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Comparative Histological, Histochemical and Immunohistochemical Examination of the Cranial and Caudal Gland of Each Lactating Mammary Gland Quarter of One Humped She Camel (*Camelus Dromedarius*)

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ABSTRACT

Studying the complete histological picture of the camel mammary gland plays a major role in understanding the variations in camel milk yield and composition. Therefore, the present study aimed to give more detailed description of the structure of the lactating dromedary she-camel mammary gland. The whole udder of 9 healthy lactating she-camels (*Camelus dromedaries*) was dissected of the fresh carcasses just after slaughtering. Sections were dissected out and fixed in 10% neutral buffer formalin for histological and immunohistochemical examination. Other parts were fixed in glutaraldehyde for ultrastructure examination. The gross examination of the camel mammary gland revealed that it is composed of four teats. Each teat ended by two separate orifices: cranial and caudal. Each orifice leads to a separate streak canal, separate gland cistern and separate lactating glands, cranial gland, and caudal gland. The examination of the two gland cisterns pointed out that the cranial gland cistern was significantly wider than the caudal one. The histological examination of the cranial and caudal gland revealed that the caudal gland comprised an abundant amount of interstitial connective tissue than the cranial gland. In contrast, the alveoli of the cranial gland were larger in size, more active, and stretched with secretion. The ultrastructure examination showed differences in structure and activity between the secretory cells of the two glands. The immunohistochemical examination of the lactating mammary gland showed strong expression of CK5/6 in both glands. On the other hand, the two glands showed different reactions to CK8/18, Estrogen Receptors and Progesterone Receptors (PR).

Key words: She-camel mammary gland, Histology, CK5/6, CK8/18, Estrogen Receptor (ER), Progesterone Receptor (PR)

INTRODUCTION

Camels are long been domesticated mammals known to tolerate the extremely dry and hot climate of the desert. So, they can survive, reproduce and produce meat and milk in areas where other species do not thrive and perhaps don't survive (Yagil and Etzion 1980; Wernery 2006). To perform these functions, camels had series of physiological and anatomical adaptations that allow them to withstand low water consumption that would kill most other mammals (Roberts and Michael 1986; Rizk et al. 2017). Throughout this long period of domestication, camel milk was an important source of nutrients for desert people. It is even sometimes considered a meal itself; the nomads can only live on camel milk for a month (Davidson 2006).

Nickerson (1992) and Eisa (2006) mentioned that the mammary gland of female camels consists of left and right halves separated from each other by the median suspensory ligaments. A visible groove can be seen grossly between the two halves (Eisa 2006). Each half is divided by invisible separation into two quarters (Smuts and Bezuidenhout 1987; Wernery 2006) forming four quarters; two front and two rear quarters. Each quarter has its own teat (Kausar et al. 2001; Eisa 2006).

Multiple literatures stated that the teat of the camel had more than one orifice and streak canal. Schwartz and Dioli (1992) and Alluwaimi et al. (2017) reported that the camel teat possesses 2-3 cisterns. Zayeed et al. (1991) stated that sometimes the rear quarter might have three separate mammary glands. While Kausar et al. (2001) found that the teat of the camel had two streak canals. Rizk et al. (2017) confirmed that each teat of the she-camel mammary gland is opened dorsally by two orifices: cranial and caudal. Each orifice was leading to a separate distinct gland, and the fluid produced from the two glands was different in its density.

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The mammary gland of the dromedaries she-camel is composed of connective stroma and glandular parenchyma. The glandular parenchyma of the dromedaries she-camel mammary gland showed an arrangement of lobules in between the interlobular connective tissue. Each lobule presents a group of small unequal size secretory units' "alveoli" (Kausar et al. 2001). The number and size of alveoli per lobule were decreased, and the parenchymatous tissue was reduced and replaced by interstitial connective tissue during the non-lactating phase (Nosier 1974; Kausar et al. 2001). The ultrastructure of the secretory alveoli epithelium of the one-humped she-camel during lactation represented four different types of cells (El-Habback 2007).

Immunohistochemical methods have been used to study the cellular expression and distribution of Cytokeratin's (CKs) in mammary gland different cells. Cytokeratins are sets of polypeptides, comprise the main type of intermediate filaments in epithelial cells (Mackinder et al. 2012). The intermediate filaments form a cytoplasmic network between the cells, interact with other components of the cytoskeleton, and regulate cell growth and size by regulating protein localization and synthesis (José et al. 2014). Abundant literature studied the localization of several CKs within the mammary gland in humans and different animals. Among these, both CK5 and CK6 are found to be localized in myoepithelial cells and basal epithelial (Alejandro and Hector 2020), while CK8 and Ck18 expressions were localized in luminal epithelial cells (Mervi et al. 2005; Asuka et al. 2018). CKs expression differs according to different stages of development and increases in cells subjected to mechanical stress (José et al. 2014). It was also noted that the localization of CKs was more intense in lactating than non-lactating mammary glands (Salem et al. 2012; Amr et al. 2013; Senthilkumar et al. 2019).

