part of the maxillary sinus. There was communication with the caudo medial

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part of the maxillary sinus and the middle conchal. The facial crest appeared to divide the maxillary sinus externally into dorsal and ventral parts. The representative outline of the maxillary sinus was determined externally as quadrilateral area drawn by the connection of four points; 1 cm rostral to the rostral end of the facial crest, the infraorbital foramen, the medial angle of the eye and the caudal end of the maxillary tuberosity. The most suitable site for trephining being in the center of this outline.

Sinus frontalis: Fig. (52):

In this work the frontal sinus excavated mainly the frontal bone between its external and internal plates. It was bounded dorsally by the frontal bone, cranioventrally by the ethmoturbinates, caudoventrally by the cranium, ventrolaterally by the medial wall of the orbit and medially by the interfrontal septum. It was trainagular in outline with its base at the median plane and its apex extended into the zygomatic processes of the frontal bone to a point just medial to the supraorbital foramen. The average length of the frontal sinus was about 12 cm, while the greatest width, measured by a line from the apex to the base, was about 6 cm and the maximum height from the roof to the floor of the sinus was about 3 cm. The right and left frontal sinuses were found to be separated from each other by the interfrontal septum (septum sinnuum frontalium).

The frontal sinus was roughly divided by a small bony specules into rostral and caudal divisions. The rostral one was further subdivided by a sagittal bony lamella into small medial and large lateral parts. The caudal, medial rostral and lateral rostral parts of the frontal sinus were freely joined to each other. The lateral rostral part of the frontal sinus was extended in some cases to excavate the caudal part of the nasal bone "about 2-3 cm". The lateral rostral part of the frontal sinus was communicated to the caudal part of the maxillary sinus by the fronto

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maxillary opening and communicated with the caudal part of the dorsal conchal sinus to form the conchofrontal sinus The caudal part of the frontal sinus was irregular at its internal surface due to the presence of a number of bony specules and presence of many diverticulae reaching about (8-10). From these diverticulae, three of them were roofing the orbit rostromedial, medial and cuadomedial to the supraorbital foramen.

The rostral limit of the frontal sinus reached a point leveled with the fifth cheek tooth, while the caudal limit of the sinus reached a point leveled with the tempromandibular joint. The most suitable seat for trephining being 2-3 cm medial to the supraorbital foramen.

Sinus sphenopalatinus:

In the present study, the palatine sinus excavated the perpendicular plate as well as the pyramidal process of the palatine bone. While the sphenoidal sinus excavated the body of the presphenoid and the orbital wing of it. In older cases it was extended caudally to the basisphenoid also. The palatine and sphenoidal sinuses were combined in about 80% of cases to form the sphenopalatine sinus. In the other cases each sinus was presented separately and opened into the ethmoidal meatuses. The sphenopalatine sinus opened in about 90% of cases into the the ethmoidal meatuses while in the rest of cases, it opened into the caudomedial part of the maxillary sinus.

The sphenopalatine sinus was nearly traingular in shape with its base ventrally and the apex just below the optic groove. The most ventral ethmoturbinates were projected in the cavity of the sphenopalatine sinus. The right and left sphenopalatine sinuses were separated by a sagittal bony septum. This sinus was the smallest paranasal sinus in the donkey.

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Fig. (1): A Photograph of The nostrils of the donkey:

- Crescent-shaped nostril (1)
- Normal skin between the nostrils (2)

Fig. (2): A Photograph of The mucocutaneous junction of the nasal cavity of the donkey:

Skin (1), nasal mucous membrane (2), alar fold (3)

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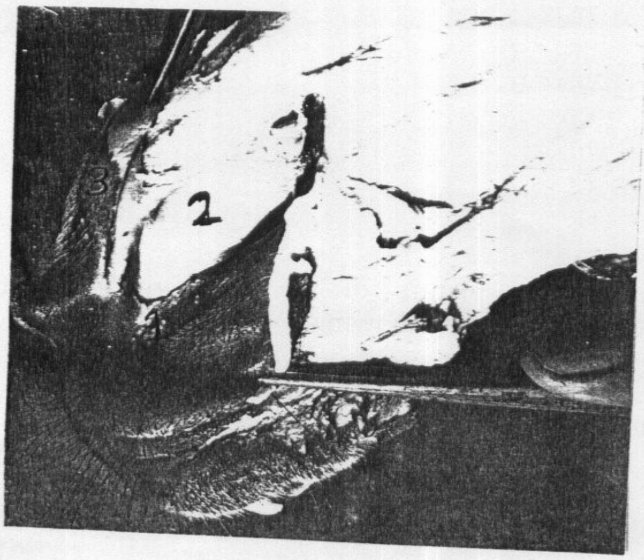

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Fig. (3): Microscopic picture of the cutaneous part of the muco cutaneous junction showing:

Epidermis	(1)
Dermis	(2)
Hair follicle	(3)
Sebaceous gland	(4)
Stain: H & E	X = 100

Fig. (4): Microscopic picture of the cutaneous part of the muco cutaneous junction showing:

Epidermal peg	(1)
Dermal papilla	(2)
Melanin pigment	(3)
Keratine	(4)
Stain: H & E	X = 1000

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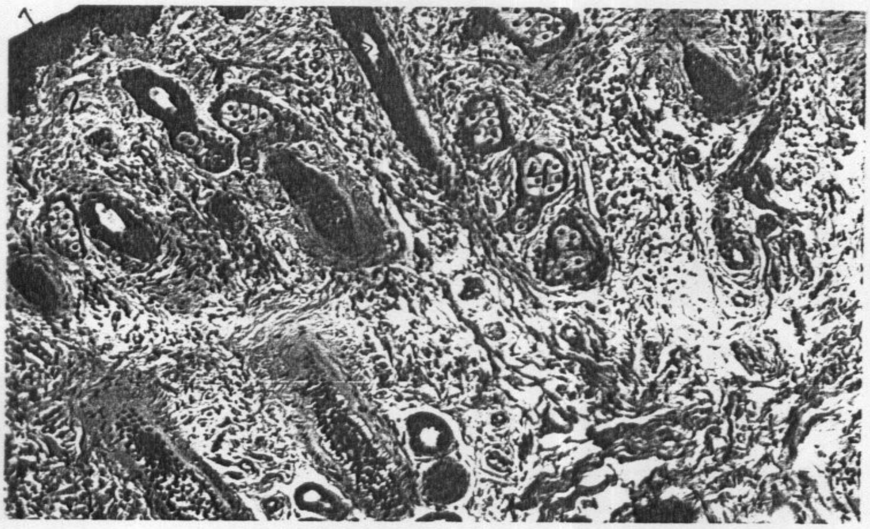

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Fig. (5): Microscopic picture of the cutaneous part of the muco cutaneous junction showing:

Epidermis	(1)	Sebaceous gland	(5)
Dermis	(2)	Sweat gland	(6)
Subcutaneous	(3)	Large artery	(7)
Hair follicle	(4)		
Stain: H & E	X = 40		

Fig. (6): Microscopic picture of the transitional zone of the muco cutaneous junction showing:

Epidermis	(1)	Serous gland	(4)
Dermis	(2)	Striated duct	(5)
Subcutaneous	(3)		
Stain: H & E	X = 100		

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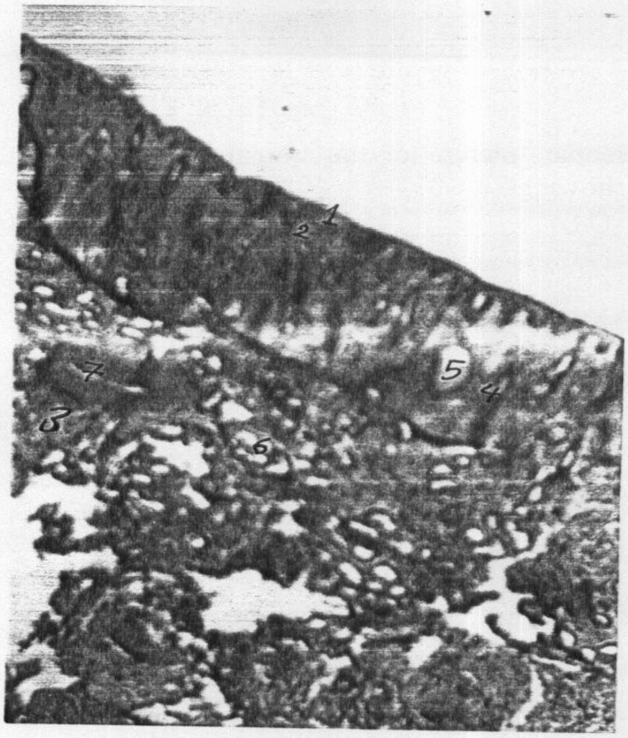

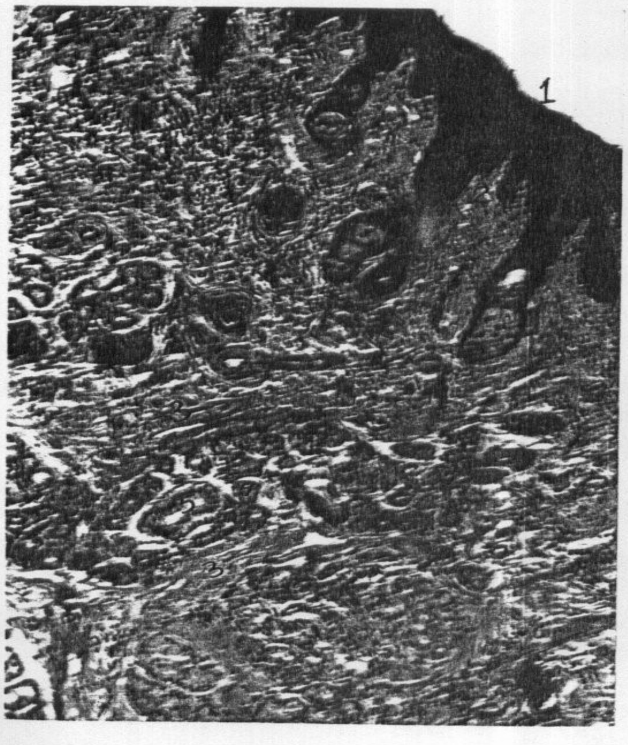

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Fig. (7): Microscopic picture of the transitional zone of the muco cutaneous junction showing:

Epidermis (1)
Epidermal peg (2)
Dermal papilla (3)
Pigment granules (4)
Keratine (5)
Stain: H & E X = 1000

Fig. (8): Microscopic picture of the rostral part of the mucous membrane of the nasal cavity showing:

Epithelium (1)
PAS +ve goblet cell (2)
Stain: PAS X = 1000

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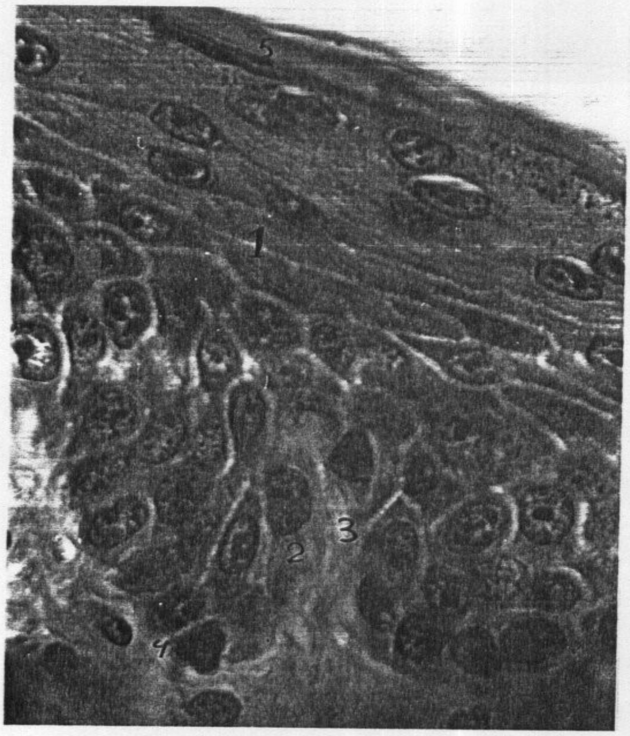

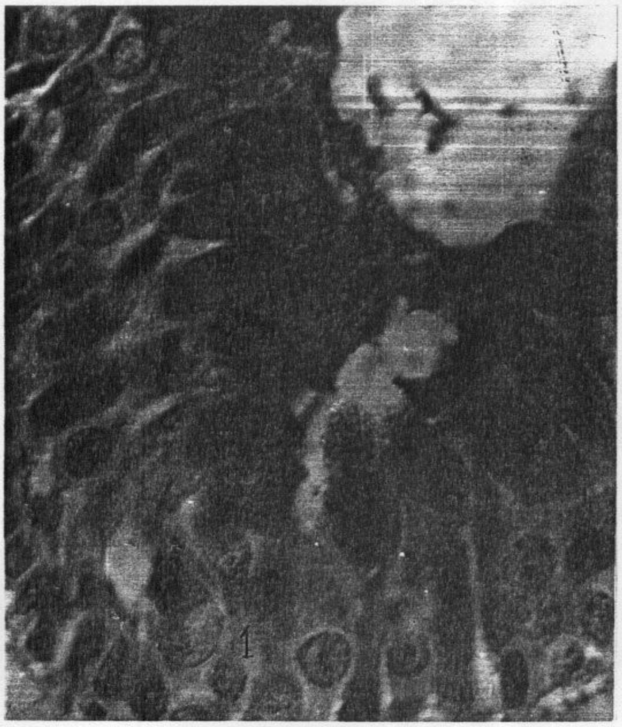

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Fig. (9): Microscopic picture of the mucous membrane of the nasal cavity showing:

Respiratory epithelium (1)
Propria submucosa (2)
Glassy non cellular membrane (3)
PAS +ve goblet cell (4)
Stain: PAS X = 1000

Fig. (10): Microscopic picture of the mucous membrane of the mucocutaneous junction showing:

Epithelium (1)
Gland lobules (2)
Stain: PAS X = 40
Propria submucosa (2)
Connective tissue septa (4)

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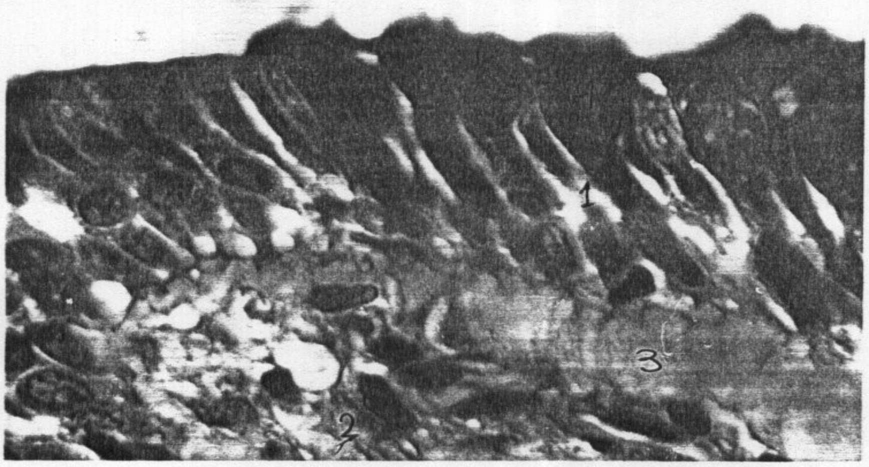

