

**COMPARATIVE HISTOLOGICAL AND  
HISTOCHEMICAL STUDY OF LACRIMAL GLAND  
IN RUMINANTS**

**TRIVENI, T.**

**DEPARTMENT OF VETERINARY ANATOMY AND  
HISTOLOGY  
VETERINARY COLLEGE, BIDAR-585 401  
KARNATAKA VETERINARY, ANIMAL AND FISHERIES  
SCIENCES UNIVERSITY, BIDAR  
JULY, 2015**

**COMPARATIVE HISTOLOGICAL AND  
HISTOCHEMICAL STUDY OF LACRIMAL GLAND  
IN RUMINANTS**

*Thesis submitted to the  
Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar  
In the partial fulfillment of the requirement for the award of the  
Degree of*

**MASTER OF VETERINARY SCIENCE**

*In*  
**VETERINARY ANATOMY AND HISTOLOGY**

*By*  
**TRIVENI, T.**

**DEPARTMENT OF VETERINARY ANATOMY AND  
HISTOLOGY  
VETERINARY COLLEGE, BIDAR-585 401  
KARNATAKA VETERINARY, ANIMAL AND FISHERIES  
SCIENCES UNIVERSITY, BIDAR  
JULY, 2015**

**KARNATAKA VETERINARY, ANIMAL AND FISHERIES  
SCIENCES UNIVERSITY, BIDAR  
DEPARTMENT OF VETERINARY ANATOMY AND  
HISTOLOGY  
VETERINARY COLLEGE, BIDAR  
CERTIFICATE**

This is to certify that the thesis entitled “*COMPARATIVE HISTOLOGICAL HISTOCHEMICAL STUDY OF LACRIMAL GLAND IN RUMINANTS*” submitted by Ms. TRIVENI, T., I.D. No. MVNK-1305 in partial fulfillment of the requirements for the award of **MASTER OF VETERINARY SCIENCE** in **VETERINARY ANATOMY AND HISTOLOGY** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar is a record of bonafide research carried out by her during the period of her study in this University under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, association ship, fellowship or other similar titles.

**BIDAR  
JULY, 2015**

**(ASHOK PAWAR)**  
Major Advisor  
Professor and Head  
Dept. of Veterinary Anatomy and Histology,  
Veterinary College, Bidar.

**Approved by :**

**Chairperson : \_\_\_\_\_  
(ASHOK PAWAR)**

**Members : 1. \_\_\_\_\_  
(D. DILIP KUMAR)**

**2. \_\_\_\_\_  
(GIRISH, M. H.)**

**AFFECTIONATELY DEDICATED**

**TO**

*My beloved MOM and DAD and  
to the Veterinary Profession*

## **ACKNOWLEDGEMENT**

It's my pleasure to acknowledge and express a deep sense of gratitude and indebtedness to **Dr. Ashok Pawar**, Professor and Head, Department of Veterinary Anatomy, Veterinary College, Bidar, and the chairperson of my advisory committee, for allotting me this research topic, guidance, technical advice, encouragement to carry out research work in a systematic way and in writing the thesis.

I am greatly thankful to **Dr. D. Dilip Kumar**, Professor, Department of Veterinary Surgery and Radiology Veterinary College, Bidar, and also my advisory committee member for his critical suggestions and encouragement throughout the study.

I am thankful to **Dr. Girish, M. H.**, Assistant Professor, Department of Veterinary Anatomy, Veterinary College, Bidar and advisory committee member, for valuable suggestions and help throughout my research work.

I extend my thanks to **Dr. B.V. Shivaprakash**, Dean and Head of the Department of Surgery and Radiology, **Dr. Ramachandra, B.**, professor, Department of Animal nutrition, **Dr. M.M. Appannavar** Professor and Head, Department of Animal Genetics and Breeding and **Dr. K.M. Gadre**, Professor, Department of Veterinary Anatomy, Veterinary College, Bidar for their valuable suggestion and support for my research work.

I am thankful to **Dr. U.S. Biradar**, Director of instruction (PGS) for providing all the requirements during this research work and **Dr. Jayachandra, Dr. Satish, Dr. Shashidar, Dr. Ashwini** for their support.

I extend my thanks to **Mr. Shekar**, lab technician, **Ramappa** and **Jagannath**, lab attenders for their support

It should be my responsibility to thank my friends, **Dr. Vijay, Dr. Vasudev Pai, Dr. Roopa, Dr. Florence, Dr. Brahmalinga, Dr. Chandrashekar, Dr. Swathi Rathode, Dr. Asharani, Dr. Anjali, Dr. Aditya** and **Dr. Anusha** for the moral support throughout this study.

I acknowledge the sacrifice and ever willing moral support shared by **my family** heartily appreciate their inspiration in all my endeavours.

Bidar  
July, 2015

Triveni, T.

## CONTENTS

<b>Chapter No.</b>	<b>Title</b>	<b>Page No.</b>
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-11
III	MATERIALS AND METHODS	12-13
IV	RESULTS	14-57
V	DISCUSSION	58-65
VI	SUMMARY	66-72
VII	BIBLIOGRAPHY	73-75
VIII	ABSTRACT	76

## LIST OF TABLES

<b>Table No.</b>	<b>Title</b>	<b>Page No.</b>
1	Various Histometric parameters ( $\mu\text{m}$ ) of the lacrimal gland in different ruminants	22

## LIST OF GRAPHS

<b>Graph No.</b>	<b>Title</b>	<b>Page No.</b>
1	Comparative size of diameter of acini in different ruminants	22
2	Comparative size of diameter of tubules in different ruminants	23
3	Comparative size of diameter of intercalated duct in different ruminants	23
4	Comparative size of diameter of intralobular duct in different ruminants	24
5	Comparative size of diameter of interlobular duct in different ruminants	24

## LIST OF FIGURES

Fig. No.	Title	Page No.
1	Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) in the capsule <span style="float: right;">Vangieson's stain X 10</span>	25
2	Photomicrograph of lacrimal gland of cattle showing elastic fibers (arrow) in the capsule <span style="float: right;">Aldehyde fuschin stain X 40</span>	25
3	Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the capsule <span style="float: right;">Gomori's stain X 40</span>	25
4	Photomicrograph of lacrimal gland of cattle showing smooth muscle fiber (arrow) in the capsule <span style="float: right;">Aldehyde fuschin stain X 40</span>	26
5	Photo micrograph of lacrimal gland of cattle showing the septa (arrow) from capsule entering the parenchyma and dividing the gland into different lobes <span style="float: right;">H&amp;E X 4</span>	26
6	Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) in the septa <span style="float: right;">Vangieson's stain X 10</span>	26
7	Photomicrograph of lacrimal gland of cattle showing elastic fibers (arrow) in the septa <span style="float: right;">Aldehyde fuschin stain X 10</span>	27
8	Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the septa <span style="float: right;">Gomori's stain X 10</span>	27
9	Photomicrograph of lacrimal gland of cattle showing interlobular duct (D) artery (A), vein (V) and nerve fiber (arrow) in the septa <span style="float: right;">H&amp;E X 10</span>	27
10	Photomicrograph of lacrimal gland of cattle showing mast cell (arrow) in the septa <span style="float: right;">Toludinie blue stain X 100</span>	28
11	Photomicrograph of lacrimal gland of cattle showing tubules (T), acini (Ac), intralobular duct (IL) and smooth muscle fibers (arrow) around the intralobular duct <span style="float: right;">H&amp;E X 40</span>	28
12	Photomicrograph of lacrimal gland of cattle showing round to oval nucleus with distinct nucleolus (arrow) in the acini <span style="float: right;">H&amp;E X 100</span>	28

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
13	Photomicrograph of the lacrimal gland of cattle showing myoepithelial cell (arrow) at the base of secretory cells H&E X 100	29
14	Photomicrograph of lacrimal gland of cattle showing reticular fibers around the secretory units (arrow head) and in the basement membrane of the intercalated duct (arrow) Gomori's stain X 40	29
15	Photomicrograph of lacrimal gland of cattle showing plasma cells (P) and lymphocyte (L) in the interstitial tissue Methyl-pyronin green stain X 40	29
16	Photomicrograph of lacrimal gland in cattle showing macrophage (arrow) in the interstitial tissue H&E X 100	30
17	Photomicrograph of lacrimal gland of cattle showing intercalated duct (IC) showing simple cuboidal epithelium (arrow head) and smooth muscle (arrow) fibers around the duct H&E X 100	30
18	Photomicrograph of lacrimal gland of cattle showing a layer of collagen fibers (arrow) around the intercalated duct Vangieson's stain X 40	30
19	Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in basement membrane of the intralobular duct Gomori's stain X 40	31
20	Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) around the intralobular duct Vangieson's stain X 40	31
21	Photomicrograph of lacrimal gland of cattle showing bilayered columnar epithelium (arrow head) and smooth muscle fiber (arrow) around the interlobular duct (D) H&E X 40	31
22	Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) around the interlobular duct (D) Vangieson's stain X 40	32
23	Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the basement membrane of the interlobular duct (D) Gomori's stain X 40	32
24	Photomicrograph of lacrimal gland of cattle showing strong PAS positive reaction (black arrow) in acini and duct showing negative reaction (red arrow) PAS stain X 40	32

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
25	Photomicrograph of lacrimal gland of cattle showing Alcian blue positive reaction in a secretory unit (arrow) and few cells positive in a secretory unit (C) Alcian blue stain at pH 2.5 X40	33
26	Photomicrograph of lacrimal gland of cattle showing acini (black arrow) positive for both PAS and Alcian blue and a acini (red arrow) positive for PAS Combined Alcian blue and PAS technique X 10	33
27	Photomicrograph of lacrimal gland of buffalo showing capsule (arrow) H&E X 10	33
28	Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) in the capsule Vangieson's stain X 10	34
29	Photomicrograph of lacrimal gland of buffalo showing elastic fibers (arrow) in the capsule Aldehyde fuschin stain X 40	34
30	Photomicrograph of capsule of lacrimal gland of buffalo showing reticular fibers (arrow) in the capsule Gomori's stain X 40	34
31	Photomicrograph of lacrimal gland of buffalo showing smooth muscle fibers (arrow) in the capsule H&E X 40	35
32	Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) in the septa Vangieson's stain X 10	35
33	Photomicrograph of lacrimal gland of buffalo showing interlobular duct (D) artery (A), vein (V) and nerve fiber (arrow) in the septa H&E X 10	35
34	Photomicrograph of lacrimal gland of buffalo showing mast cell (arrow) in the septa Toludinie blue stain X 100	36
35	Photomicrograph of parenchyma of lacrimal gland of buffalo showing tubular (T) and acinar (Ac) serous secretory units in buffalo H&E X 40	36
36	Photomicrograph of lacrimal gland of buffalo showing myoepithelial cell (arrow) at the base of secretory cells H&E X 100	36
37	Photomicrograph of lacrimal gland of buffalo showing multinucleated giant cell (G) in the interstitial tissue H&E X 100	37

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
38	Photomicrograph of lacrimal gland of buffalo showing mast cell (arrow) in the interstitial tissue Toluidine blue stain X 100	37
39	Photomicrograph of lacrimal gland of buffalo showing plasma cells (P) in the interstitial tissue Methyl-pyronin green stain X40	37
40	Photomicrograph of lacrimal gland of buffalo showing plasma cells (P) and lymphocytes (L) in the interstitial tissue and distinct nucleolus (arrow) in the acinar cell H&E X 100	38
41	Photomicrograph of lacrimal gland of buffalo showing aggregation of lymphoid cells (arrow) in the parenchyma H&E X 10	38
42	Photomicrograph of lacrimal gland of buffalo showing smooth muscle fiber (arrow) around the intercalated duct(IC) and artery (A) in the septa H&E X 40	38
43	Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) around the intercalated duct(IC) and intralobular duct (IL) Vangieson's stain X 40	39
44	Photomicrograph of lacrimal gland of buffalo showing smooth muscle fiber (arrow) around the intralobular duct (IL) H&E X 40	39
45	Photomicrograph of lacrimal gland of buffalo showing reticular fibers (arrow) in the basement membrane of the intralobular duct(IL) Gomori's stain X 40	39
46	Photomicrograph of lacrimal gland of buffalo showing smooth muscle fibers (arrow) around the interlobular duct (D) H&E X 40	40
47	Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) around the interlobular duct (D) Vangieson's stain X 10	40
48	Photomicrograph of lacrimal gland of buffalo showing reticular fibers (arrow) in the basement membrane of interlobular duct (D) Gomori's stain X 40	40
49	Photomicrograph of lacrimal gland of buffalo showing strong PAS positive reaction (arrow head) and weak positive reaction (arrow) in secretory units PAS stain X 40	41

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
50	Photomicrograph of lacrimal gland of buffalo showing positive reaction in a secretory unit (arrow) and positive reaction in the few cells of a secretory unit (arrow head) for Alcian blue Alcian blue stain at pH 2.5 X40	41
51	Photomicrograph of lacrimal gland of buffalo showing positive reaction for PAS and Alcian blue in a secretory unit (arrow) Combined Alcian blue and PAS technique X 40	41
52	Photomicrograph of lacrimal gland of buffalo showing intralobular lipid (arrow) Oil red O stain X 10	42
53	Photomicrograph of lacrimal gland of buffalo showing interlobular lipid (arrow) Vangieson's stain X 10	42
54	Photomicrograph of lacrimal gland of sheep showing smooth muscle fibers (arrow) in the capsule H&E X 40	42
55	Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) in the capsule Vangieson's stain X 10	43
56	Photomicrograph of lacrimal gland of sheep showing reticular fibers (arrow) in the capsule Gomori's stain X 40	43
57	Photomicrograph of lacrimal gland of sheep showing elastic fibers (arrow) in the capsule Aldehyde fuschin stain X 40	43
58	Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) and interlobular duct(D) in the septa Vangieson's stain X 10	44
59	Photomicrograph of lacrimal gland of Sheep showing artey (A) and vein (V) in the septa Aldehyde fuschin stain X 4	44
60	Photomicrograph of lacrimal gland of sheep showing mast cell (arrow) in the septa Toludinie blue stain X 100	44
61	Photomicrograph of lacrimal gland of sheep showing macrophage (M), plasma cells (P) and lymphocyte (L) in the septa H&E X 100	45

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
62	Photomicrograph of lacrimal gland of sheep showing tubular (T), acinar (Ac) serous secretory units and myoepithelial cells (arrow) in the parenchyma H&E X 40	45
63	Photomicrograph of lacrimal gland of sheep showing binucleated cell (arrow) in the interstitial tissue H&E X 100	45
64	Photomicrograph of lacrimal gland of sheep showing macrophage (arrow) in the interstitial tissue H&E X 100	46
65	Photomicrograph of lacrimal gland of sheep showing plasma cells (P) in the interstitial tissue Methyl-pyronin green stain X100	46
66	Photomicrograph of lacrimal gland of sheep showing smooth muscle fibers (arrow) around the intercalated duct (IC) H&E X 40	46
67	Photomicrograph of lacrimal gland of sheep showing smooth muscle fiber (arrow head) around the intralobular duct (IL) H&E X 40	47
68	Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) around the intercalated duct(IC) and intralobular duct (IL) Vangieson's stain X 40	47
69	Photomicrograph of lacrimal gland of sheep showing stratified columnar epithelium (arrow) and smooth muscle fiber (arrow) surrounding the interlobular duct (D) H&E X 40	47
70	Photomicrograph of lacrimal gland of sheep showing strong PAS positive reaction (arrow) in the secretory units PAS stain X 40	48
71	Photomicrograph of lacrimal gland of sheep showing strong PAS positive reaction (arrow) in goblet cells of interlobular duct PAS stain X 40	48
72	Photomicrograph of lacrimal gland of sheep showing Alcian blue positive reaction in a tubule (arrow) and few cells (arrow head) in a acini Alcian blue stain at pH 2.5 X40	48
73	Photomicrograph of lacrimal gland of sheep showing positive reaction for PAS in a secretory unit (arrow) and showing positive reaction for both PAS and Alcian blue (arrow head) in a secretory unit Combined technique of PAS and Alcian blue X 10	49

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
74	Photomicrograph of lacrimal gland of sheep showing intralobular lipid (arrow) H&E X 40	49
75	Photomicrograph of lacrimal gland of goat showing smooth muscle fibers (arrow) in the capsule Alcian blue X10	49
76	Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) in the capsule Vangieson's stain X 10	50
77	Photomicrograph of lacrimal gland of goat showing elastic fibers (arrow) in the capsule Aldehyde fuschin stain X 40	50
78	Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the capsule Gomori's stain X 40	50
79	Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) in the septa Vangieson's stain X 10	51
80	Photomicrograph of lacrimal gland of goat showing elastic fibers (arrow) in the septa Aldehyde fuschin stain X 10	51
81	Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the septa Gomori's stain X 40	51
82	Photomicrograph of lacrimal gland of goat showing interlobular duct (D), artery (A) and vein (V) in the septa H&E X 4	52
83	Photomicrograph of lacrimal gland of goat showing lymphocytes (L), plasma cells (P) and fibrocytes (F) in the septa H&E X 40	52
84	Photomicrograph of lacrimal gland of goat showing acidophilic acini (Ac) and basophilic acini (arrow) in the parenchyma H&E X 40	52
85	Photomicrograph of lacrimal gland of goat showing myoepithelial cell (arrow) at the base of secretory cells in tubule (T) H&E X 40	53
86	Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) around the secretory units Vangieson's stain X 40	53

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
87	Photomicrograph of lacrimal gland in goat showing reticular fibers (arrow) between the secretory units and in basement membrane of secretory units Gomori's stain X 40	53
88	Photomicrograph of lacrimal gland in goat showing macrophage (arrow) in the interstitial tissue Oil red O X 100	54
89	Photomicrograph of lacrimal gland of goat showing bilayered cuboidal epithelium (arrow) in the intercalated duct (IC) H&E X 40	54
90	Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the basement membrane of the intercalated duct(IC) Gomori's stain X 40	54
91	Photomicrograph of lacrimal gland of goat showing smooth muscle fibers (arrow) in the intralobular duct ((IL) H&E X 40	55
92	Photomicrograph of lacrimal gland of goat showing goblet cells (arrow) in the epithelium and smooth muscle fibers (arrow head) around the interlobular duct (D) Aldehyde fuschin X 40	55
93	Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the basement membrane (arrow) of interlobular duct (D) Gomori's stain X40	55
94	Photomicrograph of lacrimal gland in goat showing strong PAS positive Reaction (arrow) in secretory units PAS stain X 40	56
95	Photomicrograph of lacrimal gland of goat showing Alcian blue positive reaction in a acini (arrow) and few cells in the tubule (arrow head) Alcian blue stain at pH 2.5 X40	56
96	Photomicrograph of lacrimal gland of goat showing positive reaction for PAS (arrow) in a tubule and positive reaction for both PAS and Alcian blue (arrow head) in a acini Combined Alcian blue and PAS technique X 40	56
97	Photomicrograph of lacrimal gland of goat showing intralobular lipid (arrow) Oil red O stain X 40	57
98	Photomicrograph of lacrimal gland of goat showing interlobular lipid (arrow head) and nerve fiber (arrow) in the septa H&E X 10	57

## LIST OF ABBREVIATIONS AND SYMBOLS

%	Per cent
±	Plus or minus
µm	Micrometer
Fig	Figure
PAS	Periodic acid schiff
GDP	Gross domestic product
Lab	Laboratory
No.	Number
X	Magnifying power
<i>et al.</i>	Co -workers

# Introduction



## I. INTRODUCTION

The population of cattle in India is about 190.90 million, buffalo 108.7 million, sheep 65.06 million and goat 135.17 million. In Karnataka the population of cattle is 95, 16,484 buffalo 34, 70,505 sheep 95, 83,761 and goat 47, 961, 47 (19<sup>th</sup> livestock census). They are the major source of milk, meat, wool and hide. The livestock sector alone contributes nearly 25.6% of value of Agriculture output including Fisheries and Forestry sector. Overall contribution of Livestock Sector to total GDP is nearly 4.11% where majority of the income comes from cattle, buffalo, sheep, and goat. Dry eye disease (keratitis sicca), which is caused by corneal desiccation because of lacrimal gland dysfunction, is one of the most prevalent eye diseases that cause corneal epithelial damage and results in significant loss of vision or complete blindness.

Lacrimal gland is a compound tubulo-alveolar or tubulo-acinar gland and located at dorso-lateral aspect of the eye ball. The gland is serous type in all domestic mammals other than the pig in which it is mucoid ( Konig and Liebich, 2009). The lacrimal gland is responsible for production and secretion of tears which clean and nourish cornea and helps to maintain its health. The overall tear film that moistens and protects the surface of the eye is made up of three layers. They are inner mucous layer, middle aqueous layer, outer oily layer, the lacrimal gland contributes to the middle aqueous layer is about 60% to the aqueous portion of the tear film. This tear film flushes the foreign materials from the conjunctival sac, nourishes and lubricates the palpebral and corneal interfaces. It also acts as a medium through which oxygen, immunoglobulins and protective cells can reach the cornea.

Lacrimal is a capsulated gland. The connective septa radiate from the capsule and divide the gland into lobules. The septa contains blood vessels, nerves, interlobular ducts. Each lobule of gland contains round or oval serous alveoli. The alveoli presents a relatively small lumen lined by pyramidal cells. Their cytoplasm is finely granular. The gland consisted of intercalated ducts, intralobular, interlobular ducts (Singh *et al.*, 1975).

The lacrimal glands are unique structures possessing both epithelial and lymphoid tissue and may fall prey to an unusually wide range of pathogens because the cornea is a wet, warm surface and thus is an ideal pathway for pathogens to invade the body and to affect the cornea. The plasma cells are found in the interstitial spaces of the gland and migrate into it from lymphoid organs such as the gut-associated lymphoid tissue (GALT). These plasma cells secrete immunoglobulin A (IgA) which is important in protecting the ocular surface from infection. (Walcott, 1998)

The acinar cells of the secretory epithelium have three main functions, to synthesize and secrete a number of tear-specific proteins, to secrete water, and to transport the IgA secreted by the plasma cells from the interstitial compartment into the lumen of the gland to protect the cornea from viral and bacterial infections.

The lacrimal gland-specific proteins found at highest concentrations in the tears are lactoferrin, tear-specific prealbumin (TSP or lipocalin), and lysozyme. Other proteins occurring at lower concentrations are amylase, peroxidase, plasminogen activator, prolactin, epidermal growth factor (EGF), transforming growth factor- $\beta$  (TGF- $\beta$ ), endothelin-1, and retinol. Lactoferrin, TSP, peroxidase, and lysozyme as well as IgA function to protect the cornea from viral and bacterial infections. Retinol, which is

derived from vitamin A, is necessary for the health of the cornea. The growth factors, TGF, EGF, and endothelin-1, are thought to be involved in the wound healing process in response to corneal abrasion or ulceration (Walcott, 1998).

It has been observed that there is a variation in the structure and secretion among the animals. The lacrimal gland epithelium also is an elegant secretory tissue of multiple functions with complex control systems that can serve as a model for understanding the other secretory epithelia. There is limited scientific work carried out on the comparative histological and histochemical study of lacrimal gland in ruminants i.e. cattle, buffalo, sheep and goat. The Present study will contribute structural differences and also indicates the nature of secretions of the lacrimal gland in the ruminants. Hence the present research work on lacrimal gland is under taken with following objectives.

- a) To study the histology of the lacrimal gland in ruminants.
- b) To study histochemistry of the lacrimal gland in ruminants.
- c) To correlate any histological and histochemical variations in the lacrimal gland of ruminants.

# Review of Literature



## **II. REVIEW OF LITERATURE**

Lacrimal gland is a compound tubulo-alveolar or tubulo-acinar gland situated on the dorsolateral aspect of the eye ball. It is a lobulated gland in the ruminants. Histologically it is a seromucous gland. It contributes about 60% to the aqueous portion of the tear film which flushes the foreign materials from the conjunctival sac and lubricates the palpebral and corneal interfaces. It also acts as a medium through which oxygen, immunoglobulins, protective cells can reach the cornea.

### **2.1 HISTOMORPHOLOGY**

#### **2.1.1 STROMA**

Singh *et al.* (1975) reported that the lacrimal gland of buffalo was covered by fibrous capsule which is comparatively thicker ( 181.5 $\mu$ m) on the face of lacrimal gland related to the periorbita than that of supraorbital process. The connective tissue septa radiate from the capsule into the parenchyma of gland and divided the gland into different lobules and contained blood vessels, nerve fibers, interlobular ducts.

Pinard *et al.* (2003) observed that the gland of bison and cattle consisted of tubulo acinar units separated by the dense sheet of connective tissue which divided the parenchyma into lobules. Inter and intralobular ducts, veins and arteries were seen in the connective tissue septa.

Cabral *et al.* (2005) stated that glandular lobes of canines were separated by interstitial tissue consisted of mainly collagen fibers and myoepithelial cells, plasma cells, lymphocytes were noticed.

Maala and De ocampo (2007) stated that the capsule of the lacrimal gland of water buffalo consisted of mainly collagen fibers. The connective tissue septa divided the gland into lobules and contained interlobular ducts and blood vessels.

Getty (2012) stated in ruminants that connective tissue septa were detached and pass between the serous secreting cells of the ducts of the gland. The presence of capillaries, macrophages, plasma cells and some pigmented cells were noticed in the septa.

### **2.1.2 PARENCHYMA**

Singh *et al.* (1975) observed in buffaloes that the lobule of the gland contained round to oval serous alveoli measured 35.2 $\mu$ m to 66.0 $\mu$ m. The alveoli presented a relatively small lumen and are lined with pyramidal cells. The nuclei of glandular cells were spherical in shape and located in the basal region of the cells. Their cytoplasm was finely granular and acidophilic in the supranuclear region but slightly basophilic in the basal zone. The inter cellular secretory canaliculi and basket cells were more evident almost in all the alveoli. Basket cells were characterised by fusiform or stellate shaped basophilic nuclei situated in close contact with the basement membrane of the secretory alveoli.

The lacrimal gland was serous in all domestic animals except in pigs where it was mucoid in nature (Banks 1993, Konig and Liebich 2009).

Garguilo *et al.* (1999) described that the gland in sheep was tubulo acinar type consisted of serous, mucous and seromucous acini in the secretory portion. Mucous acini were preferentially located at the periphery of glandular lobules. The acinus composed of

pyramidal or columnar cells and two third of which were filled with the morphologically heterogeneous granules.

Trautmann and Fiebiger (2002) described that secretory cells of lacrimal gland were serous in all domestic animals and mucous in swine.

