



## Anatomical & Morphometrical Study of the Lacrimal Apparatus in Adult Iraqi Local Breed Cattle (*Bos taurus*)

Nabeel Abd Murad AL-Mamoori <sup>1\*</sup> and Mahdi Abdul-Kareem Atyia <sup>2</sup>

<sup>1</sup>Department of Anatomy & Histology, College of Veterinary Medicine, University of Al-Qadisiyah, Iraq.

<sup>2</sup>Department of Anatomy & Histology, College of Veterinary Medicine, University of Baghdad, Iraq.

Received: 05 Sep 2018

Revised: 09 Oct 2018

Accepted: 12 Nov 2018

### \*Address for Correspondence

**Nabeel Abd Murad AL-Mamoori**

Department of Anatomy & Histology,

College of Veterinary Medicine,

University of Al-Qadisiyah, Iraq.

Email: Nabeel.almamoori@qu.edu.iq



This is an Open Access Journal / article distributed under the terms of the **Creative Commons Attribution License** (CC BY-NC-ND 3.0) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. All rights reserved.

### ABSTRACT

Used 10 fresh heads of cattle specimens were collected from AL-Diwaniyah abattoir directly after slaughter. The present study was found the lacrimal apparatus in the adult local breed of cattle (*Bos taurus*) consists of glandular part & ducts system convey the secretion. The glandular part was consisting of right & left lacrimal glands, while duct system consists of a number of canals started by an excretory duct, dorsal & ventral puncta, dorsal & ventral lacrimal canaliculi & finally the nasolacrimal duct. The lacrimal glands in was situated on the dorsolateral aspect of the eyeball, elongated, lobulated, flattened, brown in color. Each gland was consist of two parts main part (body) & accessory part (appendage). The mean weight, length, width, thickness & volume of a body the right lacrimal gland was  $4.055 \pm 0.197$  gm,  $37.232 \pm 1.447$  mm,  $23.112 \pm 0.966$  mm,  $7.746 \pm 0.345$  mm &  $4.083 \pm 0.153$  cm<sup>3</sup> respectively, while the mean weight, length, width, thickness & volume of the body the left lacrimal gland was  $4.358 \pm 0.222$  gm,  $37.207 \pm 1.622$  mm,  $24.053 \pm 0.523$  mm,  $8.043 \pm 0.333$  mm &  $4.166 \pm 0.247$  cm<sup>3</sup> respectively. There were two puncta can be observed in the medial canthus of the eyeball. The two puncta lead into two cylinders, narrow & short canaliculi (dorsal & ventral). The lacrimal sac consists from joined the lacrimal canaliculi together in the distal end to form the small a dilated lacrimal sac. The nasolacrimal ducts in cattle represent last part of the lacrimal apparatus. It was started from the distal end of the lacrimal sac. The mean total length of the right & left nasolacrimal duct in cattle was  $185.268 \pm 7.602$  mm &  $190.008 \pm 5.731$  mm respectively.

**Keywords:** cattle, morphology, lacrimal apparatus, lacrimal gland, nasolacrimal duct.





## INTRODUCTION

A cattle is most important types of ruminants, which provide meat, milk and leather. Many of them are spread in different region of the country (1). The eyes were the sensory organ responsible for eyesight. It is well protected from damage by the bone which formed the orbit. It has accessory structures important in the process of maintaining eye, including the lacrimal gland, 3rd eyelid gland (2). The lacrimal apparatus group of structures that production & drain away tears. It consist of lacrimal gland, lacrimal puncta, lacrimal canaliculi, lacrimal sac, nasolacrimal duct & nasal punctum. The lacrimal gland is pink in color, lying on the dorsolateral aspect of eyeball. It releases seromucous secretions by a number of ducts onto the surface of the eyeball which are responsible for the protection the eye & conjunctiva from drying & also nourishes & lubricates. The duct system that conveys the lacrimal fluid after it has washed over the eye, into the nasal cavity (2; 3 & 4 ) In bovine, caprine, ovine, camel & equine except canine, swine, feline the lacrimal gland was situated within a special division of the periorbital between the dorsolateral part of the eyeball & the supraorbital process of the frontal bone and the frontal process of the zygomatic bone. The major part of the gland was covered by the supraorbital & frontal processes dorsally, whereas a small caudal part (about 1cm wide) was covered only by adipose tissue, fascia and skin in canine and feline the orbital cavity shallow due to the absence of frontal and zygomatic process (5 & 6). In most of the domestic mammalian the two lacrimal ducts beginning with a small dorsal & ventral openings, the lacrimal punctum located near to the medial canthus of the eyes. The puncta of the camel are absent (4;7; 8 & 9)

## MATERIALS AND METHODS

### Morphological and biometrical study

For anatomical & morphometric studies used 10 fresh heads specimens were collected from AL-Diwaniyah abattoir directly after slaughtering of the cattle by dislocation of heads from the carcasses at the level of atlanto-occipital joint. The first step clean the specimens by washed with tap water & kept in clean plastic containers. It was transported into the laboratory to record the required relationship of the apparatus & biometric measurement. The second step should be carefully dissecting the specimen by remove the skin, muscles & bone to exposure the lacrimal apparatus (lacrimal gland & duct system). For studying the lacrimal gland should be dissected the superior orbital skin, zygomatic process of the frontal bone & frontal processes of zygomatic bone. The periorbital connective tissues were carefully dissected & lastly the glands were carefully detached.

To study the duct system that consist of lacrimal duct, lacrimal sac & nasolacrimal duct should be dissected superior maxillary & incisive skin & muscle, & made longitudinal incision to divided the head into symmetrical parts. After that dissected to remove the nasal concha to exposure the course of nasolacrimal duct. Injected the nasolacrimal duct with the red colored latex substance (2 : 3 latex with ammonia mixed with carmine stain) to exposure the duct. We using blunt needle & syringe. Glacial acetic acid was used with cotton to prevent any leakage of latex from the damaged duct by pressing on the site of oozing. Then the specimens were immersed in 10% formalin for 24 hours to fixing the tissue & setting of the injected material. Finally described the morphological features including the shape, location, relationship & color of the lacrimal apparatus. Record the measurements by using vernia, measurement tape, ruler & sensitive balance.