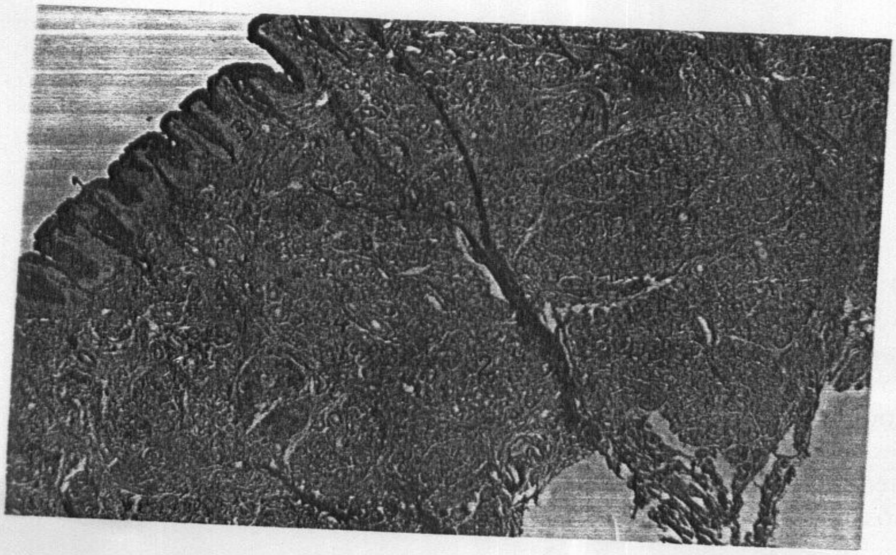

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Fig. (11): Microscopic picture of the mucous part of the muco cutaneous junction showing:

Epithelium	(1)	Glassy non cellular membrane	(4)
Goblet cells	(2)	Elastic fibers	(5)
Propria submucosa	(3)	Serous glands	(6)
Stain: Verhoeff	X = 400		

Fig. (12): Aphotogrph of The nasal diverticulum of the donkey:

- Closed diverticulum (1)
- Caudal limit of the nasoincisive notch (2)
- Caudoventral part of the diverticulum (3)
- Rostrodorsal part of the diverticulum (4)
- Opened diverticulum (5)
- Cutaneous fold (6)
- The nostril (7)

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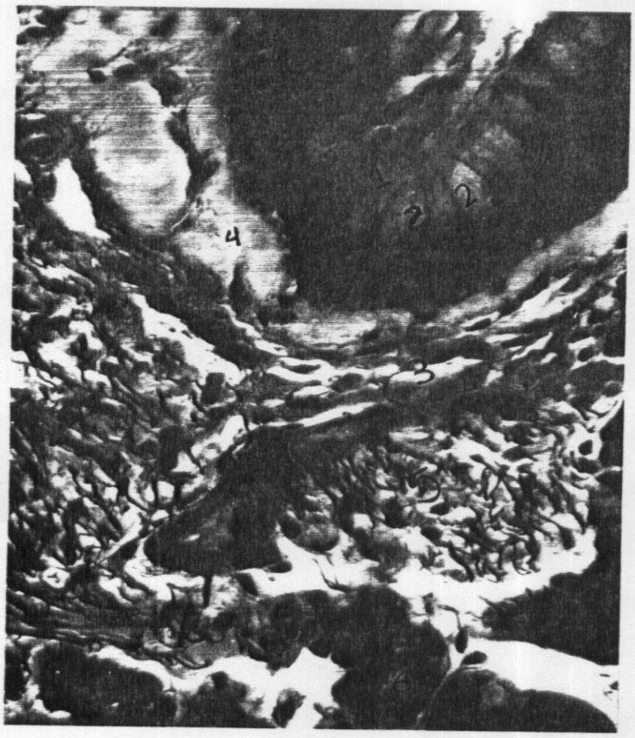

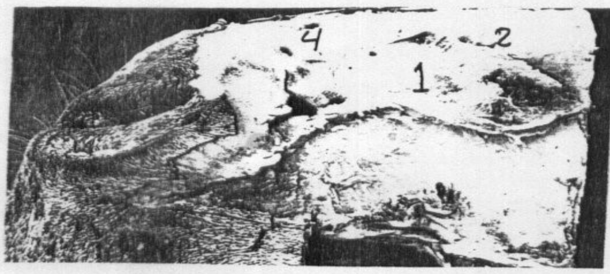

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Fig. (13): Microscopic picture of the nasal diverticulum showing:

Epidermis	(1)	Sebaceous gland	(4)
Dermis	(2)	Sweat gland	(5)
Hair follicle	(3)	Large blood vessel	(6)
Stain: H & E	X = 40		

Fig. (14): Microscopic picture of the nasal diverticulum showing:

Epidermis	(1)
Dermis	(2)
Sebaceous gland	(3)
Sweat gland	(4)
Stain: H & E	X = 100

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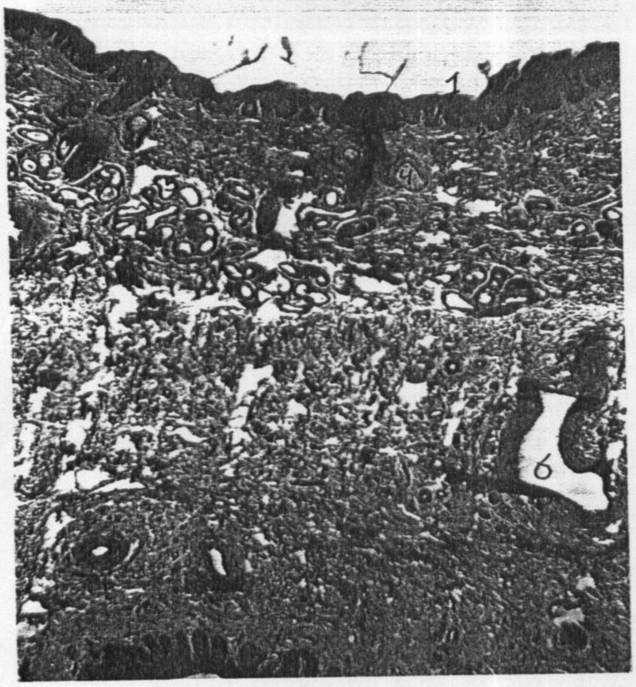

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Fig. (15): Aphotogrph of The nasal cartilages of the donkey:

- Alar cartilage (1)
    - Lamina of alar cartilage (L)
    - Cornu of alar cartilage (c)
- Dorsal lateral nasal cartilage (2)
- medial accessory nasal cartilage (3)

Fig. (16): Aphotogrph of The ventral lateral nasal cartilage:

- The rostral projection of the ventral lateral nasal cartilage (1)
- Ventro lateral nasal cartilage (2)
- Incisive canal (3)
- Palatine process of incisive bone (4)

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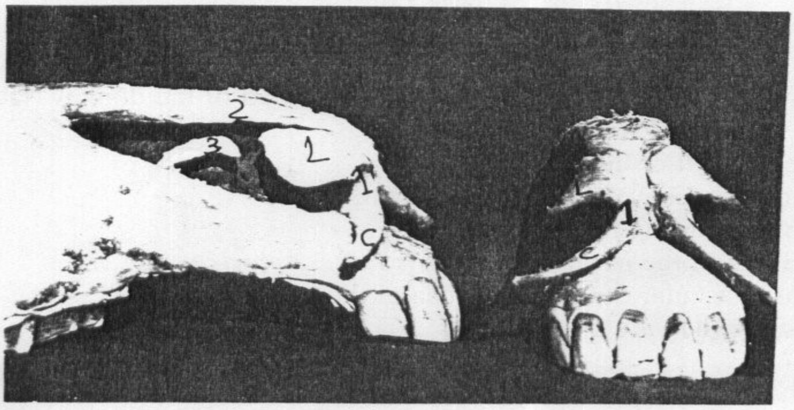

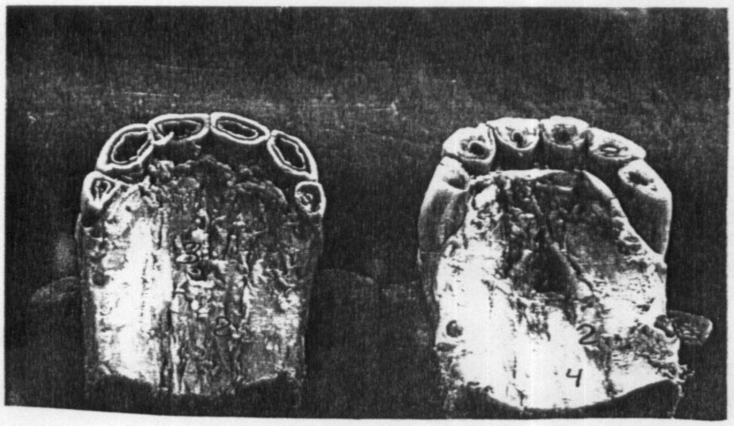

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Fig. (17): Aphotogrph of Sagittal section of the head of the donkey (lateral view) showing:

- The osseous part of the nasal septum (1)
  - Perpendicular plate of ethmoid bone (a)
  - Vomer bone (b)
- The cartilage of the nasal septum (2)
- The highly vascular covering mucosa of the septum (3)
- Frontal sinus (4)
- Choana (5)

Fig. (18): Aphotogrph of Sagittal section of the skull of the donkey (lateral view) showing:

- The osseous part of the nasal septum (1)
  - The perpendicular plate of ethmoid bone (a)
  - The vomer bone (b)
- Dorsal turbinate bone (2)
- Ventral turbinate bone (3)

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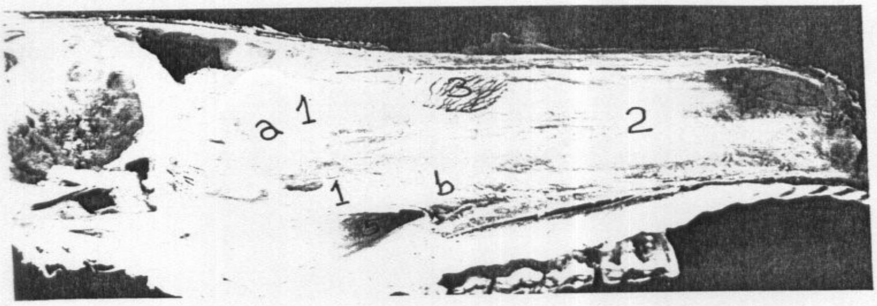

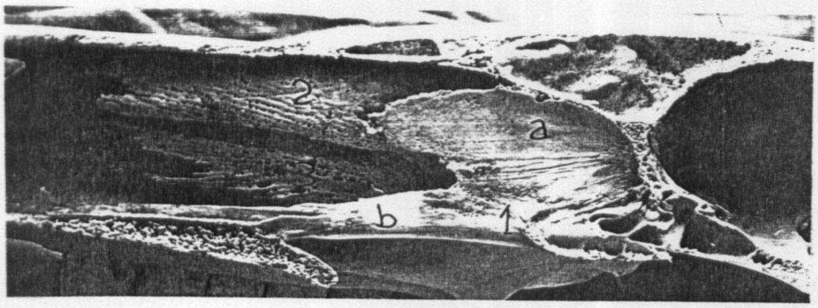

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Fig. (19): Ventrodorsal radiographic of the skull of the donkey ventro dorsally showing:

- The choanae (1)
- The vomer bone (2)

Fig. (20): A photograph of the ventral aspect of the skull of the donkey showing The choana (1) divided by the vomer bone (2)

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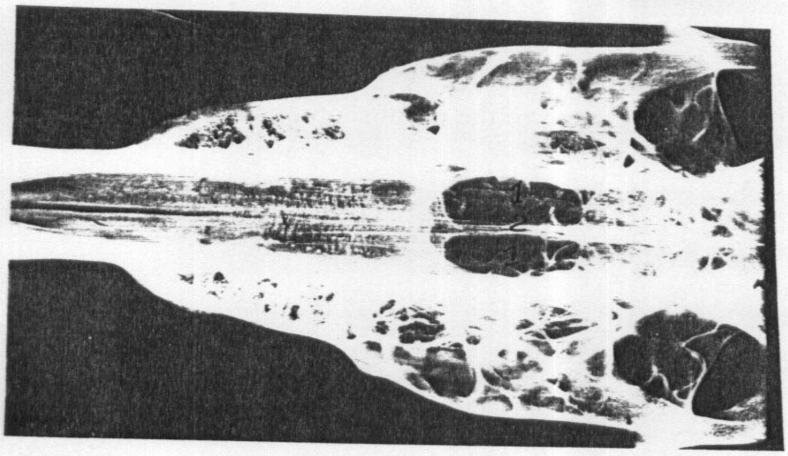

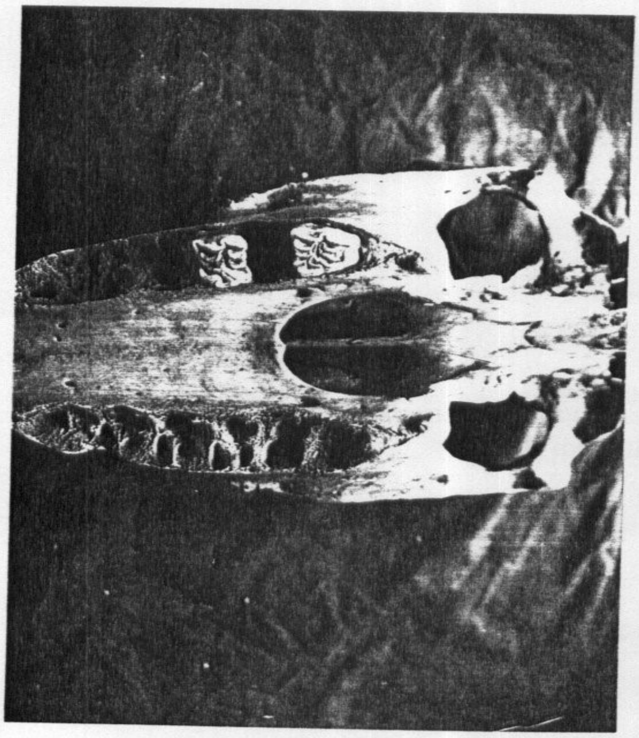

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Fig. (21): Microscopic picture of the nasal septum showing:

epithelium	(1)
Propria submucosa	(2)
Seromucoid glands	(3)
Large artery	(4)
Perichondrium	(5)
Hyaline cartilage	(6)
Stain: PAS	X = 100

Fig. (22): Microscopic picture of the nasal septum showing:

Respiratory epithelium	(1)	Goblet cell	(2)
Propria submucosa	(3)	Seromucoid glands	(5)
Striated duct	(5)	Blood vessels	(6)
Stain: PAS	X = 400		

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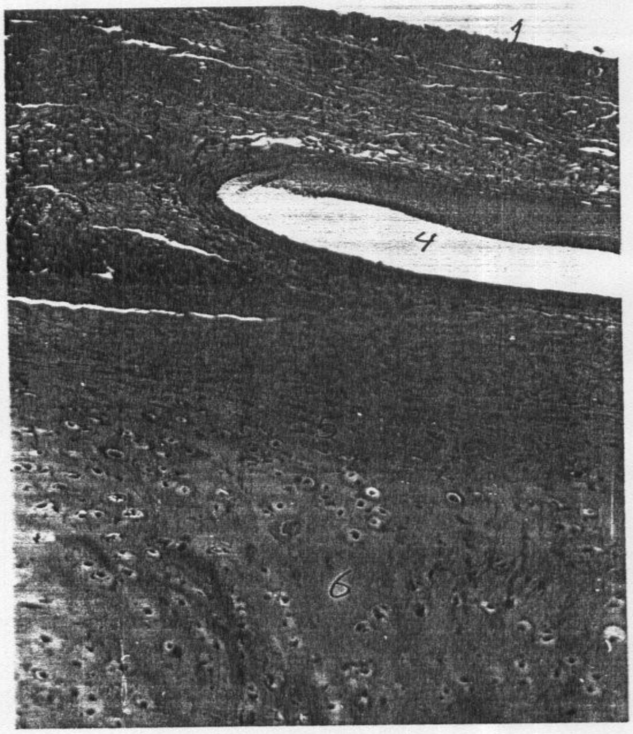

