Morphological Examination of the Accessory Sex Glands of the Barki Goat (*Capra hircus*)

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ABSTRACT

Introduction: The goal of the present investigation is to describe the accessory sex glands of the Barki goat, grossly, by using the histological technique. The Barki goat have four sex glands: ampullary, vesicular, prostate, and bulbourethral. The ampullary gland is an enlargement of the terminal part of the ductus deferens; its glandular part has branched tubuloalveolar glands, and its secretory alveoli are lined with a pseudostratified epithelium composed of cuboidal to columnar cells. The vesicular gland takes the appearance of a cluster of grapes, and the left vesicular gland is enlarged and higher than the right one. It presents as a lobulated tubulo-alveolar gland with wide intralobular space, which contains a secretory unit that is lined with pseudo-stratified columnar epithelium, while the interlobular ductules are lined with the stratified epithelium, and the interlobular duct is lined with simple cuboidal epithelium; moreover, the epithelium lining of the secretory part consists of tall columnar cells. The prostate gland consists of the disseminated part (pars disseminate), and it is enclosed by a connective tissue capsule, which is thin dorsally, thick laterally, and reduced in thickness ventrally. The prostatic acini are lined with simple cuboidal epithelium. The bulbourethral gland is similar in size to a walnut and is surrounded by a capsule; there are interlobular connective tissue septa that divide the gland into lobes and lobules of different sizes. The bulbourethral gland contains secretory units that are lined with mucous, tall columnar epithelium with basally located nuclei, and whose eosinophilic cytoplasm contain granular secretion.

Keywords: Ampullary gland; Vesicular gland; Prostate gland; Bulbourethral gland; Goat

Introduction

The ruminant anatomy was generally concentrated on the bovine, particularly the ox, with limited comparative points to small ruminants, especially the goat. The goat belongs to the subfamily *Caprinae*, which is part of the *Bovidae* family, in the sub-order *Ruminantia* of the order *Artiodactyla*. In Egypt, the goat is considered as an important source of meat, milk, and hair. The male goat is a very familiar animal in the Egyptian farms. There are about 7 to 10 goat breeds in Egypt, such as *Zaraibi*, *Barki* (*Sahrawi*), *Wahati*, *Sharkawi*, and *Black Sinai*.¹ The three major breeds in Egypt are *Ossimi*, *Rahmani*, and *Barki*, which are characterized by a fat tail, a fleece of coarse wool, and their small-to-medium size.¹

There goats have four accessory sex glands; prostate, seminal vesicle, bulbourethral gland, and ampullary gland, as reported by,²⁻⁹ while Pérez *et al*¹⁰ reported that the pampas deer carry only three accessory sex glands: prostate, vesicular, and the ampullary gland. The lesser anteater also carries

only three accessory sex glands: prostate, seminal vesicle, and bulbourethral glands, as noted by Rossi *et al*.¹¹

The purpose of the present work is to describe the anatomical position and appearance of the accessory sex glands of the *Barki* (*Sahrawi*) male goat as well as the microscopic structure of these glands as there is a little available information published about this topic. Then, we conducted a comparison between the obtained data and the previously published anatomical data about the accessory sex glands. The study of the accessory sex gland of the male goat is very important due to its significant role in the fertility rate.

Materials and Methods

Animals

The present work was performed on 8 apparently healthy *Barki* male goats, whose weight was 25 to 30 kg and that were between 1 and 2 years old. The *Barki* male goats were collected from the goat farms in from the government of Matrouh and

transported to the anatomical laboratory in the anatomy and embryology department of the Faculty of Veterinary Medicine at Alexandria University. The collected goats were treated according to the rules of the committee on Animal Welfare and Ethics of the Faculty of Veterinary Science of Alexandria University and according to the Egyptian laws.