- Weight, length, width, thickness & volume of lacrimal gland.
- Length & diameter of nasolacrimal duct.





## RESULTS

### Anatomical study

The current study was found in the lacrimal apparatus in the adult local breed of cattle (*Bos taurus*) consists of glandular part & ducts system convey the secretion. The glandular part was consist of right & left lacrimal glands. The duct system consists of a number of canals started by an excretory duct, dorsal & ventral puncta, dorsal & ventral lacrimal canaliculi & finally the nasolacrimal duct.

### Lacrimal glands

The lacrimal glands in was situated on the dorsolateral aspect of the eyeball. Where was above dorsal rectus muscle & extend on the lateral rectus muscle. It was extended caudally along the medial surface of the zygomatic process of the frontal bone & frontal process of the zygomatic bone & the gland confined between these two bones of the orbit & the eyeball. (Fig.1). The lacrimal glands were elongated, lobulated, flattened with an irregular outline. It had light brown in color, covered by a capsule & surrounded by adipose tissue. Each gland was consist of two parts main part (body) & accessory part (appendage). It has two surfaces (Dorsal & ventral), two extremities (cranial & caudal extremities) & two borders (medial & lateral borders). The dorsal surface was convex opposite the inner surface of the orbit so that it takes the shape of the inner surface of it. While the ventral surface was concave opposite the convexity of dorsal (upper) surface of the eyeball & take the fitting shape of it (Fig.1, 2 &3).

The body of lacrimal gland was flattened oval in shape & the cranial end narrowing than the caudal end (Fig.2 &3). The mean weight, length, width, thickness & volume of body the right lacrimal gland was  $4.055 \pm 0.197$ gm,  $37.232 \pm 1.447$ mm,  $23.112 \pm 0.966$ mm,  $7.746 \pm 0.345$ mm &  $4.083 \pm 0.153$ cm<sup>3</sup> respectively, while the mean weight, length, width, thickness & volume of body the left lacrimal gland was  $4.358 \pm 0.222$ gm,  $37.207 \pm 1.622$ mm,  $24.053 \pm 0.523$ mm,  $8.043 \pm 0.333$ mm &  $4.166 \pm 0.247$ cm<sup>3</sup> respectively (Table 1). The appendage of lacrimal gland was cylinder elongated shape with irregular outline & extend on the lateral rectus muscle. It has dorsal & ventral surfaces, medial & lateral borders & cranial & caudal extremities (Fig. 2&3). The mean weight, length, width, thickness & volume of appendage of the right lacrimal gland was  $0.983 \pm 0.072$ gm,  $35.108 \pm 1.699$ mm,  $11.95 \pm 0.351$ mm,  $4.53 \pm 0.303$ mm &  $1.083 \pm 0.083$ cm<sup>3</sup> respectively, while the mean weight, length, width, thickness & volume of appendage the left lacrimal gland was  $1.105 \pm 0.058$ gm,  $35.377 \pm 2.392$ mm,  $13.908 \pm 0.828$ mm,  $4.098 \pm 0.333$ mm &  $1.166 \pm 0.105$ cm<sup>3</sup> respectively (Table 2).

### Excretory ducts in cattle

The main macroscopic excretory ducts origin from the lacrimal glands to convey the secretion into the superior conjunctival fornix in the lateral canthus of the eyeball. (Fig.4&5). In cattle, the excretory ducts origin from the lateral borders of the middle area of the body of lacrimal glands. The mean number of ducts were 6-7 take slit-like opening & it has the same color of the conjunctival mucosa (Fig.4&5).

### Lacrimal puncta in cattle

The puncta were slit-like opening & take grayish black in color. There were two puncta can by observed in the medial canthus of the eyeball (Fig.6). In cattle the diameter & distance of punctum from medial canthus of right & left dorsal puncta were  $2.3166 \pm 0.089$ mm,  $2.163 \pm 0.090$ mm,  $5.688 \pm 0.804$ mm &  $5.828 \pm 0.626$ mm respectively, while the right & left ventral puncta were  $2.246 \pm 0.089$ mm,  $2.308 \pm 0.157$ mm,  $6.23 \pm 0.626$ mm &  $5.688 \pm 0.804$ mm respectively (Table 3).



**Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia****Lacrimal ducts (canaliculi) in cattle**

The lacrimal ducts were started from the lacrimal puncta in the medial canthus of the eyeball & reached into the lacrimal sac. The two puncta lead to two cylinder, narrow & short canaliculi (dorsal & ventral). The mean length of the right & left dorsal lacrimal canaliculi were  $15.14 \pm 1.082\text{mm}$  &  $14.55 \pm 1.849\text{mm}$  respectively, while the right & left ventral lacrimal canaliculi were  $14.935 \pm 0.752\text{mm}$  &  $14.773 \pm 1.321\text{mm}$  respectively (Table 3).

**Lacrimal sac in cattle**

In cattle the two lacrimal canaliculi were joined together in the distal end to formation the small a dilated lacrimal sac. It was located in the small depression the lacrimal fossa of the lacrimal bone. It was continuous from the distal end with nasolacrimal duct. The mean length of right & left lacrimal sac were  $23.603 \pm 2.985\text{mm}$  &  $16.583 \pm 3.314\text{mm}$  respectively (Table 3).