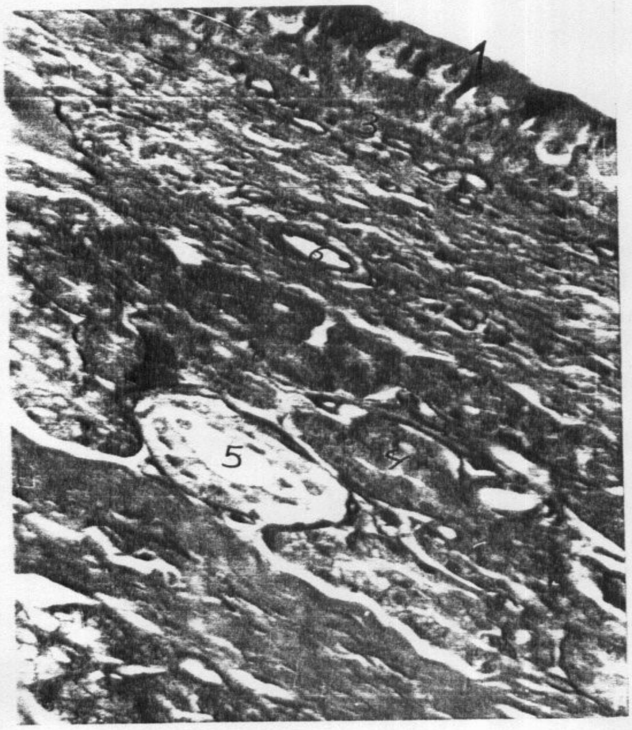

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Fig. (23): Microscopic picture of the nasal septum showing:

Epithelium	(1)	Propria submucosa	(2)
Seromucoid glands	(3)	Elastic fiber	(4)

Stain: Verhoeff X = 100

Fig. (24): A photograph of Sagittal section of the rostral end of the nasal cavity (medial view) showing:

- The vomeronasal organ injected with coloured latex (1)
- Dorsal nasal Concha (2)
- ventral nasal Concha (3)
- The straight fold (4)
- The alar fold (5)
- The basal fold (6)

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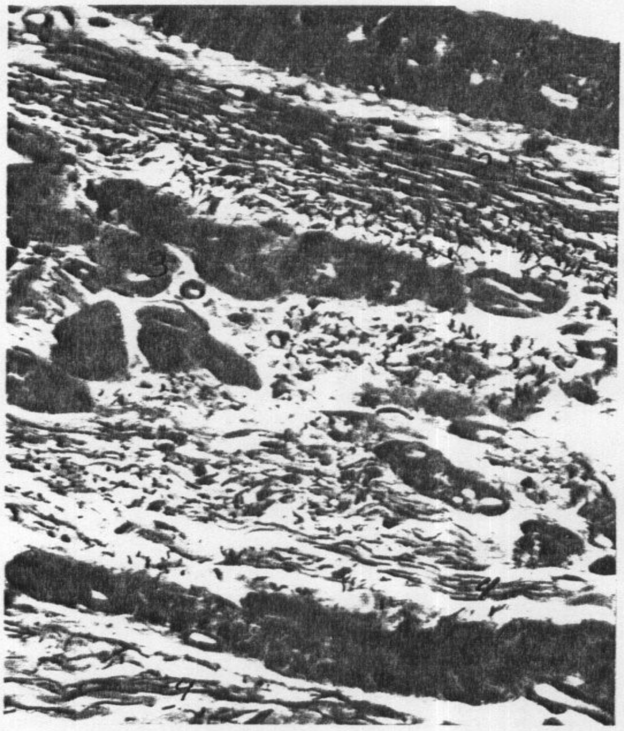

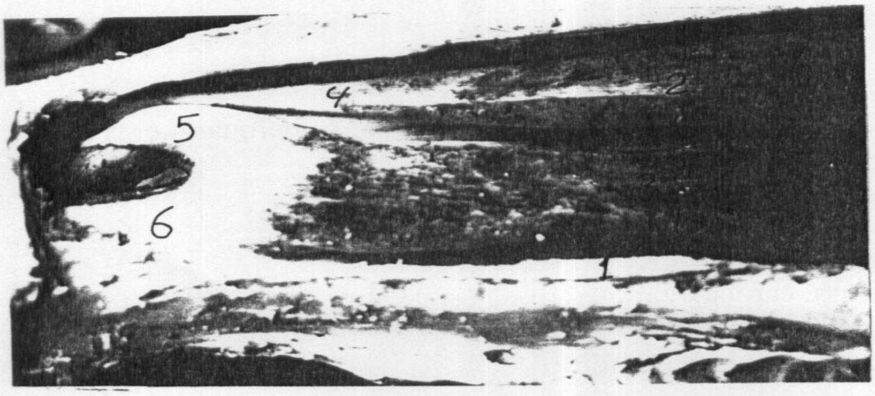

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Fig. (25): A photograph of Sagittal section of the rostral part of the nasal cavity (medial view) showing:

- The vomeronasal organ (1)
- The incisive duct (2)
- Straight fold (3)
- Alar fold (4)
- Basal fold (5)

Fig. (26): Stereo microscopic picture of the vomeronasal organ and the ventral part of the nasal septum showing:

Cartilage of the nasal septum	(1)
Mucous membrane of the septum	(2)
Vomeronasal duct	(3)
Vomeronasal cartilage	(4)

Stain: H & E X = 12

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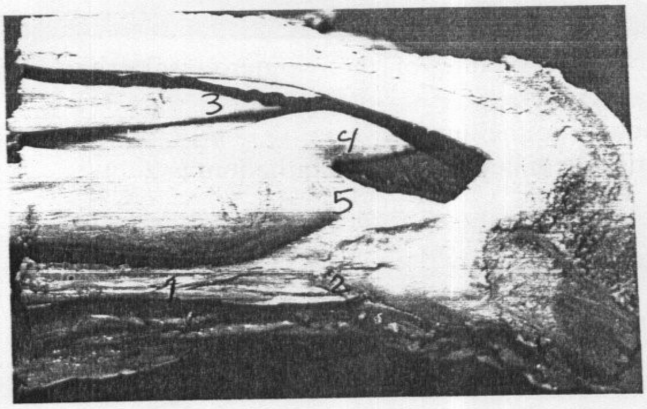

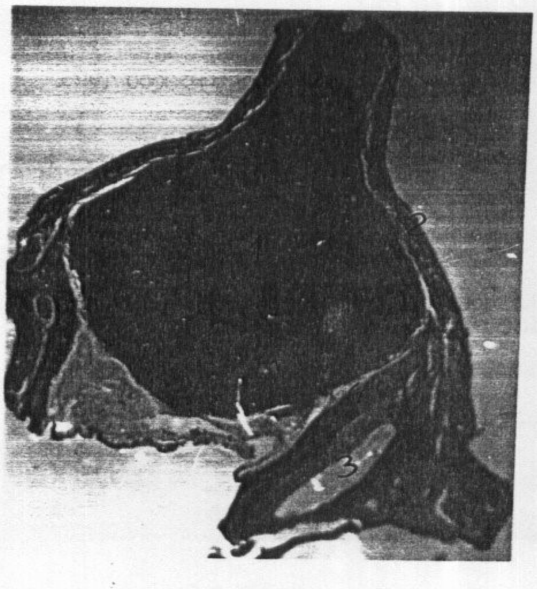

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Fig. (27): Microscopic picture of the vomeronasal organ of the donkey showing:

- Medial olfactory epithelium (1)
- Lateral stratified ciliated columnar epithelium (2)

(Stain H & E, X = 400)

Fig. (28): Microscopic picture of the vomero nasal organ showing:

Vomero nasal cartilage (1)
Vomero nasal duct (2)
Fibers nerve (3)
Dorsal opening of vomero nasal cartilage (4)
Stain: PAS X = 40

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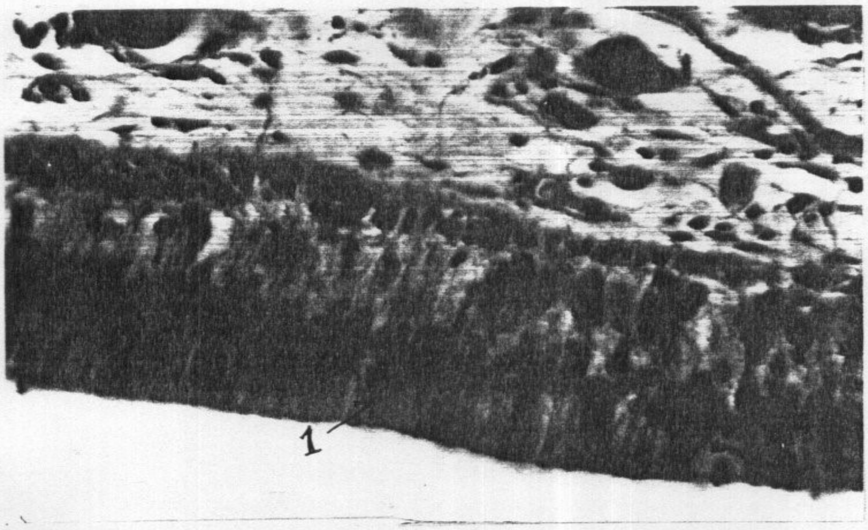

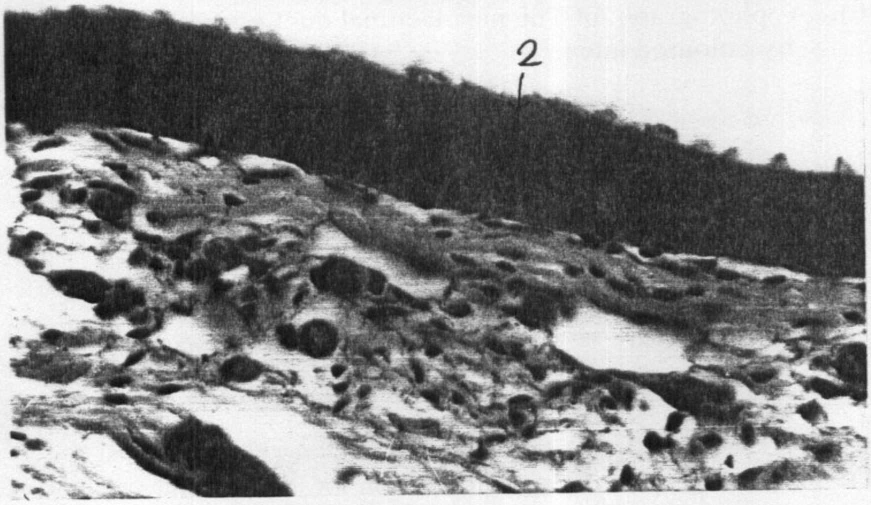

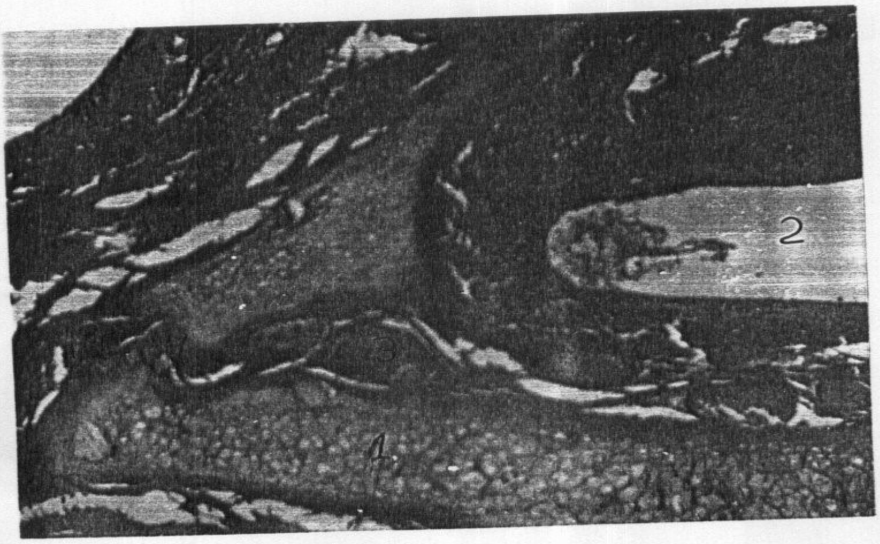

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Fig. (29): Microscopic picture of the vomero nasal organ showing:
Elastic cartilage of the vomero nasal organ (1)
Vomero nasal duct (2)
Stain: Verhoeff X = 40

Fig. (30): A photograph of The nasolacrimal duct of the donkey injected by coloured latex.

Fig. (31): A photograph of Sagittal section of the skull (medial view) showing the course of the nasolacrimal duct.