Pinard *et al.* (2003) observed that the lacrimal gland was tubuloacinar type in bison and cattle, the acini were lined by tall columnar cells with small lumen and tubules were lined by short columnar cells with large lumen, the nuclei were oval to round in shape and were basally located. The acinar cells were consisted of basophilic granular with vacuolated cytoplasm in bison whereas, cattle had eosinophilic granules with uniform cytoplasm and more infiltration cells were seen between the acini.

Eurell and Frappier (2006) stated that the lacrimal gland was serous in cats and seromucous in dogs and ungulates, the acinar cells were surrounded by myoepithelial cells.

Shadkhast and Bigham (2010) described that the lacrimal gland of the buffalo was tubulo acinar type and separated by a sheet of connective tissue. The acini were composed of tall pyramidal or columnar cells with small lumens whereas, the tubules were lined by short columnar cells with large lumens. The tubules were intermingled between the nests of acini. The acinar cells had basophilic, granular, vacuolated cytoplasm and arranged in a loosely irregular fashion.

Klećkowska *et al.* (2012) stated that the acini in Roe deer were composed of 2 types of cells. The tall conical cell which was serous in nature surrounded by basal, and

myoepithelial cells with small lumen whereas, sporadic conical cells which were mucous in nature consisted of large and irregular lumen. The secretory cell nuclei were round to oval located both in basal and central part of the cell. These cells had basophilic granular and vacuolated cytoplasm and glandular secretion was aggregated in the apical parts of the cells.

Daryuos and Ahmed (2012) stated that the lacrimal gland of Awasi sheep and Black goat was mixed tubulo acinar gland, and the mucous acini were comparatively more in sheep than black goat. There was considerable increase in numbers of myoepithelial cells of secretory acini of lacrimal glands in Black goat.

Abbasi *et al.* (2014) described that the lacrimal gland of sheep was mixed type the serous acini were lined by cuboidal to low columnar cells with rounded nuclei located near the basal region and the cytoplasm of these cells were eosinophilic in nature. The mucous cells consisted vacuolated cytoplasm and noticed presence of elongated nuclei situated at the base of the cell.

### **2.1.3 DUCT SYSTEM**

Singh *et al.* (1975) described that duct system of lacrimal gland of buffalo as intercalated, intralobular, interlobular ducts. The intercalated ducts connects the intralobular ducts with the secretory alveoli and were lined by simple cuboidal epithelium whereas, the intralobular ducts were lined by simple columnar epithelium. The interlobular ducts were lined by bilayered cuboidal epithelium. The cytoplasm was acidophilic in supranuclear zone of the cells lining the intercalated and intralobular ducts.

The diameter of the intercalated, intra lobular, inter lobular ducts were ranged from 16.5 $\mu\text{m}$ , 33.0  $\mu\text{m}$ -49.5  $\mu\text{m}$ , 199.5 $\mu\text{m}$  – 266.0 $\mu\text{m}$  respectively.

Garguilo *et al.* (1999) stated that the lacrimal gland of sheep was made up of interlobular and intralobular ducts. The striated ducts were lacking whereas, terminal ducts had the appearance of intercalated ducts of major salivary glands and were lined by simple cuboidal epithelium.

Garguilo *et al.* (2000) observed the presence of goblet cells in the interlobular excretory ducts of lacrimal gland in sheep. Their function is to contribute to the organic content of the secretion.

Trautmann and Fiebiger (2002) stated that the smaller intercalated ducts were lined by simple cuboidal epithelium whereas, larger ducts were lined by bilayered cuboidal epithelium in all domestic animals. The presence of tall columnar epithelium in the larger excretory ducts was noticed in pig.

Pinard *et al.* (2003) observed in the interlobular ducts in lacrimal gland of cattle and bison were lined by pseudostratified epithelium.

Eurell and Frappier (2006) stated that the intercalated and secretory ducts were lined by simple and stratified cuboidal epithelia respectively in swine

Maala and De ocampo (2007) stated that the interlobular ducts in the lacrimal gland of buffalo were lined by simple to stratified columnar epithelium.

Shadhast and Bigham(2010) reported that interlobular ducts of lacrimal gland of river buffalo were lined with pseudostratified epithelium.

Daryuos and Ahmed (2012) described that intercalated ducts in lacrimal gland of Awasi sheep and Black goat were consisted of low cuboidal epithelium, then gradually transformed into stratified cuboidal to stratified columnar epithelium in larger ducts. The percentage of light cells and goblet cells in the duct epithelium inside the glands of Awasi sheep was greater than that of Black goat. There was variable amount of smooth muscle fibers around the connective tissue of interlobular ducts.

Klećkowska *et al.* (2012) observed that the excretory ducts were lined by a layer of cuboidal cells with nuclei located in the central part of the cell in lacrimal gland of Roe deer.

Abbasi *et al.* (2014) in sheep stated that intra lobular ducts were lined by simple cuboidal epithelium whereas, interlobular ducts and excretory ducts were lined by stratified cuboidal epithelium. Goblet cells were also seen in the epithelium of interlobular ducts.

## **2.2 HISTOCHEMISTRY**

### **2.2.1 PARENCHYMA**

Singh *et al.* (1975) observed that diffuse cytoplasmic sudanophilia in the glandular cells of lacrimal gland of buffalo.

Martin *et al.* (1998) described that the acinar cells were positive for Alcian blue at pH 2.5 in dogs.

Gargiulo *et al.* (2000) observed strong PAS positive reaction in mucous cells whereas, seromucous showed weak reaction for PAS. Mucous and seromucous cells showed moderate reaction in Alcian blue at pH 1.0 and 2.5 in the lacrimal gland of sheep.

Trautmann and Fiebiger (2002) described that secretory cells often contained fat droplets in all domestic animals, and also cells showed positive reaction for mucin in sheep, goat and dog.

Pinard *et al.* (2003) in bison and cattle stated that the presence of PAS positive granules in all acini and tubular cells of the gland. The acinar cells were positive for Alcian blue at pH 1.0 and 2.5 whereas, the tubular cells did not show any reaction.

Cabral *et al.* (2005) observed the presence of intra and interlobular adipose cells in canines.

Eurell and Frappier (2006) described that the presence of lipid inclusion in the cells of the gland in pig.

Maala and De ocampo (2007) described that majority of the secretory acini reacted strongly to the PAS and Alcian blue at pH 2.5 stains and weak reaction was observed with Alcian blue pH 1.0 stain. Secretory acini of the female buffaloes showed stronger reaction to PAS and Alcian blue at pH 2.5 than those of the male.

Mohammadpour (2011) observed the positive reaction in Alcian blue and PAS in the lacrimal gland of the camel.

Klećkowska *et al.* (2012) observed the presence of PAS positive reaction in few secretory cells whereas, majority cells were PAS negative. Alcian blue at pH 2.5 staining indicated the presence of negative granules in apical parts of the acini cells and it has also revealed the presence of single cells fully filled with Alcian blue pH positive granules in Roe deer.

Abbasi *et al.* (2014) described the strong positive reaction for PAS and Alcian blue at pH 2.5 in the mucous cells of sheep.

### **2.2.2 DUCT SYSTEM**

Singh *et al.* (1975) stated that the intralobular duct was positive for fat whereas, it was rarely noticed in the interlobular duct in the lacrimal gland of the buffalo.

Garguilo *et al.* (2000) in sheep noted that the apical portion of the cells lining the terminal ducts were positive for PAS and Alcian blue at pH 1.0. Goblet cells in the interlobular excretory ducts showed strong positive reaction for both PAS and Alcian blue at pH 2.5 and weak reaction for Alcian blue at pH 1.0.

Abbasi *et al.* (2014) in sheep observed that the goblet cells in interlobular ducts were positive for PAS and Alcian blue at pH 2.5.

# *Materials and Methods*



### **III. MATERIALS AND METHODS**

#### **3.1 MATERIALS**

The present study was carried out in the Department of Veterinary Anatomy and Histology, Veterinary College, Bidar, Karnataka. The materials for the study were collected from Six adult cattle, Six adult sheep and Six adult goat immediately after slaughter from local slaughter house, Six adult buffalo samples were collected from the Allana slaughter house located at zaheerabad.

The collected glands were cut into tissue pieces and washed in normal saline and later fixed in different fixatives like 10% Neutral buffered formalin, Zenker's fluid and Bouin's fluid. The samples were processed in isopropyl alcohol- xylene sequence and embedded in paraffin by routine method (Luna, 1968). Sections were cut at 5-6 $\mu$ m thickness and were utilized for histomorphological and histochemical studies. The glandular tissue fixed in Neutral buffered formalin were pre-frozen for 1-2 hrs and embedded in freezing media, using cryostat 6-7  $\mu$ m thickness sections were cut and utilised for lipid studies.

#### **3.2 METHODS**

The following staining techniques were carried out to study histomorphological and histochemical feature of lacrimal gland in ruminants.

### **3.2.1 HISTOLOGICAL STAINING TECHNIQUES**

1. Ehrlich's Haematoxylin and Eosin stain (Luna, 1968)
2. Van Geison's stain for collagen fibres (Bancroft *et al.*, 2008)
3. Gomori's method for reticular fibres (Luna, 1968)
4. Aldehyde fuschin's method for elastic fibres (Bancroft *et al.*, 2008)
5. Toluidine blue method for mast cells (Singh and Sulochana, 1996)
6. Methylgreen –pyronin method for plasma cells (Luna, 1968)

### **3.2.2 HISTOCHEMICAL STAINING TECHNIQUES**

1. PAS technique for mucopolysaccharides (Bancroft, *et al.*, 2008)
2. Alcian blue pH 2.5 for sulphated sulfomucins and sialomucins (Bancroft *et al.*, 2008)
3. Combined PAS- Alcian blue pH 2.5 technique for mucins (Bancroft, *et al.*, 2008)
4. Oil red O for lipids (Luna, 1968)

### **3.2.3 STATISTICAL ANALYSIS**

Diameter of acini, tubules, intercalated ducts, intralobular ducts and interlobular ducts were measured by using image analyser software Motic image plus 2.0. and the available data were tested for statistical significance by one way Annova using software SAS. SAS/START (2012).

*Results*



## **IV. RESULTS**

### **4.1 CATTLE**

#### **4.1 HISTOMORPHOLOGY**

##### **4.1.1 STROMA**

The lacrimal gland of cattle was covered with a layer of connective tissue capsule consisted of collagen fibers, elastic fibers, reticular fibers (Fig. 1, 2, 3). Smooth muscle fibers were also observed in the capsule (Fig. 4). The septa from the capsule divided the gland into different lobules and contained connective tissue fibers mainly collagen fibers, elastic fibers, reticular fibers and the elastic fibers were more in the septa of cattle (Fig. 5, 6, 7, 8). Interlobular ducts, arteries, veins, nerve fibers (Fig.9) and plasma cells, lymphocytes, mast cells were also noticed in the septa (Fig.10).

##### **4.1.2 PARENCHYMA**

The lacrimal gland in cattle was tubulo acinar type. The acini and tubules were serous in nature and lined by pyramidal shaped cells with basal nuclei. The nuclei were spherical to oval in shape with distinct nucleolus. The cytoplasm was acidophilic, granular and cell boundaries were indistinct. The acini consisted of small round lumen whereas, the tubular portion contained long narrow lumen. (Fig.11, 12). The myoepithelial cells at the base of the secretory cells and reticular fibers in the basement membrane of the secretory units were observed (Fig.13, 14). The plasma cells, lymphocytes and macrophages were also observed in the interstitial tissue of the lacrimal gland of cattle (Fig. 15, 16).

### **4.1.3 DUCT SYSTEM**

The lacrimal gland of cattle consisted of intercalated, intralobular and interlobular ducts. Intercalated duct which connects acini to the intralobular duct was lined by simple cuboidal epithelium with centrally placed nucleus. A single layer of smooth muscle cells and thin layer of collagen fibers were observed around the duct (Fig. 17, 18). The reticular fibers were noticed in the basement membrane of duct (Fig.14). The intralobular ducts were many and lined by simple columnar epithelium with centrally placed nucleus. The reticular fibers were noticed in the basement membrane of cells of duct. Smooth muscle fibers and collagen fibers were also observed around the duct (Fig. 11, 19, 20). Inter lobular ducts between the lobules were lined by bilayered columnar epithelium with centrally placed nuclei. Smooth muscle fibers, collagen fibers around the duct and reticular fibers in the basement membrane of the duct were observed (Fig. 21, 22, 23).

### **4.1.4 HISTOCHEMISTRY**

A strong PAS positive reaction was observed in all secreting units of the gland, the intercalated ducts, intralobular ducts, interlobular ducts of the gland did not show any PAS reaction (Fig.24). Few secretory units and few cells in secretory units were positive for Alcian blue at pH 2.5 (Fig.25). In combined Alcian blue and PAS technique, cells of few secretory units were positive for both Alcian blue and PAS but majority of the secretory cells gave PAS positive reaction (Fig.26). Intralobular and interlobular lipids were not observed.

## **4.2 BUFFALO**

### **4.2 HISTOMORPHOLOGY**

#### **4.2.1 STROMA**

The lacrimal gland of buffalo was tubulo acinar type and was covered with the connective tissue capsule consisted of collagen fibers, reticular fibers, and elastic fibers, (Fig. 27, 28, 29, 30). Smooth muscle fibers were more in the capsule of buffalo (Fig.31). The connective tissue septa from the capsule entered into the gland and divided the gland into different lobules and contained connective tissue fibers mainly collagen fibers and elastic fibers (Fig.32). Arteries, veins, nerve fibers, interlobular ducts, the plasma cells and mast cells were also observed in the septa (Fig.33, 34).

#### **4.2.2 PARENCHYMA**

The parenchyma of lacrimal gland of buffalo was tubulo acinar type and serous in nature. The acini and tubules were lined by pyramidal shaped cells with basal nuclei. The nuclei were spherical to elongate in shape with distinct nucleolus. The lumen of the acini was small and round, whereas, lumen of tubular portion was long and narrow. The cytoplasm of secretory cells was acidophilic at the base of the cell and basophilic towards the apical portion, and granular in appearance and myoepithelial cells were observed at the base of the secretory cells (Fig.35, 36, 40). The multinucleated giant cells, mast cells, plasma cells, macrophages, and lymphocytes were observed in the interstitial tissue (Fig. 37, 38, 39, 40). The plasma cells and lymphocytes were more in the interstitial tissue of lacrimal gland in buffalo. Aggregation of lymphoid cells in the parenchyma of the gland was also noticed (Fig. 41).

### **4.2.3 DUCT SYSTEM**

The lacrimal gland of buffalo consisted of intercalated, intralobular and interlobular ducts. Intercalated ducts were lined by simple cuboidal with centrally placed spherical nucleus (Fig. 42). The smooth muscle fibers and collagen fibers were observed around the duct (Fig. 42, 43). Intralobular ducts were lined by simple columnar epithelium with centrally placed nuclei, they were surrounded by smooth muscle fibers and collagen fibers (Fig. 43, 44). The reticular fibres were observed in the basement membrane of the intralobular duct (Fig. 45). Interlobular ducts were lined by bilayered columnar epithelium with centrally located nucleus. The smooth muscle fibers, collagen fibers were observed around the duct. The reticular fibers were observed in the basement membrane of the ducts (Fig. 46, 47, 48).

### **4.2.4 HISTOCHEMISTRY**

A Strong to weak PAS positive reactions were observed in the secretory units of the lacrimal gland of buffalo whereas, the ducts did not show any reaction for PAS (Fig. 49). Few secretory units and few cells in the secretory units were positive for Alcian blue at pH 2.5 (Fig.50). In combined Alcian blue and PAS technique secretory cells were positive for both PAS and Alcian blue (Fig.51). The intralobular and interlobular lipids were observed (Fig. 52, 53).

## **4.3 SHEEP**

### **4.3. HISTOMORPHOLOGY**

#### **4.3.1 STROMA**

The sheep lacrimal gland was covered with a layer of capsule consisted of smooth muscle fibers, collagen fibers, reticular fibers and elastic fibers (Fig. 54, 55, 56, 57). The septa from the capsule entered into parenchyma and divided the gland into different lobules and contained mainly collagen fibers, reticular fibers, elastic fibers, arteries, nerve fibers, veins and interlobular ducts (Fig.58, 59). The mast cells, macrophages, plasma cells and lymphocytes were also observed in the septa (Fig. 60, 61).

#### **4.3.2 PARENCHYMA**

The lacrimal gland parenchyma of sheep was tubulo acinar type and serous in nature. The acinar and tubular secretory units were lined by pyramidal shaped cells with basal nuclei with distinct nucleolus. The cytoplasm was moderately acidophilic granular. The acinar secretory portion consisted of small round lumen whereas, the tubular portion consisted of long narrow lumen and myoepithelial cells were observed at the base of secretory cells (Fig.62). The binucleated cells, macrophages, plasma cells and lymphocytes were observed in the interstitial tissue (Fig. 63, 64, 65).

#### **4.3.3 DUCT SYSTEM**

The lacrimal gland of sheep consisted of intercalated, intralobular and interlobular ducts. The intercalated ducts were lined by simple cuboidal epithelium with centrally located nucleus, and collagen fibers, smooth muscle fibers were noticed around the duct

(Fig. 66, 68). The intralobular ducts were lined by bilayered columnar epithelium with centrally placed nuclei. Smooth muscle fibers, collagen fibers, were noticed around the duct (Fig. 67, 68). The interlobular ducts were lined by stratified columnar epithelium and goblet cells were observed in the epithelium of these ducts. Smooth muscle fibers and collagen fibers were seen around the duct (Fig. 69).

#### **4.3.4 HISTOCHEMISTRY**

A strong PAS positive reaction was seen in all the secretory units whereas, the ducts did not show any reaction for PAS, but the goblet cells in the interlobular ducts showed strong positive reaction for PAS (Fig. 70, 71). Few secretory units and few cells in the secretory units showed positive reaction for Alcian blue at pH 2.5 (Fig.72). In combined Alcian blue and PAS technique majority secretory cells were positive for PAS and whereas, cells of few secretory units showed positive reaction for both Alcian blue and PAS (Fig.73). Intralobular lipids were observed in the lacrimal gland of sheep (Fig.74).

### **4.4 GOAT**

#### **4.4 HISTOMORPHOLOGY**

##### **4.4.1 STROMA**

The lacrimal gland of goat was covered by a layer of capsule consisted of collagen fibers, elastic fibers, reticular fibers and smooth muscle fibers (Fig.75, 76, 77, 78). The septa from the capsule entered the parenchyma and divided the gland into different lobules and consisted of mainly collagen fibers, elastic fibers, reticular fibers

and the elastic fibers were more in the septa of goat (Fig.79, 80, 81).. Arteries, veins, nerve fibers, interlobular ducts, mast cells, plasma cells, lymphocytes and fibrocytes were also noticed in the septa (Fig. 82, 83, 98).

#### **4.4.2 PARENCHYMA**

The parenchyma of lacrimal gland of goat was tubulo acinar type and serous in nature. Acinar and tubular units were lined by pyramidal shaped cells with basal nucleus, nucleus were spherical to oval shape with distinct nucleolus. The cytoplasm of few cells was acidophilic granular whereas cytoplasm of few cells was basophilic, with granular cytoplasm. Small round lumen was observed in the acinar portion whereas, long narrow lumen in the tubular portion and myoepithelial cells were observed at the base of secretory cells (Fig. 84, 85). Collagen fibers, and reticular fibers were observed around secretory units (Fig. 86, 87). Plasma cells, lymphocytes and macrophages were observed in the interstitial tissue (Fig. 88).

#### **4.4.3 DUCT SYSTEM**

The lacrimal gland of goat consisted of intercalated, intralobular, interlobular ducts. Intercalated ducts were lined by bilayered cuboidal epithelium with centrally placed nucleus, the presence of reticular fibers in the basement membrane were noticed (Fig. 89, 90). The intralobular ducts were lined by bilayered columnar epithelium and collagen fibers and smooth muscle fibers were observed around the duct (Fig.91). Interlobular ducts were lined by stratified columnar epithelium, with the goblet. Smooth muscle fibers, and reticular fibers were observed around the duct (Fig. 92, 93).

#### **4.4.4 HISTOCHEMISTRY**

Strong PAS positive reactions were observed in all the secretory units of the gland (Fig. 94) and the ducts did not show any reaction for PAS whereas, the goblet cells in the interlobular ducts showed PAS positive reaction. Few secretory units and few cells in secretory units were positive for Alcian blue at pH 2.5 (Fig. 95). In combined Alcian blue and PAS technique few secretory units were completely positive for PAS whereas, cells of few secretory units showed positive reaction for both PAS and Alcian blue (Fig. 96). The goblet cells of interlobular ducts showed positive reaction for aldehyde fuchsin. Intralobular and interlobular lipids were observed in the gland (Fig. 97, 98, 92).

#### **4.5 HISTOMETRY**

The various parameters of the lacrimal gland of ruminants were measured and statistical analysis were carried out and are presented in table no.1 and graphs 1, 2, 3, 4, 5.

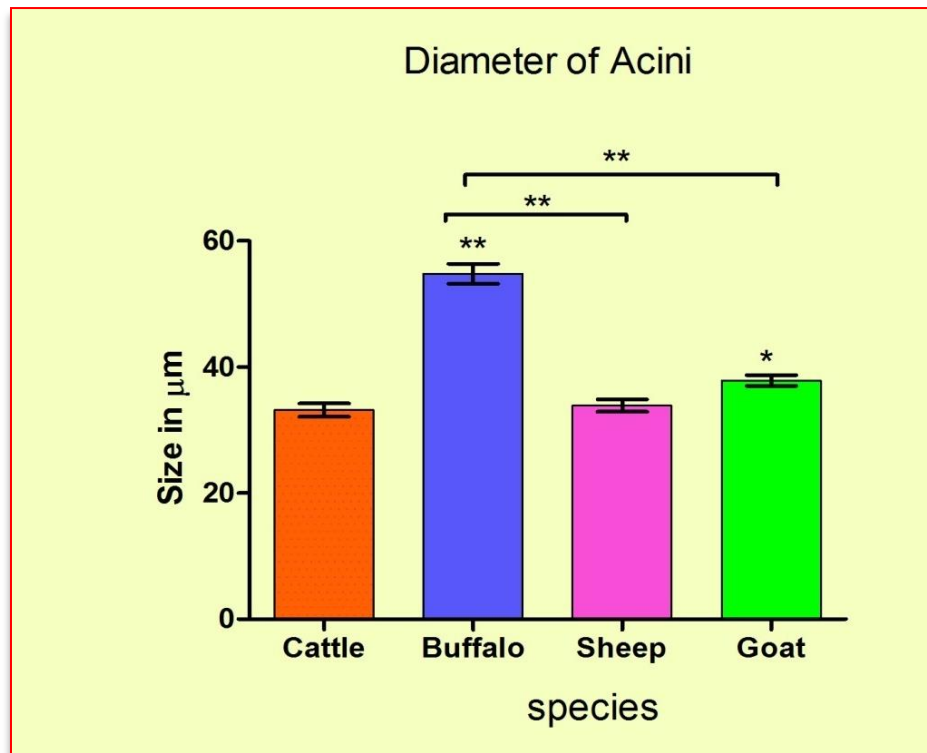
**Table No. 1. Various histometric parameters ( $\mu\text{m}$ ) of the lacrimal gland in different ruminants**

Sl. No.	Size in $\mu\text{m}$	Species			
		Cattle	buffalo	sheep	goat
1	Diameter of Acini	33.18 $\pm$ 1.05 <sup>aC</sup>	54.81 $\pm$ 1.56 <sup>**cB</sup>	33.89 $\pm$ 0.97 <sup>aA</sup>	37.88 $\pm$ 0.86 <sup>*bA</sup>
2	Diameter of Tubules	47.27 $\pm$ 0.77 <sup>aC</sup>	69.56 $\pm$ 1.77 <sup>**bB</sup>	41.50 $\pm$ 1.12 <sup>**bA</sup>	45.70 $\pm$ 1.01 <sup>aA</sup>
3	Diameter of Intercalated Duct	50.28 $\pm$ 1.26 <sup>aC</sup>	46.79 $\pm$ 0.83 <sup>aB</sup>	39.87 $\pm$ 0.85 <sup>**bA</sup>	43.36 $\pm$ 1.00 <sup>**bA</sup>
4	Diamter of Intralobular Duct	71.54 $\pm$ 1.68 <sup>aB</sup>	60.96 $\pm$ 1.39 <sup>**bA</sup>	63.49 $\pm$ 1.89 <sup>**bA</sup>	59.78 $\pm$ 1.16 <sup>**bA</sup>
5	Diameter of Inter lobular Duct	88.82 $\pm$ 4.48 <sup>aB</sup>	96.50 $\pm$ 4.32 <sup>aA</sup>	101.00 $\pm$ 6.73 <sup>aA</sup>	115.10 $\pm$ 8.55 <sup>*cA</sup>

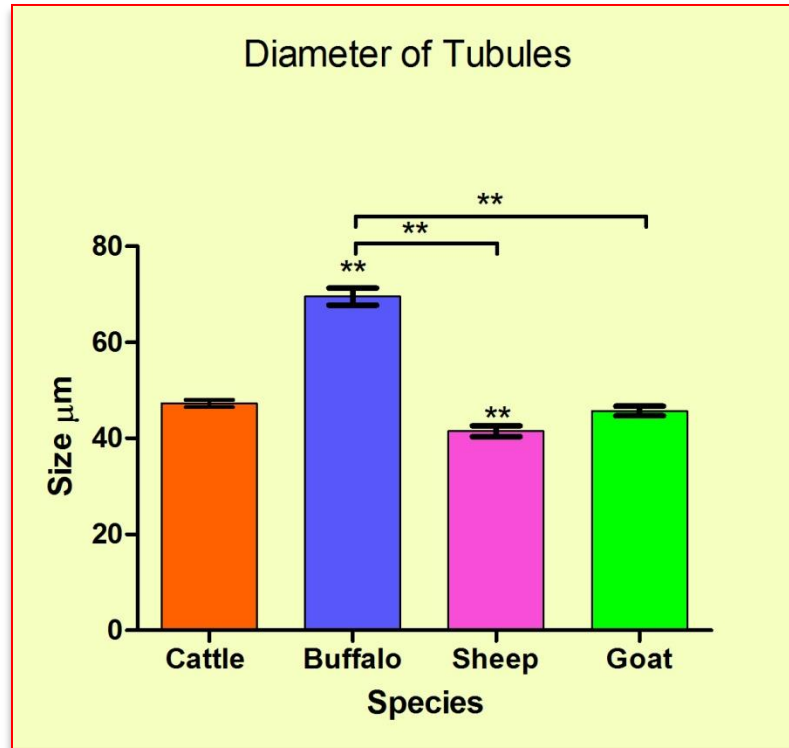
Different Superscripts differ significantly whereas, common superscripts have no significant difference.