**Nasolacrimal ducts in cattle**

The nasolacrimal ducts in cattle represent last part of the lacrimal apparatus. It was started from the distal end of the lacrimal sac. It runs dorsally & distally to lacrimal sac. It extends ventrally on the medial side of the lacrimal, maxillary & incisive bones. The nasolacrimal duct runs on the medial side of the lateral wall of the nasal cavity (Fig.7). The mean total length of the right & left nasolacrimal duct in cattle was  $185.268 \pm 7.602\text{mm}$  &  $190.008 \pm 5.731\text{mm}$  respectively. The nasolacrimal duct divided into three parts according to course of ducts (Fig.7). The proximal part pass through the osseous canal in the lacrimal & maxillary bone. It could be observed after removed the dorsal & ethmoid (middle) nasal concha. The mean length of the right and left the proximal part in cattle was  $55.081 \pm 4.096\text{mm}$  &  $52.806 \pm 3.264\text{mm}$  respectively. The middle part was consisting of only mucous membrane & extends into the junction with the skin of the vestibule of the nasal cavity. It passes ventrally to the ventral nasal concha & covered by it. It could seem after removed the ventral nasal concha. The mean length of the right & left the middle part in cattle was  $95.008 \pm 2.122\text{mm}$  &  $94.03 \pm 3.342\text{mm}$  respectively.

The distal part was referred to cutaneous part supported by nasal cartilage. It was shorter part of the nasolacrimal duct ended by the external orifice of the nasolacrimal duct. The mean length of the right & left the distal part in cattle was  $41.28 \pm 3.208\text{mm}$  &  $45.44 \pm 2.117\text{mm}$  respectively. In cattle, the external orifice of the nasolacrimal duct has oval shape & located ventral to the alar fold of the ventral nasal concha. The mean diameter was  $2.47 \pm 0.154\text{mm}$  &  $2.185 \pm 0.168\text{mm}$ , also the mean distance of nasolacrimal orifice from nostrils opening (external nasal opening) was  $16.166 \pm 1.728\text{mm}$ ,  $15.395 \pm 1.066\text{mm}$  in right & left side respectively (Table 3).

**DISCUSSION**

In the current study show the lacrimal apparatus in the adult local breed of cattle consists of glandular part & ducts system. This finding agreement with (10). But disagreement with (11 & 12) described the lacrimal apparatus in one humped camel was consists lacrimal gland & excretory duct, lacrimal sac, nasolacrimal duct & lack the two punctum. The lacrimal glands in cattle situated on the dorsolateral aspect of the eyeball. Our results accordance with the findings (4;10;13; & 14) in buffalo, sheep & dog. The lacrimal glands in cattle take light brown in color, covered by a capsule & surrounded by adipose tissue. This results accordance with (6;15;16;17&18) in Zavot fetuses, Bactrian camels, camel, goat, donkey & Lori sheep. Whereas disagreement with (19) described the lacrimal gland in American bison and cattle were pale yellowish in color & (13) show the lacrimal gland of the Philippine water buffalo was pink to red in color. (20 & 21) explain in buffalo was pale yellow. We believe the cause of discoloration of the lacrimal glands may be due to differing the species of animals & the amount of blood remaining in the blood vessels that supply the gland or delayed time took the samples for anatomical study after slaughtering the animal. The lacrimal





### Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia

glands in cattle was elongated, lobulated, flattened oval in shape, while the appendage was cylinder elongated. It was consist of two parts main part. This results accordance with (4;8;9;15;16;19;22 &23). While disagreement with (24) the lacrimal gland in European bison was uniform & undivided. (25) explain the lacrimal gland in goat & sheep consist one compact part undivided. Also (26) described the lacrimal gland in alpaca was uniform & undivided gland. This difference due to species of animal.

The recent results in cattle revealed that the mean weight, length, width, thickness & volume of body the right lacrimal gland disagreement with (27) explain in bovine the mean width and length of the lacrimal gland was 35 & 65 mm respectively. The current results find the excretory ducts of lacrimal gland in cattle had a slit-like opening & take the same color of the conjunctival mucosa of upper eyelids. This finding agreement with (12 & 14). But the disagreement with (12 & 28) in camel found that the excretory ducts of lacrimal gland difficult to find but were detected by black color imparted to them by melanin. In the present study seen the mean number of ducts in cattle was 6-7 take slit-like opening. This results agreement with (29) found the excretory duct of the lacrimal gland in porcine was 7 main excretory ducts responsible for transporting tear to the eye surface. But disagreement with (6) reported the lacrimal gland in camel was possessed 3 excretory ducts origin from the ventral surface of the gland. The current study finds that the puncta in cattle was two slit-like opening & takes grayish black in color. This result was compatible with (10;18;20; 21 & 25) show most mammals had two lacrimal puncta of upper & lower eyelids in the medial canthus of eyes & the colour of puncta differs. But disagreement with (9;11;12 & 30) explains the lacrimal puncta in camel was absent & the lacrimal ducts start blindly.

We found the mean diameter & distance of punctum from medial canthus nearly accordance in some measurements & differ in other with (25) reported that in goat the diameter & distance of punctum from medial canthus of right & left dorsal puncta were  $1.21 \pm 0.13$ mm,  $1.08 \pm 0.06$ mm,  $4.94 \pm 0.22$ mm &  $4.81 \pm 0.27$ mm respectively, while the right & left ventral puncta were  $1.54 \pm 0.15$ mm,  $1.50 \pm 0.14$ mm,  $3.63 \pm 0.16$ mm &  $3.75 \pm 0.16$ mm respectively. The lacrimal ducts in cattle were started from the lacrimal puncta in the medial canthus of the eyeball & reached into the lacrimal sac. This was similar to that explained by (18& 20) in buffalo & Lori sheep. Whereas disagreement with (9;11& 18) explain that most of the domestic mammals have two lacrimal ducts starts by a small upper & lower openings, but in camel, the lacrimal ducts start blindly. In the present study show in cattle the two lacrimal canaliculi joined together in the distal end to form the small a dilated lacrimal sac. This finding similar with (10;18;20;21&25) in goat, buffalo & Lori sheep. The nasolacrimal ducts in cattle represent last part of the lacrimal apparatus. It was started from the distal end of the lacrimal sac. This finding agreement with (4;8 & 21). The mean total length of the right & left nasolacrimal duct in cattle was  $185.268 \pm 7.602$ mm &  $190.008 \pm 5.731$ mm respectively this finding disagreement with (10) described the total length left & right nasolacrimal duct in buffalo was about 232 mm & 235 mm. (20) show the mean length of nasolacrimal 263mm.