Further, one of the essential factors affecting mammary epithelial proliferation and differentiation are ovarian steroid hormones; estrogen, and progesterone (Cowie et al. 1980; Daniel and Silberstein 1987). Estrogen stimulates the development of mammary ducts, and a combination of progesterone and estrogen stimulates the development of alveolar tissues. The action of these hormones is mediated via their specific intracellular receptors; Estrogen receptor (ER) and Progesterone receptors (PR). The localization of the ER and PR in the mammary gland during the different stages of development varies between the different species (Schams et al. 2003; Colitti and Parillo 2013; Ellen et al. 2017). However, a descriptive study for their localization in camel mammary glands is not available, but in all species, the proliferating cells are expected to contain these receptors (Punyadeera et al. 2008; Abdel-Hamid and Amal 2018).

There was a paucity in previous literature concerned with the illustration of the morphological and immunohistochemical differences between the cranial and caudal glands for the same quarter of the she camel mammary gland. So, the present research aimed to investigate the differences of structure and localization of immunohistochemical receptors between the cranial and caudal gland of the same lactating mammary gland quarter of the one- humped she-camel through anatomical, histological, ultrastructure and immunohistochemical studies.

MATERIALS AND METHODS

Sample Collection

The whole udder of 9 Healthy one-humped she-camels (*Camelus dromedaries*) was completely dissected of the fresh carcasses just after slaughtering. The study was performed according to the ethics of the Institutional Animal Care and Use Committee (IACUC) at Faculty of Veterinary Medicine, Cairo University. The samples had been selected from apparently healthy dromedary she-camels, without any signs of illness. The examined mammary glands were collected from 6 mature she-camels on mid of lactation, and 3 on end of lactation, elderly 5-7 years. They were labeled for their age and stage of lactation at the time of slaughtering, then the samples were divided according to a type of examination.

Gross Examination

The exterior anatomy of the freshly selected whole mammary glands was studied grossly just after slaughtering.

Histological Examination

Light Microscope Examination

Small pieces (5mm in thickness) were taken from the teat, teat cistern and glandular parenchyma of each separate gland of each mammary gland quarter. These tissue specimens were immediately fixed in 10% neutral buffered formalin for 24 hours. Then dehydrated in ascending grades of alcohol, cleared in xylene, and embedded in paraffin wax overnight. The 4-5µm paraffin sections were obtained by a rotatory microtome and stained with the following stains for light microscopic examination:

1. Harris hematoxylin and eosin for general histological examination.
2. Reticulin stain for an exhibition of reticular fibers.
3. Masson`s Trichrome stain for collagenous fibers.

These methods were conducted according to Bancroft and Gamble (2013).

Transmission Electron Microscope Examination

Small pieces from the mammary gland were fixed in 3% glutaraldehyde. Then examined with a JEOL 1010 transmission electron microscope at the Regional Center for Mycology and Biotechnology (RCMB), Al-Azhar University.

Immunohistochemical Evaluation

The sections were processed according to the manufacturer's directions (Ultra view Universal Dab Detection Kit). Briefly, slides were prepared on a positively charged slide then baked 1 hour at 60°C oven. The slides are then loaded onto the Benchmark GX. The automated Benchmark system puts the slides through a series of de-paraffinization and antigen retrieval steps. The antibodies (Table 1) were pre-diluted and incubated for 16 mins at 37ºC. The counterstain and post-counter stain comprise Hematoxylin for 4 mins and Post Counterstain by Bluing reagent for 4 mins.

	Cytokeratin (D5/16B4)	5/6 Cytokeratin 8/18 (B22.1/B23.1)	ER (SP1)	PR (1E2)
Isotypes	IgG1	IgG1	IgG	IgG
Clone Name	D5/16B4	B22.1 and B23.1	SP1	1E2
Species	Mouse	Mouse	Rabbit	Rabbit
Catalogue No.	790-4554.	760-4344	790-4325	790-2223

Evaluation of Immunohistochemical Observations (Area percent)

Immunohistochemically stained sections were examined using Leica Quin 500 analyzer computer system (Leica Microsystems, Switzerland) in the Faculty of Dentistry, Cairo University. The image analyzer was calibrated automatically to convert the measurement units (pixels) produced by the image analyzer program into actual micrometer units. Immunohistochemical reactions were measured as area percent in a standard measuring frame in 5 fields from different slides in each group using magnification (X400) by light microscopy transferred to the monitor's screen. The areas showing the positive immunohistochemical reaction were chosen for evaluation, regardless of the intensity of the staining. These areas were masked by a blue binary color to be measured by the computer system**.** Mean value and standard deviation (SD) were obtained for each specimen and statistically analyzed.