Note: \* =  $P \leq 0.05$ , \*\* =  $P \leq 0.01$

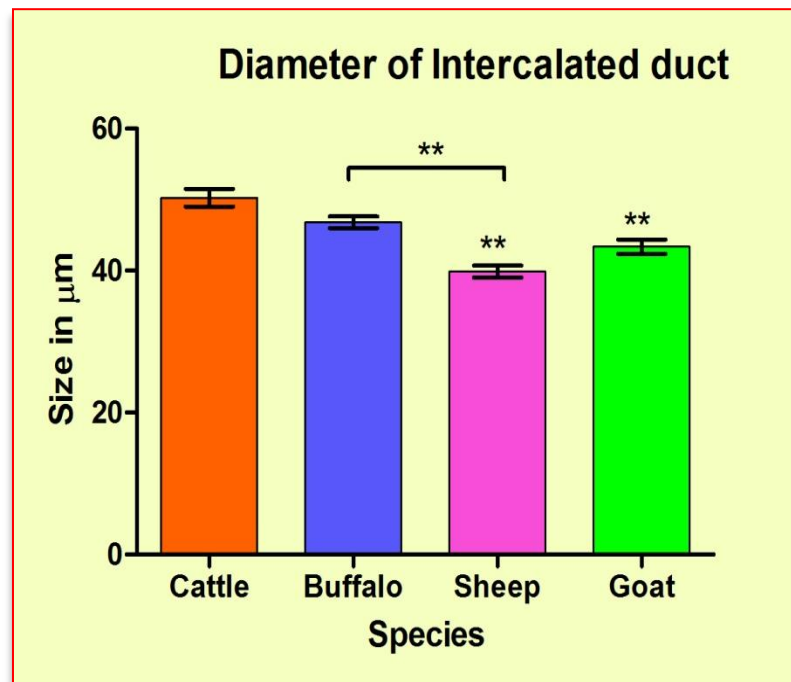
**Graph 1. Comparative size of diameter of Acini in different ruminants.**



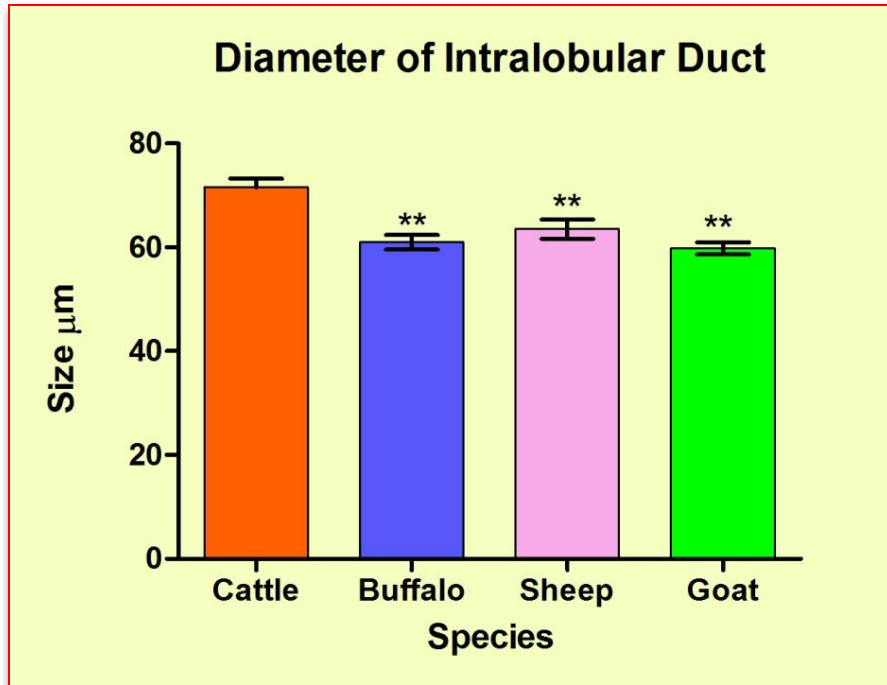
Note: \* =  $P \leq 0.05$ , \*\* =  $P \leq 0.01$

**Graph 2. Comparative size of diameter of Tubules in different ruminants.**

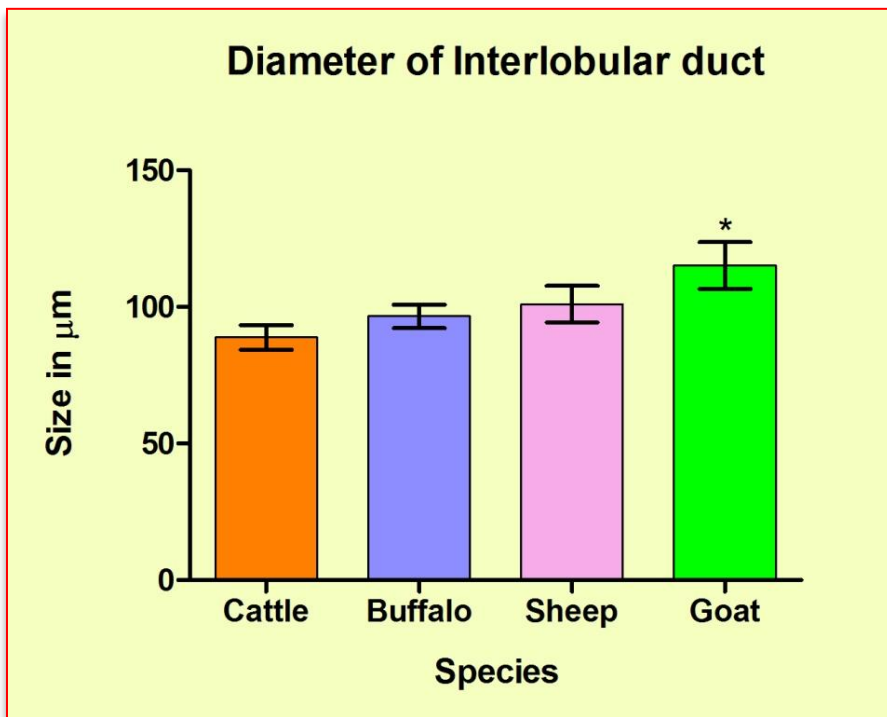
Note: \*\* = P ≤ 0.01

**Graph 3. Comparative size of diameter of Intercalated duct in different ruminants.**

Note: \*\* = P ≤ 0.01

**Graph 4. Comparative size of diameter of Intralobular duct in different ruminants**

Note: \*\* =  $P \leq 0.01$

**Graph 5. Comparative size of diameter of Interlobular duct in different ruminants**

Note: \* =  $P \leq 0.05$

Fig.1: Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) in the capsule

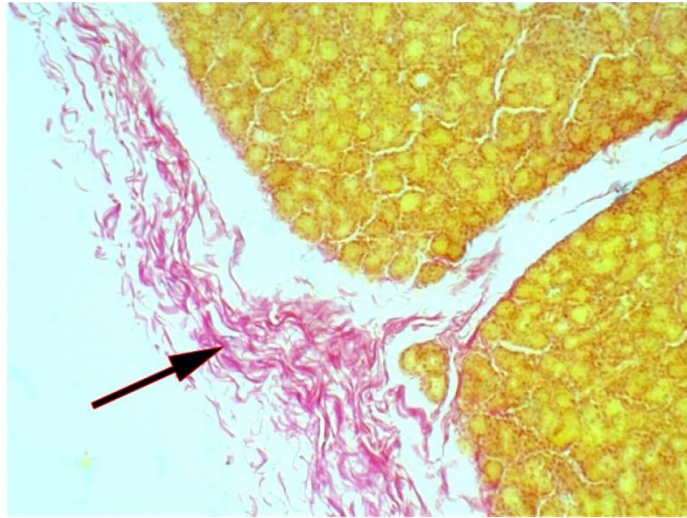
Vangieson's stain X 10

Fig. 2: Photomicrograph of lacrimal gland of cattle showing elastic fibers (arrow) in the capsule

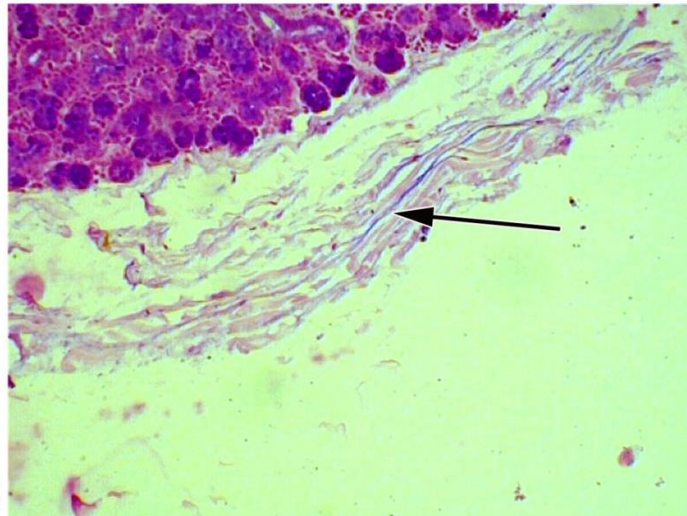
Aldehyde fuschin stain X 40

Fig. 3: Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the capsule

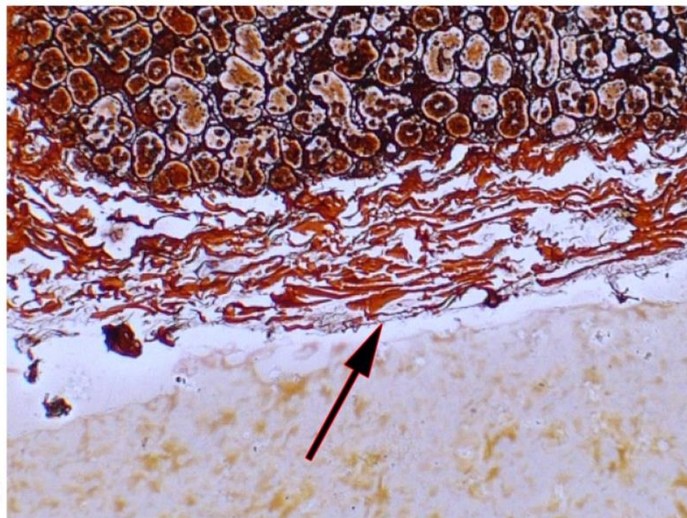
Gomori's stain X 40



**Fig.1**



**Fig.2**



**Fig.3**

Fig. 4: Photomicrograph of lacrimal gland of cattle showing smooth muscle fiber (arrow) in the capsule

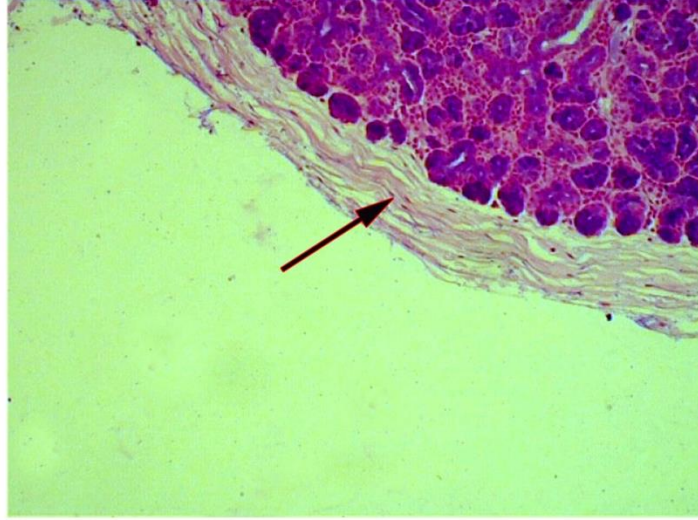
Aldehyde fuschin stain X 40

Fig. 5: Photo micrograph of lacrimal gland of cattle showing the septa (arrow) from capsule entering the parenchyma and dividing the gland into different lobes

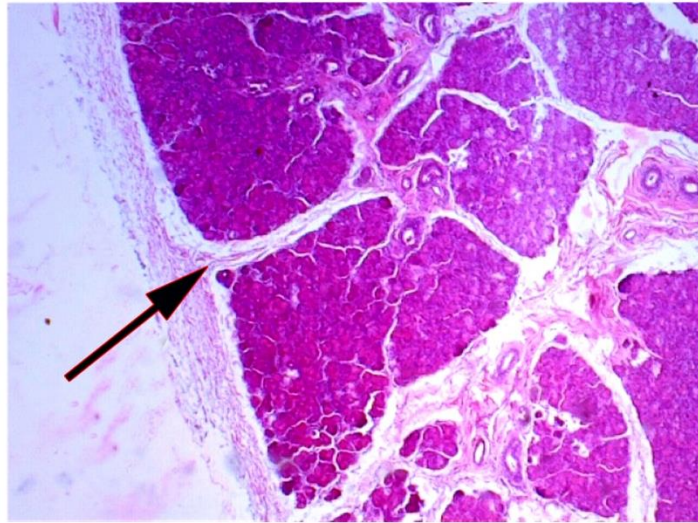
H&E X 4

Fig. 6: Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) in the septa

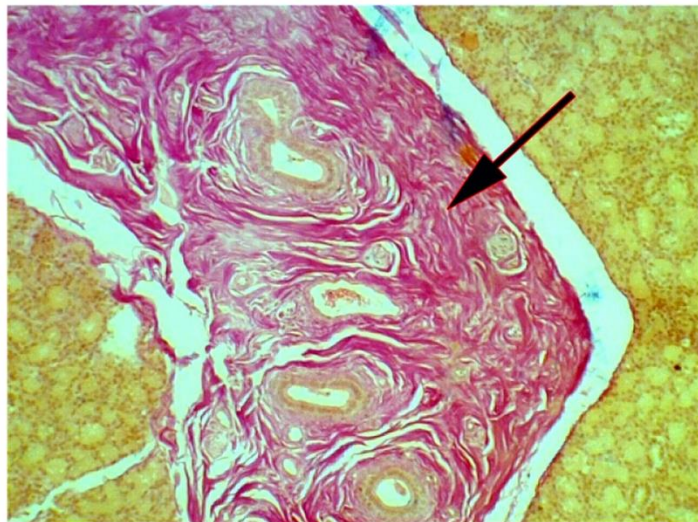
Vangieson's stain X 10



**Fig.4**



**Fig.5**



**Fig.6**

Fig. 7: Photomicrograph of lacrimal gland of cattle showing elastic fibers (arrow) in the septa

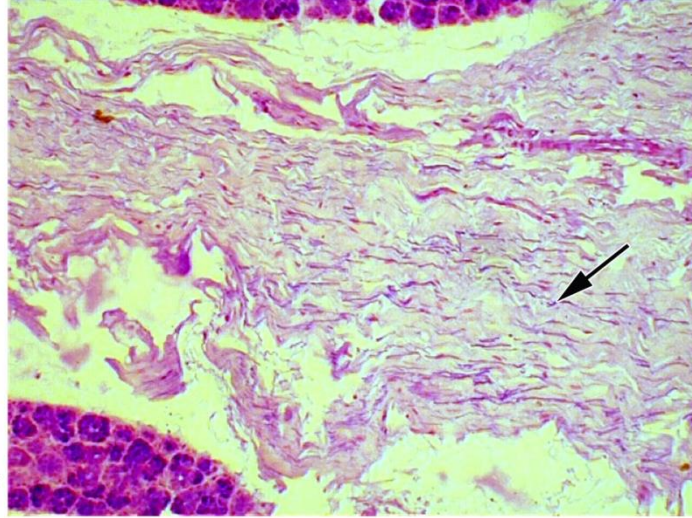
Aldehyde fuschin stain X 10

Fig. 8: Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the septa

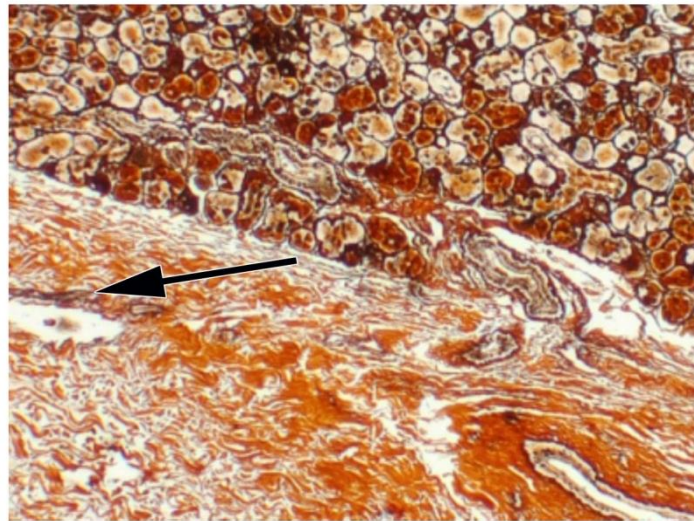
Gomori's stain X 10

Fig. 9: Photomicrograph of lacrimal gland of cattle showing interlobular duct (D) artery (A), vein (V) and nerve fiber (arrow) in the septa

H&E X 10



**Fig.7**



**Fig.8**



**Fig.9**

Fig. 10: Photomicrograph of lacrimal gland of cattle showing mast cell (arrow) in the septa

Toluidine blue stain X 100

Fig. 11: Photomicrograph of lacrimal gland of cattle showing tubules (T), acini (Ac), intralobular duct (IL) and smooth muscle fibers (arrow) around the intralobular duct

H&E X 40

Fig. 12: Photomicrograph of lacrimal gland of cattle showing round to oval nucleus with distinct nucleolus (arrow) in the acini

H&E X 100

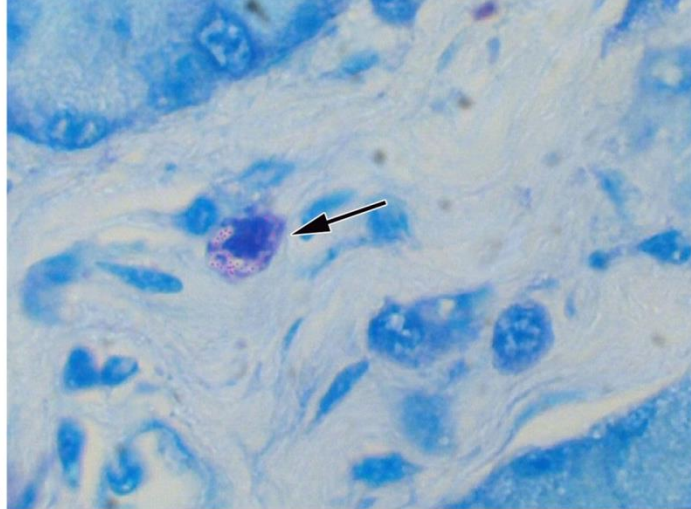


Fig.10

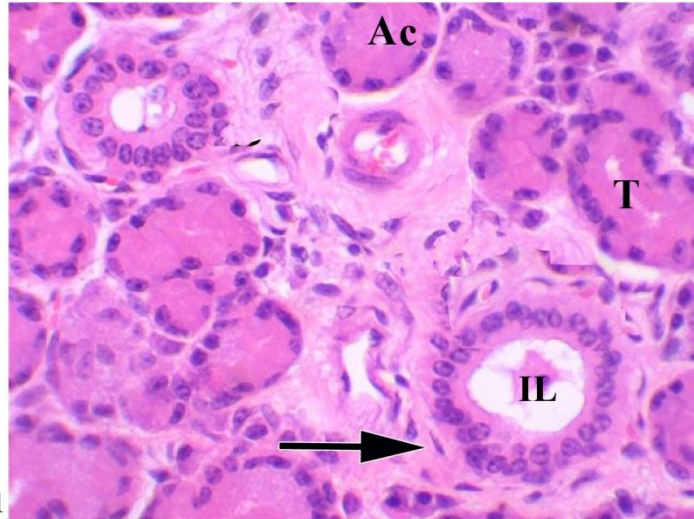


Fig.11

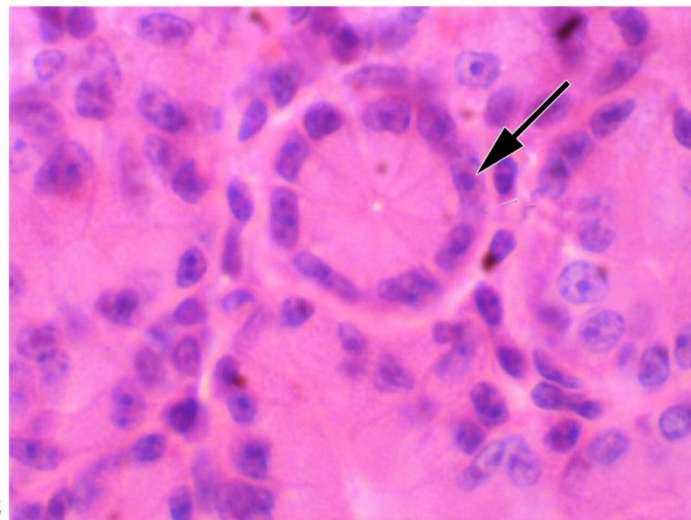


Fig.12

Fig. 13: Photomicrograph of the lacrimal gland of cattle showing myoepithelial cell (arrow) at the base of secretory cells

H&E X 100

Fig. 14: Photomicrograph of lacrimal gland of cattle showing reticular fibers around the secretory units (arrow head) and in the basement membrane of the intercalated duct (arrow)

Gomori's stain X 40

Fig.15: Photomicrograph of lacrimal gland of cattle showing plasma cells (P) and lymphocyte (L) in the interstitial tissue

Methyl-pyronin green stain X 40

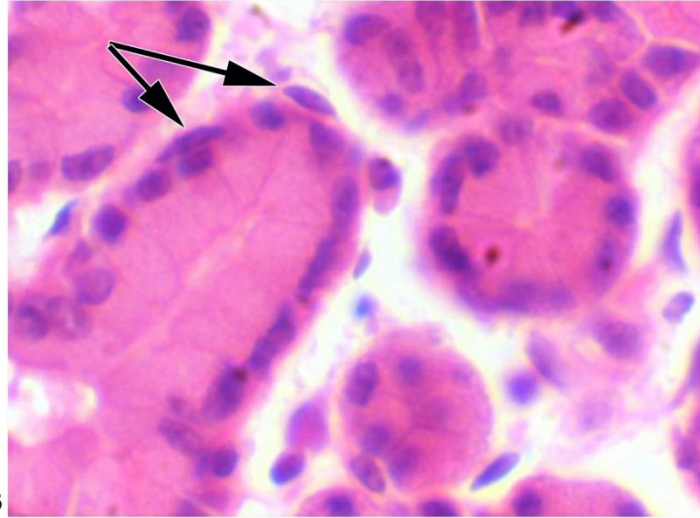


Fig.13

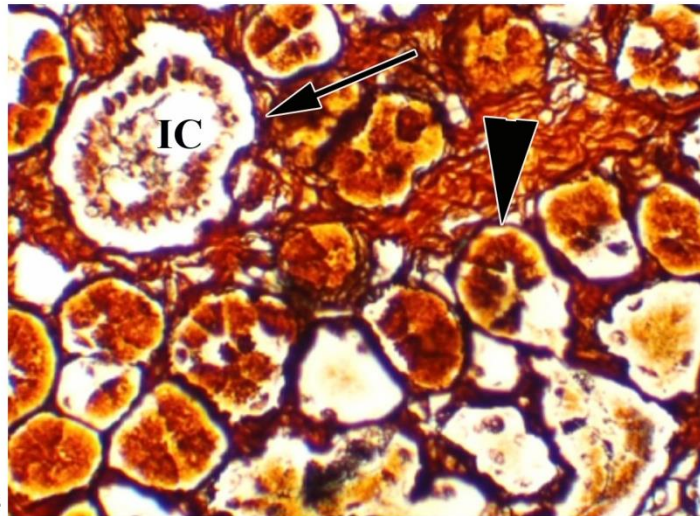


Fig.14

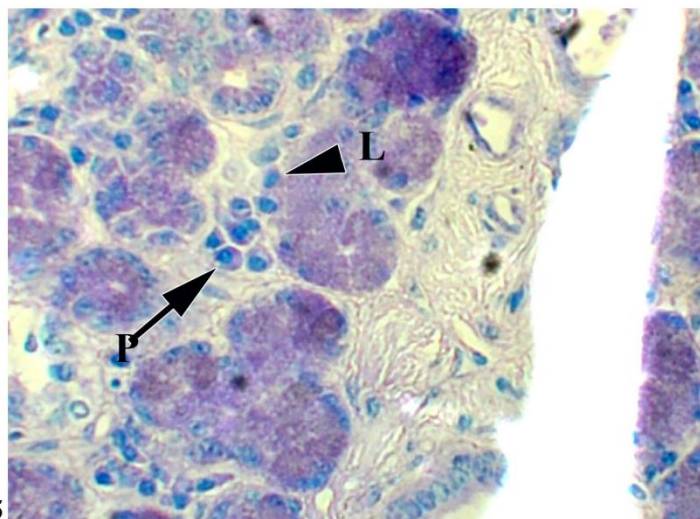


Fig.15

Fig. 16: Photomicrograph of lacrimal gland in cattle showing macrophage (arrow) in the interstitial tissue

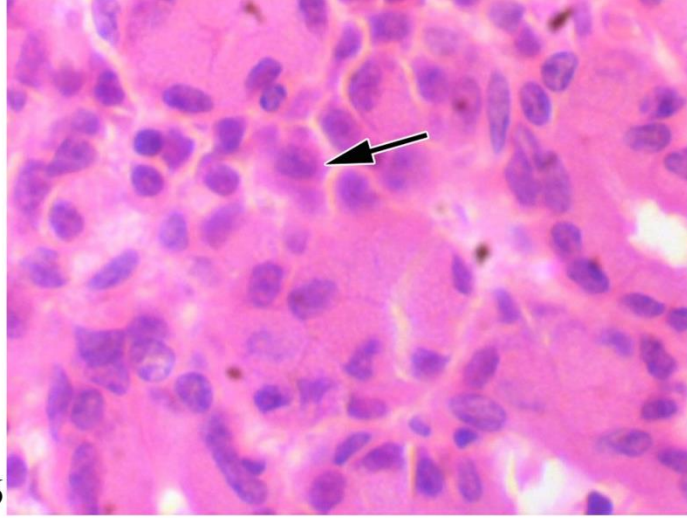
H&E X 100

Fig. 17: Photomicrograph of lacrimal gland of cattle showing intercalated duct (IC) showing simple cuboidal epithelium (arrow head) and smooth muscle (arrow) fibers around the duct