- Bony lacrimal canal (1)
- Nasolacrimal groove (2)
- Probe introduced inside the nasolacrimal canal (3)

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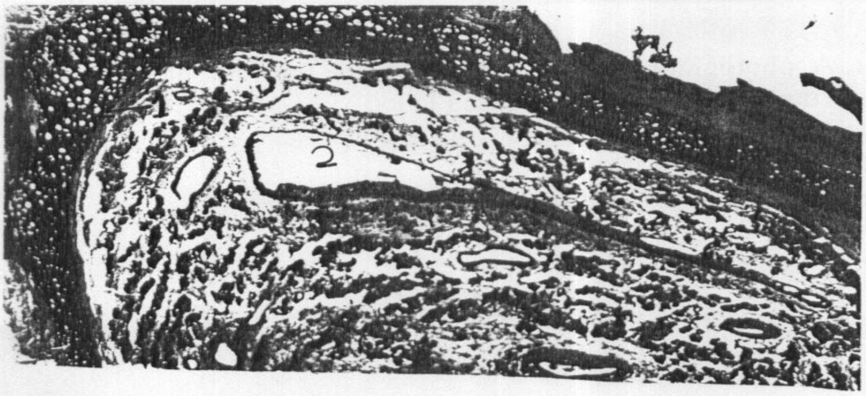

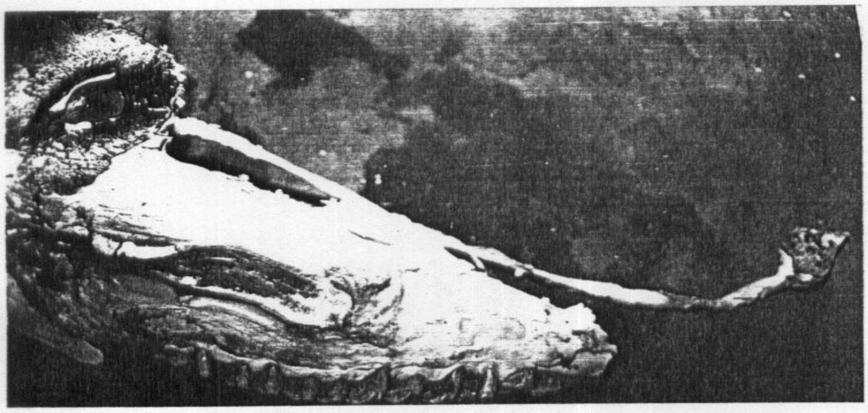

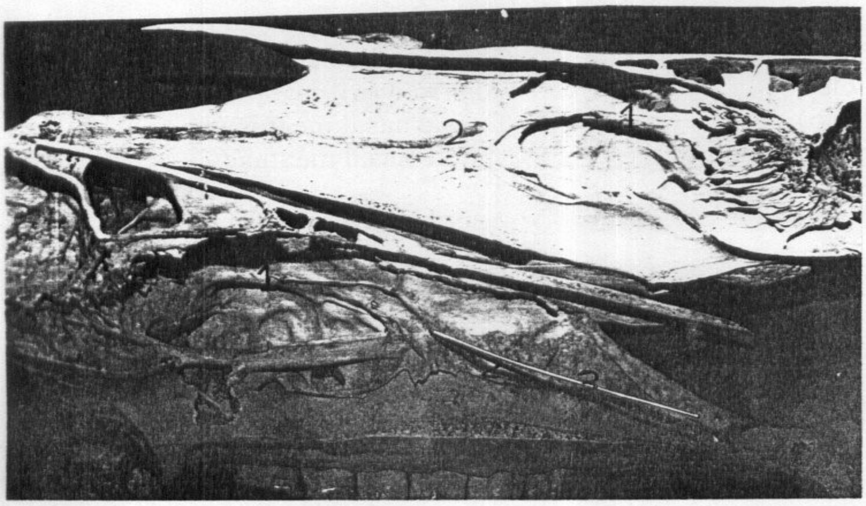

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Fig. (32): A photograph of The course of the nasolacrimal duct of the donkey injected by coloured latex:

- Nasolacrimal duct (1)
- Rostral nasolacrimal orifice (2)
- Vomeronasal organ (3)
- Incisive duct (4)

Fig. (33): Radiographic picture of the nasal cavity of the donkey (lateral view) showing the course of the nasolacrimal duct (1)

Fig. (34): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) showing

- Dorsal nasal concha (d)
- Middle nasal concha (m)
- Straight fold (s)
- Basal fold (b)
- Ventral nasal meatus (3)
- Ventral nasal concha (v)
- Ethmoidal conchae (e)
- Alar fold (a)
- Dorsal nasal meatus (1)
- Middle nasal meatus (2)

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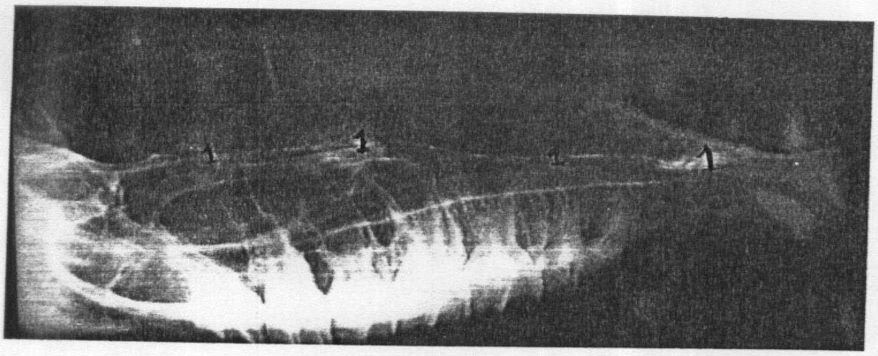

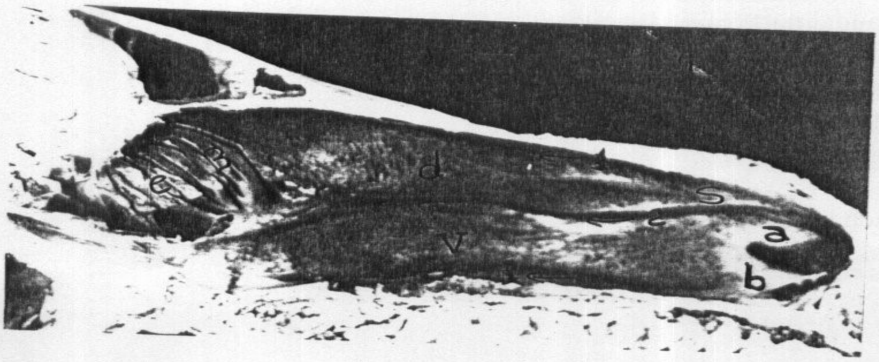

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Fig. (35): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) showing:

- Dorsal conchal sinus (ds)
- Bulla of dorsal nasal concha (1)
- Straight fold (s)
- Partially divided ventral conchal sinus (vs)
- Bulla of the ventral nasal concha (2)
- Alar fold (a)
- Basal fold (b)
- Ethmoidal conchae (e)

Fig. (36): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) showing:

- Dorsal conchal sinus (ds)
- Bulla of dorsal nasal concha (1)
- Recess of dorsal nasal concha (2)
- Straight fold (s)
- Completely divided ventral conchal sinus (vs)
  - Large caudal part (c)
  - Small rostral part (r)
- Bulla of ventral nasal concha (3)
- Recess of ventral nasal concha (4)
- Alar fold (a)
- Basal fold (b)
- Ethmoidal conchae (e)
- Middle conchal sinus (ms)

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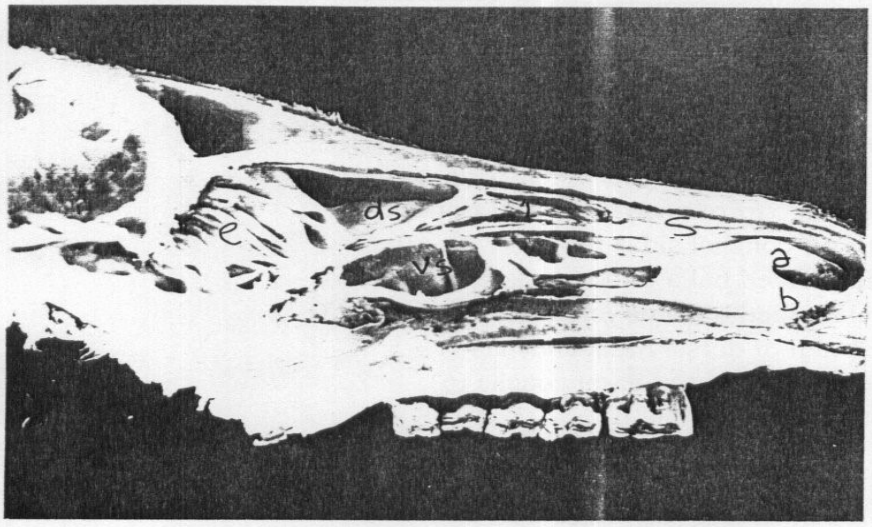

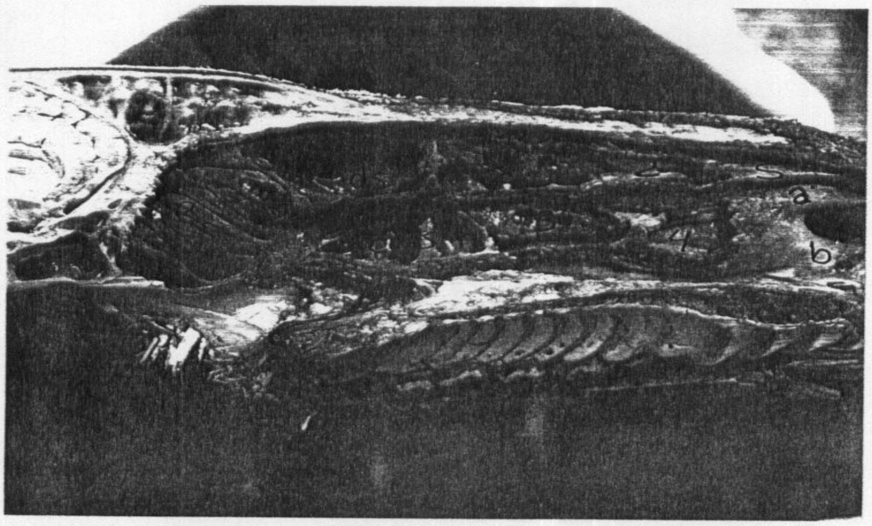

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Fig. (37): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) after removal of the endoturbinates showing:

- 2^{nd} row of ethmoidal conchae (e2)
- Septum of ventral conchal sinus (1)
- Rostral part of ventral conchal sinus (r)
- Caudal part of ventral conchal sinus (c)
- Dorsal conchal sinus (ds)
- Subdivided bulla of dorsal nasal concha (2)
- Subdivided bulla of ventral nasal concha (3)
- Septum of dorsal nasal concha (4)
- Septum of ventral nasal concha (5)
- Ethmoidal meatus (6)

Fig.(38): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) showing:

- The 3^{rd} row of ethmoidal conchae (e3)

Fig. (39): A photograph of Sagittal section of the nasal cavity of the donkey (medial view) showing the fourth row of ethmoidal conchae (e4)

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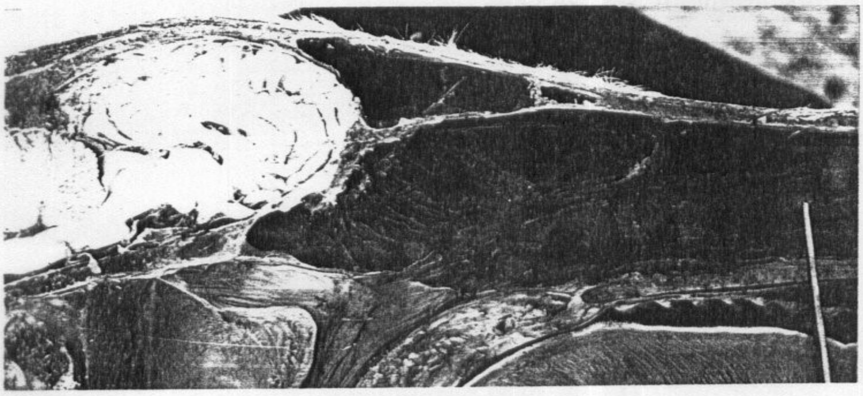

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Fig. (40): Microscopic picture of the nasal concha showing:
Outer epithelium (1)
Inner epithelium (2)
Propria submucosa (3)
Bone (4)
Blood vessel (5)
Stain: H & E X = 40

Fig. (41): A photograph of Microscopic picture of the nasal concha showing:
Outer respiratory epithelium (1)
Inner epithelium (2)
Propria submucosa (3)
Bone (4)
Large blood space (5)
Stain: PAS, X = 400

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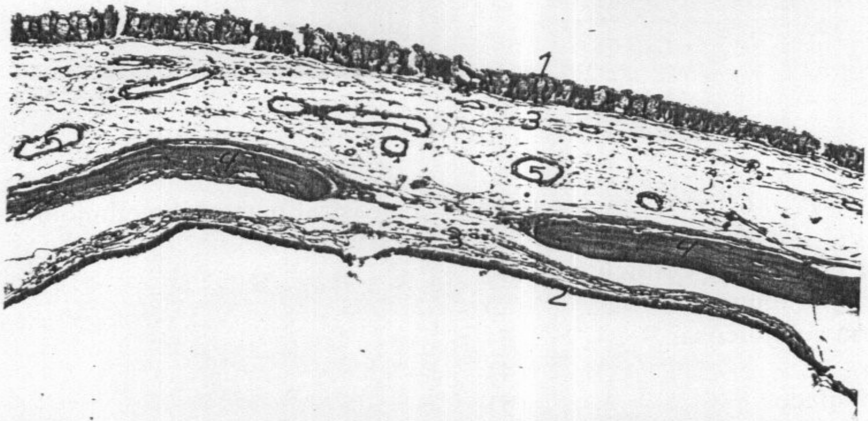

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Fig. (42): Microscopic picture of the rostral part of the ethmoid concha showing:

Outer respiratory epithelium (1)
Inner epithelium (2)
Propria submucosa (3)
Bone (4)
blood space (5)
Stain: H & E X = 400

Fig. (43): Microscopic picture of the caudal part of ethmoid concha showing:

Outer olfactory epithelium (1)
Inner epithelium (2)
Propria submucosa (3)
Serous gland (4)
Nerve fiber (5)
bone (6)
Blood space (7)
Stain: H & E X = 100

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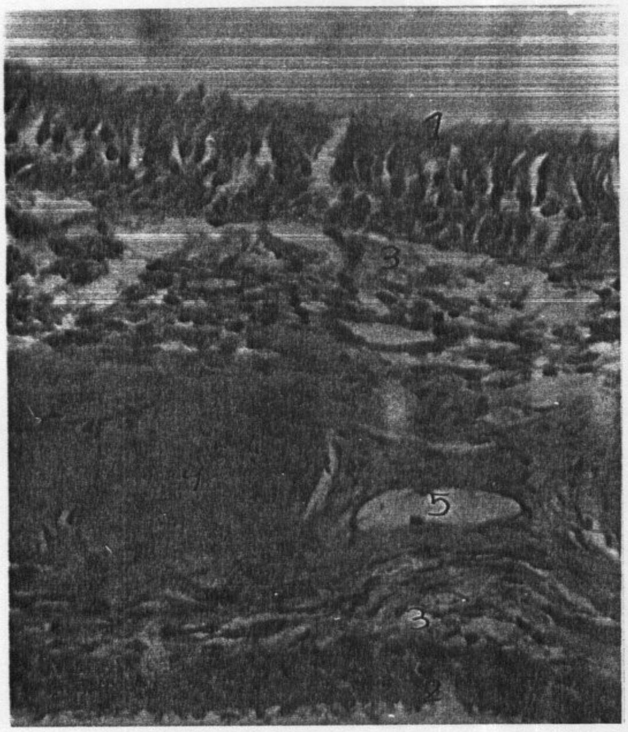

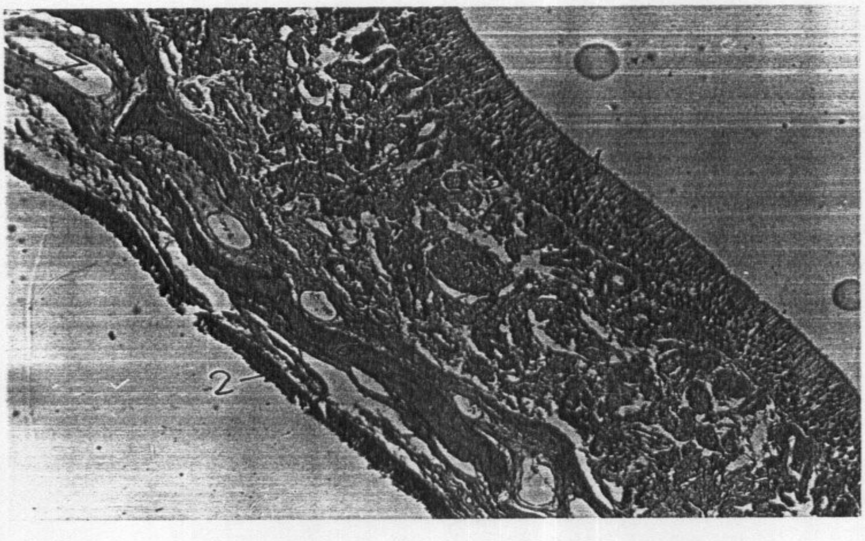

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Fig. (44): Microscopic picture of the caudal part of ethmoidal concha showing:

Olfactory epithelium	(1)
Sensory hair	(2)
Propria submucosa	(3)
Serous gland	(4)
Melanin pigment	(5)
Stain: Trichrome,	X = 400

Fig. (45): Microscopic picture of the caudal part of the ethmoidal concha showing:

Olfactory epithelium	(1)
Melanin pigment	(2)
Propria submucosa	(3)
Serous gland	(4)
Stain: H & E	X = 400

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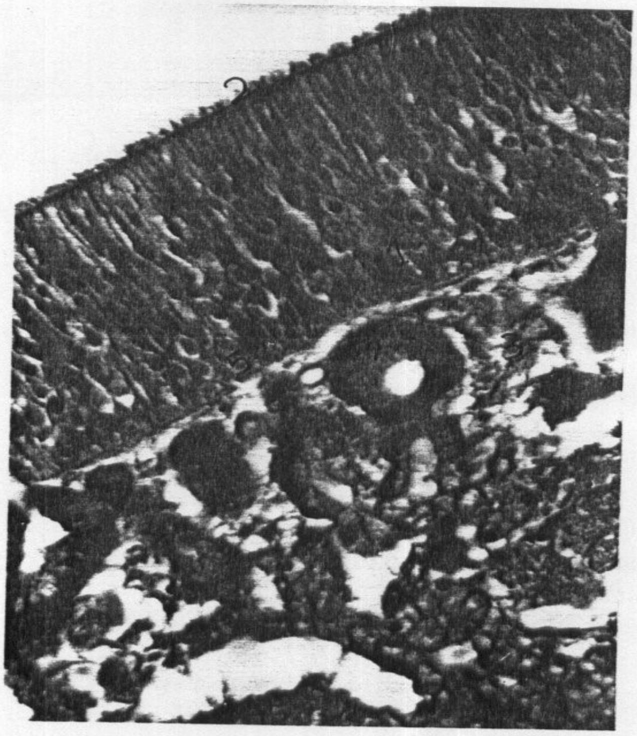

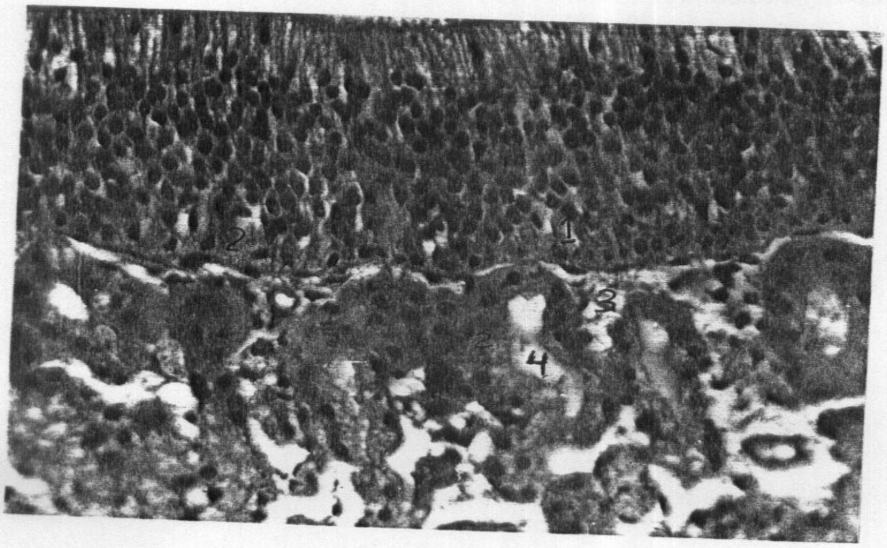

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Fig. (46): A photograph of Coloured silicon cast of the paranasal sinuses of the donkey (medial view):

- Maxillary sinus (green) (m)
- Frontal sinus (red) (f)
- Ventral conchal sinus yellow) (vs)
- Dorsal conchal sinus (brown) (ds)

Fig. (47): A photograph of Coloured silicon cast of the paranasal sinuses of the donkey (lateral view):

- Maxillary sinus (m)
- Frontal sinus (f)

Fig. (48): Radiographic picture of the nasal cavity of the donkey showing the sites of location of the paranasal sinuses (medial view):

- Frontal sinus (f)
- Maxillary sinus (m)
- Nasolacrimal canal (1)
- Sagittal bony lamella (3)
- Conchofrontal sinus (cf)
- Sphenopalatine sinus (sp)
- Infraorbital canal (2)

Fig. (49): A photograph of Lateral view of the maxillary sinus of the donkehy showing:

- latral part of maxillary sinus (1),
- medial part of maxillary sinus (2),
- Sagittal bony lamella (3)
- nasolacrimal duct (4)

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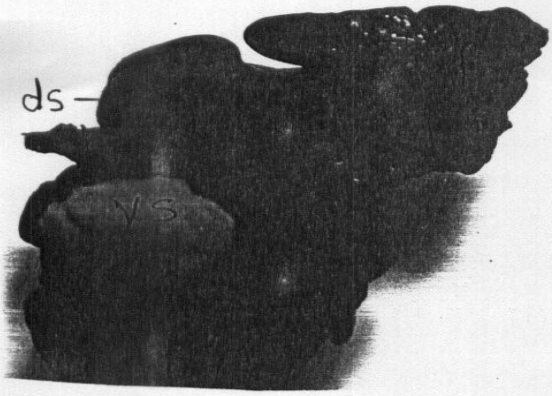

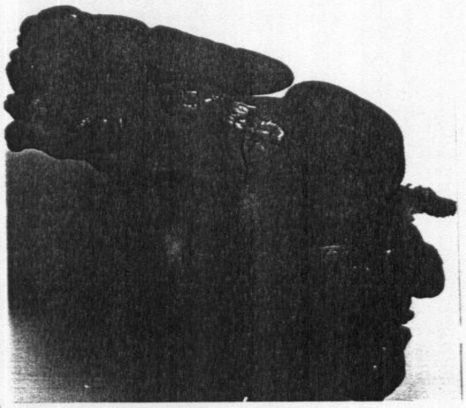

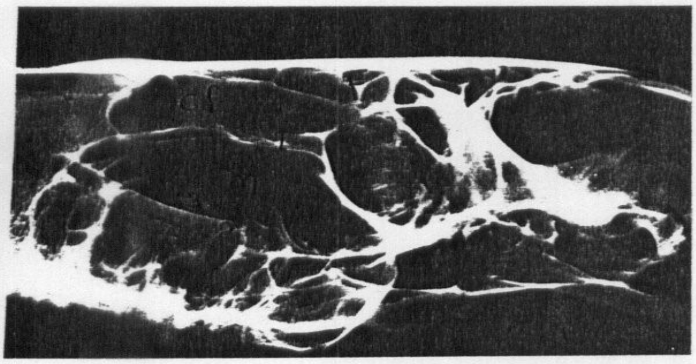

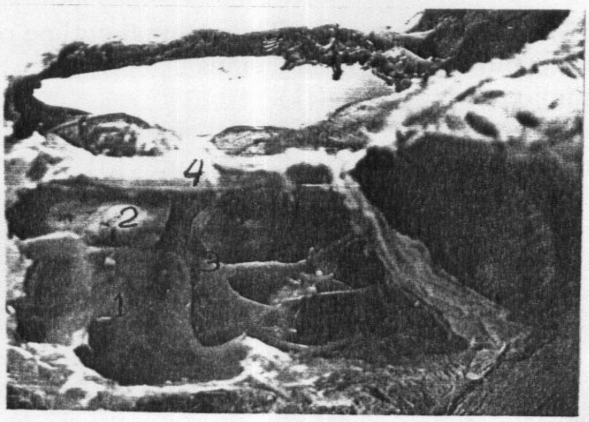

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Fig. (50): A photograph of Dorsal view of the frontal and maxillary sinuses of the donkey showing:

- Frontal sinus (f)
- Maxillary sinus (m)
- Frontomaxillary opening (1)

Fig. (51): A photograph of The external outline of the maxillary sinus of the donkey.

- Facial crest (1)
- Infraorbital foramen (2)
- Medial angle of the eye (3)
- Maxillary tuberosity (4)
- The proper seat for trephining the maxillary sinus (5)

Fig. (52): A photograph of The external outline of the frontal sinus of the donkey and Opened frontal sinus :

- Nasomaxillary opening (1)
- Medial rostral part of the frontal sinus (2)
- Lateral rostral part of the frontal sinus (3)
- Caudal part of the frontal sinus (4)
- Supraorbital foramen (5)
- The proper seat for trephining the frontal sinus (6)

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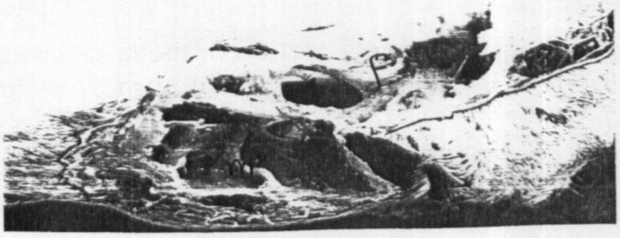

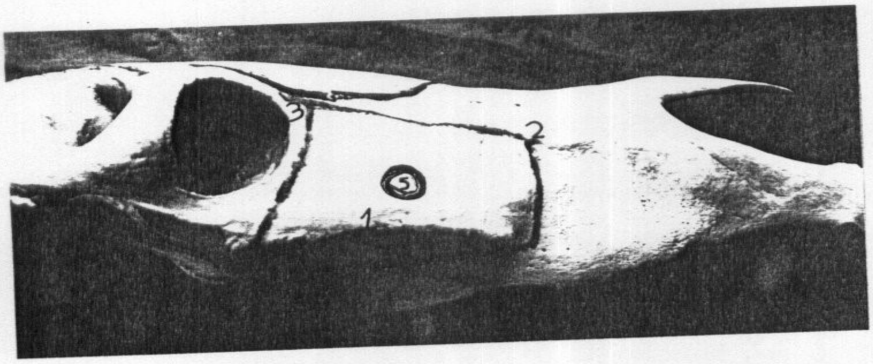

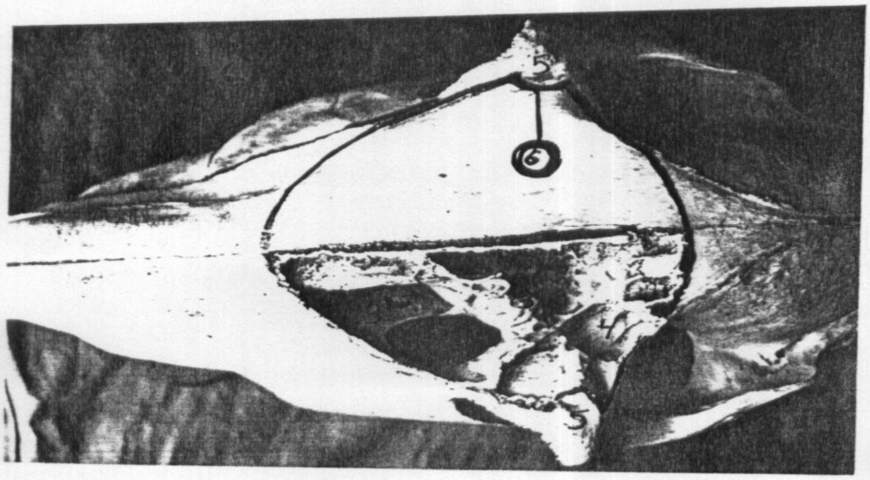

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Fig. (53): A photograph of Transverse section of the nasal cavity at the level of 1 cm caudal to the nostril (A) with its C.T picture (B) (rostral view)

- Alar fold (1)
- Nasal diverticulum (2)
- Nasal septum (3)

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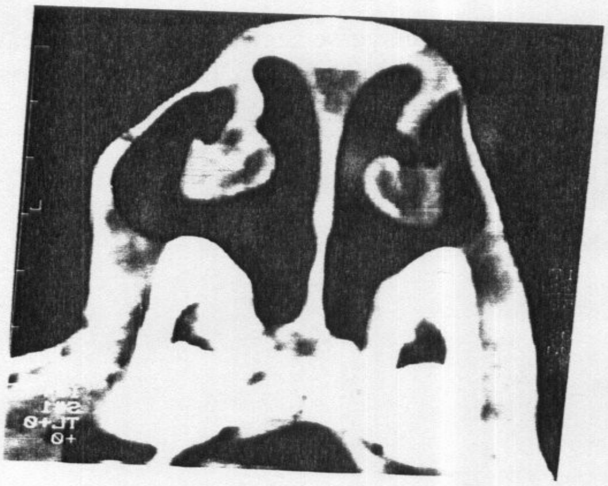

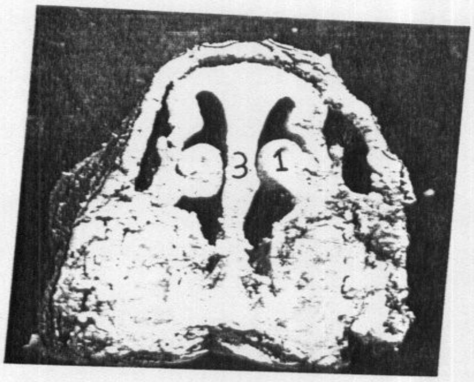

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Fig. (54): A photograph of Transverse section of the nasal cavity at 4 cm caudal to the nostril (A) and its C.T picture (B)(rostral view)

- Ventral nasal concha (vc)
- Recess of ventral nasal concha (1)
- Straight fold of dorsal nasal concha (s)
- Nasal diverticulum (2)
- Nasal septum (3)

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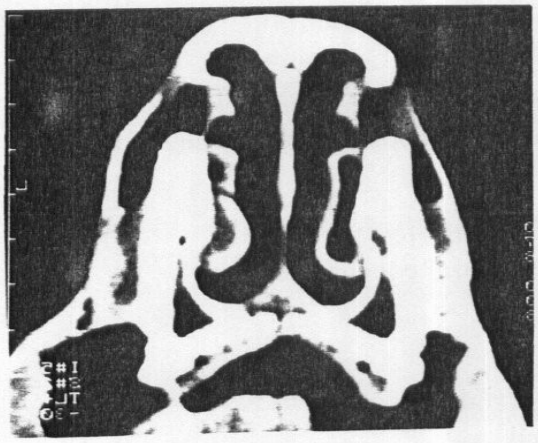

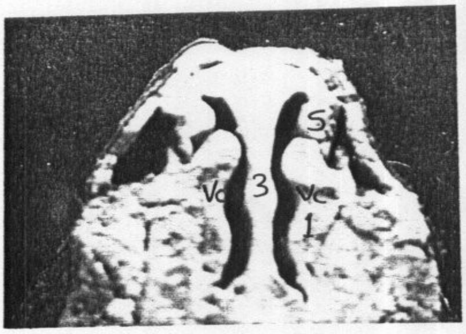

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Fig. (55): A photograph of Transverse section of the nasal cavity of the donkey at 7 cm caudal to the nostril(A) and its C.T picture(B) (rostral view)

- Ventral nasal concha (vc)
- Recess of ventral nasal concha (1)
- Straight fold of dorsal nasal concha (s)
- Nasal diverticulum (2)
- Nasal septum (3)