## REFERENCES

1. AL-Sadi, H I. Animal wealth in Iraq and means of improving it. University of Mosul press: 203-204, 1980.
2. Akers, R M and D M Denbow. Anatomy and physiology of domestic animals. 2nd Ed. Wiley Blackwell, 2013.
3. Pasquini, C, T Spurgeon and S Pasquini. Anatomy of domestic animal. 7th Ed. SUDZ publishing, 1997.
4. Dyce, K M, W O Sack and C J G Wensing. Textbook of Veterinary 4th edition. Philadelphia. London. New: W.B. Saunders Company, 2010.
5. Bacha, W J and L M Bacha. Color atlas of veterinary histology. 2nd Ed. Maryland, USA: Lippincott Williams & Wilkins, 2000.
6. Alsafy, M A. "Comparative morphological studies on the lacrimal apparatus of one humped camel, goat and donkey." Journal of Biological Sciences 10(3) 2010: 224-230.
7. May, N D. The anatomy of the sheep. 3rd Ed. Australia: Brisbane Australia university of queens land press, 1970.




**Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia**

8. Sisson, S and J D Grossman. The anatomy of domestic animals. Philadelphia. London. Toronto: W.B. Saunders Company, 1975.
9. Saber, A S and F M Makady. "Anatomy and clinical studies on the lacrimal system in camel (*Camelus dromedarius*).". Assuit Veterinary Medical Journal 19 1987: 12-17.
10. Al-Bayati, Mustafa kamal. Anatomical and histological study of the lacrimal gland and nasolacrimal apparatus in indigenous buffalo (*bubalus bubalis*). thesis: vet. Med. Baghdad university, 2015.
11. Abdalla, O, M F Fahmy and I Arnactovic. "Anatomical study of the lacrimal apparatus of the one-humped camel." Acta. Anat 75 1970: 638-650.
12. Elmahadi, Huyam Elmahadi Mustafa. Studies on morphological and histochemical seasonal changes on the lacrimal apparatus of the One-humped camel (*Camelus dromedarius*). Thesis: Vet Me Sudan University of Science and Technology, 2017.
13. Maala, Ceferino P, Ruth A Cartagena and Grace D Ocampo. "Macroscopic, histological and histochemical characterization of the lacrimal gland of the Philippine Water Buffalo (*Bubalus bubalis*).". Philipp. J. Vet. Med 2 44 2007: 69-75.
14. AL-Obeady, Walaa Fadil. Morphometrical and histochemical comparative study of lacrimal gland and conjunctival glands between dog (*Canis familiaris*) and ram (*Ovis aris*). Thesis: Vet Med University of Baghdad, 2016.
15. Aslan, Kadir, et al. "Gross anatomy of the lacrimal gland (*gllacrimalis*) and its arterial vascularization in the fetus of zavot-bred cattle." Kafkas Univ. Vet. Med. J 1 11 2005: 47-49.
16. Ibrahim, Z H, A B Abdalla and D I Osman. "A gross anatomical study of the lacrimal apparatus of the camel (*Camelus dromedarius*).". Journal of Science and Technology 9 2006: 1-8.
17. Chengjuan, G, et al. "Anatomical and histochemical characteristics of the lacrimal glands in bactrian camels." Chinese journal of Anatomy 2008.
18. Abbasi, Mohsen, Hamid Karimi and Ahmad Gharzi. "Preliminary anatomical and histological study of lacrimal gland in Lori sheep." Journal Veterinary Science & Technology 1 5 2014: 154-158.
19. Pinard, C L, et al. "Normal anatomical and histochemical characteristics of the lacrimal glands in the american bison and cattle." Anat. Histol. Embryol 32 2003: 257-262.
20. Ali, mohammad Abbas. Anatomical and histological study of local buffalos eye (*Bubalus bubalis*). thesis: Vet Med University of Basrah, 2009.
21. Shadkhast, M and A S Bigham. "A Histo-Anatomical study of dorsal lacrimal gland in iranian river buffalo." Iran Online Veterinary Journal 1 5 2010: 50.
22. Getty, R. The anatomy of domestic animals. Philadelphia. London. UK: W.B. Saunders Company, 1975.
23. Budras, K D, et al. The atlas of bovine anatomy. 2nd Ed. Schlutersche. Germany: Hans-BOckler Allee, 2011.
24. Kleckowska-Nawrot, Joanna, et al. "Histology, histochemistry and fine structure of the Harderian gland, lacrimal gland and superficial gland of the third eyelid of the European bison, *Bison bonasus bonasus* (Artiodactyla: Bovidae)." Zoologia 5 32 2015: 380-394.
25. Daryuos, M M and N S Ahmed. Comparative morphological and morphometrical study of lacrimal apparatus of Awasi sheep and black goat." AL-Qadisiyah Journal of Veterinary Medicine Sciences 11 1 2012a: 123-133.
26. Kleckowska-Nawrot, J, et al. "Histological, histochemical and fine structure studies of the lacrimal gland and superficial gland of the third eyelid and their significance on the proper function of the eyeball in alpaca (*Vicugna pacos*).". Folia Morphol Via Medica 2 4 2015: 195-205.
27. Diesem, D V. "Gross anatomic structure of equine and bovine orbit and its contents." American Journal of Veterinary Research 29 1968: 505-510.
28. Ibrahim, Z H, A B Abdalla and D I Osama. "A gross anatomical study of the lacrimal apparatus of the camel (*Camelus dromedarius*).". Sudan Journal of science and technology 2006: 1-8.
29. Henker, R, et al. "Morphological features of the porcine lacrimal gland and its compatibility for human lacrimal gland xenografting." Journal pone 9 8 2013: 40-46.
30. Sadegh, Amin Bigham, et al. "Lacrimal apparatus system in One-humped camel of iran (*Camelus dromedarius*): Anatomical and radiological study." Iranian Journal Of Veterinary Surgery Vol.: 2 No.: 5 2007: 75-80.






**Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia**

<b>Table 1. Macroscopic parameters of the body lacrimal gland in cattle (Mean <math>\pm</math>SE).</b>		
<b>Parameter</b>	<b>Side</b>	<b>Cattle</b>
Weight	Right side	4.055 $\pm$ 0.197gm
	Left side	4.358 $\pm$ 0.222gm
Length	Right side	37.23 $\pm$ 1.447mm
	Left side	37.21 $\pm$ 1.622mm
Width	Right side	23.11 $\pm$ 0.966mm
	Left side	24.05 $\pm$ 0.523mm
Thickness	Right side	7.747 $\pm$ 0.345mm
	Left side	8.044 $\pm$ 0.333mm
Volume	Right side	4.083 $\pm$ 0.153ml
	Left side	4.167 $\pm$ 0.247ml

<b>Table 2. Macroscopic parameters of the appendage part of lacrimal gland in cattle (Mean <math>\pm</math>SE).</b>		
<b>Parameter</b>	<b>Side</b>	<b>Cattle</b>
Weight	Right side	0.983 $\pm$ 0.072gm
	Left side	1.105 $\pm$ 0.058gm
Length	Right side	35.108 $\pm$ 1.699mm
	Left side	35.377 $\pm$ 2.392mm
Width	Right side	11.950 $\pm$ 0.351mm
	Left side	13.908 $\pm$ 0.828mm
Thickness	Right side	4.53 $\pm$ 0.303mm
	Left side	4.098 $\pm$ 0.382mm
Volume	Right side	1.083 $\pm$ 0.083ml
	Left side	1.166 $\pm$ 0.105ml

<b>Table 3. Macroscopic parameters of the duct system in cattle (Mean <math>\pm</math>SE).</b>		
<b>Parameter</b>	<b>Side</b>	<b>Cattle</b>
Diameter of dorsal punctum.	Right side	2.317 $\pm$ 0.089mm
	Left side	2.163 $\pm$ 0.090mm
Diameter of ventral punctum.	Right side	2.247 $\pm$ 0.089mm
	Left side	2.308 $\pm$ 0.157mm
Distance of dorsal punctum to medial canthus.	Right side	5.828 $\pm$ 0.626mm
	Left side	5.688 $\pm$ 0.804mm
Distance of ventral punctum to medial canthus.	Right side	6.230 $\pm$ 0.470mm
	Left side	5.576 $\pm$ 0.509mm
Length of dorsal lacrimal canaliculi.	Right side	15.14 $\pm$ 1.082mm
	Left side	14.55 $\pm$ 1.849mm
Length of ventral lacrimal canaliculi.	Right side	14.94 $\pm$ 0.752mm
	Left side	14.77 $\pm$ 1.321mm
Length of lacrimal sac.	Right side	23.6 $\pm$ 2.985mm
	Left side	16.58 $\pm$ 3.314mm
Length of nasolacrimal duct.	Right side	185.3 $\pm$ 7.60mm
	Left side	190.01 $\pm$ 5.73mm
Length of proximal part of nasolacrimal	Right side	55.08 $\pm$ 4.096mm




**Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia**

duct inside of bone canal.	Left side	52.807±3.26mm
Length of middle part of nasolacrimal duct (mucous part).	Right side	95.01±2.122mm
	Left side	94.03±3.342mm
Length of distal part of nasolacrimal duct from mucous part to nasolacrimal opening.	Right side	41.28±3.208mm
	Left side	45.44±2.11mm
Diameter of nasal punctum of nasolacrimal duct.	Right side	2.47±0.154mm
	Left side	2.185±0.16mm
Distance of nasal punctum from nostrils opening.	Right side	16.17±1.728mm
	Left side	15.398±1.06mm