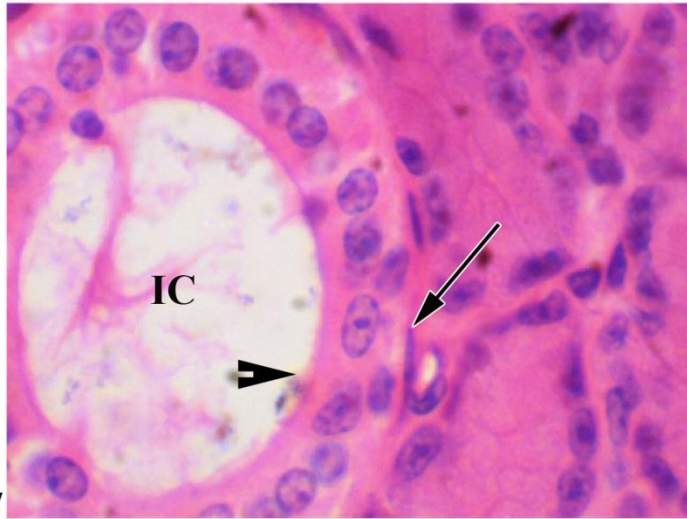
H&E X 100

Fig. 18: Photomicrograph of lacrimal gland of cattle showing a layer of collagen fibers (arrow) around the intercalated duct

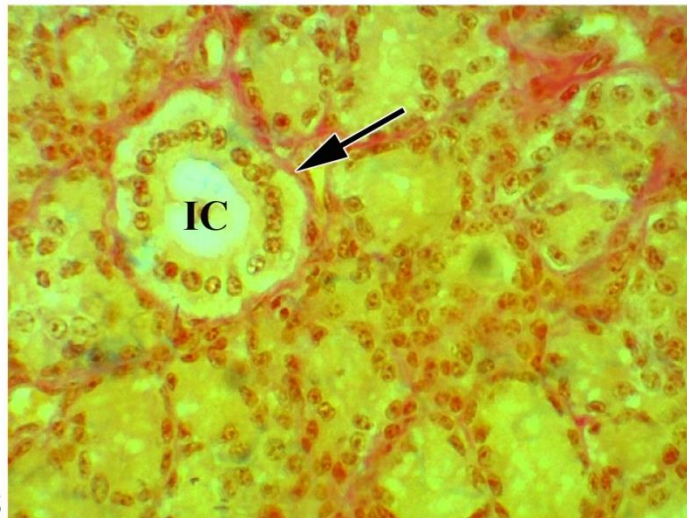
Vangieson's stain X 40



**Fig.16**



**Fig.17**



**Fig.18**

Fig. 19: Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in basement membrane of the intralobular duct

Gomori's stain X 40

Fig. 20: Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) around the intralobular duct

Vangieson's stain X 40

Fig. 21: Photomicrograph of lacrimal gland of cattle showing bilayered columnar epithelium (arrow head) and smooth muscle fiber (arrow) around the interlobular duct (D)

H&E X 40

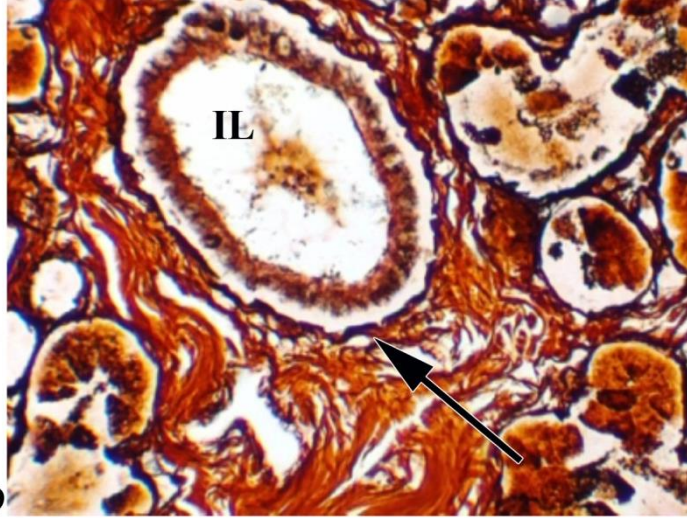


Fig.19

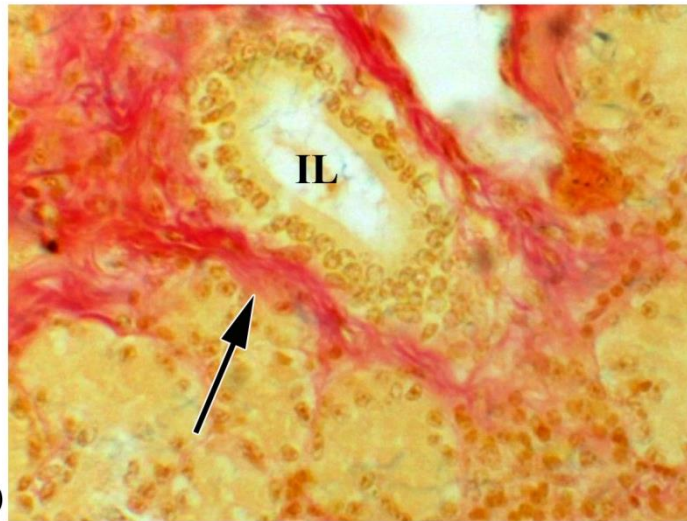


Fig.20

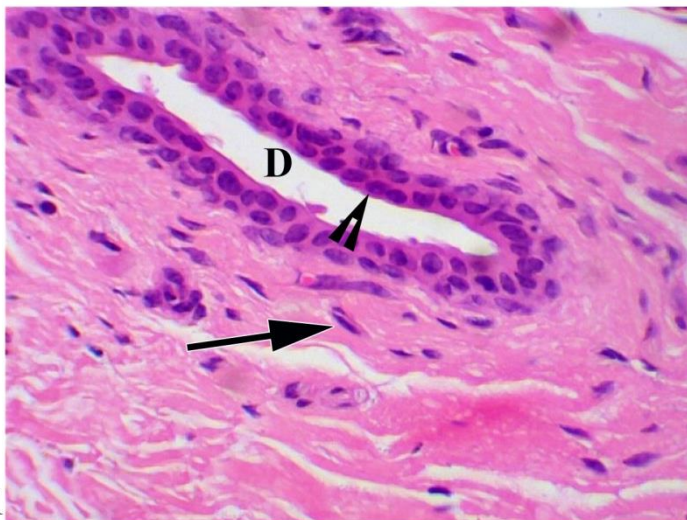


Fig.21

Fig. 22: Photomicrograph of lacrimal gland of cattle showing collagen fibers (arrow) around the interlobular duct (D)

Vangieson's stain X 40

Fig. 23: Photomicrograph of lacrimal gland of cattle showing reticular fibers (arrow) in the basement membrane of the interlobular duct (D)

Gomori's stain X 40

Fig. 24: Photomicrograph of lacrimal gland of cattle showing strong PAS positive reaction (black arrow) in acini and duct showing negative reaction (red arrow)

PAS stain X 40

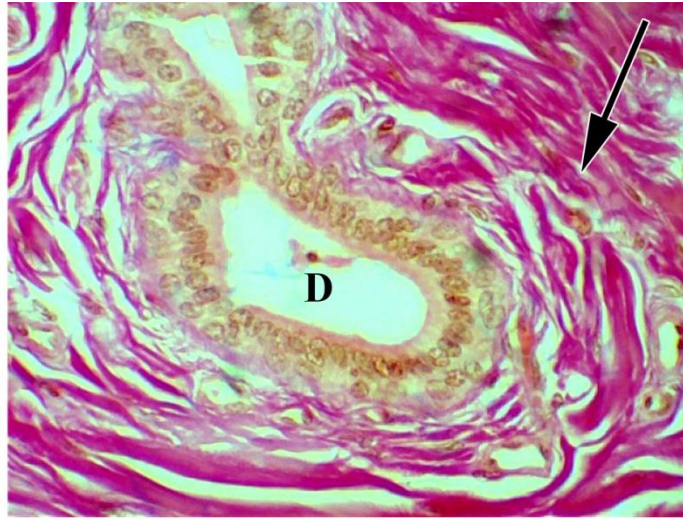


Fig.22

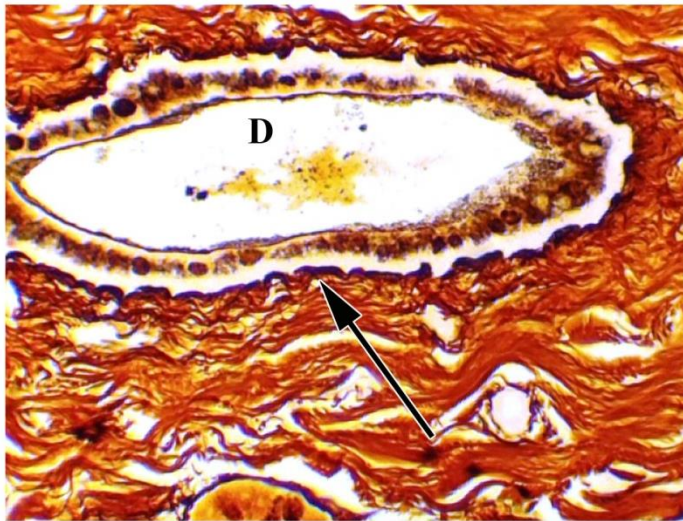


Fig.23

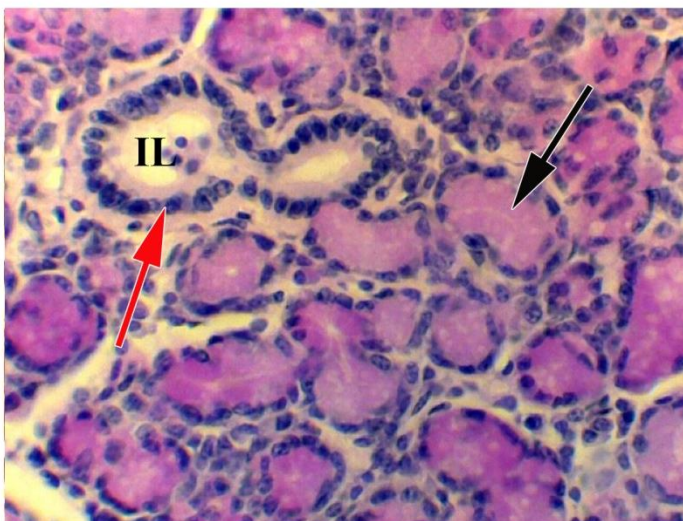


Fig.24

Fig. 25: Photomicrograph of lacrimal gland of cattle showing Alcian blue positive reaction in a secretory unit (arrow) and few cells positive in a secretory unit (C)  
Alcian blue stain at pH 2.5 X40

Fig. 26: Photomicrograph of lacrimal gland of cattle showing acini (black arrow) positive for both PAS and Alcian blue and a acini (red arrow) positive for PAS  
Combined Alcian blue and PAS technique X 10

Fig. 27: Photomicrograph of lacrimal gland of buffalo showing capsule (arrow)  
H&E X 10

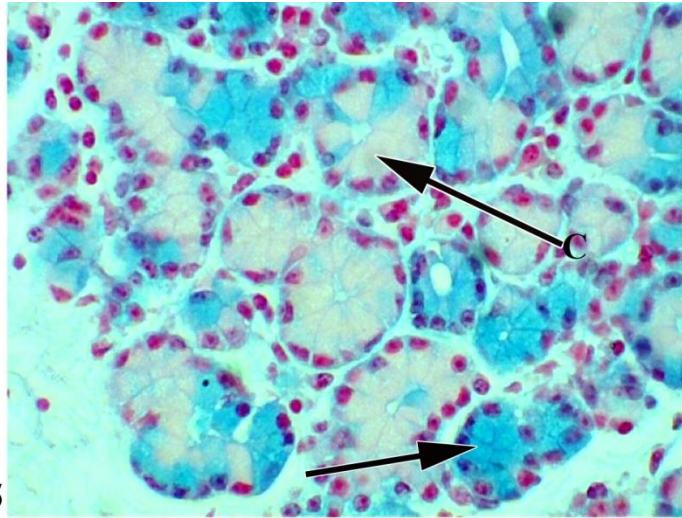


Fig.25

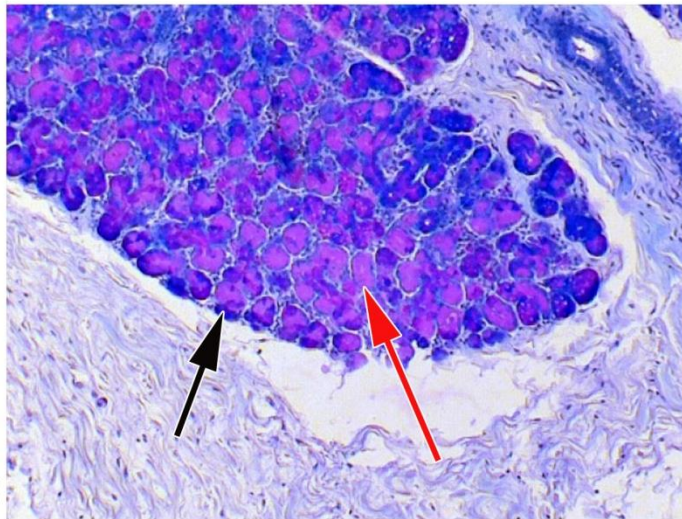


Fig.26

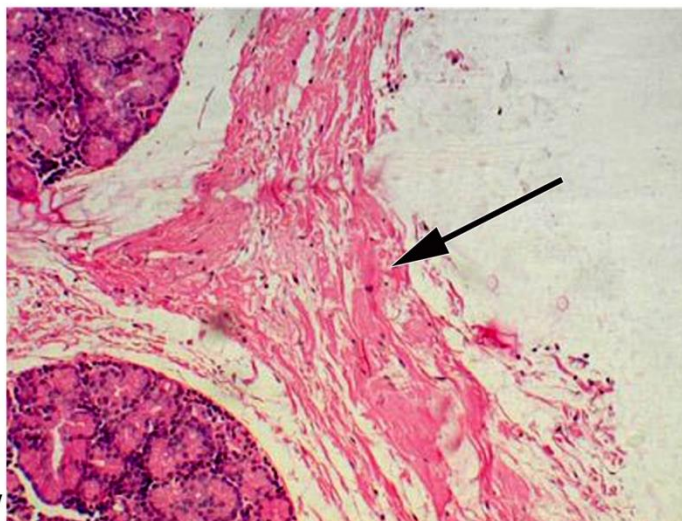


Fig.27

Fig. 28: Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) in the capsule

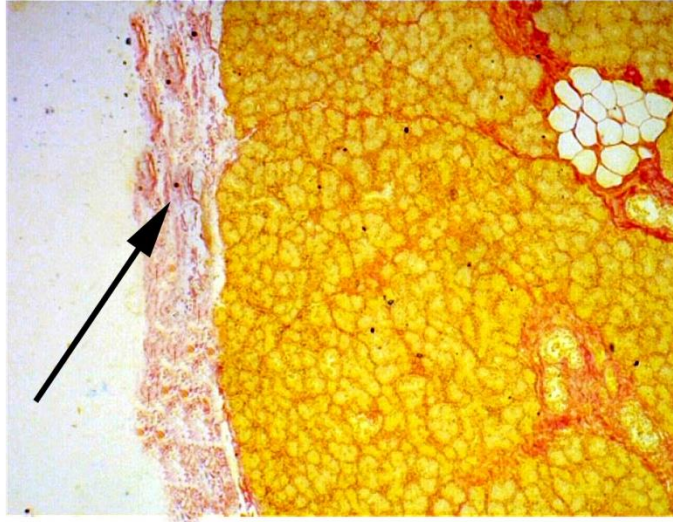
Vangieson's stain X 10

Fig. 29: Photomicrograph of lacrimal gland of buffalo showing elastic fibers (arrow) in the capsule

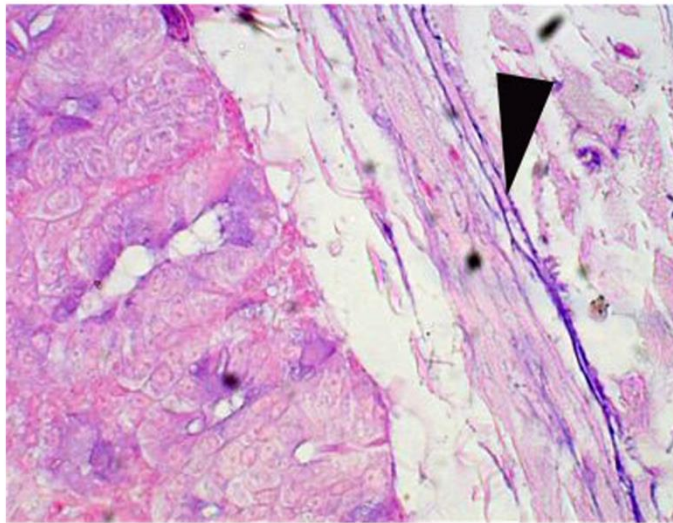
Aldehyde fuschin stain X 40

Fig. 30: Photomicrograph of capsule of lacrimal gland of buffalo showing reticular fibers (arrow) in the capsule

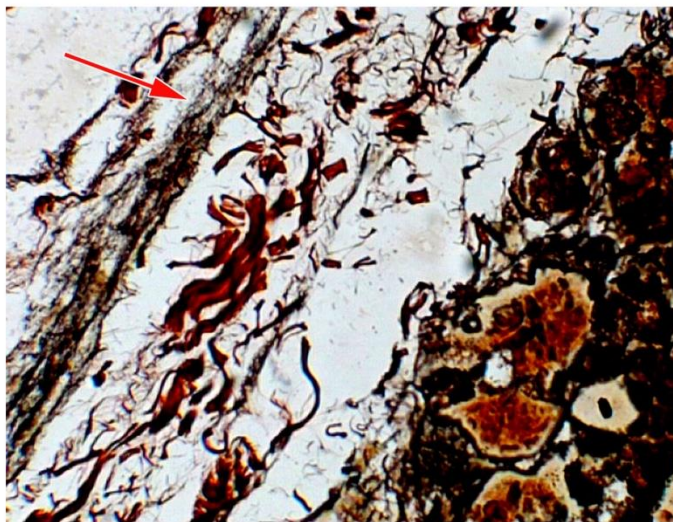
Gomori's stain X 40



**Fig.28**



**Fig.29**



**Fig.30**

Fig. 31: Photomicrograph of lacrimal gland of buffalo showing smooth muscle fibers (arrow) in the capsule

H&E X 40

Fig. 32: Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) in the septa

Vangieson's stain X 10

Fig. 33: Photomicrograph of lacrimal gland of buffalo showing interlobular duct (D) artery (A), vein (V) and nerve fiber (arrow) in the septa

H&E X 10

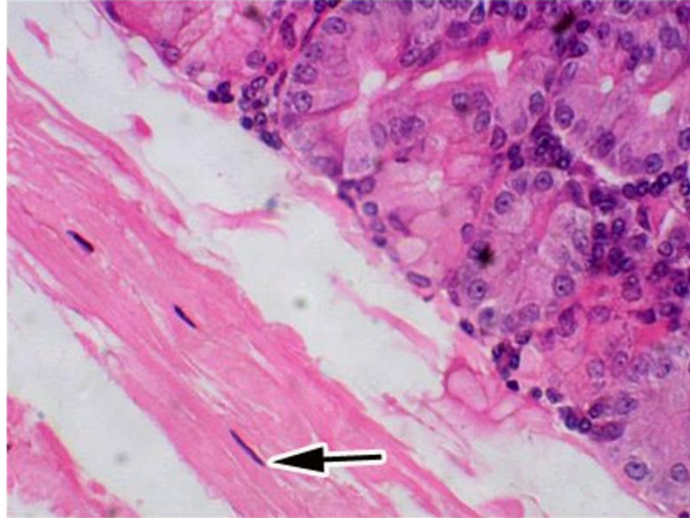


Fig.31

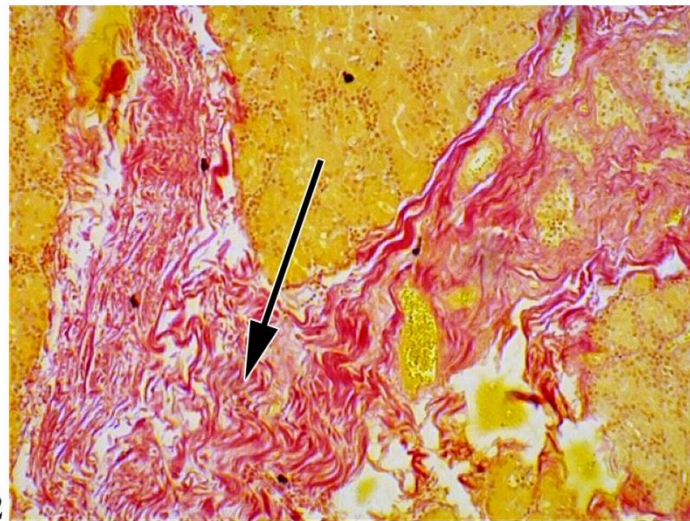


Fig.32

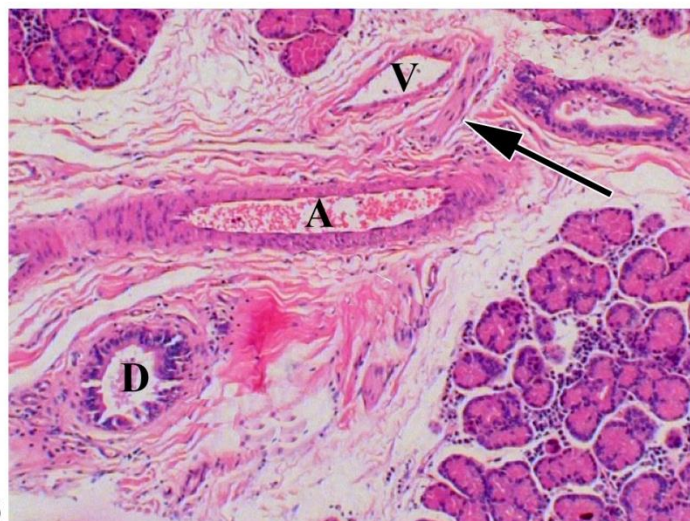


Fig.33

Fig. 34: Photomicrograph of lacrimal gland of buffalo showing mast cell (arrow) in the septa

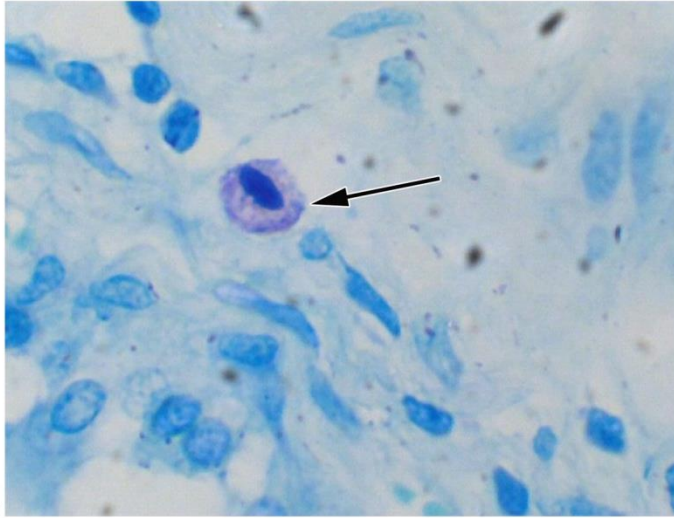
Toluidine blue stain X 100

Fig. 35: Photomicrograph of parenchyma of lacrimal gland of buffalo showing tubular (T) and acinar (Ac) serous secretory units in buffalo

H&E X 40

Fig. 36: Photomicrograph of lacrimal gland of buffalo showing myoepithelial cell (arrow) at the base of secretory cells

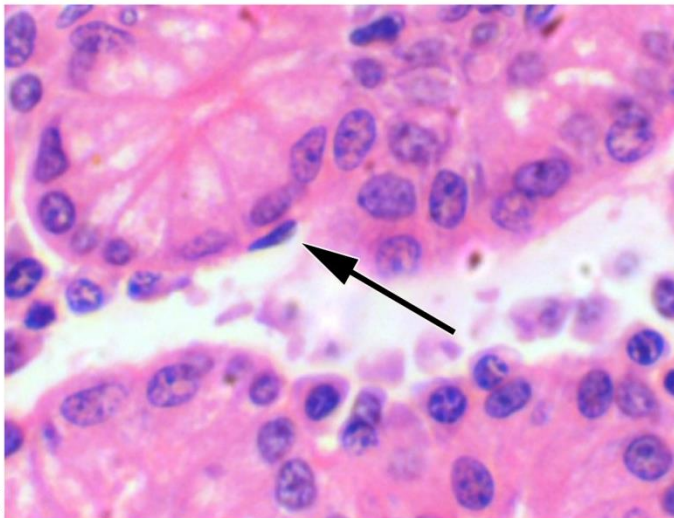
H&E X 100



**Fig.34**



**Fig.35**



**Fig.36**

Fig. 37: Photomicrograph of lacrimal gland of buffalo showing multinucleated giant cell (G) in the interstitial tissue

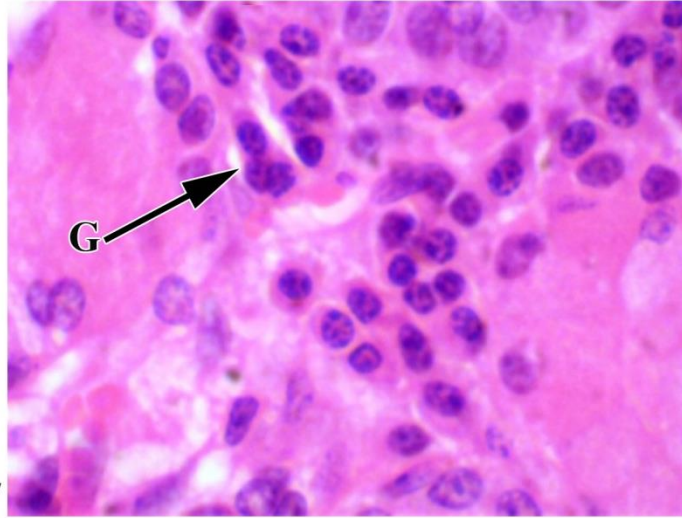
H&E X 100

Fig. 38: Photomicrograph of lacrimal gland of buffalo showing mast cell (arrow) in the interstitial tissue