Statistical Analysis

The results were expressed as mean±SD. Data were analyzed using Paired Samples T-Test. P-value<0.05 was considered statistically significant**.**

RESULTS

Gross Examination

The gross examination of the camel mammary gland showed that this is composed of four quarters, each quarter ended by one teat. Each teat is opened externally by two separate orifices: cranial orifice, and caudal orifice (Fig. 1A). Each orifice leads to a separate streak canal (Fig. 1B) and separate cistern (Fig. 1C). Each gland cistern collected the milk from large lactiferous ducts (Fig. 1C) which split up to lobar ducts, those ducts were deemed the primary excretory passage of the mammary gland lobes. Lobar ducts radiated again to smaller lobular ducts then to intralobular ducts.

Histological Examination

Light Microscopic Observations

The histological examination of the two gland cisterns pointed out that the cranial gland cistern was significantly wider than the caudal one (Fig. 2A). The two teat canals showed that the lining epithelium of the caudal canal was thicker than the cranial one at the same level. In contrast, the submucosa of the cranial canal was thicker than the caudal one (Fig. 2B and 2C).

The camel mammary gland is attached to the body wall by median and lateral suspensory ligaments. Both median and lateral suspensory ligaments from a fibro elastic connective tissue capsule (Fig. 3A). The capsule sends connective tissue septa into the glandular tissue of the mammary gland forming interlobar and interlobular connective tissue divided the parenchyma into lobes and lobules. The interlobular connective tissue of the cranial gland is thinner and highly vascularized than in the caudal gland that had thick and less vascularized interlobular connective tissue (Fig. 3B and 3C).

The glandular tissue stained by reticulin stain showed the presence of few reticular black fibers in the interlobular connective tissue of the cranial gland (Fig. 3D). In contrast, the reticular fibers were abundant in the interlobular C.T. and intralobular C.T. around the secretory units in the caudal gland (Fig. 3E).

By using Masson trichrome stain (MT), the cranial gland tissue showed few collagen fibers in both interlobular and intralobular C.T. when compared to the caudal gland of the same quarter and the same animal (Fig. 3F and 3G).

The parenchyma of the cranial gland composed of the secretory alveoli that filled with alveolar secretion had few interstitial connective tissues between the alveoli and lined by stretched and flattened alveolar epithelium (Fig. 4A). While the secretory alveoli in the caudal gland was smaller in size, less extended by the alveolar secretion, had abundant interstitial connective tissue between the secretory alveoli, and were lined by cuboidal alveolar epithelium (Fig. 4B).

At the end of lactation, the number and size of alveoli per lobule were decreased. As well, the parenchymatous tissue was reduced and replaced by connective tissue and clusters of adipocytes. This process appeared faster in the caudal gland (Fig. 4D) than the cranial gland of the same quarter (Fig. 4C).

Transmission Electron Microscopic Observations

The ultrastructure examination revealed that the cranial gland lined by columnar secretory cells had rounded to oval nuclei that appeared more heterochromatic than that of the caudal gland. Some of the nuclei showed pronounced indentation. The cytoplasm had mitochondria and many secretory vesicles toward the apex. The secretory vesicles joined the apical membrane and evacuated their contents into the alveolar lumen (Fig. 5A).

However, the caudal gland lined by low cuboidal secretory cells had round and less heterochromatic nuclei. The cytoplasm contained rough endoplasmic reticulum (rER) and few secretory vesicles compared to the secretory cells of the cranial gland. The apical part of the cell membrane had short microvilli (Fig. 5B). Secretory cells were surrounded by myoepithelial cells (Fig. 5C).

Immunohistochemical Examination

a- Ck5/6 Marker Expression at the Cranial and Caudal Glands of the Lactating Mammary Gland

The basal part of the alveolar epithelium and basal interlobular ducts epithelium in both cranial and caudal glands expressed a strong positive reaction to CK5/6 and was not expressed in the vascular epithelium or stromal cells in both glands (Figs. 6A-D).

b- Ck8/18 Marker Expression at the Cranial and Caudal Glands of the Lactating Mammary Gland

In the cranial gland, positive expression of CK8/18 was revealed in the luminal part of the alveolar epithelium (Fig. 6E) and the interlobular lactating ducts (Fig. 6F) while vascular epithelium and interstitial C.T. showed a negative reaction. On the other hand, in the caudal gland, the luminal part of the alveolar epithelium showed a very weak reaction to CK8/18 (Fig. 6G), and its expression was not detected in the epithelium of the interlobular ducts and vascular epithelium (Fig. 6H).