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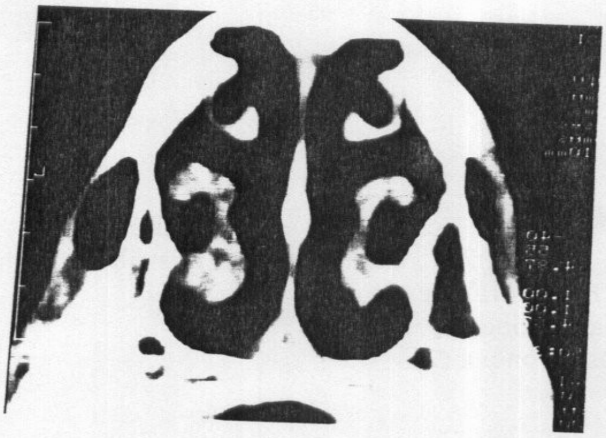

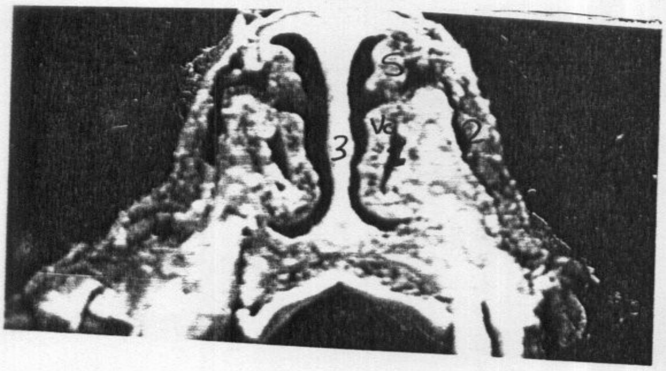

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Fig. (56): A photograph of Transverse section of the nasal cavity of the donkey at 10 cm caudal to the nostril(A) with its C.T picture(B) (rostral view):

- Bulla of ventral nasal concha (1)
- Bulla of dorsal nasal concha (2)
- Nasal septum (3)

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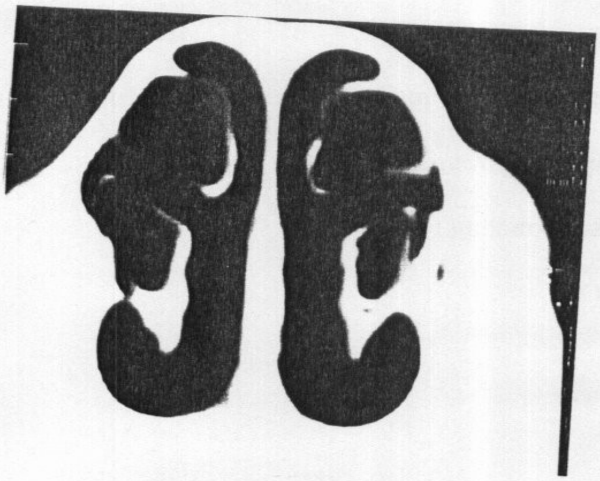

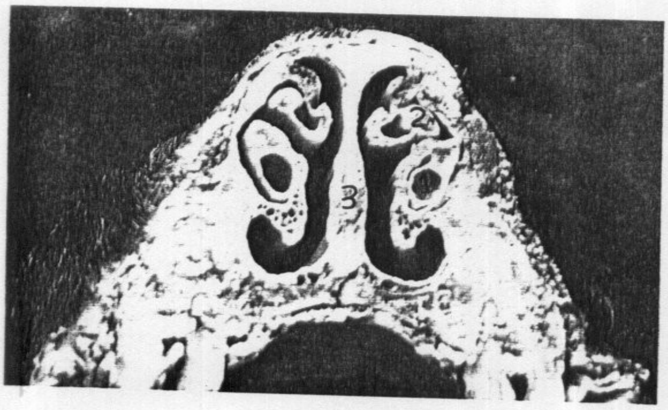

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Fig. (57): A photograph of Transverse section of the nasal cavity of the donkey at 13 cm caudal to the nostril(A) with its C.T picture(B) (rostral view):

- Ventral conchal sinus (vs)
- Bulla of dorsal nasal concha (1)
- Maxillary sinus (m)
- Infraorbital canal (2)

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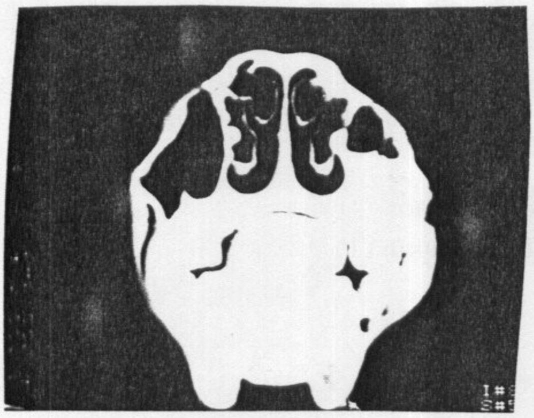

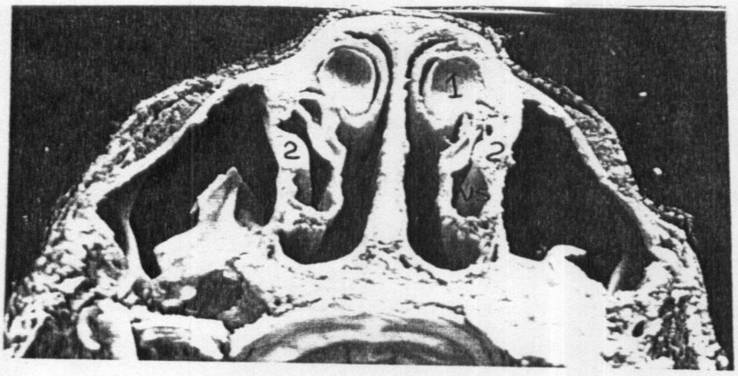

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Fig. (58): A photograph of Transverse section of the nasal cavity of the donkey 16 cm caudal to the nostril(A) with its C.T picture(B) (rostral view)

- Maxillary sinus (m)
- Conchofrontal sinus (cf)
- Incomplete maxillary septum (1)

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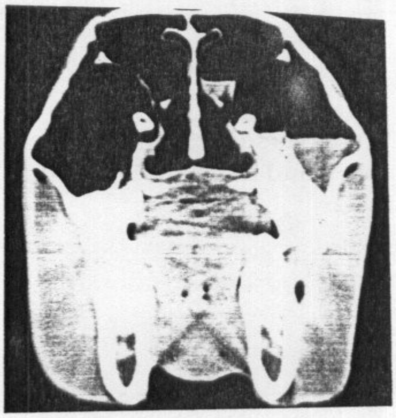

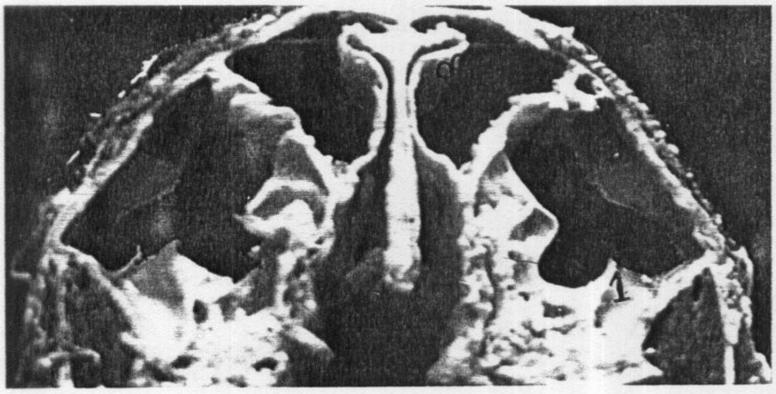

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Fig. (59): A photograph of Transverse section of the nasal cavity of the donkey at 19 cm caudal to the nostril(A) with its C.T picture(B) (rostral view):

- Maxillary sinus (m)
- Frontal sinus (f)
- Medial rostral part (1)
- Lateral rostral part (2)
- Ethmordal conchae (e)

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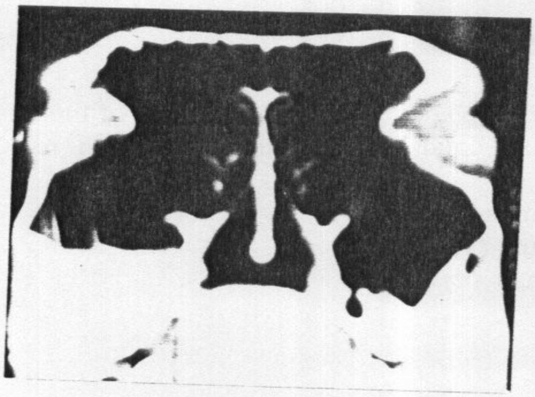

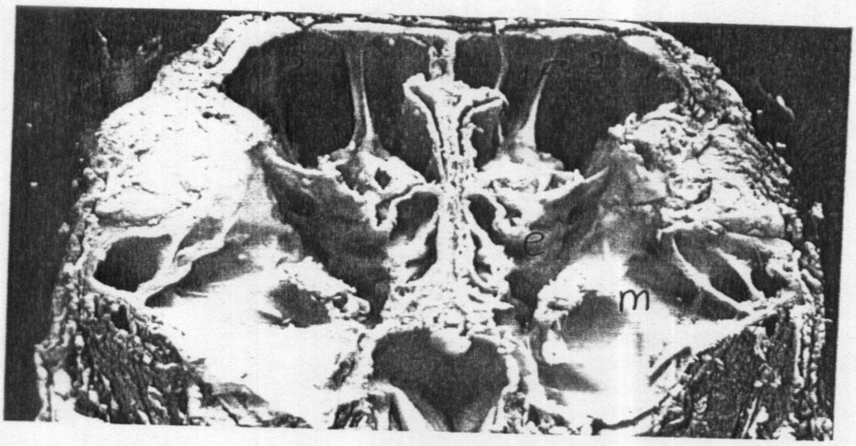

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Fig. (60): A photograph of Transverse section of the nasal cavity of the donkey at 22 cm caudal to the nostril(A) with its C.T. picture(B) (rostral view)

- Caudal frontal sinus (f)
- Interfrontal septum (1)
- Ethmoidal conchae (e)

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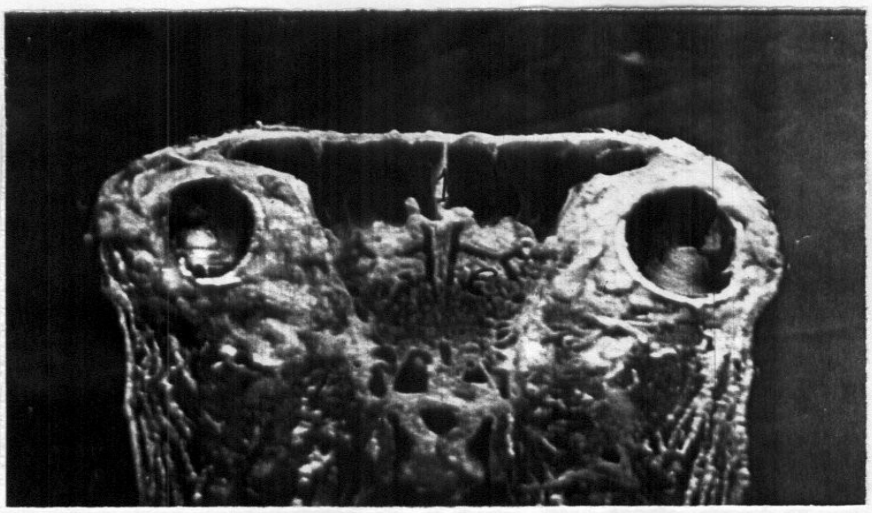

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DISCUSSION

Nostrils (Nares):

Species variations were met with concerning the form, size and the surrounding integument of the nostrils. In the present study the nostrils of the donkey were crescent-shaped (semilunar). Similar to that reported by **Chauveau and Arloing (1891), El-Hagri (1967), Sisson and Grossman (1969) and Schummer *et al.* (1979)** in equines, while in ox the nostrils were oval and in small ruminants were slit like in shape (**Chauveau and Arloing, 1891; Raghavan and Kachroo, 1964, El-Hagri 1967 and Schummer *et al.,* 1979**). In the camel, the nostrils were described by **Badawi and Fath El-Bab, (1974)** as curved slit like. While in the pig, the nostrils were round in shape (**Hare, 1975 and Schummer *et al.,* 1979**).

In donkey as in horse, (**Hare, 1975 and Schummer *et al.,* 1979).** The area surrounding the nostril and between them is covered by normal skin with short hairy interspersed by many tactile hairs . Moreover, In the camel the nostrils were covered by a relatively thin hairy skin (**Badawi and Fath El-Bab, 1974**). While the other domestic animals showed a large difference, where the area between the nostrils is covered by a modified skin and formed the nasolabial plate in the ox (**El-Hagri, 1967; Hare, 1975 and Schummer *et al.*, 1979**) and buffalo (**Abdel Aziz, 1983**) or nasal plates in the small ruminants and dog or rostral plate as in pig (**Hare 1975, and Schummer *et al.,* 1979**).

Our results showed that, the cutaneous area was covered with hairy thin skin contained hair follicle, sebaceous and sweat glands. The presence of hair which connected through its hair follicle with the erector pili muscle, enables the vibrissae to erect properly. The erected vibrissae act

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as a sieve that assist in keeping dust and sand particles a way from the inspired air (**Badawi and Fath El-Bab, 1974**).

The presence of sebaceous glands that opened in the hair follicle play an important role in the defense mechanism, as it secretes sebum which is consisted of accumulated fatty acids, cholesterol, and vitamin "D" precursors. This sebum reduce the possible entry of microorganisms through the skin, diminishes water loss, and keeps the hairs and outer skin surface soft and pliable (**Banks, 1993**).

The presence of sweat glands in the cutaneous portion serve both cooling and excretory function. The secretory product is watery and strongly alkaline in equine and contain albuminoids, serum globulins and some urea (**Banks, 1993**). The serous glands found in the transitional zone of the mucocutaneous junction and in the propria submucosa of the mucous membrane help in keeping the nostrils moistened in hot climatic conditions (**Badawi and Fath El-Bab 1974**), also moisten the air entered the nasal cavity.

The presence of large amount of pigment granules (melanin) in the epidermis responsible for the dark colouration of the skin. This pigment granules decreased in the transitional zone and absent in the mucous membrane.

Dyce *et al.* (1993) added that this area of modified skin is kept moist in the ox, pig and dog a result which not observed in donkey.

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In the present investigation the distance between the dorsal angles of the nostrils was wider than that between the ventral ones. The medial wing of the nostril was supported by the lamina of the alar cartilage while the lateral nasal wing had no support. These results agreed with the results observed by **Hare (1975) and Schummer *et al.* (1979)** in the horse. The absence of support of the lateral nasal wing permits the free movement of it which resulted in widening of the nostril during forcible respiration and increasing the volume of the inspired air. It was also found that the alar fold extended from the caudal border of the lamina of the alar cartilage in a horizontal manner to divide the nostril into narrow dorsal false nostril, leading to the nasal diverticulum, and a ventral wide true nostril leading to the nasal cavity, a result which presented only in equines and absent in other domestic animals.

The form of the nostril may be altered principally by raising the lateral wing actively by certain facial muscles or passively when the air flow is increased in strenuous beraething or when sniffing. These changes can be very pronounced in the donkey leading to compression and almost complete obliteration of the nasal diverticulum. This obliteration of the diverticulum results in great widening of the nostril which needed during stress and running because mouth breathing is impossible. On the other hand, during rest, we supposed that the diverticulum was filled with amount of air extracted from the inspired air to avoid the hyper ventillation of the lung, this amount of air is expelled during the next expiration. The nostril of the donkey became ovoid when dilated while that of the horse becomes rounded "**Schummer *et al.*, 1979**".