Gross Anatomy

Four Barki male bucks were used in the gross morphological descriptions after their sedation with intramuscular (I/M) injection of 2% xylazine hydrochloride (Hcl) (0.2 mg/kg of body weight) and atropine (0.04 mg/kg). Then, these goats were anaesthetized by intravenous (I/V) injection of ketamine (5 mg/kg). After that, the goats were injected with heparin (1,000 IU) to obtain bleeding and prevent blood coagulation. Then, the goats sacrificed by bleeding through the common carotid artery received an injection of 10% formalin, after which they were stored for 2 weeks in formalin 10%. The cadavers received injections in several sites of the body and on the pelvic cavity using the ordinary preservation solution (10% formalin, 2% phenol, and 1% glycerin). The nomenclature used in this work is in accordance with the Nomina Anatomica Veterinaria.¹²

Computed Tomography (CT) Scans

Two goats were used for carrying the CT scans after the normal physical examination and were anaesthetized by using the combination of ketamine hydrate (0.5–2 mg/kg of body weight) and 2% xylazine Hcl (1–3 mg/Kg of body weight). The cadavers were immediately taken to the CT center and fixed in the sternal recumbency position and, then, serially sectioned using the CT-W450–10A Hitachi CT scanner (Hitachi, Chiyoda, Tokyo, Japan) and this CT machine called Asteion Super 4 Multi-slice 4 CT apparatus (Toshiba, Minato, Tokyo, Japan) at 120 KV and ~ 200 MA Q11, the windows width and level (W/L) : 2,000/250Q12) to examine the accessory male sex reproductive glands. The thickness of the sections was 0.5 cm in the interval between the cross section from the level of the last lumbar to the 4th caudal vertebrae. The CT images helped in the identification of the structures that were located between the levels of the 5th lumbar and the 4th caudal vertebrae.

In order to obtain bone window images with good resolution, the CT machine was set to a window width of 200 Hounsfield and a window level of 1,600 Hounsfield units. However, in the soft tissue, we set

the apparatus to a windows width of 30 Hounsfield units, and a window level of 290 Hounsfield units.

A 3rd generation single-slice CT scanner (Asteion Super 4 Multi-slice 4 CT apparatus [Toshiba]) was used for all procedures. The helical scan mode was used with the following parameters: 120 kVp, 130 mA, 1.0 second scan time, slice thickness of 5 mm, and 5-mm table advancement. The standard acquisition preset of a 25-cm field of view, matrix of 512 512 pixels, bone reconstruction algorithm, and WWQ of 300 and WL of 1,000 were used. The raw dataset was retro-reconstructed to a slice thickness of 0.3 mm. To obtain better reconstruction images, the overlapping technique, with slice thickness of 5 mm and 3-mm table advancement, pitch of 0.6 Q15, (X-ray beam in overlapping) was also used. Images were visualized using the picture archiving and communication system (PACS) software OsiriX DICOM Viewer (Pixmeo SARL, Bernex, Geneva, Switzerland), for transverse scanning, multiplanar reformatting (MPR), and 3D rendering reconstruction.

Histological Observations

Two male goats were used for histological examinations. The accessory sex glands were removed from the freshly slaughtered male goats and then put on 10% normal buffer formalin solution, after which they were transported to the histological laboratory for the histological preparation of the slides (cutting and staining) to allow the examination of the specimen under the light microscope to know the characteristic points of each gland. Then, the samples were put in a 70% alcohol solution. After that, the samples were put in ascending grades of ethanol for dehydration, after which they were cleared by being immersed in xylene and embedded in paraffin wax. Samples sections of 5 µm were cut by Leica rotatory microtome and mounted on glass slides. Finally, the paraffin sections were used for ordinary staining (H&E). The histological techniques were carried according to Bancroft's Theory and Practice of Histological Techniques.¹³

Results

In all examined goats, we found four accessory sex glands (*Glandulae genitales accessoriae*); the paired ampulla of the ductus deferens (ampullary gland), the paired vesicular gland (*Glandula vesicularis*), the prostate (*glandula prostatica*), and the paired bulbourethral gland (*Glandula bulbourethralis*). All accessory sex glands were located along the pelvic urethra, and their ducts opened and emptied their

secretion into the urethra.

Ampulla Ductus Deferens (Ampullary Gland)

The ampullary gland (Fig. 1A\LA and RA; 1B/ R.dd; 6A/4) is a glandular enlargement of the terminal part of the ductus deferens. The length of the ampullary gland reaches 3.5 ± 0.4 cm and the width reaches 0.5 ± 0.12 cm. The ampullary glands were directed ventrocaudally on the dorsal surface of the urinary bladder and attached to each other by the genital fold (Fig. 1A\GF).