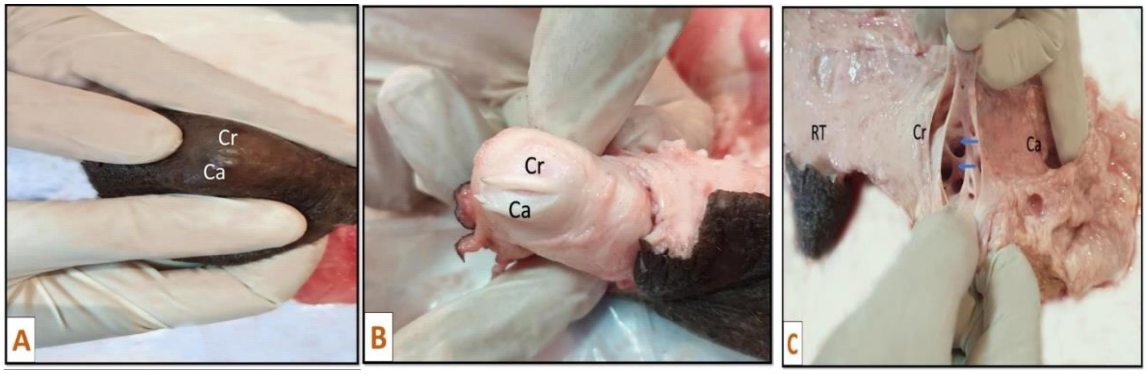

Fig. 1: (A:C) Photograph showing the cranial and caudal duct system of each mammary gland quarter of one humped She camel. A: showing two separate teat orifices; cranial (Cr) and caudal (Ca). B: Two separate streak canal. C: Right teat (Rt) showing two separate gland cisternae and the large lactiferous ducts (arrows) of the cranial cistern.

Fig. 2: (A: C) Photomicrograph showing the cranial and caudal teat cisternae and canals at the same level of lactating mammary gland teat. A: The cranial gland (Cr) cistern was significantly wider than the caudal one (Ca). 5X. B: Cranial teat canal showing thicker submucosa (line) compared to caudal teat canal. X50 and lined with thin epithelial layer (arrow) as shown in cube with higher magnification. X400. C: Caudal teat canal showing thin submucosa (line). X50, and thick lining epithelium (arrow) as shown in cube with higher magnification. X400. H & E stain.

c- Estrogen and Progesterone Receptors Marker Expression at the Cranial and Caudal Glands of the Lactating Mammary Gland

In the cranial gland, both Estrogen Receptors (ER) and Progesterone Receptors (PR) immunoreactivity showed moderate cytoplasmic localization in the alveolar epithelial cells and interlobular ducts epithelium and little expression in the stromal cells (Figs. 7A, 7B, 7E and 7F). Positive reaction to PR was observed in some nuclei of the alveolar and ductal epithelium cells.

While the caudal gland showed weak localization of the ER and PR in the alveolar epithelium and very low abundance in stromal cells (Figs. 7C and G) with negative immunoreaction in interlobular ducts epithelium (Figs. 7D and H). Scattered staining of PR was observed in the nuclei of the ductal epithelium.

DISCUSSION

The gross examination of the camel mammary gland revealed that this is composed of four teats. Each teat ended by two separate orifices: cranial and caudal. Each orifice leads to a separate streak canal and separate gland cistern. The examination of the two gland cisterns pointed out that the cranial gland cistern was significantly wider than the caudal one. These findings were agreed with the results of Rizk et al. (2017). On the other hand, Kausar et al. (2001) stated that the teat of the camel had two streak canals and the luminal width of both streak canals was wider in lactating than non-lactating groups. These findings disagreed with the results of Schwartz and Dioli (1992) who reported that the camel teat possesses 2-3 cisterns.

The two separate orifices of the camel mammary gland are contrary to cow, sheep, and goat teats that are connected to the exterior by a unique orifice (Schwartz and Dioli 1992; Ruberte et al. 1994). On the other hand, pigs have two openings per teat. So, each teat possesses two glands and each of them sends out one projection and comes out of one lactiferous sinus (Hurley 2021). In humans, there are 10-20 openings per gland (Zucca-Matthes et al. 2016). But there is no evidence of a difference between the glands of each teat, in contrary to the results found in the camel mammary gland in the present study.

