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Female reproductive tract anatomy of the endangered Arabian oryx *(Oryx leucoryx)* in Jordan

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Summary

Female reproductive anatomy of the Arabian oryx is unknown. In this study, reproductive tracts of seven female Arabian oryx (aged 2 to 7 years) were examined to characterize their reproductive anatomy. Observations and measurements were obtained in situ from dead animals during necropsy. Animals were allocated into two groups: cycling (n=3; follicles or corpora lutea present) and not-cycling (n=4; follicles or corpora lutea absent). Different reproductive tract segments for each animal in both groups were measured using a digital caliper. The mean, SD and range for each reproductive tract segment were generated and compared between groups. Female oryx reproductive anatomy share some anatomical characteristics with that of domestic ruminants except that the oryx uterus has no distinct uterine body and the cervix has two internal openings for each respective uterine horn. In addition, there were more than 8 rows of caruncles within each uterine horn. There were significant differences in the length and width ($P<0.05$), but not in height, of both the right and left ovaries between cycling and not-cycling animals ($P>0.05$). Posterior and anterior vaginal lengths varied between cycling and not-cycling groups ($P<0.05$). Length of right and left oviducts, left and right uterine horns, cervix and vulva did not vary between cycling and not-cycling groups ($P>0.05$). Defining this unique morphology of female Arabian oryx reproductive anatomy will help in the development of appropriate reproductive techniques in order to propagate this endangered species and control its reproduction.

Key words

Female reproductive system; ovary; vagina; morphometry; cycling animals; not-cycling animals.

Introduction

The Arabian oryx (*Oryx leucoryx*) is an antelope of the *Hippotraginae* subfamily of the *Bovidae* family (Wilson and Reeder, 2005). Historically, this species inhabited Jordan, Syria, Iraq, Israel, Sinai and the Arabian peninsula (Henderson, 1974). In Jordan, oryx occurred historically throughout the northern steppe grasslands and east-

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ern desert (the "badia"). They were hunted intensively after 1932 (Quemsiyeh *et al*., 1996) and some were killed by pesticides used to control locusts across the *badia* in 1950's (Hatough, 1988). The Arabian oryx became listed as endangered species by the International Union for Conservation of Nature in 1972 (IUCN, 2010). In 1978, the Royal Society for the Conservation of Nature (RSCN) promoted a reintroduction program in a fenced portion of the 342 km^2 Shaumari Nature Reserve in Eastern Jordan. The population has reached 200 animals by year 2000. However, the population has decreased within the past few years to an alarming number of 44 individuals due to many reasons. Some of the animals have been donated to neighbor countries while some other animals died due to flooding and predation by wolves, especially newborns. Inbreeding depression has also been considered by the reserve officials, however this hypothesis has to be further investigated and proved. The Shaumari Nature Reserve is a semi-arid desert with temperatures frequently above 42 ^oC in summer and down to -10 ^oC in winter. Rain falls only during winter and averaged 62.2 mm/year from 1967 to 1997 at nearby Azraq (Government of Jordan Data). After those captive breeding efforts, Arabian oryx has been reintroduced into the wild (Stanley Price, 1989; Ancrenaze and Flamand, 1995), however the population has remained low and this species remains endangered. Captive breeding efforts have been hindered by a lack of knowledge about the reproductive characteristics of this species and an insufficient number of animals. There are few reports concerning the reproductive characteristics of the Arabian oryx and to our knowledge, there are no published studies of the reproductive anatomy and there are few on physiology, reproductive behavior and fertility problems in both sexes. The feasibility of the propagation and genetic management of several endangered species has been demonstrated, but success relies upon understanding of both female and male reproductive physiology. This will help in overcoming managing problems as well as other infertility problems. The main objective of this study is to conserve and propagate Arabian oryx, by providing knowledge on the reproductive characteristics in female animals. By studying their reproductive characteristics and their normal reproduction, abnormalities can be identified and strategies to propagate and conserve this species can be therefore established.