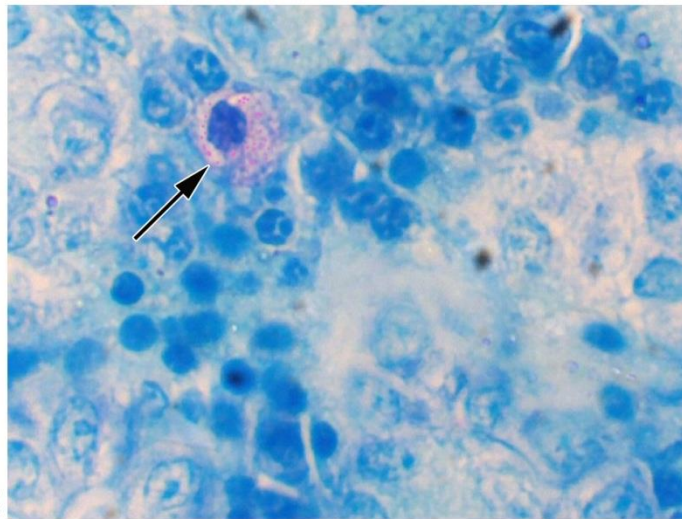
Toluidine blue stain X 100

Fig. 39: Photomicrograph of lacrimal gland of buffalo showing plasma cells (P) in the interstitial tissue

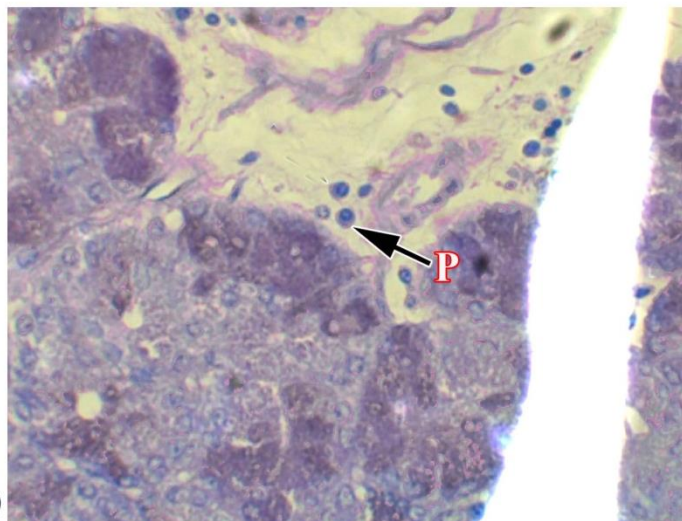
Methyl-pyronin green stain X40



**Fig.37**



**Fig.38**



**Fig.39**

Fig. 40: Photomicrograph of lacrimal gland of buffalo showing plasma cells (P) and lymphocytes (L) in the interstitial tissue and distinct nucleolus (arrow) in the acinar cell

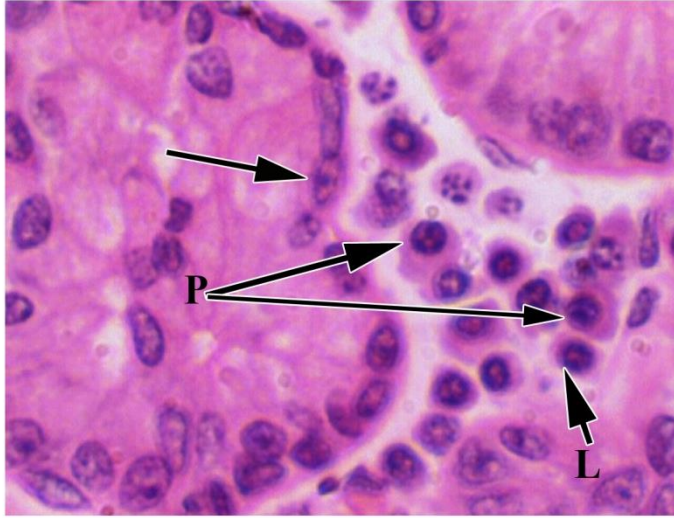
H&E X 100

Fig. 41: Photomicrograph of lacrimal gland of buffalo showing aggregation of lymphoid cells (arrow) in the parenchyma

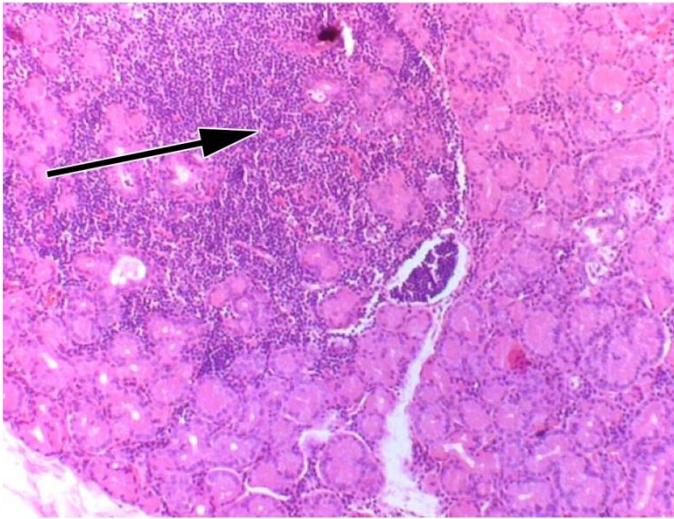
H&E X 10

Fig. 42: Photomicrograph of lacrimal gland of buffalo showing smooth muscle fiber (arrow) around the intercalated duct(IC) and artery (A) in the septa

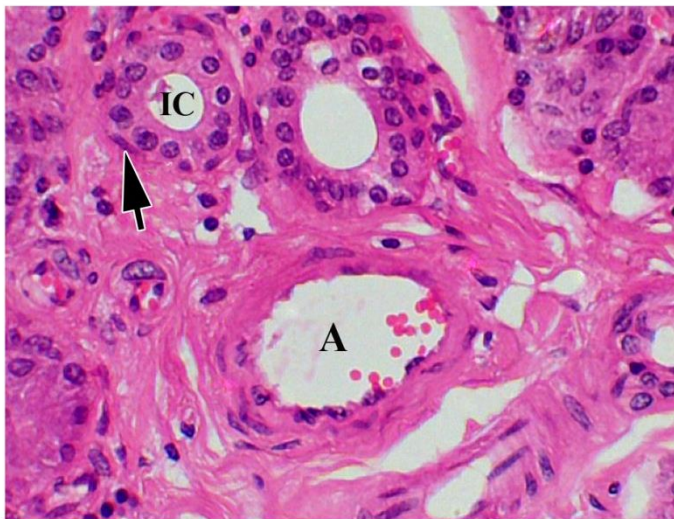
H&E X 40



**Fig.40**



**Fig.41**



**Fig.42**

Fig. 43: Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) around the intercalated duct(IC) and intralobular duct (IL)

Vangieson's stain X 40

Fig. 44: Photomicrograph of lacrimal gland of buffalo showing smooth muscle fiber (arrow) around the intralobular duct (IL)

H&E X 40

Fig. 45: Photomicrograph of lacrimal gland of buffalo showing reticular fibers (arrow) in the basement membrane of the intralobular duct(IL)

Gomori's stain X 40

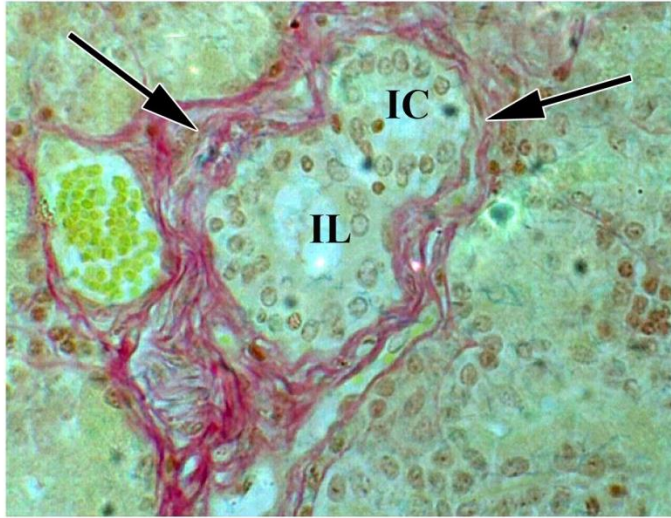


Fig.43

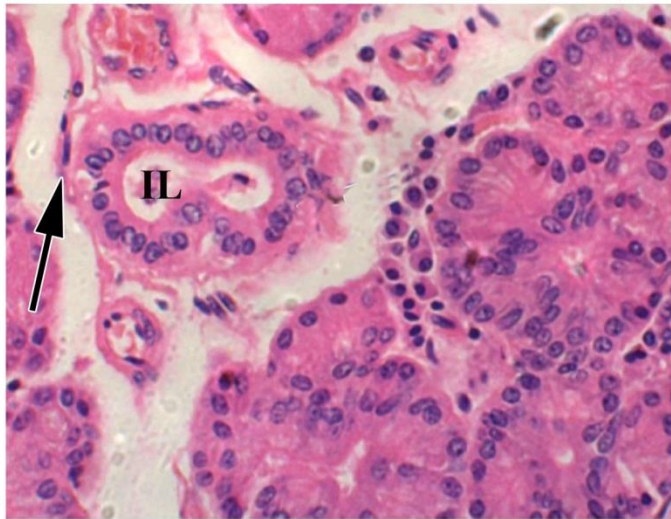


Fig.44

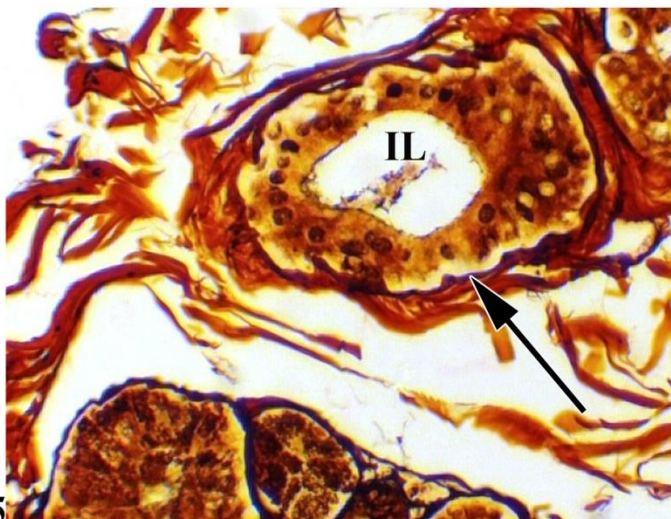


Fig.45

Fig. 46: Photomicrograph of lacrimal gland of buffalo showing smooth muscle fibers (arrow) around the interlobular duct (D)

H&E X 40

Fig. 47: Photomicrograph of lacrimal gland of buffalo showing collagen fibers (arrow) around the interlobular duct (D)

Vangieson's stain X 10

Fig.48: Photomicrograph of lacrimal gland of buffalo showing reticular fibers (arrow) in the basement membrane of interlobular duct (D)

Gomori's stain X 40

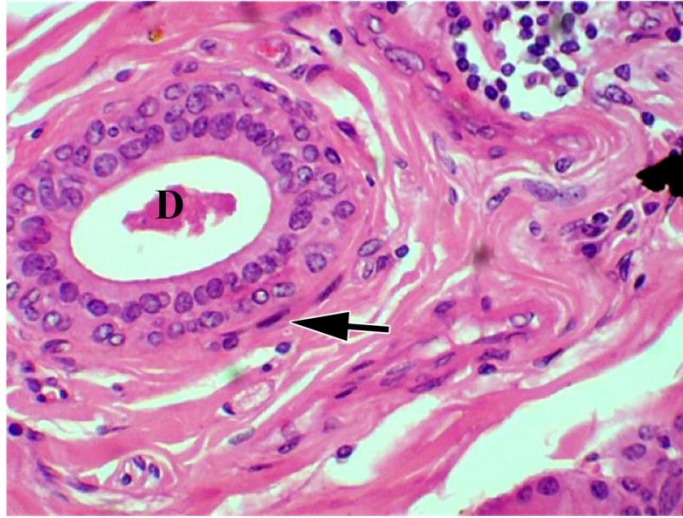


Fig.46

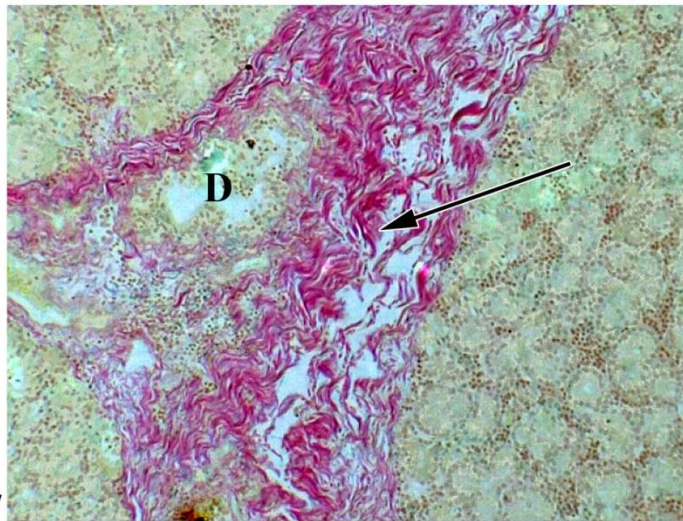


Fig.47

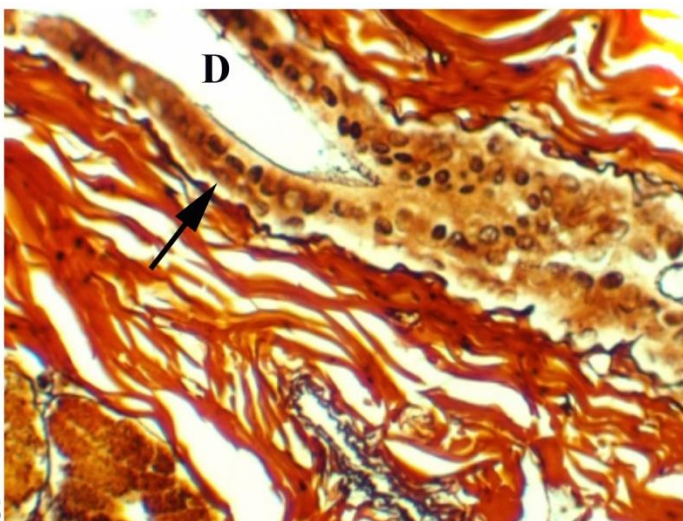
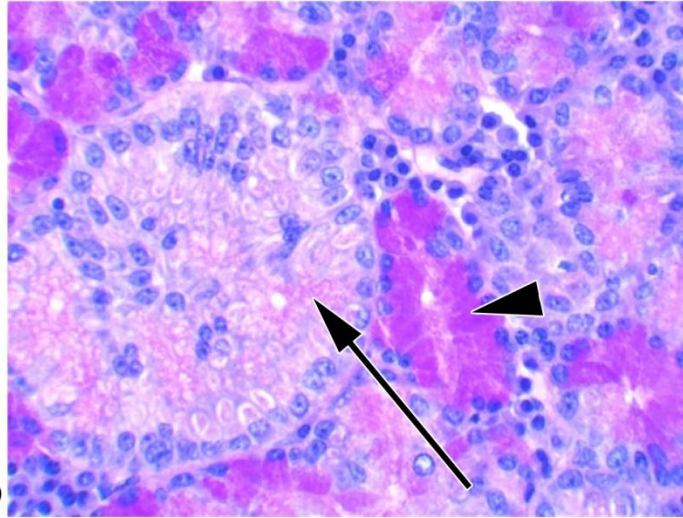


Fig.48

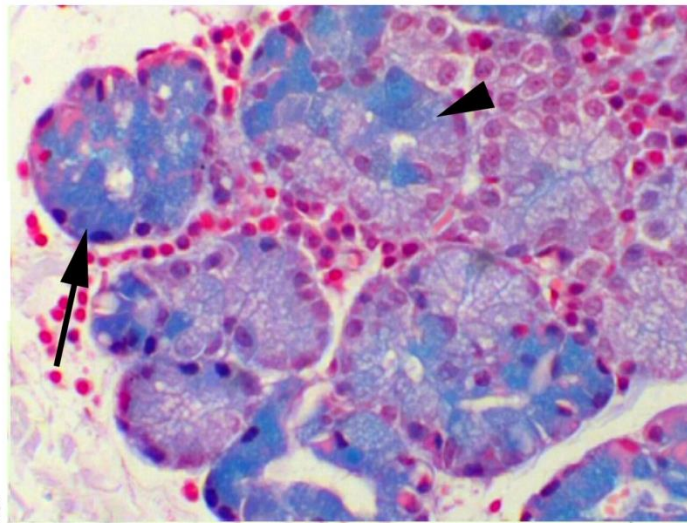
Fig. 49: Photomicrograph of lacrimal gland of buffalo showing strong PAS positive reaction (arrow head) and weak positive reaction (arrow) in secretory units  
PAS stain X 40

Fig. 50: Photomicrograph of lacrimal gland of buffalo showing positive reaction in a secretory unit (arrow) and positive reaction in the few cells of a secretory unit (arrow head) for Alcian blue  
Alcian blue stain at pH 2.5 X40

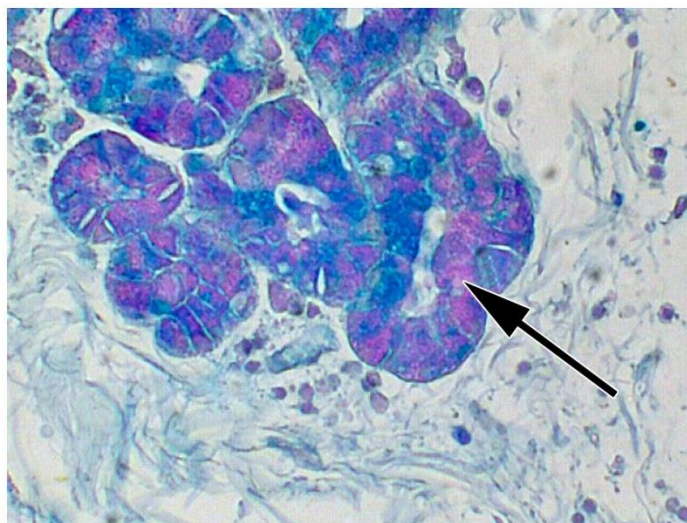
Fig. 51: Photomicrograph of lacrimal gland of buffalo showing positive reaction for PAS and Alcian blue in a secretory unit (arrow)  
Combined Alcian blue and PAS technique X 40



**Fig.49**



**Fig.50**



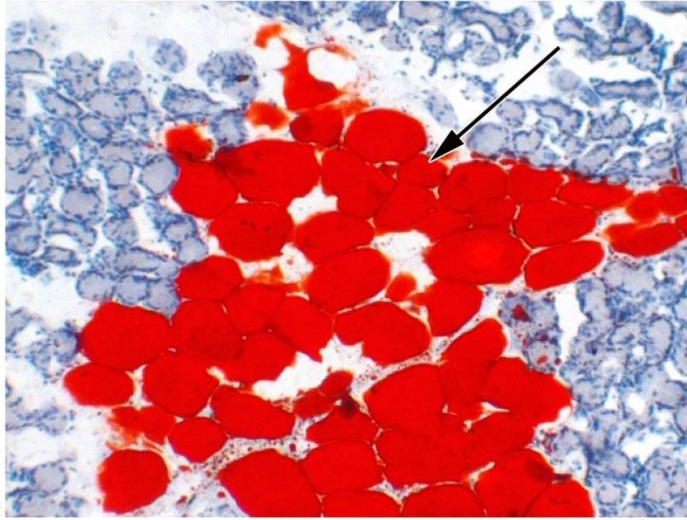
**Fig.51**

Fig. 52: Photomicrograph of lacrimal gland of buffalo showing intralobular lipid (arrow)  
Oil red O stain X 10

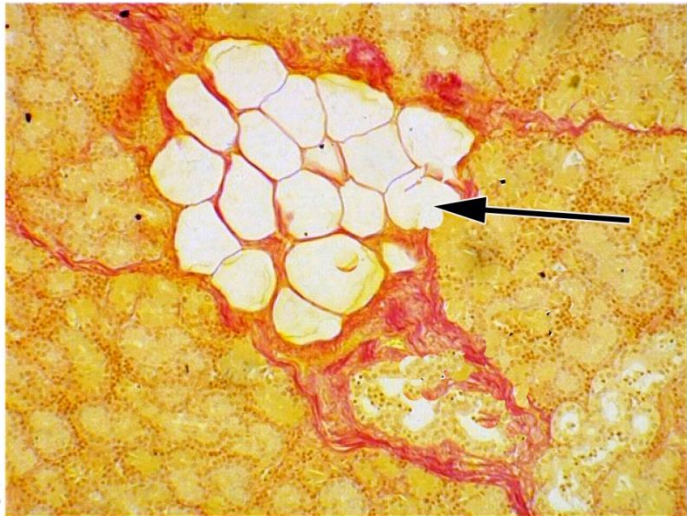
Fig. 53: Photomicrograph of lacrimal gland of buffalo showing interlobular lipid (arrow)  
Vangieson's stain X 10

Fig. 54: Photomicrograph of lacrimal gland of sheep showing smooth muscle fibers  
(arrow) in the capsule

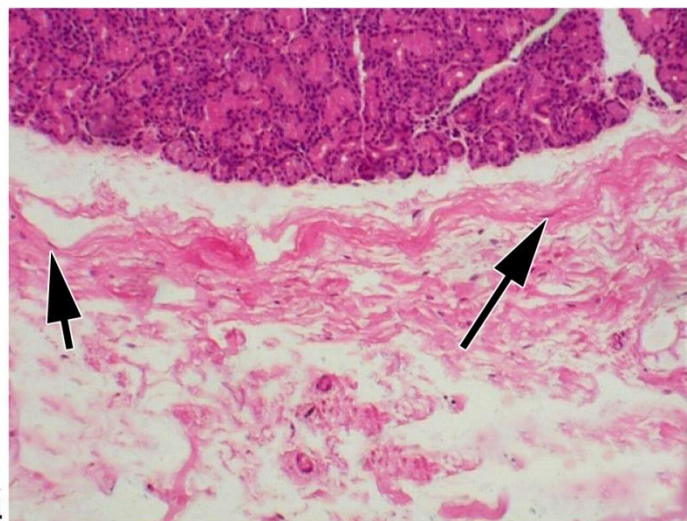
H&E X 40



**Fig.52**



**Fig.53**



**Fig.54**

Fig. 55: Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) in the capsule

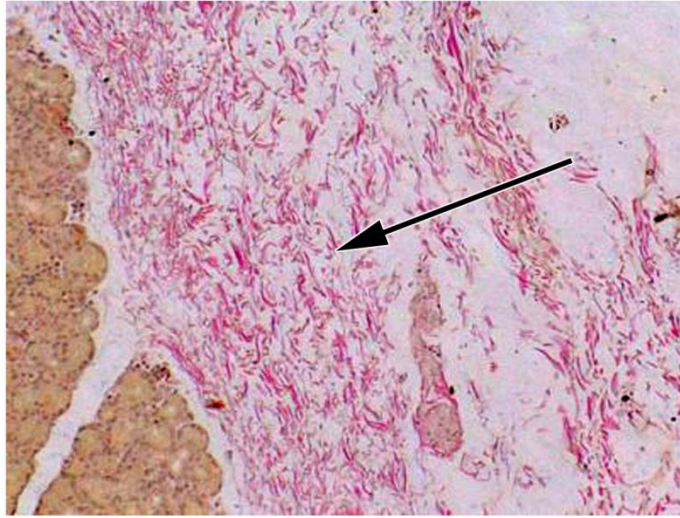
Vangieson's stain X 10

Fig. 56: Photomicrograph of lacrimal gland of sheep showing reticular fibers (arrow) in the capsule

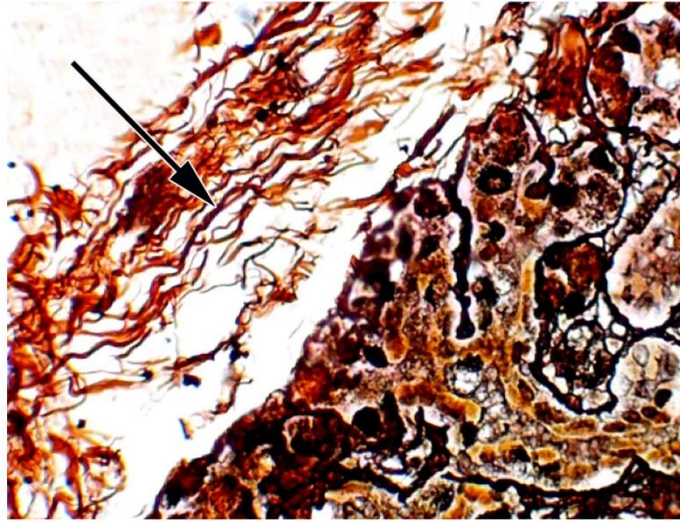
Gomori's stain X 40

Fig. 57: Photomicrograph of lacrimal gland of sheep showing elastic fibers (arrow) in the capsule

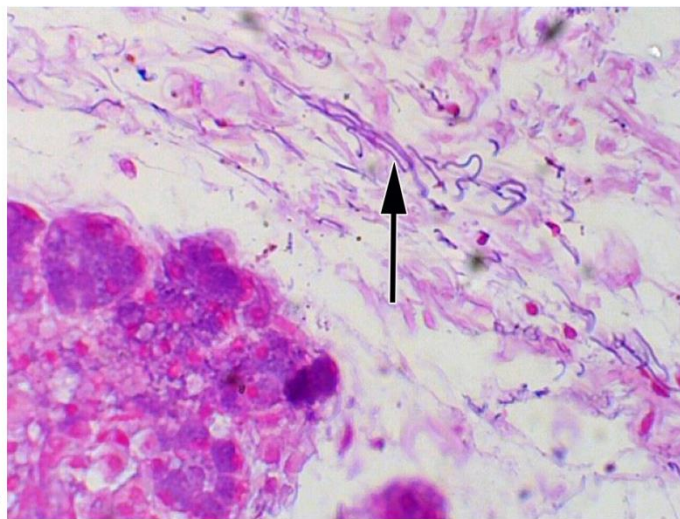
Aldehyde fuschin stain X 40



**Fig.55**



**Fig.56**



**Fig.57**

Fig. 58: Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) and interlobular duct(D) in the septa