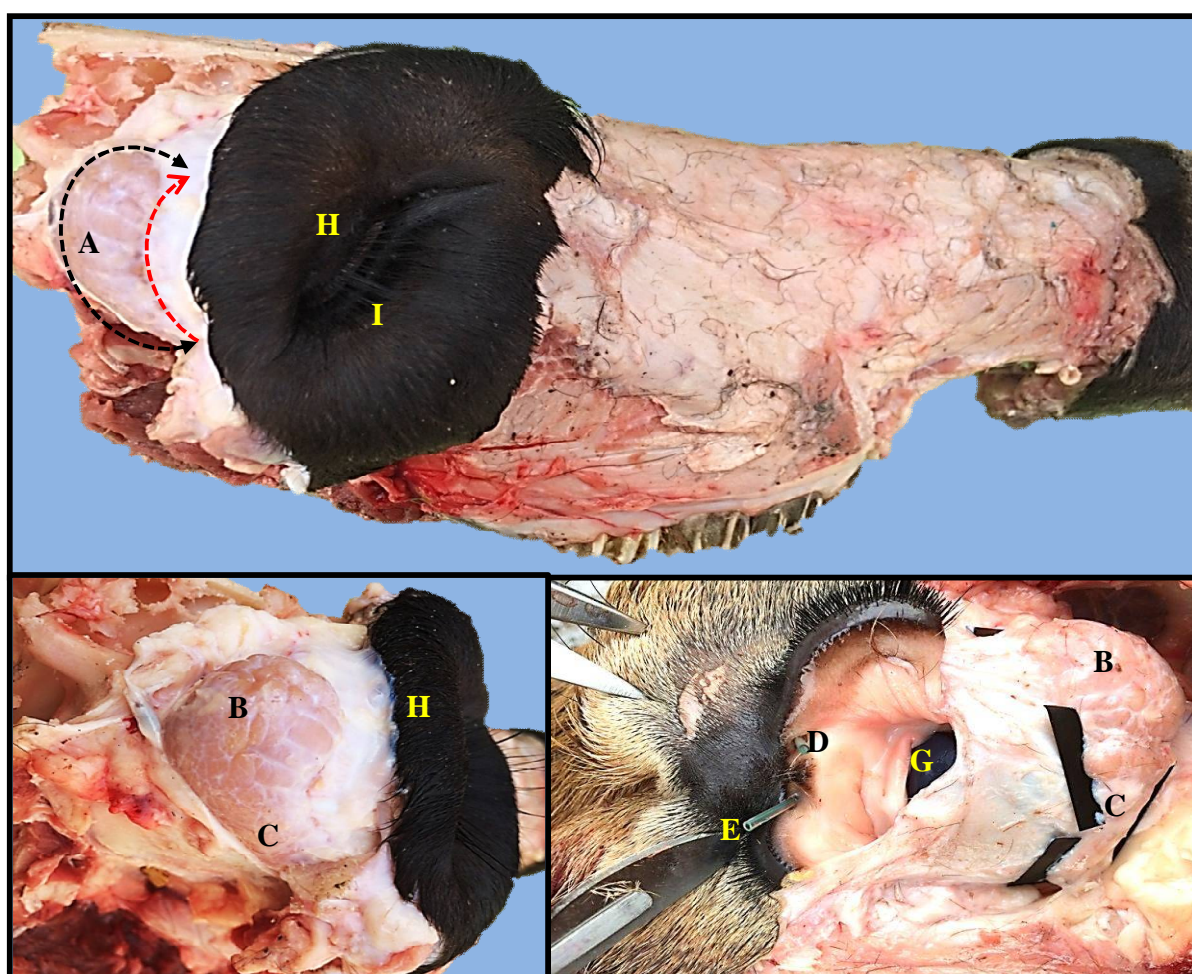


Fig.(1). Lacrimal gland in cattle Show: A- Lacrimal gland. B- Body of lacrimal gland. C-Appendage of lacrimal gland. D- Dorsal punctum. E- Ventral punctum. G- Eyeball. H- Upper eyelid. I- Lower eyelid.







Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia

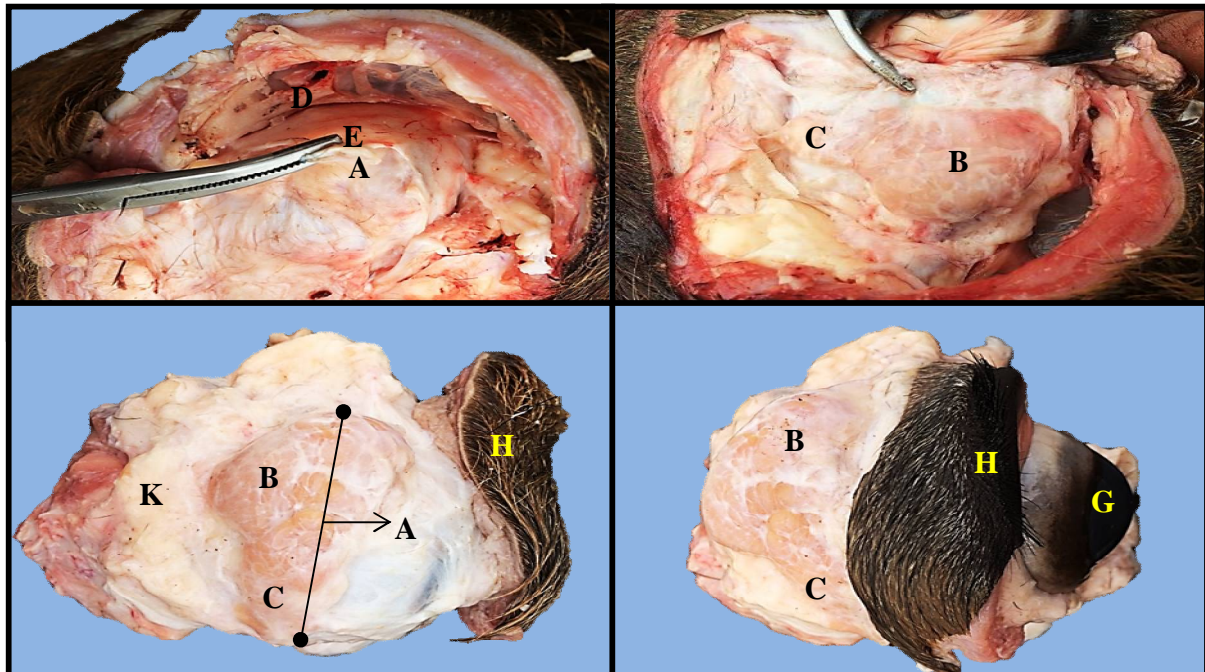


Fig.(2). Lacrimal gland in cattle Show: A- Lacrimal gland. B- Body of lacrimal gland. C-Appendage of lacrimal gland. D- Orbital cavity. E- Periorbital connective tissue. G- Eyeball. H- Upper eyelid. K-Adipose tissue.