The histological observations of the gland (Fig. 2) showed that they appeared to consist of the tunica mucosa, tunica muscularis, lamina propria, and tunica adventitia as well as some blood vessels. The glandular part contains branched tubuloalveolar

glands. The secretory alveoli are lined with a pseudo-stratified epithelium composed of cuboidal to columnar cells with some basal cells.

The Vesicular Gland (*Glandula vesicularis*)

In all investigated goats, the paired vesicular gland (Fig. 1A\LV-RV; 1B/V; 6A/3) was located on the craniodorsal aspect of the neck of the urinary bladder (Vesica urinaria) and lateral to the ampullary glands. It can be easily identified by its appearance, which looks like a cluster of grapes, and it is also important to note that the left vesicular gland is enlarged and higher than the right one in the same goat.

The histological study clarifies that the vesicular gland (Fig. 3) is a lobulated tubuloalveolar gland with wide intralobular space or sinuses for storage

Figure 1. Morphological appearance of the position of the accessory sex reproductive glands of the buck: View (A) of the isolated genital organs with the accessory sex reproductive glands of the buck. Abbreviations: GF, genital fold; LA-RA, ampulla of ductus deferens; LB-RB- left and right bulbourethral gland; LD-RD, left and right ductus deferens; LU-RU, left and right ureter; LV- RV, left and right vesicular gland, P, prostate gland; U, urethra; UB, urinary bladder. View (B): represented the left side of the pelvic cavity showing the topography of the accessory sex reproductive glands of the buck: 1 - pararectal fossa, 2 - vesicogenital pouch, 3 - rectogenital pouch, 4 - pubovesical pouch, 5 - ampulla recti, 6 - muscle sphincter ani internus, 7 - muscle sphincter ani externus. Abbreviations: BL, bulbourethral gland; C, caudal vertebrae; IM, mesorectum; L, lumbar vertebrae; P, prostate gland; R, rectum; R.dd - right ampulla of ductus deferens; RU, right ureter; S, sacral vertebrae; UB, urinary bladder; U, urethra; V, vesicular gland.

Figure 2. Micrograph (views A and B) of the ampullary gland of the adult buck showing: Alveoli (As); Tunica muscularis (Ms); Tunica adventitia (Ad); Blood vessels (BVs); Pseudo-stratified epithelium (St); Basal cell (BC); Lamina propria (L). hematoxylin and eosin (H&E) x160.

Figure 3. A cross section micrograph of the vesicular gland of the mature buck showing: View (A) clarify; SU- Secretory units lined by pseudo stratified columnar epithelium, intralobular ducts lined by stratified epithelium (black arrow) and intralobular duct lined by simple cuboidal epithelium (red arrow) with intraluminal eosinophilic secretion (As). Hematoxylin and eosin (H&E) x160. View (B) clarify; the lining epithelium of secretory part consists of tall columnar cells (arrow), Apical blebs of granular end pieces (red head arrows) and detached blebs in lamina Q17 (blue head arrows), Small and spherical basal cells (black head arrows). H&E x400.

of large amount of secretions. The gland contains a secretory unit, which is lined with pseudostratified columnar epithelium, and the interlobular ductules are lined by the stratified epithelium, while the interlobular duct is lined with simple cuboidal epithelium with intraluminal eosinophilic secretion. The epithelium lining of the secretory part consists of tall columnar cells, apical blebs of granular end pieces and detached blebs in lamina, and small and spherical basal cells.

The Prostate Gland (*Glandula prostatica*) In all the examined goats, the single prostate gland (Fig. 1/P; 6B/16) was present close to the junction of the vesicular gland at the pelvic region. It is constituted only of the disseminated part (*pars disseminate*). The *pars disseminate* surrounds the pelvic urethra, which is covered by the male urethra.

According to the histological studies, the prostate gland (Fig. 4) is enclosed by a connective tissue capsule, which is thin dorsally, thick laterally, and reduced in thickness ventrally. The gland capsule is enveloped by a layer of skeletal muscle (urethralis muscle) that is surrounded by a layer of loose connective tissue extending from the capsule and descending into the parenchyma of the gland forming the interlobular connective tissue and dividing the gland into lobules. The glandular substance consists of numerous follicles that open into the elongated canal. The prostatic acini are lined by simple cuboidal epithelium.