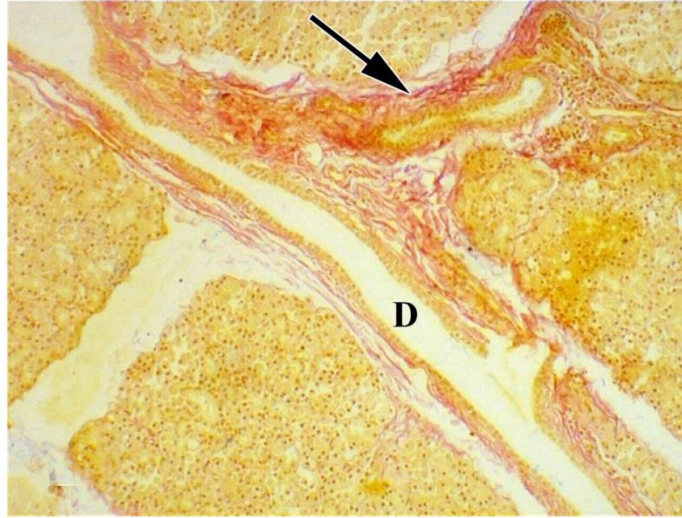
Vangieson's stain X 10

Fig. 59: Photomicrograph of lacrimal gland of Sheep showing artery (A) and vein (V) in the septa

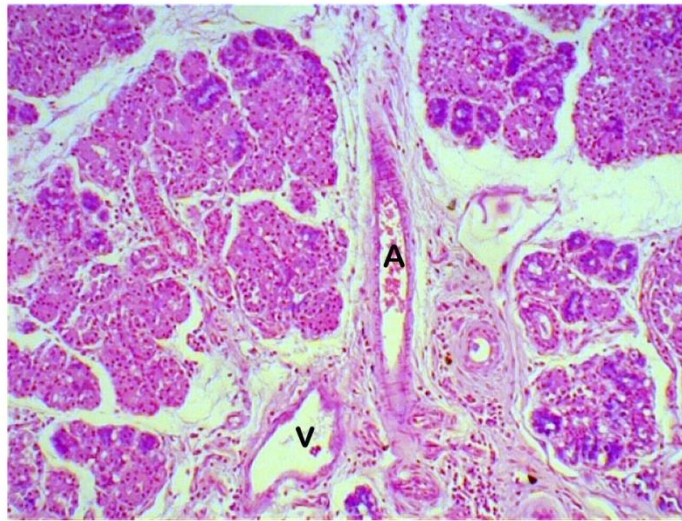
Aldehyde fuschin stain X 4

Fig. 60: Photomicrograph of lacrimal gland of sheep showing mast cell (arrow) in the septa

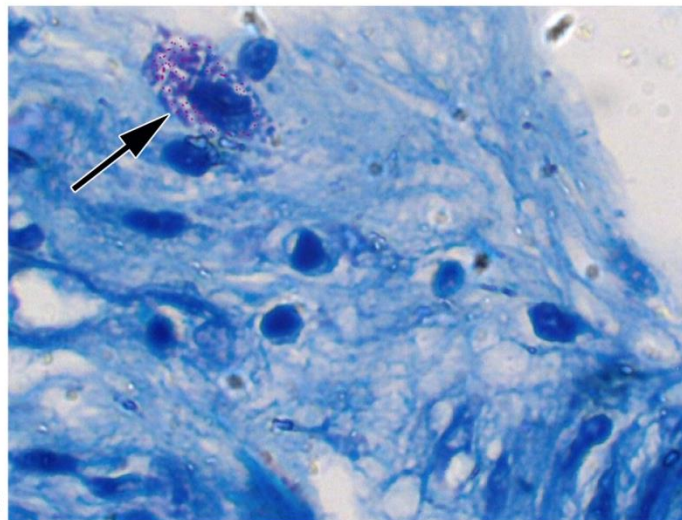
Toludinie blue stain X 100



**Fig.58**



**Fig.59**



**Fig.60**

Fig. 61: Photomicrograph of lacrimal gland of sheep showing macrophage (M), plasma cells (P) and lymphocyte (L) in the septa

H&E X 100

Fig. 62: Photomicrograph of lacrimal gland of sheep showing tubular (T), acinar (Ac) serous secretory units and myoepithelial cells (arrow) in the parenchyma

H&E X 40

Fig. 63: Photomicrograph of lacrimal gland of sheep showing binucleated cell (arrow) in the interstitial tissue

H&E X 100

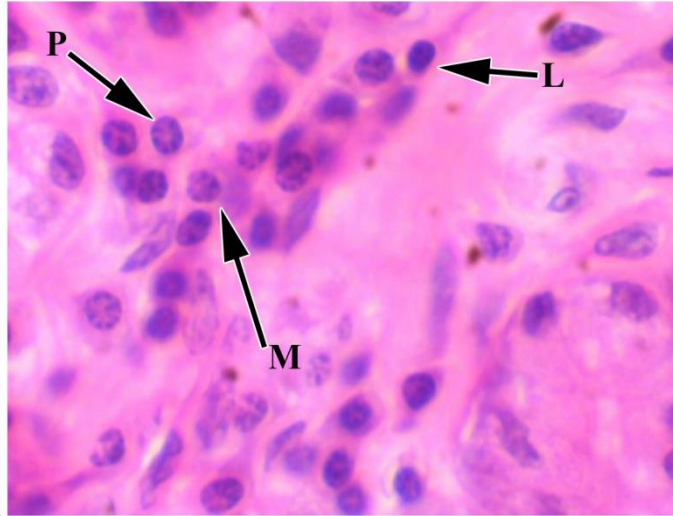


Fig.61

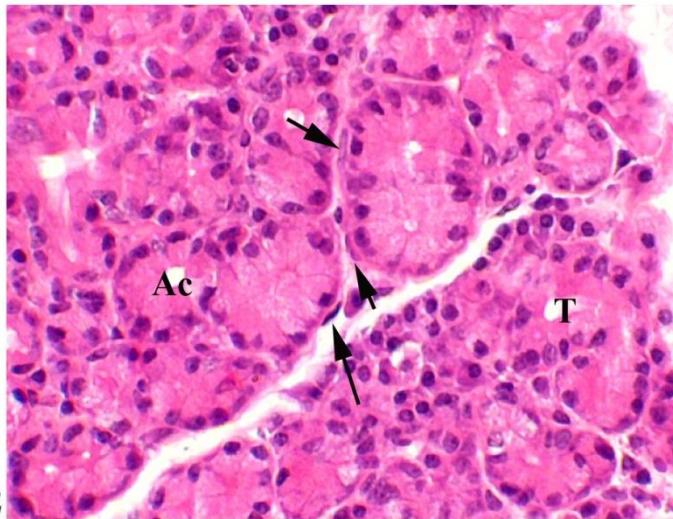


Fig.62

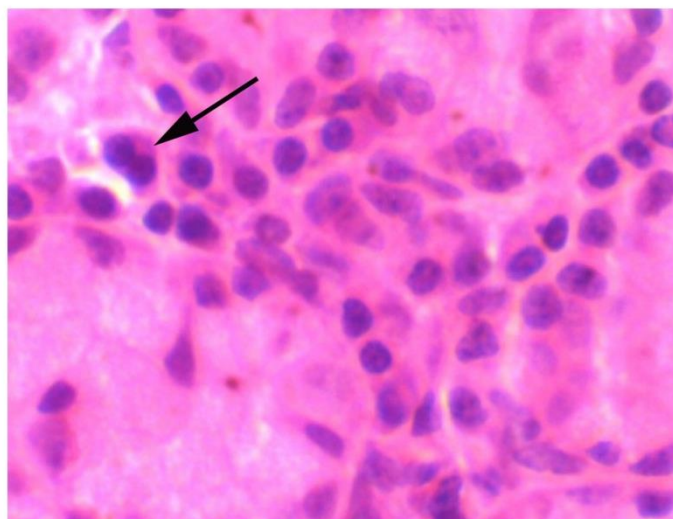


Fig. 63

Fig. 64: Photomicrograph of lacrimal gland of sheep showing macrophage (arrow) in the interstitial tissue

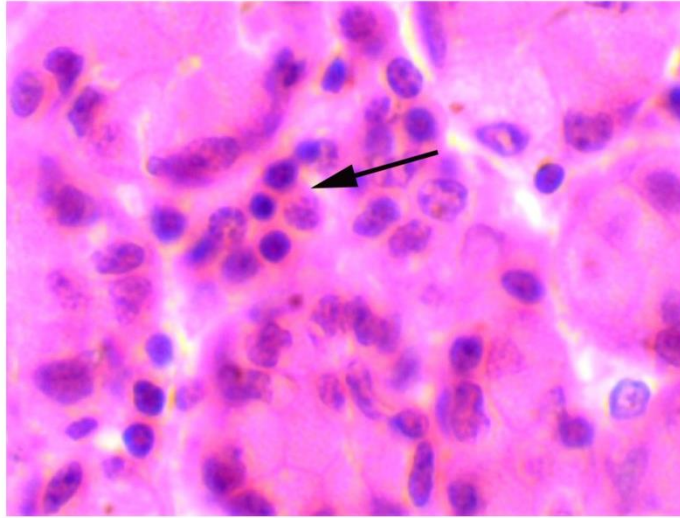
H&E X 100

Fig. 65: Photomicrograph of lacrimal gland of sheep showing plasma cells (P) in the interstitial tissue

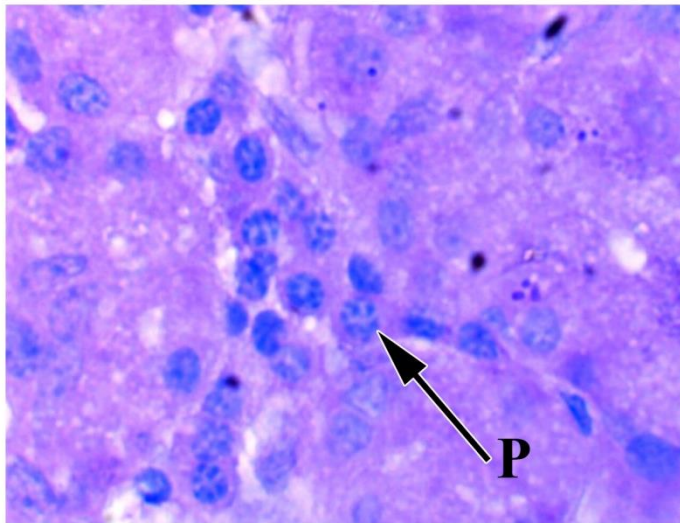
Methyl-pyronin green stain X100

Fig. 66: Photomicrograph of lacrimal gland of sheep showing smooth muscle fibers (arrow) around the intercalated duct (IC)

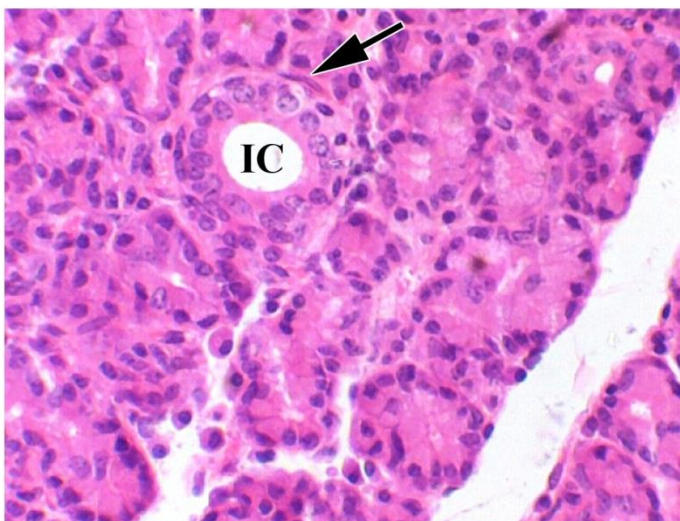
H&E X 40



**Fig.64**



**Fig.65**



**Fig.66**

Fig. 67: Photomicrograph of lacrimal gland of sheep showing smooth muscle fiber (arrow head) around the intralobular duct (IL)

H&E X 40

Fig. 68: Photomicrograph of lacrimal gland of sheep showing collagen fibers (arrow) around the intercalated duct(IC) and intralobular duct (IL)

Vangieson's stain X 40

Fig .69: Photomicrograph of lacrimal gland of sheep showing stratified columnar epithelium (arrow) and smooth muscle fiber (arrow) surrounding the interlobular duct (D)

H&E X 40

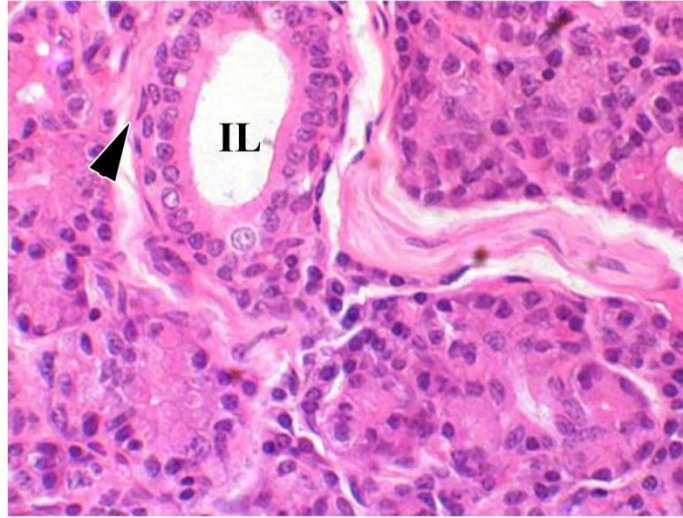


Fig.67

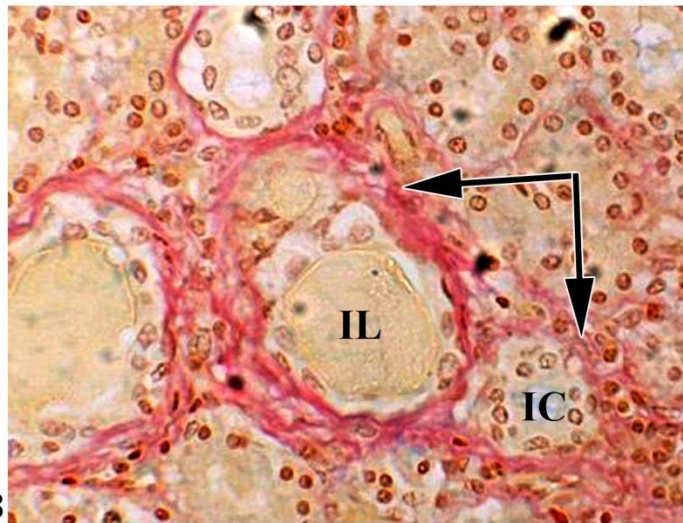


Fig.68

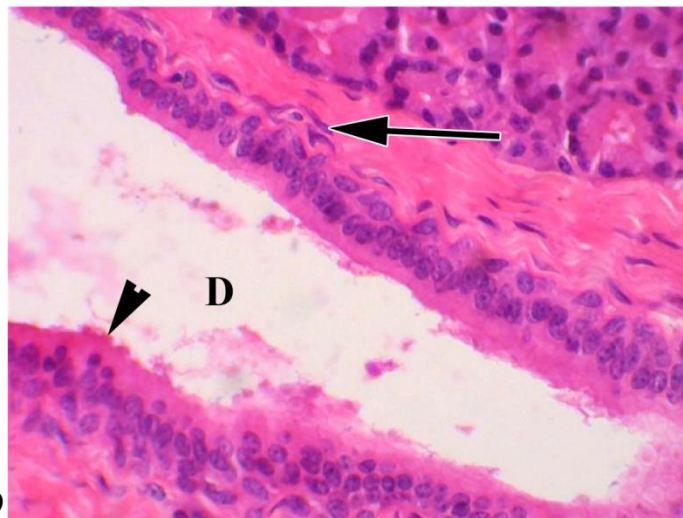


Fig.69

Fig. 70: Photomicrograph of lacrimal gland of sheep showing strong PAS positive reaction (arrow) in the secretory units

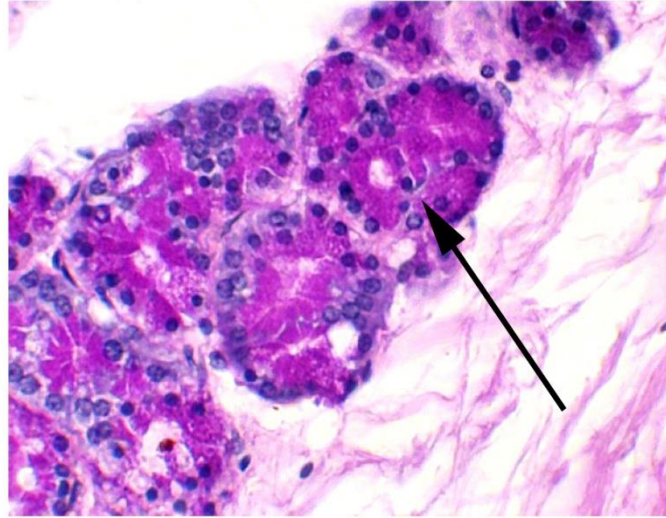
PAS stain X 40

Fig. 71: Photomicrograph of lacrimal gland of sheep showing strong PAS positive reaction (arrow) in goblet cells of interlobular duct

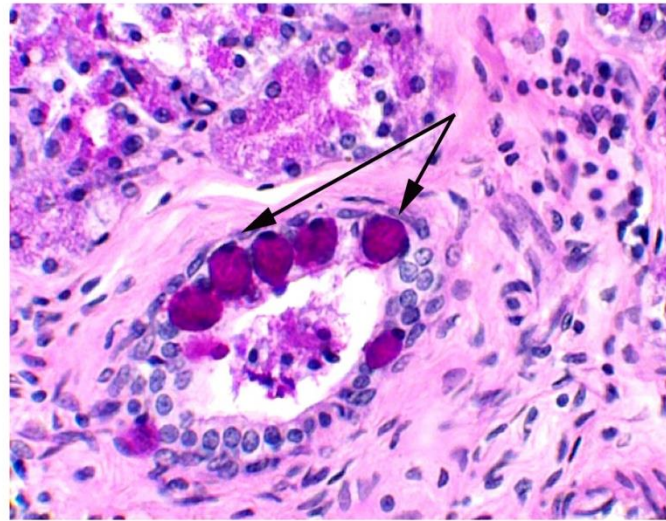
PAS stain X 40

Fig. 72: Photomicrograph of lacrimal gland of sheep showing Alcian blue positive reaction in a tubule (arrow) and few cells (arrow head) in a acini

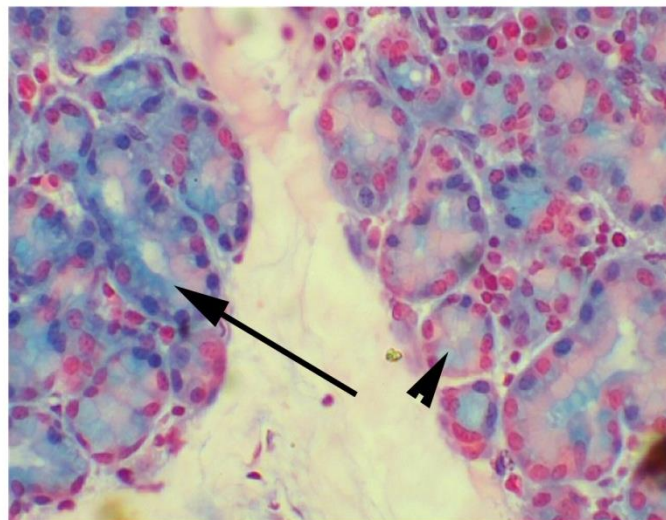
Alcian blue stain at pH 2.5 X40



**Fig.70**



**Fig. 71**

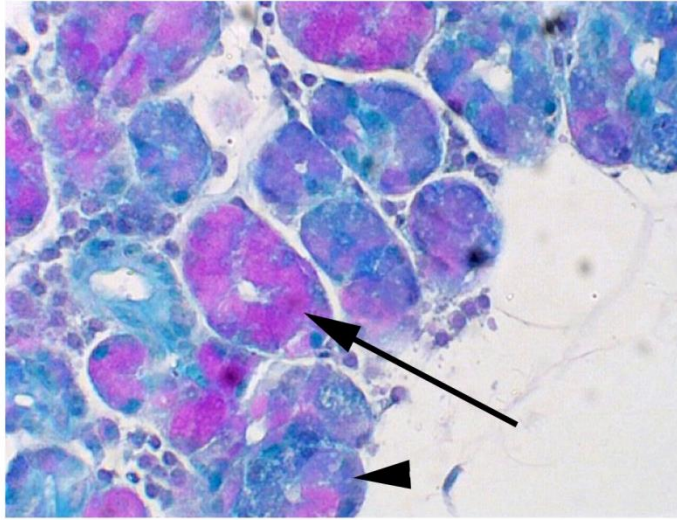


**Fig.72**

Fig. 73: Photomicrograph of lacrimal gland of sheep showing positive reaction for PAS in a secretory unit (arrow) and showing positive reaction for both PAS and Alcian blue (arrow head) in a secretory unit  
Combined technique of PAS and Alcian blue X 10

Fig. 74: Photomicrograph of lacrimal gland of sheep showing intralobular lipid (arrow)  
H&E X 40

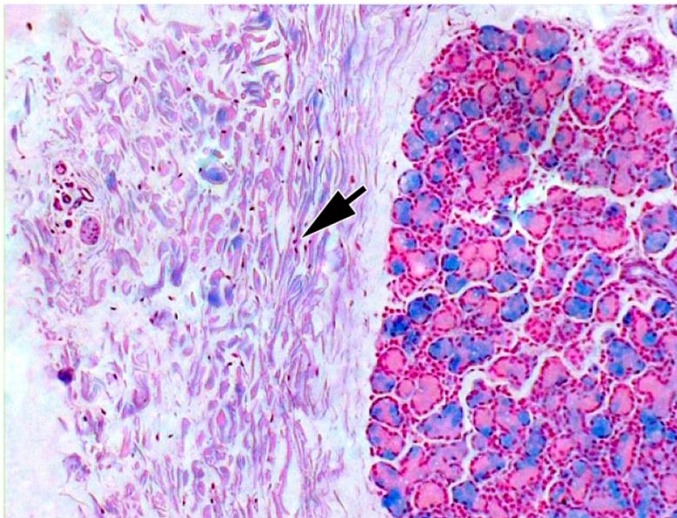
Fig. 75: Photomicrograph of lacrimal gland of goat showing smooth muscle fibers (arrow) in the capsule  
Alcian blue X10



**Fig.73**



**Fig.74**



**Fig.75**

Fig. 76: Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) in the capsule

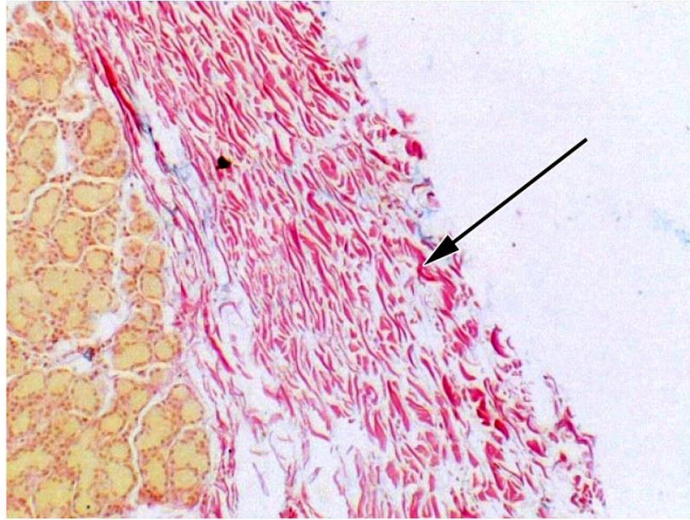
Vangieson's stain X 10

Fig. 77: Photomicrograph of lacrimal gland of goat showing elastic fibers (arrow) in the capsule

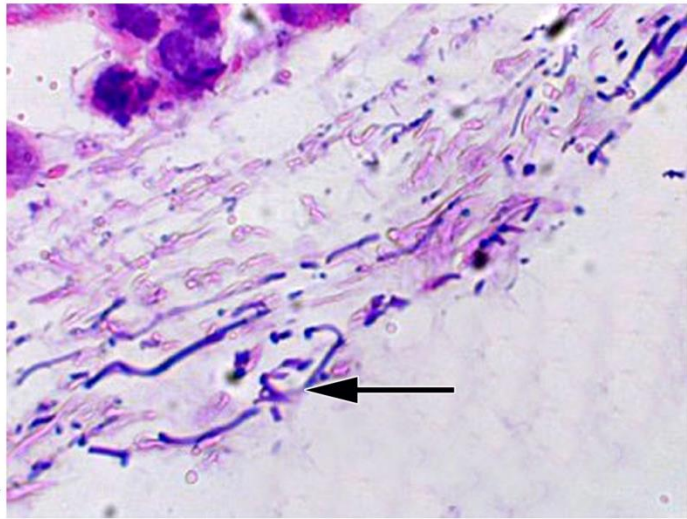
Aldehyde fuschin stain X 40

Fig. 78: Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the capsule

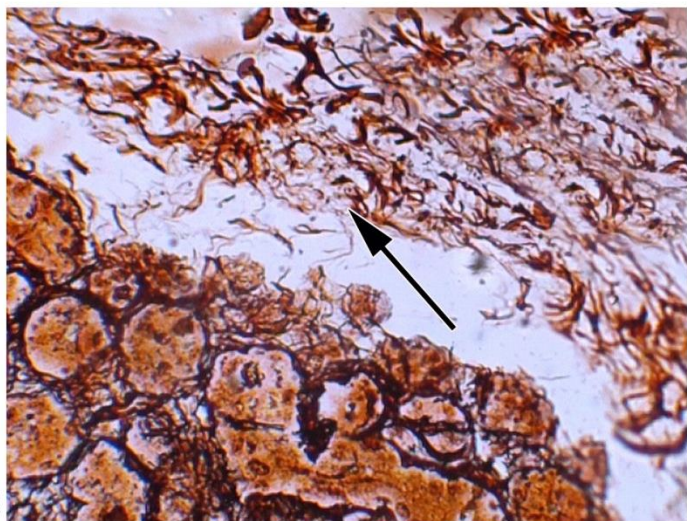
Gomori's stain X 40



**Fig.76**



**Fig.77**



**Fig.78**

Fig. 79: Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) in the septa

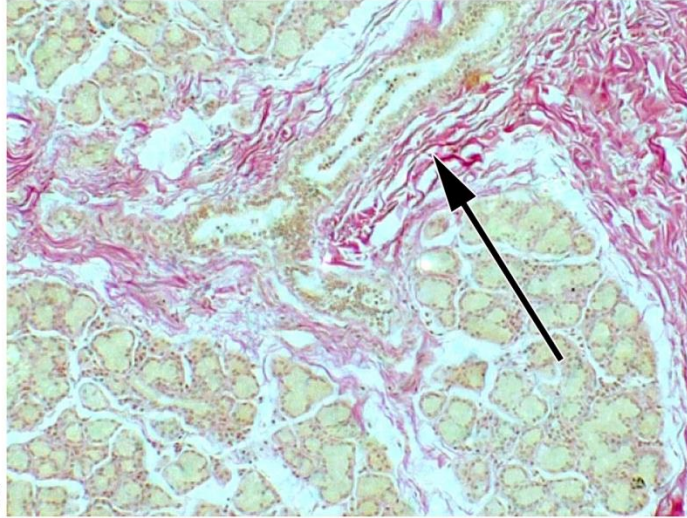
Vangieson's stain X 10

Fig. 80: Photomicrograph of lacrimal gland of goat showing elastic fibers (arrow) in the septa