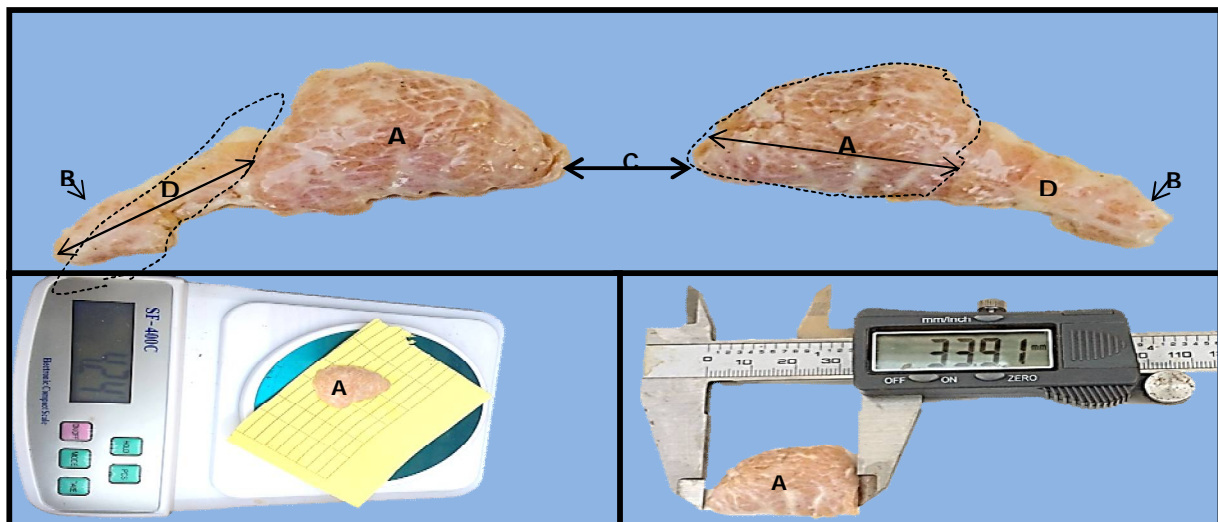


Fig.(3). Lacrimal gland in cattle Show: A- Body of lacrimal gland. B- Caudal end of lacrimal gland. C- Cranial end of lacrimal gland . D- Appendage of lacrimal gland.





Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia

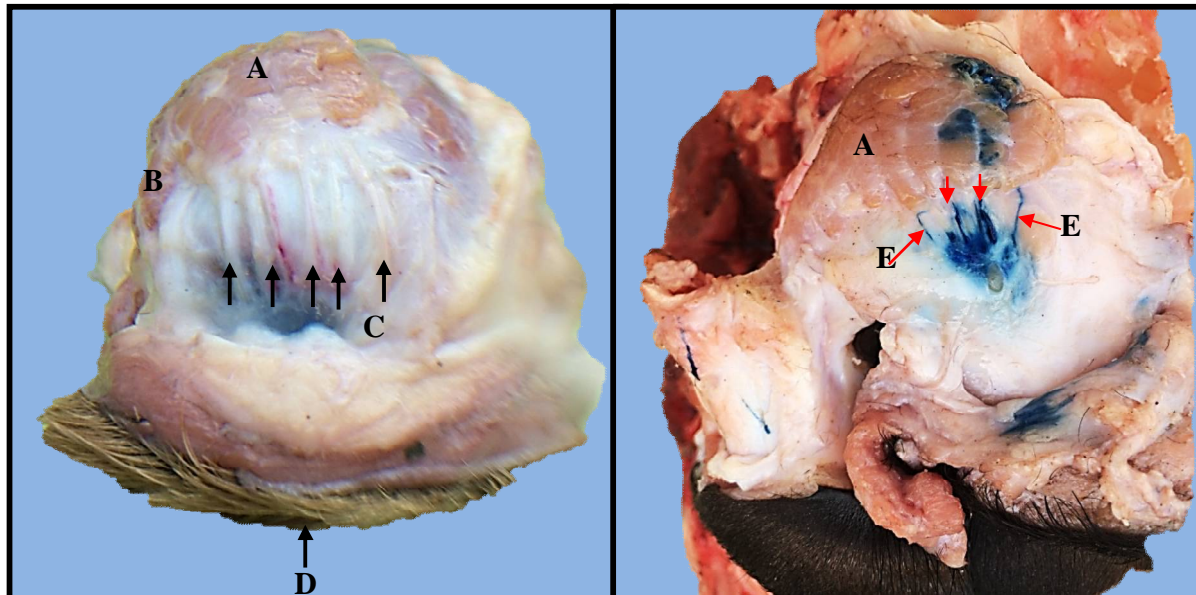


Fig.(4). Major excretory ducts of lacrimal gland in cattle show: A- Body of lacrimal gland. B- Appendage lacrimal gland. C- Major excretory duct of lacrimal gland (Black arrow). D- Upper eyelid. E- Major excretory duct injection with blue dye (Red arrow).

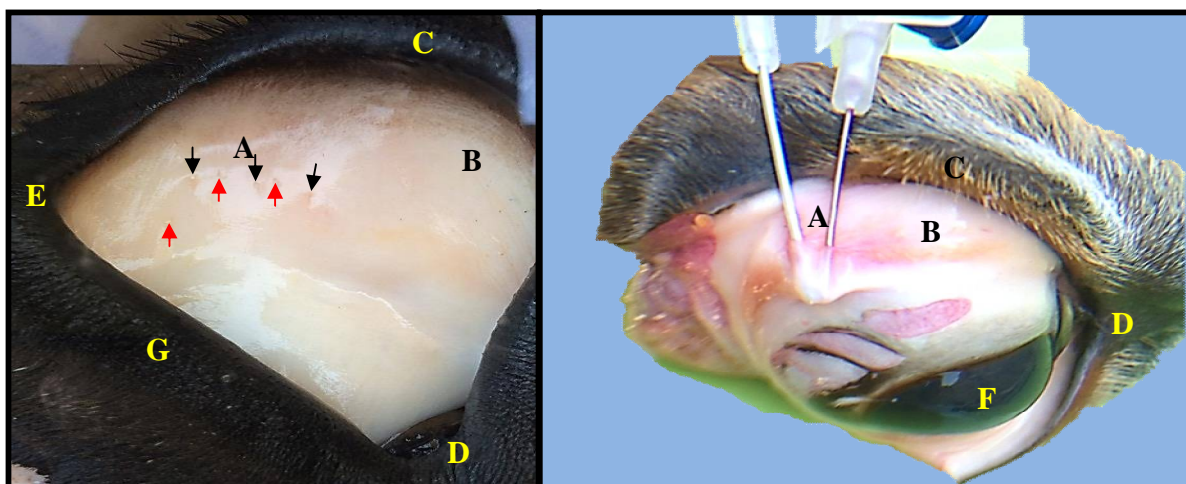


Fig.(5). Conjunctival surface of the upper eyelid in cattle Show: A- Major excretory duct of lacrimal gland (Black & red arrow). B- Conjunctival surface of upper eyelid (Fornix). C- Upper eyelid. D- Medial canthus. E- Lateral canthus. F- eyeball. G- Lower eyelid.