Dyce *et al.* (1993) stated that the nasal diverticulum occupies the nasoincisive notch. Whereas in this study we found that the nasal

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diverticulum was extended further caudad beyond the naso incisive notch by about 2.5 cm.

The nasal diverticulum was covered with pigmented skin which had the character of little amount of keratin and decreased number of hair follicles and sebaceous glands which indicate that these part have no role in defense. And the number of hair is so few because it is a blind sac not lead to respiratory passages, but the presence of sweat glands indicate that it have an excretory function.

Nasal cartilages:

In the present work the nasal cartilages in donkey included the dorsal lateral nasal cartilage, the ventral lateral nasal cartilage, the medial accessory nasal cartilage, the alar cartilage as well as the rostoral part of the septal cartilage, similar findings in the horse were mentioned by **El-Hagri (1967), Hare (1975) and Schummer *et al.* (1979)**. Also, the ventral lateral nasal cartilage is weakly developed in equines as mentioned by **Bradley and Grahame (1947), Popvic (1964), El-Hagri (1967), Sisson and Grossman (1969) and Hare (1975)** or may be absent **(Schummer *et al.*, 1979)**. In the donkey, the dorsal and ventral lateral nasal cartilages were illdeveloped. The dorsal lateral nasal cartilage was extended laterally from the dorsal border of the rostral part of the septal cartilage. Its rostral end was connected to the medial border of the lamina of the alar cartilage by a fibrous tissue, while the caudal part was overlapped dorsally by the nasal bone. The division of the dorsal lateral nasal cartilage by the fissure in the ox and by a transverse groove in the pig **(El-Hagri, 1967; Hare 1975 and Schummer *et al.*, 1979)** into a rostral part and caudal one was not observed in this study. Also, the communication between the dorsal lateral nasal cartilage and the ventral

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lateral nasal cartilage which present in the ruminant, pig and dog, was found to be absent in the donkey. The ventral lateral nasal cartilage was thick and narrow in the donkey, it extended from the ventral border of the rostral part of the septal cartilage and filled the palatine fissure.

In donkey, the medial accessory nasal cartilage was well developed while the lateral accessory was absent. The medial accessory nasal cartilage was be hock-shaped and considered the rostoral continuation of the cartilaginous basal lamella of the ventral nasal concha. It was embedded in the alar fold and supported it, this result was not differed largely from the findings in the horse where the medial accessory nasal cartilage is well developed and S-shaped (**Hare, 1975; and Schummer *et al.,* 1979),** while in other domestic animals it was greatly differed, it was more extensive, irregularly quadrilateral in shape and continued with the ventral nasal concha, ventral lateral nasal cartilage and the ventral projection of the nasal septum in ruminants (**Popvic, 1964; El-Hagri 1967; Hare 1975 and Schummer *et al.* 1979**). This is in accordance with the statement of **Abdel Aziz (1983)** in the buffalo. However, **Hare (1975), and Schummer *et al.* (1979)** in the pig and dog **Badawi and Fath El-Bab (1974)** in the camel stated that the medial accessory nasal cartilage was small and embedded within the alar fold.

Concerning the alar cartilage, it was characteristic for the equine and found to be comma shaped in the donkey and gave a cartilaginous support to the nostril dorsally, medially and ventrally. It was connected to its fellow by a fibrous tissue and with the rostral end of the septal cartilage by a synovial joint, the movement of this joint is required for the widening of the nostril. The same findings were presented in the horse as mentioned by **Schummer *et al.* (1979)** who also stated that the connection between

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the alar cartilage and the rostral end of the septal cartilage may be through a fibrous tissue or trough a synovial joint. In ox, the rostoral part of the dorsal lateral nasal cartilage as mentioned by **El-Hagri (1967) and Schummer *et al.* (1979)** was considered as alar cartilage as mentioned by **Sisson and Grossman (1969).** Moreover, **Abdel-Aziz (1983)** described a separate alar cartilage in buffalo. The development and arrangement of the nasal cartilage made the nostrils of donkeys more pliable and dilatable, while they were most rigid in the other species specially in the pig. Nostril dilatation is advantageous when more air is required as in running and in situations in which breathing is not done through the mouth as in the case of equines. So it appeared that the dilatable nostrils are functional adaptation in equines.

Nasal septum:

Similar to other domestic animals. The nasal septum of the donkey was composed of a cartilaginous part and an osseous part. The latter was formed from the vomer bone and the perpendicular plate of the ethmoid bone. It was completely dividing the nasal cavity into two similar halves from the nostril rostrally to the choana caudally. This result agreed with that of the horse (**Hare, 1975; Schummer *et al.*, 1979 and Dyce *et al.*, 1993**), buffalo (**Abdel Aziz, 1983**) and camel (**Badawi and Fath El-Bab, 1974**). The size of the perpendicular plate of the ethmoid bone, as presented in the current study, differed in relation with the age, and this was due to the ossification of the caudo middle part of the septal cartilage. The latter statement agreed with the report of **Hare (1975)** in domestic animals. Furthermore, **Abdel Aziz (1983)** pointed to the usage of the extension of the rostral end of the perpendicular plate of ethmoid bone as a guide for age identification of the buffalo.

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In, the donkey, the nasal septum was covered on either side with respiratory epithelium under it propria submucosa contained seromucoid glands which play a role in moistening. The nasal cavity epithelium and air in hot climate. The cartilage in closed between the above mentioned layers was hyaline with some elastic fibers indicate little mobility in the free end of the nasal septum. The presence of large blood vessels wand cavernous spaces that worming the air in the cold weather.

The vomeronasal organ:

In the present study, the vomeronasal organ was a paired tubulo cartilaginous structure presented under the mucous membrane of the floor of the nasal cavity on both sides of the nasal septum. It was communicated with the incisive duct which was blind orally, therefore, the organ communicated indirectly with the nasal cavity only and not communicated with the oral cavity. These results simulated the findings in the horse **(Bradley and Grahame, 1947, El-Hagri, 1967; Hare, 1975 and Schummed *et al.*, 1979)** and camel **(Badawi and Fath El-Bab, 1974)** and disagreed with the findings in other domestic animals in which the vomeronasal organ was communicated with the oral cavity through the incisive duct which opened into the oral cavity **(Hare, 1975 and Schummer *et al.*, 1779)**.

The caudal blind end of the vomeronasal organ leveled with the second cheek tooth while it leveled with the second to fourth cheek tooth in the horse **(Bradly and Grahame, 1947, Hare, 1975 and Schummer *et al.*, 1979)**, **Frewien, 1972,** stated that the caudal end of the vomeronasal organ extended to 2 cm rostral to the first cheek tooth in ox, and to the level of the fourth cheek tooth in sheep, second cheek tooth in goat, first premolar in foal and cat, third cheek tooth in dog and third incisor in the

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pig. Regarding the length of the vomeronasal organ, species variation was observed (Table 1).

Table (1): Showing the variation in the length of the vomeronasal organ in different species.

Animal	Length	Reference
Donkey	9-13 cm	Present study
Horse	15-20 cm	Hare, 1975 and Schummer *et al.*, 1979
Ox	15-20 cm	Schummer *et al.*, 1979
Buffalo	13-26 cm	Abdel-Aziz, 1983
Sheep	7 cm	Hare, 1975
Goat	6-7 cm	Gharib *et al.*, 1983
Camel	19 cm	Badawi and Fath El-Bab, 1974
Pig	2 cm	Schummer *et al.*, 1979
Dog	2-3 cm	Hare, 1975

The vomeronasal duct in the donkey was enclosed in the vomeronasal cartilage along its whole length except at its extremities. This result resembled that reported by **Lindsay *et al.* (1978)** in donkey and horse. The vomeronasal cartilage in the donkey was found to be elastic in type. This result is in contrast with that of **Lindsay *et al.* (1978) and Dellman and Brown (1992),** in the donkey, horse and in domestic animals, who mentioned that the vomeronasal cartilage was hyaline in type. In the current study, the lining epithelium of the vomeronasal duct was olfactory type medially and pseudostratified ciliated columnar to stratified ciliated columnar laterally, this is in great resemblance with the **Trautmann and Fiebiger (1957)** in the domestic animals, **Filotto and**

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Vigo (1957) in equines and bovines, **Lindsay *et al.* (1978)** in donkey and horse and **Dellmann and Brown (1992)** in domestic animals. The glands were found to be concentrated in the propria submucosa of the lateral side of the duct and were mainly serous or seromucoid in nature, this agreed with the results of **Lindsay *et al.* (1978)** in donkey and horse but differed from that of **Dellmann and Brown (1992)** in domestic animals who stated that these glands were mucous in nature or seromucoid.

The function of the vomeronasal organ has been the subject of considerable speculation **Read (1908)** described it as being closely related to the olfaction. **Negus (1956)** in the dog stated that the most likely function of the organ is related to the after smell of the food rather than to its immediate detection and associated with the secretion of gastric juice is possible. **Arey (1971)** recorded that this organ is not functional in man, yet, in many tetrapods it evidently constitute a supplementary olfactory apparatus. **Lindsay *et al.* (1978)** in the donkey and horse stated that, the possible function of the vomeronasal organ is related to the sexual behaviour. **Schummer *et al.* (1979)** added that this organ performs a special olfactory functions notably the investigation of urinary pheromones. This seems to be related to the "Flehmen" reaction, a peculiar sustained retraction of the upper lip.

Incisive duct:

The present study revealed that the incisive duct was very short duct 0.5 cm length enclosed in a cartilaginous prolongation from the ventral lateral nasal cartilage. The basal opening was a slight like and located in the floor of the nasal cavity 0.5 cm rostral to the canine tooth while the oral end of the duct was blind under the mucous membrane of the hard palate. Moreover, the vomeronasal duct opened into the incisive duct.

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These results were in a line with that mentioned by **Chauveau and Arloing (1891), Bradley and Grahame (1947), El-Hagri (1967), Hare (1975) and Schummer *et al.* (1979)** in the horse and **Badawi and Fath El-Bab (1974)** in the camel. While in other species, the incisive duct opened into the oral cavity on both sides of the incisive papilla (**Hare, 1975 and Schummer *et al.*, 1979**).

The nasolacrimal duct:

The present study showed that the nasolacrimal duct of the donkey was about 25 cm length and extended from the nasolacrimal sac to the rostral opening of the nasolacrimal duct. The course of the nasolacrimal duct included three parts, firstly, it coursed inside the lacrimal canal which located in the medial wall of the lacrimal and maxillary bones, and then in the nasolacrimal groove of the maxillary bone in which it was supported by a plate of cartilage, lastly it coursed on the lateral surface of the ventral nasal concha and its basal fold in which it was covered by the nasal mucous membrane only. So, the course of the nasolacrimal duct included osseous part, cartilaginous part and membranous part. These results were in great similarity to the findings in the donkey, **Said *et al.*, 1977 and Taha, 1990),** in the mule **(Ebeid, 1985)** and horse, **(Diesem, 1975 and Latimer *et al.*, 1984)**.

The osseous part was extended in the donkey along the lacrimal and maxillary bones. This agreed with the findings of **Taha (1990)** in the donkey who also mentioned that this part extends along the lacrimal bone only in the buffalo and camel.

We found that the osseous part of the course of the nasolacrimal duct in the donkey ran between the maxillary and frontal sinuses

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bordering, the frontomaxillary opening laterally, but **Taha (1990)** mentioned that this part runs in the maxillary sinus bordering the concho frontal sinus while **Diesem (1975)** in the horse stated that it runs in the frontal sinus.

The presence of the nasolacrimal duct between the frontal and maxillary sinus laterally has a clinical importance, since the duct may be injured during the dorsal trephination of the maxillary sinus.

In the donkey, the nasolacrimal opening was located dorsally, in the medial surface of the lateral nasal wing just below the dorsal nasal angle this fact agreed with the statement of **Chauveau and Arloing (1891)** in the ass and mule and **Smallwood (1992)** in the donkey The situation of the rostral nasolacrimal opening was differed in other domestic animals, in the horse it is present in the floor of the nasal vestibule at or near to the mucocutaneous junction while in ruminants it is present on the ventromedial aspect of the alar fold, as stated by **Sisson and Grossman (1969), Hare (1975), Schummer *et al.* (1979) and Smallwood (1992)**. So, the back flushing of the nasolacrimal duct in equines is more easier and available than that in ruminants.

Nasal conchae:

In general, the nasal conchae in the donkey had a highest degree of vascular complexity of their mucous membrane. This structural accommodation may be needed by such animal which adapted for hard working and running. In this respect **Scott (1954)** in horse, sheep, dog, deer, kangaroo, lemur and new world monkey and **Negus (1958)** in the dog correlated the surface area of the nasal conchae to the efficiency of temperature and moisture regulation by the nasal cavity. The tapering

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shape of the dorsal nasal conchae at it's rostral end and the widest caudal end in the donkey was similar to that found in the horse due to the small size of the middle nasal concha which occupied only the caudal part of the nasal cavity (**Bradley and Grahame, 1947; El-Hagri 1967; Hare, 1975 and Schummer *et al.,* 1979**). However, the dorsal nasal Concha was tapered at either ends and wide at the middle part due to the large size of the middle nasal concha in ox (**El-Hagri, 1967; Hare, 1975 and Schummer *et al.,* 1979**), buffalo (**Abdel-Aziz, 1983**) and the camel (**Badawi and Fath El-Bab, 1974**). **William (1991)** stated that the mucosa of the nasal conchae is well vascularized and serves to warm and humidity the inhaled air. He added that the conchae involves cooling the blood that supplies the brain. Arteries that supply blood to the brain divide into many smaller arteries at its base and then rejoin before entering the brain, these smaller arteries are bathed in a pool of venous blood that comes from the walles of the nasal passages, where it has been cooled. As a result, brain temperature might be 2° or 3°C lower than body temperature. The brain is the most heat-sensitive body organ, so this cooling method is particularly important during times of extreme activity.

The arrangement of the dorsal nasal concha in the donkey simulated that presented in the horse (**Hare, 1975**). In this study the dorsal conchal sinus was freely opened into the rostral part of the frontal sinus, this finding was in contrast with that observed in other domestic animals in which the dorsal conchal sinus was separated from the frontal sinus by a double mucous membrane as mentioned by **Sisson and Grossman (1969)** in the ox and **Abdel Aziz (1983)** in the buffalo. However, in the camel, this sinus was separated from the frontal sinus by a thin osseous lamina (**Badawi and Fath El-Bab, 1974**). This study revealed that the ventral

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nasal concha was formed from one dorsal spiral lamella which rolled towards the middle nasal meatus forming a recess with subdivided bulla rostrally and ventral conchal sinus caudally.In accordance to the same data recorded in the horse (**Schummer *et al.*, 1979),** while the ventral conchal sinus in the donkey was divided into a large caudal cavity that opened into the maxillary sinus and a small rostral cavity that open into the middle nasal meatus. This fact differed from that of the horse in which the division of the ventral conchal sinus was not recorded by any investigator.