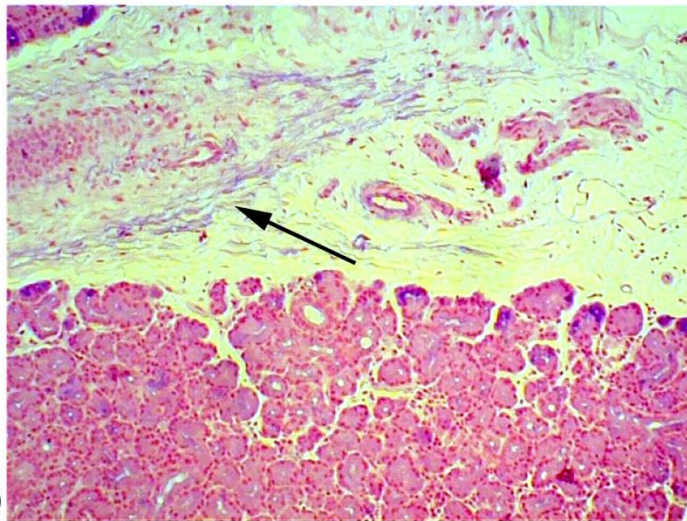
Aldehyde fuschin stain X 10

Fig. 81: Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the septa

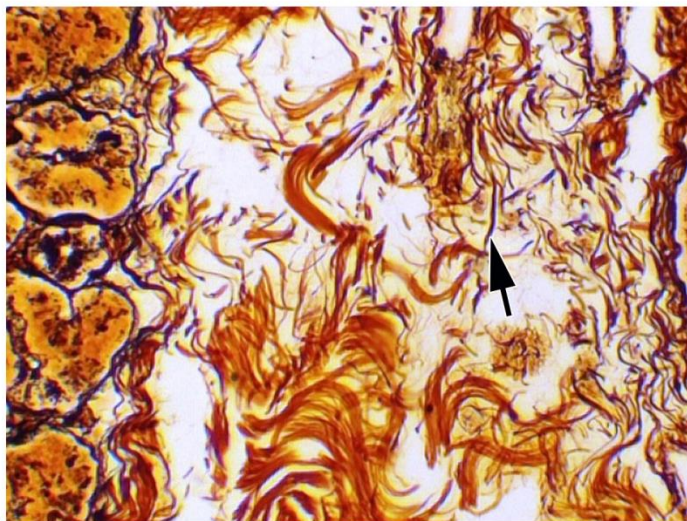
Gomori's stain X 40



**Fig.79**



**Fig.80**



**Fig.81**

Fig. 82: Photomicrograph of lacrimal gland of goat showing interlobular duct (D), artery (A) and vein (V) in the septa

H&E X 4

Fig. 83: Photomicrograph of lacrimal gland of goat showing lymphocytes (L), plasma cells (P) and fibrocytes (F) in the septa

H&E X 40

Fig. 84: Photomicrograph of lacrimal gland of goat showing acidophilic acini (Ac) and basophilic acini (arrow) in the parenchyma

H&E X 40

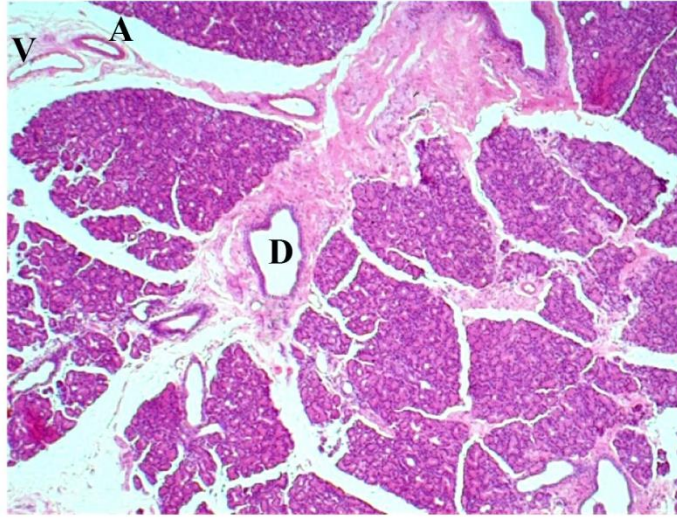


Fig.82

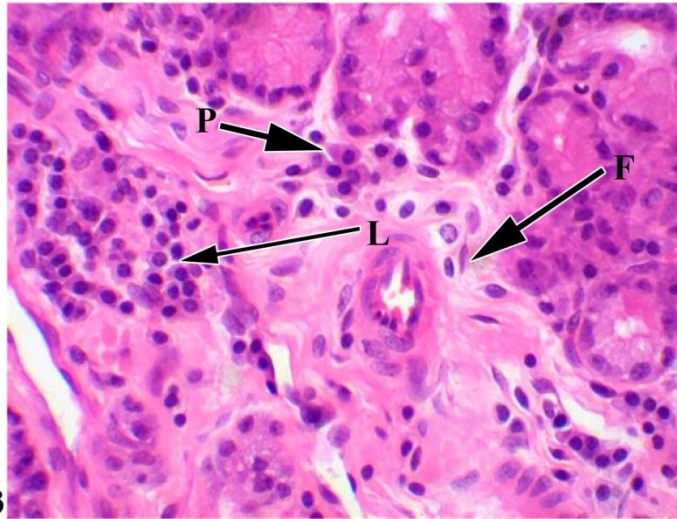


Fig.83

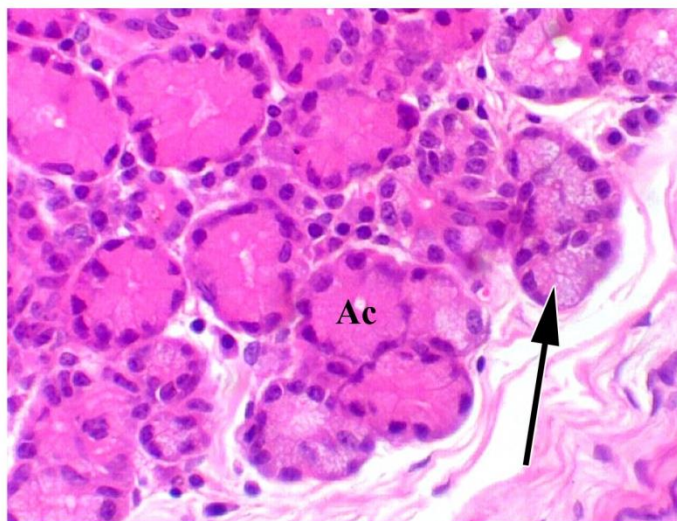


Fig.84

Fig. 85: Photomicrograph of lacrimal gland of goat showing myoepithelial cell (arrow) at the base of secretory cells in tubule (T)

H&E X 40

Fig. 86: Photomicrograph of lacrimal gland of goat showing collagen fibers (arrow) around the secretory units

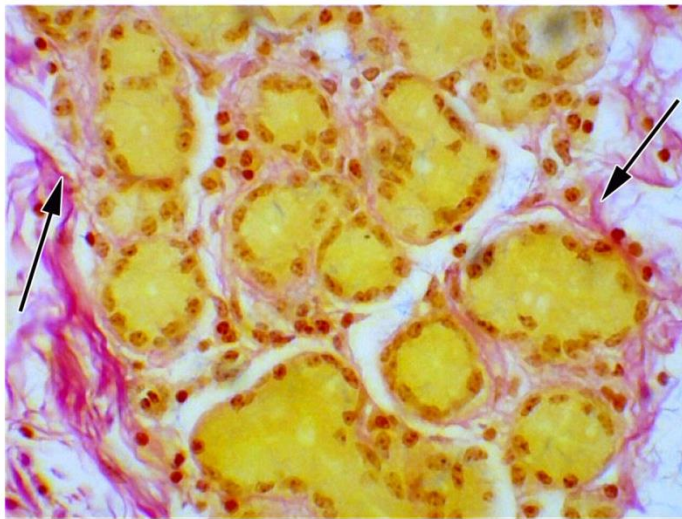
Vangieson's stain X 40

Fig. 87: Photomicrograph of lacrimal gland in goat showing reticular fibers (arrow) between the secretory units and in basement membrane of secretory units

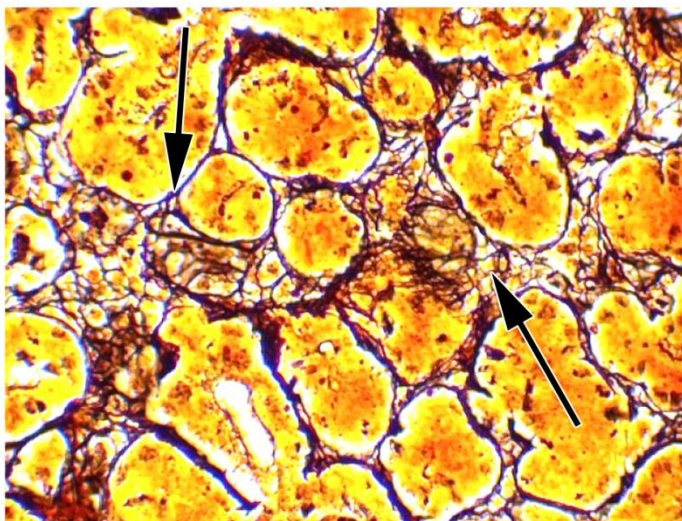
Gomori's stain X 40



**Fig.85**



**Fig.86**



**Fig.87**

Fig. 88: Photomicrograph of lacrimal gland in goat showing macrophage (arrow) in the interstitial tissue

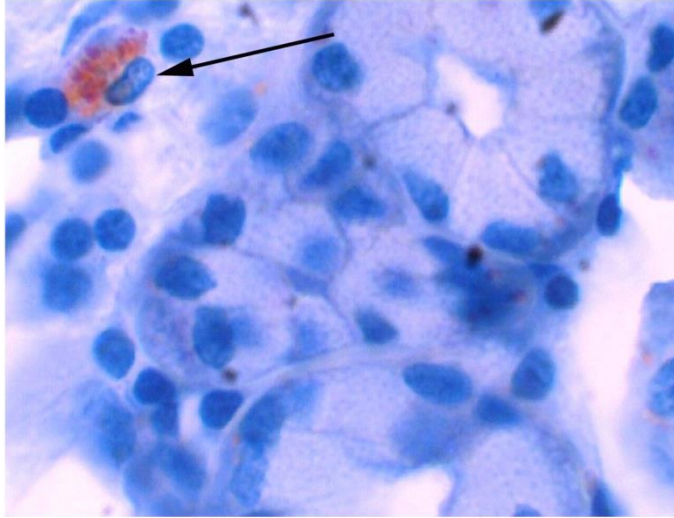
Oil red O X 100

Fig. 89: Photomicrograph of lacrimal gland of goat showing bilayered cuboidal epithelium (arrow) in the intercalated duct (IC)

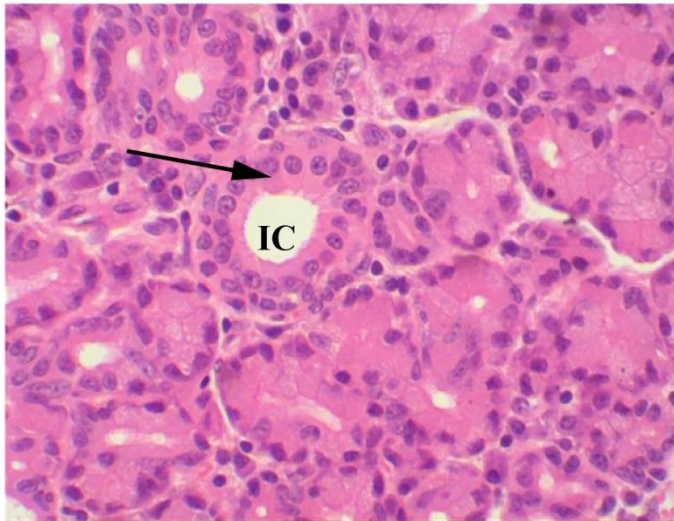
H&E X 40

Fig. 90: Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the basement membrane of the intercalated duct(IC)

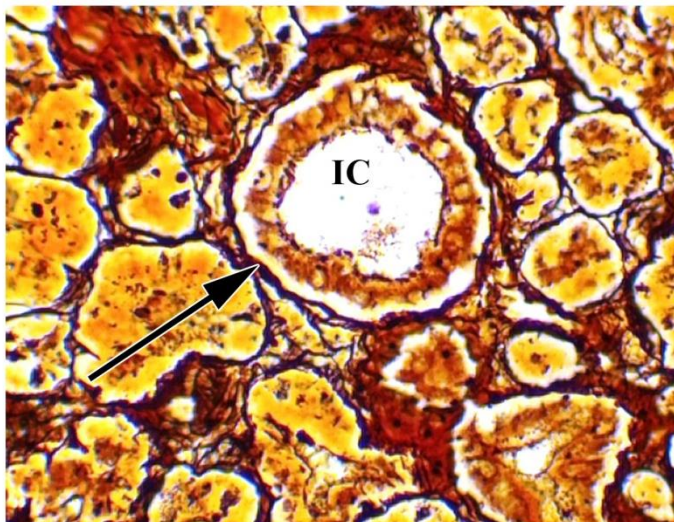
Gomori's stain X 40



**Fig.88**



**Fig.89**



**Fig.90**

Fig. 91: Photomicrograph of lacrimal gland of goat showing smooth muscle fibers (arrow) in the intralobular duct ((IL)

H&E X 40

Fig. 92: Photomicrograph of lacrimal gland of goat showing goblet cells (arrow) in the epithelium and smooth muscle fibers (arrow head) around the interlobular duct (D)

Aldehyde fuschin X 40

Fig. 93: Photomicrograph of lacrimal gland of goat showing reticular fibers (arrow) in the basement membrane (arrow) of interlobular duct (D)

Gomori's stain X40

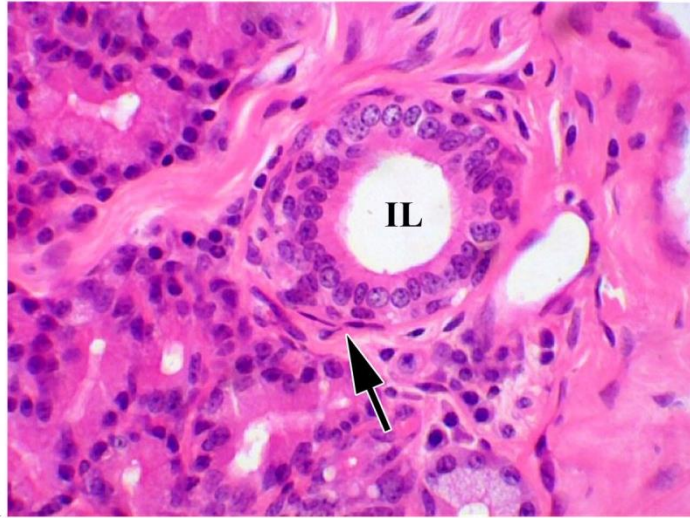


Fig.91

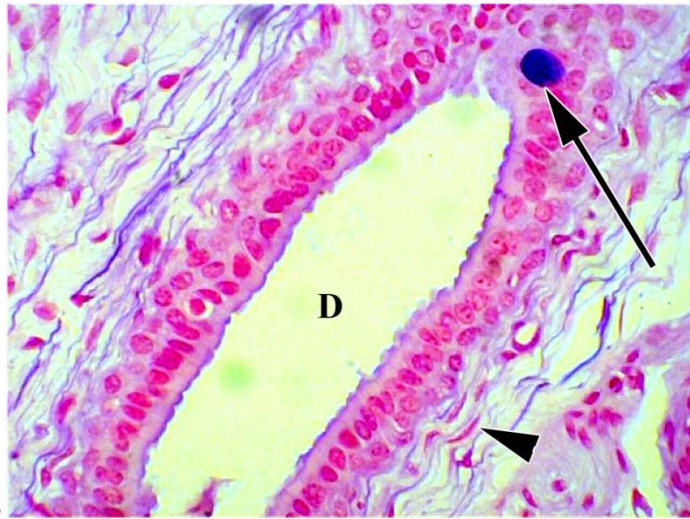


Fig.92



Fig.93

Fig. 94: Photomicrograph of lacrimal gland in goat showing strong PAS positive Reaction (arrow) in secretory units

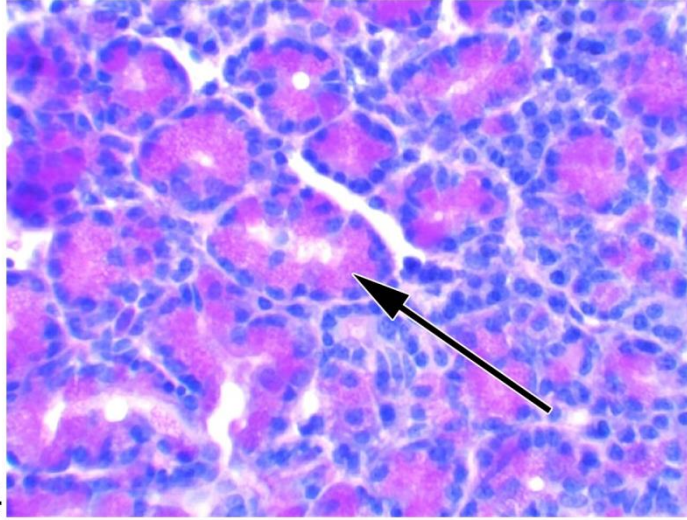
PAS stain X 40

Fig. 95: Photomicrograph of lacrimal gland of goat showing Alcian blue positive reaction in a acini (arrow) and few cells in the tubule (arrow head)

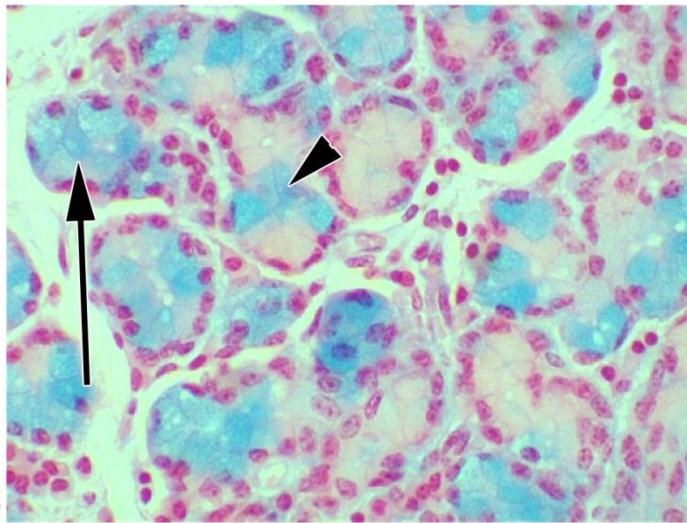
Alcian blue stain at pH 2.5 X40

Fig. 96: Photomicrograph of lacrimal gland of goat showing positive reaction for PAS (arrow) in a tubule and positive reaction for both PAS and Alcian blue (arrow head) in a acini

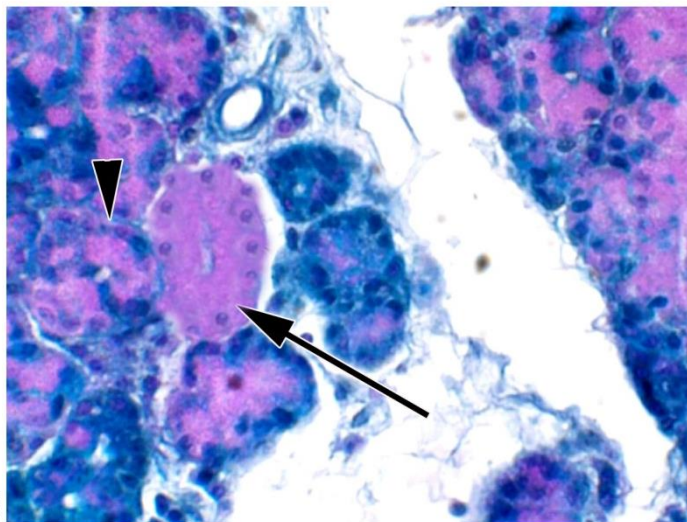
Combined Alcian blue and PAS technique X 40



**Fig.94**



**Fig.95**



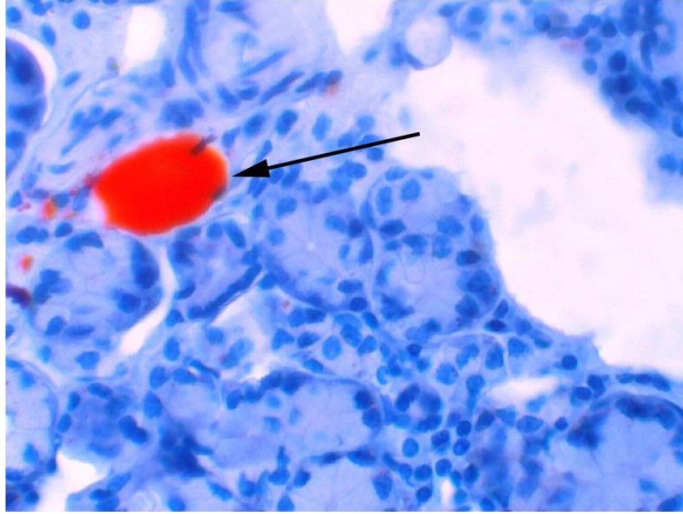
**Fig.96**

Fig. 97: Photomicrograph of lacrimal gland of goat showing intralobular lipid (arrow)

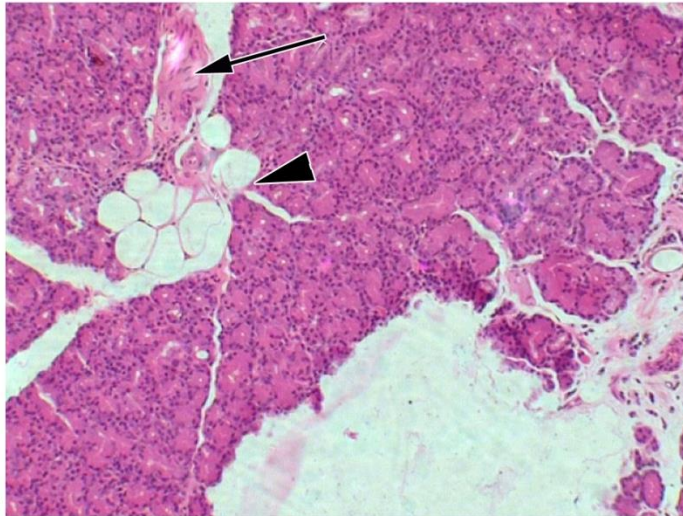
Oil red O stain X 40

Fig. 98: Photomicrograph of lacrimal gland of goat showing interlobular lipid (arrow head) and nerve fiber (arrow) in the septa

H&E X 10



**Fig.97**



**Fig.98**

# Discussion



## V. DISCUSSION

### 5.1 HISTOMORPHOLOGY

#### 5.1.1 STROMA

Singh *et al.* (1975) reported that lacrimal gland of buffalo was covered by fibrous capsule and Maala and De ocampo (2007) stated that the capsule of the water buffalo mainly consisted of collagen fibers. Whereas, in the present study the lacrimal gland of cattle, buffalo, sheep and goat was covered by connective tissue capsule and consisted of collagen fibers, elastic fibers, reticular fibers and smooth muscle fibers. The presence of large number of smooth muscle fibers were seen in buffalo than that of cattle, sheep and goat. This might be due to the species variation.

In the present study the septa from the capsule divided the gland into different lobules and it consisted of connective tissue fibers mainly collagen fibers, elastic fibers, reticular fibers, interlobular ducts, arteries, veins and nerve fibers in cattle, buffalo, sheep and goat. This finding was similar to the earlier reports of Singh *et al.* (1975) in buffalo, Pinard *et al.* (2003) in bison and cattle, Maala and De ocampo (2007) in water buffaloes, Getty (2012) in ruminants. However, in the present study the elastic fibers were more in the septa of cattle and goat than that of buffalo and sheep, this may be due to the species variation.

In the present study plasma cells, lymphocytes, macrophages and mast cells were observed in the septa of cattle, buffalo, sheep and goat. This finding is similar to the earlier reports of Cabral *et al.* (2005) in canines and Getty (2012) in ruminants. However,

in the present study the presence of more number of plasma cells and more number of lymphocytes were observed in the buffalo than that of cattle, sheep and goat indicating its role in immunological response against the infection.

### **5.1.2 PARENCHYMA**

In the present study the parenchyma of lacrimal gland in cattle, buffalo, sheep and goat was tubulo acinar type this finding is in agreement with the reports of Garguilo *et al.* (1999) in sheep, Pinard *et al.* (2003) in bison and cattle, Shadkhast and Bigham (2010) in buffaloes, Daryuos and Ahmed (2012) in sheep and goat.