This study revealed the difference in the epithelium thickness and composition of the cranial and caudal teat canals. These results were like that found by Rizk et al. (2017) on the two-milk system of the camel mammary gland.

The histological and histochemical examination of the cranial gland and caudal gland connective tissue stroma revealed that the caudal gland contained a higher amount of interstitial connective tissue than the cranial gland. Contrarily, the alveoli of the cranial gland were larger in size, more active, and more filled with secretion than the caudal gland alveoli. These findings correlated to the results of Rizk et al. (2017). As well, these results were discussed by Nosier (1974); Kausar et al. (2001); Ellen et al. (2017) and Al-Bazii et al. (2019) in non-lactating camel

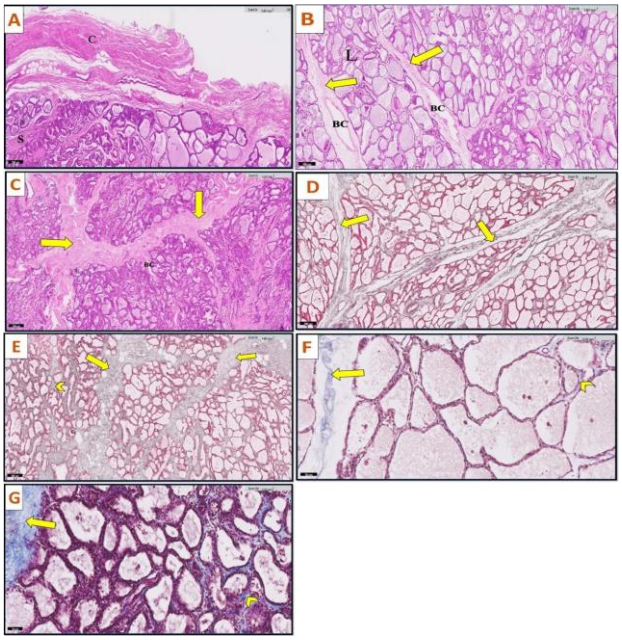

Fig. 3: (A: G) Photomicrograph of the cranial and caudal gland stroma of the same quarter of lactating mammary gland. A: Mammary gland surrounded by fibroelastic C.T. capsule (C) sending C.T. septae (S). H & E X50. B: Cranial gland had thin and well vascularized interlobular C.T (arrow) between the lobules (L). H & E X50. C: Caudal gland had thick and less vascularized interlobular C.T (arrow). H & E X50. D: Cranial gland showed few reticular fibers in the interlobular C.T. (arrow). Reticulin stain X50. E: Caudal gland showed abundant reticular fibers in the interlobular (arrow) and intralobular C.T. (chevron). Reticulin stain X50. F: Cranial gland showed few collagen fibers in the interlobular (arrow) and intralobular C.T. (chevron). MT stain X200. G: Caudal gland showed abundant collagen fibers in the interlobular (arrow) and intralobular C.T. (chevron). MT stain X200.

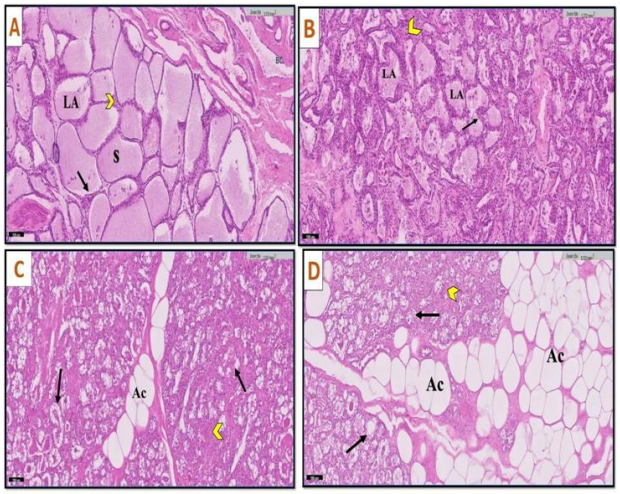

Fig. 4: (A: D) Photomicrograph of the cranial and caudal gland parenchyma of the same quarter of mammary gland during lactation and end of lactation. A: Cranial gland of lactating mammary gland contained lactating alveoli (LA) filled with secretion (S), lined by flat epithelial cells (arrow) and had few interstitial C.T. (chevron). H & E X200. B: Caudal gland of lactating mammary gland contained lactating alveoli (LA) less filled with secretion (S), lined by cuboidal epithelial cells (arrow) and had abundant interstitial C.T. (chevron). H & E X200. C: Cranial gland at end of lactation composed of reduced number of alveoli (arrow) that replaced by interstitial C.T. (chevron) and some adipocytes (Ac). H & E X100. D: Caudal gland at end of lactation composed of reduced number of alveoli (arrow) that replaced by interstitial C.T. (chevron) and numerous numbers of adipocytes. (Ac). H and E X100.