The projection of the nasal conchae from the lateral wall of the nasal cavity divided the later into meatuses. The arrangement of the nasal meatuses of the donkey as dorsal, middle and ventral in addition to the common nasal meatus simulated that found in other domestic animals as mentioned in the available literature. The small size of the middle nasal concha in the donkey did not divide the caudal part of the middle nasal meatus into dorsal and ventral channels. This is supported by the reports of **Hare (1975) and Schummer *et al.* (1979)** in the horse and pig. However, the contrary was present in other domestic animals where the middle nasal concha is enlarged and divides the caudal part of the middle nasal meatus into dorsal and ventral channels as stated in ox and dog (**El-Hagri, 1967, Sisson and Grossman, 1969; Hare, 1975; Schummer *et al*, 1979 and Dyce *et al.*, 1993**), buffalo (**Abdel-Aziz, 1983**) and camel (**Badawi and Fath El-Bab, 1974**).

Species variations in the numbers of ethmoidal conchae were met. And the reduction of ethmoidal conchae was in association with the reduction in the significance of the sense of smell (**Scott, 1954**). The ethmoidal conchae in the present study were classified as endoturbinates and ectoturbinates as formerly mentioned by **Hillman (1975)** in the horse

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and pig, **Paulli (1900)** in the ox and **Getty and Hadek (1964)** in the dog. However, **Badawi and Fath El-Bab (1974)** in the camel classified the ethmoidal conchae into medial, intermediate and lateral groups (Table 2).

(Table 2). Showed the number of endoturbinates and ectoturbinates in different domestic animals.

Animal	Number of Endoturbinate	Number of Ectoturbinates	References
Donkey	(6-7)	(12-20)	The present work
Horse	6	(21-31)	Hillman (1975)
Ox	5	(18)	Paulli (1900)
Buffalo	4	(11-18)	Abdel-Aziz (1983)
Swine	7	(13)	Hillmann (1975)
Canine	4	(6)	Getty and Hadek (1964) and Hare (1975)
Camel	Medial group (2)	Intermediate group (2-3), Lateral group (1)	Badawi and Fath El-Bab (1674)

The nasal conchae were covered on the outer surface by respiratory epithelium with large numbers of goblet cells. The abundant amount of goblet cells is needed for the production of sufficient quantity of mucous necessary for the protection of the nasal mucosa against the inspired air **(Abdel-Aziz) (1983)**. Moreover, **Adams and McFarland (1972)** stated that, the removal of the entrapped particulate matter by the mucous secretion appears to be greatest in the area exposed to air current. **Holander (1954), Cecial (1990) and El-Gengehy (1990)** added that the layer of mucous secreted by the goblet cells constitutes the first line of defense, it functions by its tenacious adherence to the under laying tissue and through its general impermeability to the destructive chemical agent.

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Large cavernous spaces in the propria-submucosa suppose that accommodation of air occurs by it.

The rostral part of ethmoidal conchae simulates the nasal conchae but the caudal part was covered externally by olfactory epithelium which was formed from thick pseudostratified ciliated columnar epithelium. The cilia of it are non motile but act as a sensory hair (**Banks , 1993**). The presence of pigment granules (melanin) in the epithelium of the caudal part of the ethmoidal concha and in the glands under it is responsible for the brown colouration of the zone seen grossly.

The propria-submucosa contained serous tubulo alveolar glands. They continuously secrete a watery fluid that is probably essential for the solubilization of air-borne odorants, **Bloom and Fawcett (1975)**. In the propria-submucosa, large number of nerves were presented, which are the tributaries of the olfactory nerve which originates from the bipolare nerve cells of the olfactory epithelium.

The paranasal sinuses:

According to the available literature, there were species variations with respect to the paranasal sinuses (Table 3).

Also, the method of communication between the paranasal sinuses and the nasal cavity was either collectively through the maxillary sinus which opened into the nasal cavity in all animals by the nasomaxillary opening or independently through the ethmoidal meatuses (Table 4).

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Table (3) Showed the paranasal sinuses which present in different domestic animals.

Animals / Sinus	Donkey	Equines	Ox	Small ruminants	Pig	Dog	Cat	Camel
Frontal	+	+	+	+	+	+	+	+
Maxillary	+	+	+	+	+	Recess	Recess	+
Lacrimal	-	-	+	+	+	-	-	+
Palatine	Usually combined to form the spheno palatine sinus	Usually combined	+	+	-	-	-	-
Sphenoidal		to form sphopalatine sinus	+	-	+	-	+	+
References	The present study	Hare (1975), and Schummer *et al.* (1979)						Badawi and fath El-Bab (1974)

(+) Present (-) Absent

Table (4): Showed the methods of communications between the paranasal sinuses and the nasal cavity in different animals according to the available literature,

Animal / Sinus	Donkey	Equines	Large ruminants	Small ruminants	Pig	Dog	Cat	Camel
Maxillary	[In all animals, through the nasomaxillary aperture]							
Frontal	With the maxillary sinus	With the maxillary sinus	Through an ethmoidal meatus	Through an ethmoidal meatus	Through on ethmoidal meatus	Through an ethmoidal meatus	Through an ethmoidal meatus	Through an ethmoidal meatus
Lacrimal	-	-	With the maxillary sinus	Through an ethmoidal meatus	Through an ethmoidal meatus	-	-	With the maxillary sinus
Palatine	The spheno-palatine sinus opened	The sphenopalatine sinus opened	With the maxillary sinus	With the maxillary sinus	-	-	-	-
Sphenoid	Mainly into the ethmoidal meatuses	with the maxillary sinus	Through an ethmoidal meatus	-	Through an ethmoidal meatus	-	Through an ethmoidal meatus	Through an ethmoidal meatus
Reference	The present study	Hare (1975), Schummer *et al.* (1979) and Dyce *et al.* (1993)						Badawi and Fath El-Bab (1974)

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From the before mentioned data we concluded that the frontal sinus was presented in all animals and opened independently into the nasal cavity through an ethmoidal meatus in all animals except in equines where it opened collectively with the maxillary sinus through the nasomaxillary aperture into the middle nasal meatus. The maxillary sinus was present in all animals but in carnivores it was just a recess in the maxillary bone and this sinus opened in all animals into the middle nasal meatus through the nasomaxillary aperture. The lacrimal sinus was present in ruminants and pig only and it opened into the nasal cavity collectively with the maxillary sinus as in large ruminants and camel or independently through an ethmoidal meatus as in small ruminants and pig. The palatine sinus was presented in all domestic animals except in pig, carnivores and camel, and it opened in all cases with the maxillary sinus through the nasomaxillary opening. While the sphenoidal sinus was presented in all domestic animals except in small ruminants and dog and in all cases it opened independently through an ethmoidal meatus.

In the present study, it was found that the paranasal sinuses in the donkey included the maxillary, frontal and sphenopalatine sinuses. The maxillary sinus is the largest paranasal sinus of the donkey. In about 80% of examined heads, the maxillary sinus was not divided while in about 20% of cases, there was an oblique septum which divided the maxillary sinus into rostral and caudal divisions this division was complete only in about 5% of cases while in about 15% of cases, the septum was reduced to a low ridge which incompletely divided the maxillary sinus into rostral and caudal parts. These results were in a line with that mentioned by **Omar *et al.* (1986)** in the donkey except the case in which the septum was completely dividing the maxillary sinus in this study which not recorded by the aforementioned authors. Also, these findings were in a line with that

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mentioned by **Hare(1975)** in the mule who reported that the septum may be partially or entirely absent. However, in the horse the contrast findings were reported by **Bradley and Grahame (1947), El-Hagri (1967) and Hare (1975)** who mentioned that the maxillary sinus was completely divided by a complete maxillary septum into rostral and caudal maxillary sinuses. The nasomaxillary opening was located between the sinus parts of the dorsal and ventral nasal conchae and it was slit like. Since, the "nasomaxillary aperture" is placed high in the wall, the entry to the sinus for drainage or to give access to the teeth may required an artificial trephining of the maxillary sinus.

The frontal sinus:

The present study revealed that the frontal sinus occupied the dorsal part of the skull medial to the orbit and excavated the frontal bone mainly. It was triangular in outline with its base at the median plane. The rostral half of the sinus was divided by a thin bony partition into medial and lateral portions. These findings were in a line with that mentioned by **Omar *et al.* (1986)** in the donkey while **Selim (1982)** reported that the frontal sinus in the donkey was divided into lateral, middle and medial parts. Also, we found that the frontal sinus was communicated with the maxillary sinus through the large oval or rounded frontomaxillary aperture, so it was indirectly opened into the nasal cavity by the nasomaxillary opening in addition. It was communicated freely with the dorsal conchal sinus forming the conchofrontal sinus. These results agreed with the results of all literatures in the donkey and horse. While in all other domestic animals, the frontal sinus opened directly into the nasal cavity through the ethmoidal meatuses. The frontal sinus reached its maximal development in the ox and pig in which it surrounded the brain dorsally, laterally and caudally. It also excavated the cornual processes of the ox and small

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ruminants, so, great care should be taken during dehorning process to prevent injury to the sinus and spread of infection (**Hare, 1975, Schummer** ***et al.*****, 1979**). The frontomaxillary aperture allows easy natural drainage. Direct drainage to the nasal cavity may be obtained by punching a hole in the thin wall of the dorsal conchal sinus. Trephination in the roof of the sinus allows for irrigation or for removal of a molar through the frontomaxillary aperture (**Dyce** ***et al.*****, 1993**).

The sphenopalatine sinus:

It was found that in about 80% of cases in the donkey, the palatine and sphenoidal sinuses were combined together forming the sphenopalatine sinus, a result which was supported by the findings reported by **Omar** ***et al.*** **(1986) and Dyce** ***et al.*** **(1993)** in the horse. The separation of the sphenoidal and palatine sinuses occurred in about 20% of cases, this interfered with the reports of **Omar** ***et al.*** **(1986)** in the donkey who did not record this separation. The palatine sinus in the donkey excavated the perpendicular plate of the palatine bone, this simulated the finding in all equine while in ruminants, the palatine sinus excavated the horizontal process of the palatine bone and the palatine process of the maxillary bone, thereforeit separated the nasal cavity from the oral cavity (**Hare, 1975, Schummer** ***et*** **al, 1979**). The palatine sinus was related in equines to the ptrygopalatine fossa, so, any affection of this sinus may result in harmful effects on the nerves in this area. While the sphenoid sinus affections may result in harmful effect on the vision due to the location of the sinus under the optic groove and the optic chiasma. The sphenopalatine sinus in the present study opened in about 90% of cases in the nasal cavity through the ethmoidal meatuses, a result which was not recorded by any investigator in the donkey and other equines.

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SUMMARY AND CONCLUSION

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SUMMARY

This study was carried out on the nasal cavity of 30 apparently healthy adult donkeys in different ages, and this study included a complete anatomical description of the different parts of the nasal cavity in addition to the paranasal sinuses. Also, the microscopic structure of most of these parts was described. Radiographic pictures of the nasal cavity were taken for showing the different locations of the paranasal sinuses and the determination of the course of the nasolacrimal duct, as well as the suitable seats for trephining the maxillary and frontal sinuses.

Also, computed tomographical pictures were taken to transverse sections of the nasal cavity on different levels and compared with the photographical pictures of these sections.

The results of this study were discussed with the similar findings in equines and the other domestic animals.

This study showed that the nasal cavity of the donkey simulated the nasal cavity of the horse to a large extent although there were some differences in some parts as:

The presence of the rostral nasolacrimal orifice in the medial surface of the lateral wall of the nostril below the dorsal nasal angle.

The ventral conchal sinus was divided into tow parts by a complete septum in most cases or incomplete one in some cases.

The maxillary sinus was undivided in most cases but it was divided by incomplete oblique septum in some cases and in one case only, this septum was complete.

The opening of the sphenopalatine sinus into the nasal cavity was separated from the maxillary sinus in most cases.

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ARABIC SUMMARY

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الملخص العربى

أجريت هذه الدراسة على التجويف الأنفى فى ثلاثين حمار بالغا فى أعمار مختلفة وسليمة ظاهريا. وقد اشتملت هذه الدراسة على وصف تشريحى كامل للأجزاء المختلفة فى التجويف الأنفى بالإضافة إلى الجيوب الجار أنفية. وكذلك تم وصف التركيب المجهرى لمعظم هذه الأجزاء. وتم أخذ صور بالأشعة السينية للتجويف الأنفى لتوضيح الأماكن المختلفة للجيوب الجار أنفية وكذلك تحديد مسار القناة الأنفية الدمغية.

وتم تحديد الأماكن المناسبة لعملية التربنة للجيب الفكى العلوى والجيب الجبهى. وأيضا تم أخذ صور باستخدام الأشعة المقطعية لقطاعات عرضية من التجويف الأنفى على مستويات مختلفة وقورنت بالصور الفوتوغرافية لهذه القطاعات.

وتم مناقشة نتائج هذه الدراسة على مثيلاتها فى الفصيلة الخيلية وكذلك باقى الحيوانات المستأنسة.

وقد أظهرت هذه الدراسة أن التجويف الأنفى فى الحمار يشبه إلى حد كبير التجويف الأنفى فى الحصان رغم وجود بعض الاختلافات فى بعض الأجزاء مثل:

- وجود الفتحة الأمامية للقناة الأنفية الدمعية فى السطح الأنسى للجدار الوحشى لفتحة الأنف تحت الزاوية الأنفية الظهرية.
- انقسام الجيب المحارى البطنى إلى جزئين بواسطة حاجز كامل فى معظم الحالات أو غير كامل فى بعض الحالات.
- الجيب الفكى العلوى غير منقسم فى معظم الحالات ولكنه كان منقسما بحاجز مائل غير كامل فى بعض الحالات وفى حالة واحدة فقط كان هذا الحاجز كاملا.
- فتحة الجيب الحنكي الوتدى فى التجويف الأنفى كانت منفصلة فى معظم الحالات عن الجيب الفكى العلوى.

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جامعه طنطا - فرع كفر الشيخ
كلية الطب البيطري
قسم التشريح والهستولوجيا

قرار لجنة الحكم والمناقشه

توصى لجنة الحكم والمناقشه بجلستها المنعقده يوم الاحد الموافق ٢٠٠٠/٩/٣م. ترشيح السيد ط.ب/ حازم شاكر عبدالرحمن حموده طالب باحث بقسم التشريح والهستولوجيا بكلية الطب البيطري بكفر الشيخ - جامعة طنطا للحصول على درجة الماجستير فى العلوم الطبيه البيطريه تخصص " تشريح وأجنه".

أسم عضو اللجنه	التوقيع
أ.د/ كمال الدين هاشم أستاذ التشريح والاجنه ووكيل كلية الطب البيطري جامعة جنوب الوادى.	
أ.د/ فاروق السيد عبدالمهدي أستاذ الهستولوجيا ورئيس قسم التشريح والهستولوجيا بالكليه.	
أ.د/ علي عبدالقادر منصور أستاذ التشريح ووكيل الكليه للدراسات العليا والبحوث. (مشرفا)	

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بعض الدراسات التشريحية على التجويف الأنفى فى الحمار

رسالة مقدمة من

ط.ب/ حازم شاكر عبدالرحمن حموده

للحصول على درجة الماجستير فى العلوم الطبية البيطرية (تشريح وأجنه)

تحت إشراف

الأستاذ الدكتور/ على عبدالقادر منصور
أستاذ التشريح والأجنة
ووكيل كلية الطب البيطرى بكفرالشيخ لشئون الدراسات العليا والبحوث

الدكتورة/ منى عبدالفتاح أحمد على
مدرس الهستولوجيا
بقسم التشريح والهستولوجيا
كلية الطب البيطرى بكفرالشيخ

كلية الطب البيطرى ــ كفرالشيخ
جامعة طنطا

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