In the present study the gland was serous in nature in cattle, buffalo, sheep, and goat. This finding is similar to the earlier reports of Banks (1993), Konig and Liebich (2009), Trautmann and Fiebiger (2002) in all domestic animals except pig. However, it differs with the earlier report of Abbasi *et al.* (2014) in sheep, Daryuos and Ahmed (2012) in sheep and goat, Klećkowska *et al.* (2012) in Roe deer where the gland was mixed in nature it contained both serous and mucous acini. This is may be due to breed, species and regional variation.

The acinar and tubular units were lined by pyramidal shaped cells with the basal nuclei, the nuclei were spherical to oval shape in cattle, buffalo, sheep and goat in the present study is similar to the earlier reports of Singh *et al.* (1975) in buffalo, Garguilo *et al.* (1999) in sheep, whereas, Pinard *et al.* (2003) reported in bison and cattle that acini were lined by tall columnar cells and tubules were lined by short columnar cells, Shadkhast and Bigham (2010) in buffaloes the tubules were lined by short columnar cells.

In the present study the cytoplasm of the secretory cells was granular and acidophilic in cattle and sheep is similar to the earlier report of Pinard *et al.* (2003) in cattle and Abbasi *et al.* (2014) in sheep.

The cytoplasm was acidophilic at the base and basophilic towards the apical portion of the secretory cells in buffalo. In goat few cells were acidophilic granular and few cells were basophilic granular was observed in the present study, differs with the earlier report of Singh *et al.* (1975) in buffalo where the cytoplasm was granular and acidophilic in the supranuclear region and basophilic in the basal region and Pinard *et al.* (2003) in bison reported the cytoplasm as vacuolated basophilic granular.

In the present study the secretory units were surrounded by thin layer of collagen fibers and reticular fibers around the acini in goat and myoepithelial cells were observed at the base of the secretory cells in cattle, buffalo, sheep and goat this finding is in agreement with the report of Klećkowska *et al.* (2012) in Roe deer, Eurell and Frappier (2006) in ungulates, and Daryuos and Ahmed (2012) in sheep and goat.

Pinard *et al.* (2003) in cattle and bison reported that more infiltration cells were seen between the acini in the cattle than buffalo but did not mention the type of cells where as in the present study the plasma cells, lymphocytes, macrophages and multinucleated giant cells were observed in the interstitial tissue of cattle, buffalo, sheep and goat. The presence of large number of plasma cells and aggregation of lymphoid cells in the parenchyma of the lacrimal gland was observed in buffalo indicating its role in defence mechanism protecting the ocular surface from infection as reported by Walcott (1998).

Singh *et al.* (1975) reported that the diameter of acini ranged from 35.2 $\mu\text{m}$  to 66.0 $\mu\text{m}$  in buffaloes. Whereas, in the present study the diameter of acini were 33.18 $\pm$ 1.05 $\mu\text{m}$ , 54.81 $\pm$ 1.56 $\mu\text{m}$ , 33.89 $\pm$ 0.97 $\mu\text{m}$ , 37.88 $\pm$ 0.86 $\mu\text{m}$  in cattle, buffalo, sheep and goat respectively. There was significant difference (\*\*) in the diameter of the acini between buffalo and cattle between buffalo and sheep and between buffalo and goat. There was significant difference (\*) between cattle and goat.

In the present study and diameter of tubules were 47.27 $\pm$ 0.77 $\mu\text{m}$ , 69.56 $\pm$ 1.77 $\mu\text{m}$ , 41.50 $\pm$ 1.12 $\mu\text{m}$ , 45.70 $\pm$ 1.01 $\mu\text{m}$  in cattle, buffalo, sheep and goat respectively. There was significance difference (\*\*) in the diameter of tubules between cattle and buffalo, between buffalo and sheep, between buffalo and goat, and between cattle and sheep.

### **5.1.3 DUCT SYSTEM**

In the present study the lacrimal gland consisted of intercalated duct, intralobular duct and interlobular duct in cattle, buffalo, sheep and goat this finding is similar to the earlier report of Singh *et al.* (1975) in buffaloes. However, it differs with the earlier reports of Garguilo *et al.* (1999) where the presence of only intralobular and interlobular ducts was observed in sheep.

In the present study the intercalated ducts were lined by simple cuboidal epithelium in cattle, buffalo, sheep and this finding is in agreement with the earlier report of Trautmann and Fiebiger (2002) in all domestic animals, Singh *et al.* (1975) in buffaloes, Daryuos and Ahmed (2012) in sheep and goat. However, it differs with the lining of the intercalated duct in goat where it was bilayered cuboidal epithelium and the smooth muscle fibers, collagen fibers, around the intercalated ducts and reticular fibers in

the basement membrane of the intercalated ducts were observed in cattle, buffalo, sheep and goat in the present study.

Singh *et al.* (1975) reported that the diameter of intercalated duct was 16.5 $\mu\text{m}$ . Whereas, the diameter of intercalated ducts were 50.28 $\pm$ 1.26 $\mu\text{m}$ , 46.79 $\pm$ 0.83 $\mu\text{m}$ , 39.87 $\pm$ 0.85 $\mu\text{m}$ , 43.36 $\pm$ 1.00  $\mu\text{m}$  in cattle, buffalo, sheep and goat respectively in the present study. There was significance difference (\*\*) in the diameter of intercalated duct between cattle and sheep, between cattle and goat and between buffalo and sheep.

In the present study the intralobular ducts were lined by simple columnar epithelium in cattle and buffalo this finding is similar to the earlier reports of Singh *et al.* (1975) in buffalo. Whereas intralobular ducts in sheep and goat were lined by bilayered columnar epithelium differs with earlier reports of Abbasi *et al.* (2014) in sheep where it was lined by simple cuboidal epithelium. However, in the present study the ducts were surrounded by collagen fibers, smooth muscle fibres and reticular fibers in the basement of the duct in cattle, buffalo, sheep and goat.

Singh *et al.* (1975) reported that the diameter of intralobular ducts range from 33.0  $\mu\text{m}$  to 49.5  $\mu\text{m}$  in buffaloes. Whereas in the present study the diameter of intralobular ducts were 71.54 $\pm$ 1.68 $\mu\text{m}$ , 60.96 $\pm$ 1.39 $\mu\text{m}$ , 63.49 $\pm$ 1.88 $\mu\text{m}$ , 59.78 $\pm$ 1.16 $\mu\text{m}$  in cattle, buffalo, sheep and goat respectively. There was significance difference (\*\*) in the diameter of intralobular duct between cattle and buffalo, between cattle and sheep and between cattle and goat.

In the present study the interlobular ducts were lined by bilayered columnar epithelium in cattle and buffalo. However, it differs with the report of Singh *et al.* (1975) in buffaloes where it was bilayered cuboidal epithelium and Pinard *et al.* (2003) in bison and cattle and Shadkhast and Bigham(2010) in buffaloes where the interlobular ducts were lined by pseudostratified epithelium, and Maala and De ocampo (2007) observed simple to stratified columnar epithelium in buffaloes.

In the present study the interlobular ducts were lined by stratified columnar epithelium in sheep and goat. This finding is similar to the earlier reports of Daryuos and Ahmed (2012) in sheep and goat and it differs with reports of Abbasi *et al.* (2014) where interlobular ducts were lined by stratified cuboidal epithelium in sheep.

In the present study the goblet cells were observed in the epithelium of interlobular ducts of sheep and goat this finding is similar to the reports of Garguilo *et al.* (2000) in sheep, Daryuos and Ahmed (2012) in sheep and goat and Abbasi *et al.* (2014) in sheep.

In the present study the ducts were surrounded by smooth muscle fibers in cattle, buffalo, sheep and goat. This finding was similar to the findings of Daryuos and Ahmed (2012) where variable amount of smooth muscle fibers around the connective tissue of interlobular ducts were noticed in Awasi sheep and Black goat.

In the present study the diameter of interlobular ducts were  $88.82 \pm 4.48 \mu\text{m}$ ,  $96.50 \pm 4.32 \mu\text{m}$ ,  $101.00 \pm 6.73 \mu\text{m}$ , and  $115.10 \pm 8.55 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively. Whereas, Singh *et al.* (1975) reported  $199.50 \mu\text{m}$  to  $266.00 \mu\text{m}$  in buffalo

this variation may be due to breed, species and region. There was significance difference (\*) in the diameter of interlobular duct of cattle and goat.

## **5.2 HISTOCHEMISTRY**

### **5.2.1 PARENCHYMA**

In the present study a strong PAS positive reaction were seen in the secretory units of lacrimal gland in cattle, sheep and goat indicating the presence of high amount of neutral glycoproteins. This finding is similar to the earlier reports of Mohammadpour (2011) in camel, and Abbasi *et al.* (2014) in sheep. Whereas Gargiulo *et al.* (2000) observed a strong PAS positive reaction in mucous cells and weak PAS positive reaction in seromucous cells in sheep. But Klećkowska *et al.* (2012) observed PAS positive reaction in few secretory cells whereas, most of the cells did not show any reaction for PAS in Roe deer indicating the variation in the secretory nature of the cell.

In the present study few secretory units showed strong PAS positive reaction and few secretory units showed weak PAS positive reaction in buffalo. This finding is contrary to the reports of Pinard *et al.* (2003) where the presence of PAS positive granules were observed in all acini and tubular cells of the gland in bison and cattle. However, Maala and De ocampo (2007) in buffaloes reported that the PAS positive reaction in most of the secretory acini.

In the present study few secretory units and few cells in secretory units were positive for Alcian blue at pH 2.5 in cattle, buffalo, sheep and goat indicating the presence of sulfomucins and sialomucins. This finding is similar to the report of Martin *et*

*al.* (1988) where the presence of sialomucin in acinar granules were observed in dog. Whereas, Gargiulo *et al.* (2000) reported that mucous and seromucous cells showed moderate reaction for Alcian blue at pH 2.5 and 1.0 in sheep revealing the presence of acidic glycoconjugates. However, Pinard *et al.* (2003) in bison and cattle reported that the acinar cells were positive for Alcian blue at pH 1.0 and 2.5 whereas, the tubular cells did not show any reaction. Maala and De ocampo (2007) in buffaloes observed that most of the acini reacted strongly for Alcian blue at pH 2.5 and showed weaker reaction for pH 1.0. This indicates there was variation in the secretory nature among the animals.

In the present study the lipid granules in the cytoplasm were not observed. It differs with the earlier reports of Singh *et al.* (1975) where diffuse cytoplasmic sudanophilia was observed in buffaloes, and Trautmann and Fiebiger (2002) reported the presence of fat droplets were observed in the secretory cells of all domestic animals. However, in the present study the intralobular and interlobular lipids were observed in buffalo, sheep, and goat. This finding was similar to the earlier report of Cabral *et al.* (2005) in canines.

### **5.2.2 DUCT SYSTEM**

In the present study all the ducts of cattle, buffalo, sheep and goat showed negative reaction for PAS. But the goblet cells in the interlobular ducts of sheep and goat showed strong PAS positive reaction. This finding was in accordance with Gargiulo *et al.* (2000) in sheep, Abbasi *et al.* (2014) in sheep.

*Summary*



## **VI. SUMMARY**

Lacrimal glands are unique structures possessing both epithelial and lymphoid tissue which play important role in protecting ocular surface from infection. It has been observed that there is a variation in the structure and secretion in the lacrimal gland among the animals. The lacrimal gland epithelium is also an elegant secretory tissue of multiple functions with complex control systems that can serve as a model for understanding the other secretory epithelia. There is limited scientific work carried on the comparative histological and histochemical study of lacrimal gland in ruminants i.e. cattle, buffalo, sheep and goat. Hence the present research work on lacrimal gland is under taken during the year 2014-15 at Veterinary College Bidar with following objectives.

- a) To study the histology of the lacrimal gland in ruminants.
- b) To study histochemistry of the lacrimal gland in ruminants.
- c) To correlate any Histological and Histochemical variations in the lacrimal gland of ruminants

## **METHODOLOGY**

The lacrimal gland samples were collected from the dorsolateral aspect of the eyeball immediately after slaughter from cattle, buffalo, sheep and goat. The collected gland was cut into tissue pieces and were washed in normal saline and later fixed in different fixatives like 10% Neutral buffered formalin, Zenker's fluid and Bouin's fluid. The samples were processed in isopropyl alcohol- xylene sequence and embedded in

paraffin by routine method (Luna, 1968). Sections were cut at 5-6µm thickness and were utilised for histomorphological and histochemical studies. The glandular tissue fixed in 10% Neutral buffered formalin were pre-frozen for 1-2 hrs and embedded in freezing media, using cryostat 6-7 µm thickness sections were cut and utilised for lipid studies.

Various staining methods like Ehrlich's Haematoxylin and Eosin method (Luna, 1968) for general study, Van Geison's method for collagen fibres (Bancroft *et al.*, 2008), Aldehyde fuschin's method for elastic fibres (Bancroft *et al.*, 2008), Gomori's method for Reticular fibers (Luna, 1968), Toludine blue method for mast cells (Singh.and Sulochana, 1996), Methylgreen-pyronin method for plasma cells. (Luna, 1968), PAS technique for mucopolysaccharides (Bancroft *et al.*, 2008), Alcian blue at pH 2.5 for sulfomucins and sialomucins (Bancroft *et al.*, 2008), Combined PAS Alcian blue pH 2.5 technique for mucins (Bancroft *et al.*, 2008), Oil red O for lipids (Luna, 1968) were adopted to study the histomorphology and histochemistry.

## **MAJOR FINDINGS**

### **STROMA**

1. The capsule of lacrimal gland was made up of loose connective tissue and consisted of collagen fibers, elastic fibers, reticular fibers and smooth muscle fibers in cattle, buffalo, sheep and goat. The smooth muscle fibers were more in buffalo than in cattle, sheep and goat.
2. The septa detached from the capsule entered the parenchyma of the gland and divided the gland into different lobules in cattle, buffalo, sheep and goat.

3. The septa consisted of collagen fibers, elastic fibers and reticular fibers in cattle, buffalo, sheep and goat. The elastic fibers were more in septa of cattle and goat.
4. The macrophages, plasma cells, mast cells and lymphocytes were observed in the septa of cattle, buffalo, sheep and goat. But the lymphocytes and plasma cells were more in buffalo than in cattle, sheep and goat.

### **PARENCHYMA**

1. The parenchyma of lacrimal gland was tubular acinar type and serous in nature in cattle, buffalo, sheep and goat.
2. The acini and tubules were lined by pyramidal shaped cells with basal nuclei.
3. The cytoplasm of cattle and sheep was acidophilic granular while the cytoplasm was acidophilic in the base and basophilic in the apical portion of the cells in buffalo. The cytoplasm of few cells was acidophilic and few cells were basophilic in goat indicating variation in the secretory nature of cells.
4. The plasma cells, lymphocytes, macrophages and multinucleated giant cells were observed in the interstitial tissue of cattle, buffalo, sheep and goat.
5. The aggregation of lymphoid cells in the parenchyma of buffalo was observed and the plasma cells were more in buffalo than in cattle, sheep and goat.
6. Myoepithelial cells were observed at the base of secretory cells in cattle, buffalo sheep and goat.
7. The mean diameter of acini was  $33.18 \pm 1.05 \mu\text{m}$ ,  $54.81 \pm 1.56 \mu\text{m}$ ,  $33.89 \pm 0.97 \mu\text{m}$ , and  $37.88 \pm 0.86 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively.

8. There was significant difference (\*\*) in the mean diameter of acini between cattle and buffalo, between buffalo and sheep and between buffalo and goat.
9. The mean diameter of tubules was  $47.27 \pm 0.77 \mu\text{m}$ ,  $69.56 \pm 1.77 \mu\text{m}$ ,  $41.50 \pm 1.11 \mu\text{m}$ , and  $45.70 \pm 1.01 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively.
10. There was significant difference (\*\*) in the mean diameter of tubules between cattle and buffalo, between buffalo and sheep, between buffalo and goat and between cattle and sheep.

### **DUCT SYSTEM**

1. The lacrimal gland of cattle, buffalo, sheep and goat consisted of intercalated, intralobular and interlobular ducts.
2. The intercalated ducts were lined by simple cuboidal epithelium in cattle, buffalo and sheep, in goat it was bilayerd cuboidal. They were surrounded by smooth muscle fibers, collagen fibers in cattle, buffalo, sheep and goat.
3. The intralobular ducts were lined by simple columnar epithelium in cattle and buffalo, and bilayerd columnar in sheep and goat. They were surrounded by smooth muscle fibers and collagen fibers in cattle, buffalo, sheep and goat
4. The interlobular ducts were lined by lined by bilayered columnar epithelium in cattle and buffalo, and stratified columnar epithelium with goblet cells in sheep and goat. They were also surrounded by smooth muscle fibers, collagen fibers in cattle, buffalo, sheep and goat.

5. The mean diameter of intercalated ducts were  $50.28 \pm 1.26 \mu\text{m}$ ,  $46.79 \pm 0.83 \mu\text{m}$ ,  $39.87 \pm 0.85 \mu\text{m}$ ,  $43.36 \pm 1.00 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively.
6. There was significant difference (\*\*) in the mean diameter of intercalated duct between cattle and sheep, between cattle and goat and between buffalo and sheep.
7. The mean diameter of intralobular ducts were  $71.54 \pm 1.68 \mu\text{m}$ ,  $60.96 \pm 1.39 \mu\text{m}$ ,  $63.49 \pm 1.89 \mu\text{m}$ ,  $59.78 \pm 1.16 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively.
8. There was significant difference (\*\*) in the mean diameter of intralobular duct between cattle and buffalo, between cattle and sheep and between cattle and goat.
9. The mean diameter of interlobular ducts were  $88.82 \pm 4.48 \mu\text{m}$ ,  $96.50 \pm 4.32 \mu\text{m}$ ,  $101.00 \pm 6.73 \mu\text{m}$  and  $115.10 \pm 8.55 \mu\text{m}$  in cattle, buffalo, sheep and goat respectively.
10. There was significant difference (\*) in the mean diameter of interlobular duct of cattle and goat.

## **HISTOCHEMISTRY**

1. A strong PAS positive reaction was observed in all secretory units of the lacrimal gland in cattle, sheep and goat indicating the presence of high quantity of neutral glycoproteins. A strong to weak PAS positive reaction was observed in the buffalo. Ducts were negative for PAS in cattle and buffalo. A strong PAS positive reaction was observed in the goblet cells of interlobular ducts in sheep and goat.

2. Few secretory units and few secretory cells in a secretory unit showed positive reaction for Alcian blue at pH 2.5 in cattle, buffalo, sheep and goat indicating the presence of sulfomucins and sialomucins.
3. The secretory cells in few secretory units gave positive reaction for both PAS and Alcian blue indicating the presence of both neutral glycoproteins and sialomucins in a secretory unit.
4. Intralobular and interlobular lipids were observed in buffalo, sheep and goat.

## **CONCLUSION**

The present study of comparative histology and histochemistry of lacrimal gland in ruminants revealed little variation in structure and secretory nature among the ruminants.

The lacrimal gland of cattle, buffalo, sheep and goat was covered by a capsule consisted of collagen fibers, elastic fibers, reticular fibers and smooth muscle fibers. Smooth muscle fibers were more in buffalo. The septa divided the gland into lobules and consisted of collagen fibers, elastic fibers, reticular fibers, arteries, veins, nerve fibers and interlobular ducts. Elastic fibers were more in cattle and goat.

The lacrimal gland was tubulo acinar type and serous in nature in cattle, buffalo, sheep and goat. The acini and tubules were lined by pyramidal shaped cells with granular cytoplasm. The acini and tubules were larger in buffalo. The plasma cells and lymphocytes were more in buffalo. The lacrimal gland consisted of intercalated duct,

intralobular duct and interlobular duct. Intralobular ducts were more in cattle. The goblet cells were present in the epithelium of interlobular ducts in sheep and goat.

All the secretory units showed strong PAS positive reaction in cattle, sheep and goat, while strong to weak reaction was observed in buffalo indicating the presence of neutral glycoprotein. The goblet cells showed strong PAS positive reaction in the interlobular ducts of sheep and goat. Few secretory units and few cells in secretory units showed positive reaction for Alcian blue at pH 2.5 indicating the presence of sulfomucins and sialomucins. The intralobular, interlobular lipids were found in buffalo, sheep and goat.

# Bibliography



## VII. BIBLIOGRAPHY

- ABBASI, M., KARIMI, H. and GHARZI, A., 2014. Preliminary Anatomical and Histological Study of Lacrimal Gland in Lori sheep. *J. Vet. Sci. Technol.*, **5**(1):154-158
- BANKS, W. J., 1993. Applied Veterinary Histology, Edn. 3<sup>rd</sup>., Williams and Wilkins, Mosby Year Book, St Louis Baltimore. *pp*: 484-485
- BANCROFT, D. JHON., SUVARNA, S. KIM and CHRISTOPHER, LAYTON., 2008. Bancroft's theory and practice of histological techniques, Edn. 6<sup>th</sup> ., Churchill livingstone, Elsevier., *pp*: 148-174
- CABRAL, V. P., LAUS, J.L., ZAIDAN DAGLI, M.L., TALIERI, I.C. and MAMEDE, F.V., 2005. Canine lacrimal and third eyelid superficial glands' macroscopic and morphometric characteristics. *Ciência Rural Santa maria.*, **35**(2):391-397
- DARYUOS, M.M. and AHMED, N.S., 2012. Comparative Histological and morphometrical study of lacrimal apparatus of Awasi sheep and native black goat. *Kufa. J. For vet. medical. Sci.*, **3**(2):41-56
- EURELL, J.A. and FRAPPIER, B.L, 2006. Dellmann's Text book of Veterinary Histology. Edn.6<sup>th</sup>., Blackwell publishing., *pp* 361-362
- GARGIULO, A.M., COLIOLO, P., CECCARELLI, P. and PEDINI, V., 1999. Ultrastructural study of sheep lacrimal glands. *Vet.res.*, **30**: 345-351
- GARGIULO, A.M., DALL'AGLIO, C., COLIOLO, P., CECCARELLI, P. and PEDINI, V., 2000. Complex Carbohydrate Histochemistry and Ultracytochemistry of the sheep Lacrimal Gland. *Anat.Histo.Embryol.*, **29**:19-23
- GETTY, R., 2012. Sissons and grossman's The Anatomy of the Domestic Animals. 5<sup>th</sup> Edn. Vol.1, East- West press private limited, New Delhi. *pp*: 1184

- KLEĆKOWSKA-NAWROT, J., MARYCZ, K., CZOGAŁA, J., KUJAWA, K., JANEK, M., CHRÓSZCZ, A. and BRUDNICKI, W., 2012. Morphology of the Lacrimal Gland and Superficial Gland of the Third Eyelid of Roe Deer. *Pak. Vet. J.*, **33**(2): 139-144
- KONIG, H. and LIEBICH, H.G., 2009. A text book and colour atlas of veterinary anatomy of domestic mammals. Edn. 4<sup>th</sup>., Schattauer GmbH Stuttgart Germany., pp 588-589
- LUNA, L.G., 1968. Manual of histological staining methods of armed forces of institute of pathology. Edn. 3<sup>rd</sup>., McGraw hill book co., New York., pp: 35-141
- MAALA, C.P. and DE OCAMPO, G.D., 2007. Macroscopic, Histological and Histochemical Characterization of the Lacrimal Gland of the Philippine Water buffalo (*Bubalus bubalis*). *Philipp. J. Vet. Med.*, **44** (2): 69-75
- MOHAMMADPOUR, A.A., 2011. Histochemistry of dorsal lacrimal gland in camel (*Camelus dromedarius*). *Journal of Camel Practice and Research.*, **8**(1):1-3
- MARTIN, C.L., MUNNELL, J. and KASWAN, R., 1998. Normal ultrastructure and histochemical characteristics of canine lacrimal glands. *Am. J. Vet. Res.*, **49**(9):1566-1572
- PINARD, C.L., WEISS, M.L., BRIGHTMAN, A.H, FENWICK, B.W. and DAVIDSON, H.J., 2003. Normal anatomical and histochemical characteristics of the lacrimal glands in the American Bison and cattle. *Anat.Histo.Embryol.*, **32**:257-262
- SAS. SAS/START, 2012. User's guide, Statistical Analysis Systems Institute, Inc; version 2. 4th ed. Vol. 2. Cary, NC
- SHADKHST, M. and BIGHAM.A.S., 2010. A Histo-anatomical study of dorsal lacrimal gland in iranian river buffalo. *Online veterinary journal vet scan.*, **5** (1): 11-16

- SINGH, Y., DHINGRA, D. and GOYAL, H.O., 1975. Certain histological and histochemical studies on the lacrimal gland of buffalo. *Indian. vet. j.*, **52**:468-470.
- SINGH, U.B. and SULOCHANA, S., 1996. Handbook of Histological and Histochemical Techniques, Edn. 2<sup>nd</sup>., premier publishing house, Hyderabad. pp 84
- TRAUTMANN, A., and FIEBIGER, J., 2002. Fundamentals of the Histology of Domestic Animals. Livestock publishing associate, Ithaca, New York. pp 401-402
- WALCOTT, B., 1998. The lacrimal gland and its veil of tears. *News physiol.sci.*, **13**: 97-103

*Abstract*



**COMPARATIVE HISTOLOGICAL AND HISTOCHEMICAL STUDY OF  
LACRIMAL GLAND IN RUMINANTS**

---

TRIVENI. T  
MVNK 1305

JULY-2015

Major Advisor:  
ASHOK PAWAR

---

**ABSTRACT**

The present comparative histological and histochemical study of lacrimal gland in ruminants was carried out to know the structural differences between the ruminants. The lacrimal gland of ruminants was covered by capsule consisted of loose connective tissue capsule and smooth muscle fibers. The parenchyma of the gland was tubuloacinar type and serous in nature in ruminants. The acini and tubules were lined by pyramidal shaped cells with basal nuclei. The myoepithelial cells were observed at the base of secretory cells. The plasma cells, macrophages, multinucleated giant cells and lymphocytes were observed in the interstitial tissue. The lacrimal gland consisted of intercalated, intralobular, interlobular ducts in ruminants. The intercalated duct was lined by simple cuboidal in cattle, buffalo, and sheep and it was bilayered cuboidal in goat. The intralobular ducts were lined by simple columnar in cattle and buffalo, it was bilayered columnar in sheep and goat. The interlobular ducts were lined by bilayered columnar in cattle and buffalo whereas, in sheep and goat it was stratified columnar epithelium and goblet were found in the epithelium. A strong PAS positive reaction was observed in all the secretory units of cattle, sheep and goat. Few secretory units and few cells in secretory units showed positive reaction for Alcian blue at pH 2.5 in cattle, buffalo, sheep and goat. Intralobular and interlobular lipids were observed in buffalo, sheep and goat.