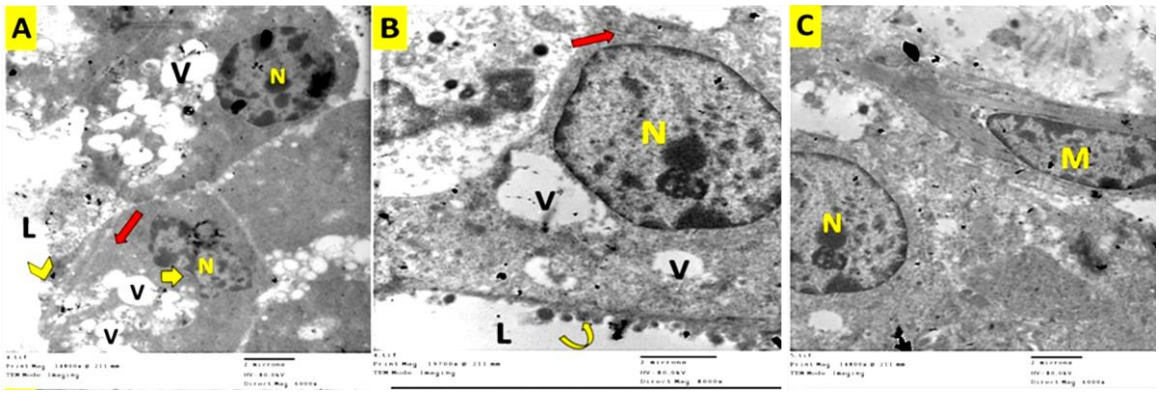

Fig. 5: (A:C) Electron micrograph showing the ultrastructure of the secretory cells of the cranial and caudal gland of lactating mammary gland. A: Cranial gland lined by columnar secretory cells had round to oval heterochromatic nuclei (N) with indentation (yellow arrow), Mitochondria (red arrow) and many secretory vesicles (V). Secretory vesicles joined the apical part of cell membrane (chevron) evacuated their secretion into lumen (L). B: Caudal gland lined by low cuboidal secretory cells had round and less heterochromatic nucleus (N), the cytoplasm had few secretory vesicles (V) and rER (red arrow). The microvilli of apical cell membrane were observed (curved arrow). C: Secretory cells were surrounded by myoepithelial cells (M).

mammary gland who reported that the number and size of alveoli per lobule were decreased, and the parenchymatous tissue was reduced and replaced by interstitial connective tissue during a non-lactating phase. This revealed less activity of the caudal gland when compared to the cranial one of the same quarter and the same level of lactation.

Moreover, Blanchette-Mackie et al. (1995) Margaret et al. (1998) and Al-Bazii et al. (2019) reported that at end of lactation, the stromal adipocytes refill with fat and can be clearly seen among the milk-filled alveoli. This process in the recent study appeared faster in the caudal gland than the cranial gland of the same quarter, which may indicate that the caudal gland enters the dry phase faster than the cranial gland.

Secretory cells of type I and II in the alveolar epithelial cells are characterized by their cuboidal structure, numerous free ribosomes, Golgi apparatus, and small mitochondria, with few numbers of secretory vesicles, that