The Bulbourethral Gland (*Glandula bulbourethralis*) or Cowper's Gland

In all the investigated goats, the paired

Figure 4. histological micrograph of the prostate gland (*pars disseminata*) from the mature buck: View (A): Lamina muscularis (LM), Prostatic acini (PA) Surrounded by fibrous capsule (C) and propria submucosa (PS) with smooth muscle bundles (black head arrows), Excretory ducts of the prostate gland (Ed). Hematoxylin and eosin (H&E) x160. View (B): Prostatic acini lined by simple cuboidal epithelium with glandular epithelium (GE). H&E x400.

bulbourethral gland (Fig. 1A/LB-RB; 1B/ BL; 6C/23), or Cowper gland, was similar in size to a walnut and located dorsal to the urethra on both sides, and cranial to the ischial arch. The paired bulbourethral gland is closely related to the bulb of the penis, and, in general, it appears to be covered mostly by the bulbospongiosus muscle. The right and left bulbourethral glands appear to be nearly equal in size and their shapes are also similar.

According to the histological observations, the bulbourethral gland (Fig. 5) was surrounded by a white fibrous capsule and there were interlobular connective tissue septa that divided the gland into lobes and lobules of different sizes. The gland contained secretory units that were lined by tall

Figure 5. Histological cross section micrograph of the bulbourethral gland of the mature buck: View (A): adventitia (Ar), capsule (C) and secretory unit (SU). Hematoxylin and eosin (H&E) x160. View (B): The lining epithelium of secretory unit is a tall simple columnar epithelium of mucous.

mucous columnar epithelium with basally located nuclei and eosinophilic cytoplasm that contained granular secretion.

Discussion

To our knowledge, there are four sex accessory glands in most mammalian species: the ampullary, the seminal vesicle, the prostate, and the bulbourethral gland, as reported in the present study. They are present in the Barki goat, horse,²⁻⁹ the bull,³⁻⁹ the spotted paca,⁴ the Brazilian gracile opossum (*Gracilinanus microtarsus*),⁵ the Arabian oryx,⁶ the elk (*Cervus canadensis*),⁷ and the red deer (*Cervus elaphus*).⁸ However, the presence of three accessory sex glands was reported by El-Hagri⁹ in the canine species (prostate, bulbourethral gland, and ampullary gland), canine (prostate, seminal vesicle, and ampullary gland),¹⁰ in the pampas deer (*Ozotoceros bezoarticus*) (prostate, vesicular, and ampullary gland),¹¹ and in the lesser anteater (prostate, seminal vesicle, and bulbourethral gland). Finally, there are only two accessory sex glands, the prostate and the vesicular gland, in the capybara.¹⁴ Furthermore, Budras et al and El-Hagri reported that the accessory sex glands were fully developed only in the bull.³⁻⁹

The present investigation reported that the ampullary gland is a glandular enlargement of the terminal part of the ductus deferens, which is a similar result to the one mentioned by.^{9,15-17} Furthermore, Frandson et al¹⁵ added that its size varies within the animal species; it is well developed in the stallion, bull, and ram, but it is absent in the boar; however, El-Hagri and Bacha et al mentioned that it is ill well developed in the boar but absent in the tomcat, and also do Nascimento Lima et al¹⁵ reported the absence

Figure 6. Computed tomography (CT) images of the male buck's pelvis; View (A) represents the transversal CT scan at the level of the pelvic urethra and surrounded by urethral masculina, a 3rd sacral vertebra. View (B) represents the Transversal CT scan at the finding that is similar to the one obtained by 9,10,30-32 while level of the 5th sacral vertebra. View (C) represents the transversal CT scan at the level of the 3rd caudal vertebra. 1 - 3rd sacral vertebra; 2 - Rectum; 3 - Vesicular gland; 4 - Ampulla of ductus deference; 5 - Neck of urinary bladder; 6 - Pubic symphysis; 7 - Iliopsoas muscle; 8 - Right ilium shaft; 9 - Superficial gluteal muscle; 10 - Testes; 11 - Right adductor muscle; 12 - External obturator muscle; 13 - 3rd caudal vertebra; 14 - Muscle sphincter ani internus and externus; 15 - Pelvic urethra; 16 - Prostate; 17 - Penis; 18 - Right sacrocaudalis dorsalis lateralis muscle; 19 - Right sacrocaudalis ventralis medialis and lateralis muscle; 20 - Anal canal; 21 - Right ischium; 22 - Ischiatic arch; 23 - Bulbourethral gland; 24 - 5th sacral vertebra; 25 - Head of femur; 26 - Greater trochanter of femur.

of this gland in *Gracilinus microtarsus*. The present histological observations of the ampullary gland were similar to those of Trautmann *et al* and Wrobel,^{19,20} that the gland consists of three layers: the tunica mucosa, tunica muscularis, and tunica adventitia.