Nabeel Abd Murad AL-Mamoori and Mahdi Abdul-Kareem Atyia

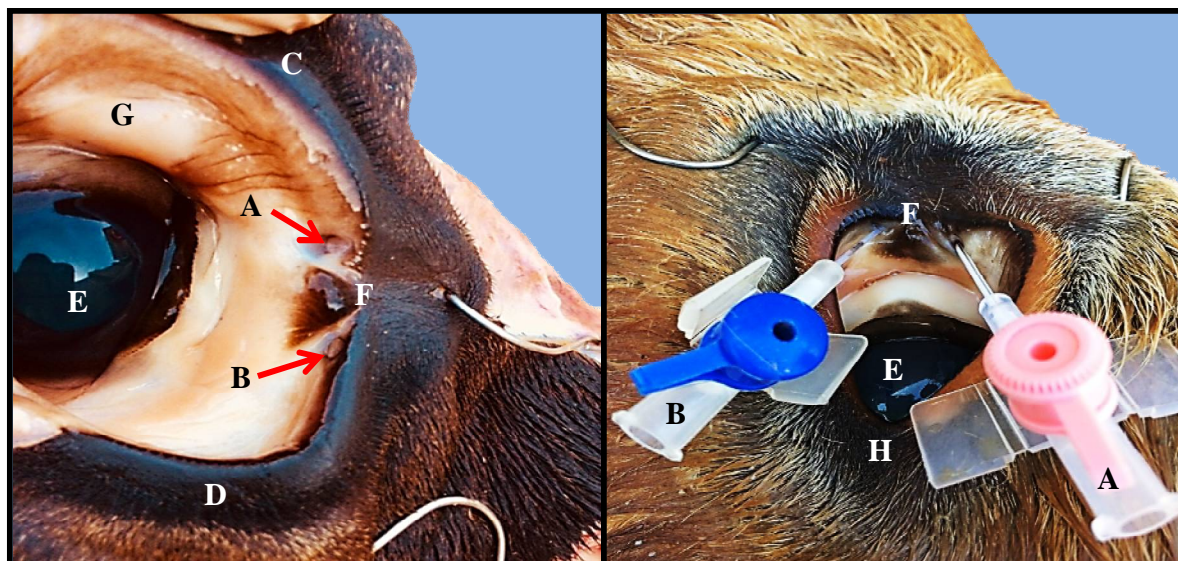


Fig.(6). Lateral view of the eye cattle Show: A- Dorsal punctum. B- Ventral punctum. C- Upper eyelid. D- Lower eyelid. E- Eyeball. F- Medial canthus. G- Conjunctival surface. H- Lateral canthus.

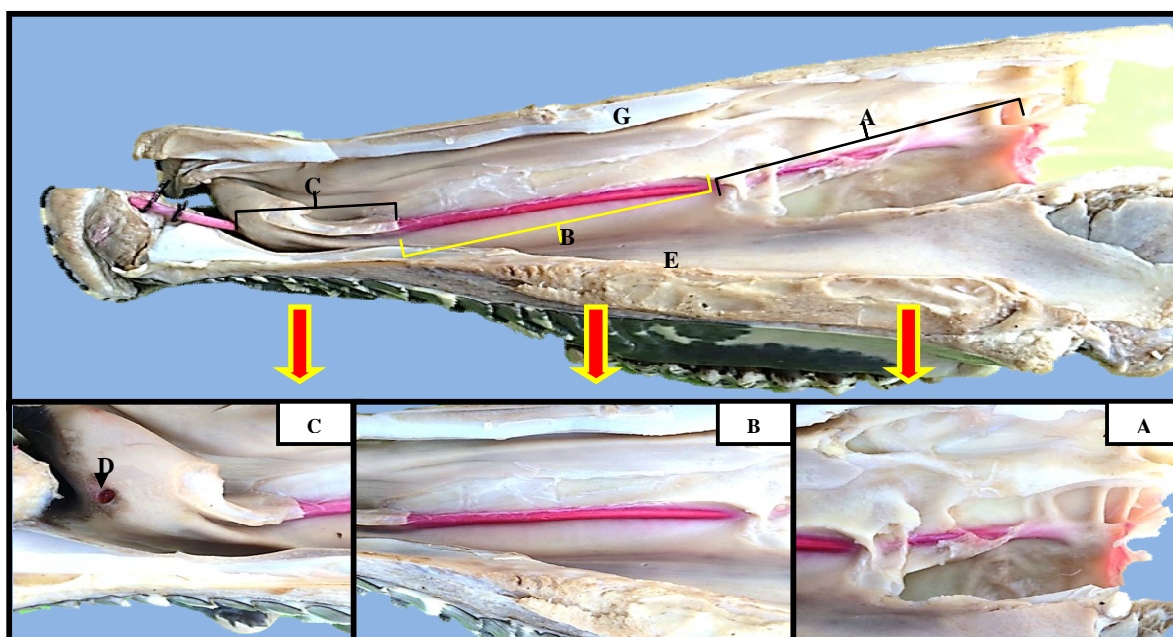


Fig.(7). Course of right side of nasolacrimal duct in cattle injected with latex & carmine Show: A- Proximal part(bony part). B- Middle part(Mucous part). C- Distal part(Cutaneous part). D- nasolacrimal opening. E- Floor nasal cavity. G- Roof nasal cavity.