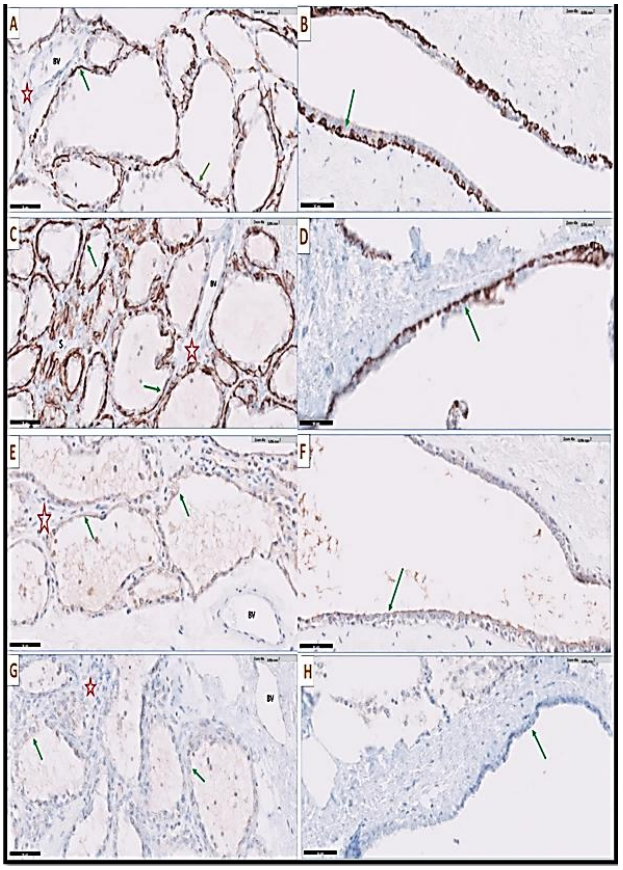

Fig. 6: Photomicrograph showing the expression of CK5,6 (A:D) and CK8,18 (E:H) markers at the cranial and caudal gland of lactating mammary gland.X400. A: Strong CK5,6 expression at the glandular tissue (arrow) and B: interlobular lactating duct (arrow)of the cranial gland. Negative immunoexpression in both interstitial C.T. (star) and blood vessels (BV) C: CK5,6 expression at the glandular tissue and D: interlobular lactating duct of the caudal gland. Negative immunoexpression in both interstitial C.T. (star) and blood vessels (BV). E: Positive CK8,18 expression at the glandular tissue (arrow) and F: interlobular lactating duct (arrow) of the cranial gland. G: Weak CK8,18 expression at the glandular tissue (arrow) and H: interlobular lactating duct (arrow) of the caudal gland. Negative immunoexpression in both interstitial C.T. (star) and blood vessels (BV).

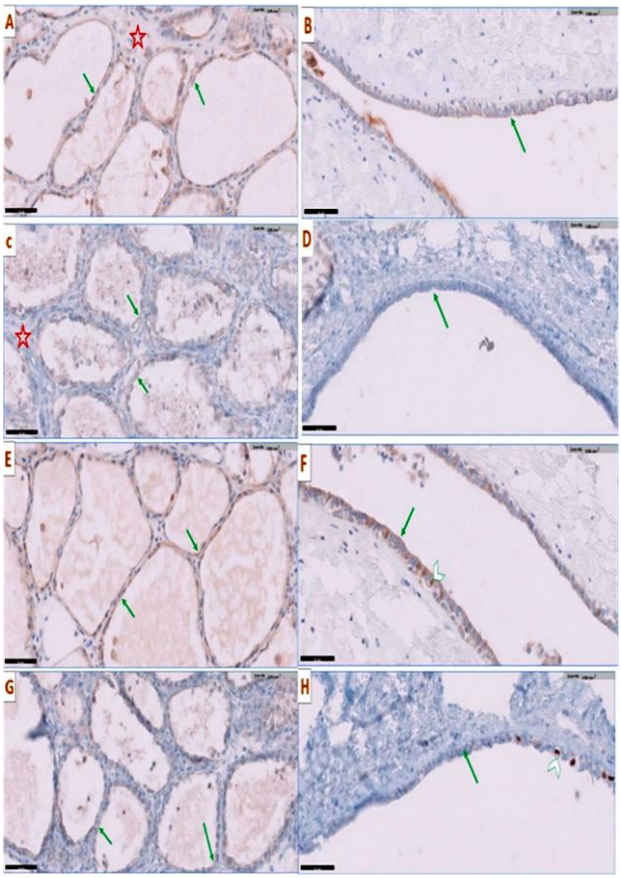

Fig. 7: Photomicrograph showing the expression of Estrogen receptors (ER) (A: D) and Progesterone Receptor (PR)(E:H) markers at the cranial and caudal gland of lactating mammary gland. X400. A: Positive ER expression at the glandular tissue and B: at the interlobular lactating duct of the cranial gland. C: Weak ER expression at the glandular tissue and D: negative at the interlobular lactating duct of the caudal gland. Negative immunoexpression in interstitial C.T. (star) E: Positive PR expression at the glandular tissue and F: at the interlobular lactating duct of the cranial gland. G: Weak PR expression at the glandular tissue and H: negative at the interlobular lactating duct of the caudal gland.

was correlated to El-Habback (2007). On the other hand, the findings in the present study indicated that cranial gland alveolar epithelium was much similar to the Type III and IV cells description in El-Habback (2007) study. Where the nuclei were round to oval with pronounced indentation, the cytoplasm filled with electron-lucent secretory vesicles more than the other cell types. This was also revealed by Rizk et al. (2017) in the she-camel mammary gland who mentioned that the alveoli of the cranial system contained more secretions than the caudal system.

Further, the variation of the height of the epithelial cells in the recent study was in relation with the findings of Nosier (1974) and Kausar et al. (2001) that the epithelial lining of the dromedary lactating alveoli varied from flattened to columnar epithelium according to the stage of lactation and secretory activity of the gland. In contrast, Rizk et al. (2017) found that the lining of the alveoli was of simple columnar epithelium in both cranial and caudal milk systems of the lactating she-camel mammary gland.