In all the investigated goats, the paired vesicular gland was located on the craniodorsal aspect of the urinary bladder, and it could be easily identified due to its appearance, which looks like a cluster of grapes. It is also important to note that the left vesicular gland is enlarged and higher than the right one, which is a finding similar to the one obtained by El-Hagri, Archana *et al* and Gofur.^{9,21,22} The vesicular gland is the largest accessory sex gland in the bull^{3,9} and in the spotted paca.⁴ However, the vesicular gland was absent in the canines,⁹ *Gracilinus microtarsus*,⁵ and in some rodents.^{23,24} According to the current histological studies, the vesicular gland is a lobulated alveolar gland containing a secretory unit that is lined with pseudo-stratified columnar epithelium, and the interlobular ductules are lined with stratified epithelium, while the interlobular duct is lined with simple cuboidal epithelium, a finding similar to the one obtained by Archana, Gofur, and Menezes *et al*,^{22,25} while it was lined by simple cuboidal epithelium as reported in the spotted paca was 4 but, it was lined by a simple columnar epithelium as observed in; G. pig,²⁶ and rat²⁷ and giant rat.^{28,29}

Morphologically, the prostate gland may be single, as present in the our study and by 9,10,22,30–32 or paired, as noted by Junqueira *et al*.³³ In our work, we found that the single prostate gland has only the pars disseminate, which is found in the pelvic urethra and surrounded by urethral masculina, a finding that is similar to the one obtained by 9,10,22,30–32 while Pathak *et al*³⁴ reported that there is an additional part named the corpus prostate, which is present in some gaddi goats; in contrast, this corpus prostate has not been reported in small ruminants in any of the published anatomical text books that we examined.^{9,30,35}

There is some variation in the parts of the prostate gland among the animal species; the present study with^{9,10,30–32} noted the presence of only one part called the disseminate part, while Gofur²² mentioned that in the Black Bengal buck the single prostate gland has two parts: the compact (external) and the disseminate (internal) parts, but in the rat, Junqueira *et al*³³ noted that the paired prostate gland has a dorsal and ventral part; Neuhaus *et al*³⁶ noted that in the G. pig the prostate gland also has two portions: the large cranial lobe and the smaller caudal lobe. Moreover,³⁷ in the capybara noted that the prostate gland consists of three parts: intermediate, dorsal, and lateral lobes.

According to our histological studies, the prostate gland enclosed by connective tissue capsule which is thin dorsally, thick laterally and reduced in thickness ventrally. The capsule enveloped by a layer of skeletal muscle that surrounded by a layer of skeletal muscle, similar to that reported by.^{22,34} In the G. pig, the prostate enveloped by a fibrous muscular layer³⁸ while, in the spotted paca,⁴ this layer consists of smooth muscle fiber, similar to that observed in the prostate gland of the mouse.^{39,40} The present study noted that, the prostatic acini lined by simple cuboidal epithelium while, in the spotted paca,⁴ noted that it is simple columnar epithelium but pseudo-stratified in some regions.

Our study revealed that the paired bulbourethral gland is small in size, similar to hazelnut, and lies dorsal to the pelvic urethra and more obvious as the gland surrounded by white fibrous capsule, similar to the observations noted by.^{3,15,21,22} In the spotted paca, the bulbourethral gland presented at the terminal part of the rectum and dorsal to the urethra and caudal to the prostate gland.⁴ The bulbourethral gland is absent in the canine and present in the feline, as noted by El-Hagri and Bacha *et al*.^{9,18} The bulbourethral gland was surrounded by striated skeletal muscle, as noted by Borges *et al*, Gude *et al* and Hebel *et al*.^{4,28,29} Our work mentioned that the bulbourethral gland contains secretory units that are lined with tall mucous columnar epithelium of. The lining columnar epithelium also noted by.²⁹ The bulbourethral gland appears to be covered mostly by the bulbospongiosus muscle, and the gland itself is covered by a white fibrous capsule, similar to that noted by Budras *et al*.³

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