The immuno-histochemical examination of the lactating mammary gland showed strong expression of CK5/6 in the basal side of alveolar and ductal epithelium, and myo-epithelial cells of cranial and caudal glands. While it was not expressed in the vascular epithelium or stromal cells in both glands. These were in agreement with the results found by Amr et al. (2013) in lactating dromedary mammary gland. On the other hand, the glands showed different reactions to CK8/18 markers. In the cranial gland, the luminal part of the alveolar epithelium and the ducts showed strong expression and weak expression on the vascular epithelium and stromal cells. This partially disagrees with a previous study by Salem et al. (2012) that restricts the expression of CD8+ in the alveolar tissue of lactating camel mammary glands parenchyma to the alveoli, not stromal cells. The caudal gland showed a weak reaction in the alveolar epithelium, and its expression was not detected in the interlobular ducts and vascular epithelium. This can be illustrated by the results of Amr et al. (2013) that the immuno-stained sections of non-lactating dromedary mammary glands

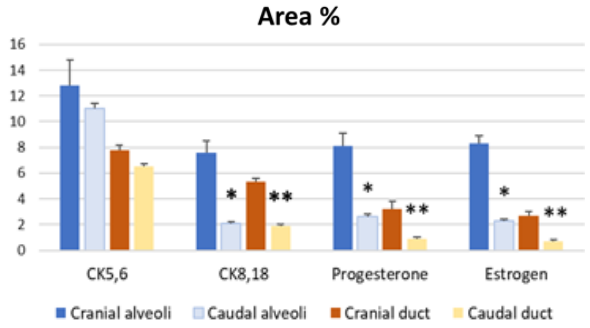

Fig. 8: Bar graph showing CK (5/6), CK (8/18), PR and ER area % and immunoreactive cells within the mammary gland cranial and caudal glands. Data are presented as mean±SE. *indicates significant difference from the cranial alveoli at P≤0.05. ** indicates significant difference from cranial duct at P≤ 0.05

showed less intense reaction to CKs than lactating tissue. This reactivity variation may relate to temporary phenotypic change corresponding with the gland activity (Silberstein et al. 1992; Deugnier et al. 1995; Amr et al. 2013).

In the cranial gland, immuno-localization of estrogen and progesterone receptors was stronger than the caudal gland in the alveolar epithelium and stromal cell cytoplasm. Besides, the interlobular lactating ducts showed moderate immuno-reaction in the cranial gland, with negative immuno-reaction in the caudal gland. The immuno-localization of ER and PR in the-cytoplasm of the epithelium and stromal cell supported by the findings of Schams et al. (2003) and Colitti and Parillo (2013), they found that in cow and ewe mammary gland during lactogenesis, the localization of ER and PR in epithelial and stromal cells were more intensive in the cytoplasm than the nucleus. Similar results were revealed by Abdel-Hamid and Amal (2018) in the dromedary camel endometrium, where the ER localization shifted to the cytoplasm during late pregnancy.

Further, it is well established that the normal development and function of the mammary gland is depending on the ovarian hormones; estrogen and progesterone (Cowie et al. 1980; Neville et al. 2002). Additionally, the actions of estrogen and progesterone are mediated via their hormone receptors (Connor et al. 2007), and their immuno-localization suggesting an involvement of these receptors in mammary gland development (Schams et al. 2003). The ER and PR expression during lactation differs across animal species, Colitti and Parillo (2013) reported expression for both ER and PR during lactation in the ovine mammary gland. As well, the PR showed higher expression than ER in the bovine mammary gland during lactogenesis (Schams et al. 2003; Connor et al. 2005). However, there is a lack of information on ER and PR expression in the camel mammary gland, but yet in our present study, the stronger reaction of the cranial gland to ER and PR than the caudal gland of the same mammary gland quarter supports the view of the less activity and less proliferation of the caudal gland.

Conclusion

The examination conducted in the recent study revealed the presence of two lactating glands in eachquarter of lactating mammary gland of one humped she camel (cranial and caudal gland). The caudal gland is significantly less active than the cranial gland.

Authors Contribution

El- Bargeesy G.A. and Khalifa E.F. set up the experiment design. Ola R.H. and Yasmine H. Ahmed carried out the scientific experiments. El-Saba A.A and Khalifa E.F. were involved in the analysis of the data and scientific discussions. Yasmine H. Ahmed and El-Bargeesy G.A. reviewed and edited the manuscript. All authors read and approved the final manuscript.

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