Materials and methods

Animals and reproductive tracts

The animals are kept in captivity at Shaumari Wildlife Reserve Center at the eastern part of Jordan (31°50′0″N, 36°49′0″E). Animals are kept in enclosures and fed hay, concentrate and water ad libitum. Reproductive tracts from seven female Arabian oryx died because of flooding were examined to characterize their anatomy. Animals were allocated into two groups: cycling (n=3; follicles or corpora lutea present) and not-cycling (n=4; follicles or corpora lutea absent). The reproductive tracts were examined and removed at necropsy after observing their orientation and relationships. Observations of the morphology of the external genitalia of the females were made before necropsy. During necropsy, the reproductive tracts were dissected, removed and placed in formalin buffered saline for further measurements and characterization. Different seg-

ments of the tract, i.e. vulva, vagina, cervix, uterine horns, oviducts and ovaries, were measured using a digital caliper (Guo Gen, China). The ovarian length was measured from pole to pole. The length of the vulva was taken from the external vulvar opening to the vestibule and that of the vagina from vestibule to the external cervical ostium. The cervical length was measured as the distance between the external and the internal ostia. The length of each uterine horn was taken from the point of bifurcation to the utero-tubal junction. The width of each uterine horn was taken at the level of intercornual ligament. The length of the oviduct was taken from the uterotubal junction to the fimbriae. In the ovaries, the presence or absence of follicles, corpora hemorrhagica, corpora lutea and corpora albicantia was recorded.

Data analysis

Mean, SD and range for each reproductive tract segment were generated and compared among groups using the PROC GLM procedure of SAS Statistical Package (v.9.1, 2003, SAS Institute, Inc., Cary, NC). Differences with a probability level (P) of 0.05 or less were considered significant.

Results

The following description corresponds to seven females (*Oryx leucoryx*) which died of natural causes at the Shaumari reserve in Jordan (Fig. 1). Their general anatomy was similar to that described for the domestic ruminant species (bovine, ovine and caprine) with few differences.

Anatomy of internal genitalia

The ovaries (Fig. 1; B, I and J) were located about 23 to 27 cm from the opening of the vulva but appeared subject to great variations depending on the physiological stage. The ovary was attached to the broad ligament by a well-defined strong ligament (ovarian ligament) which extends from the hilus of the ovary to the tip of the corresponding uterine horn. Each ovary was enclosed within a fold of the mesosalpinx (ovarian bursa). The apex of this bursa forms a large circular orifice within which the fimbriae of the oviduct lied. The ovaries were oval or circular, flattened laterally and had a regular smooth surface due to absence of follicular activity in not-cycling animals, but had follicles in the cycling ones (Fig. 1; I and J). Table 2 shows different measurements of cycling and not-cycling, formalin-fixed reproductive tracts of female Arabian oryx. There was a significant difference between cycling and not-cycling animals in the length and width of both right and left ovaries ($P<0.05$), but not in height. Grossly, the ovary consisted of two major parts, the cortex and the medulla, and the whole organ was enclosed by a thin tunica albuginea except at the hilus. Follicular activity took place in the cortex and ovulation occurred anywhere on this surface. There was no significant difference in oviduct length between cycling and not-cycling animals. The isthmus was less coiled than the ampulla, and the fimbria lied within the bursa at a short distance from the ovary. Each oviduct opened into the uterine horn via a narrow orifice at the top of a papilla which was as much

Table 1 – Measures of female Arabian Oryx formalin-fixed reproductive organs (cm, except for annular ring number).

Organ	Mean ± SD	Range
Right Ovary		
length	1.50 ± 0.66	0.81-2.41
width	0.38 ± 0.21	0.13-0.64
height	0.53 ± 0.37	0.13-0.93
Left Ovary		
length	1.32 ± 0.34	0.98-1.70
width	0.37 ± 0.21	0.12-0.58
height	0.65 ± 0.27	0.21-0.89
Right Oviduct		
length	10.72 ± 3.11	7.2-15.20
Left Oviduct		
length	10.52 ± 3.01	7.3-15.20
Right Uterine Horn		
length	14.32 ± 2.46	10.01-16.10
width	1.12 ± 0.17	0.97-1.36
left Uterine Horn		
length	14.86 ± 3.27	9.20-17.50
width	1.26 ± 0.14	1.06-1.84
Cervix		
length	3.84 ± 0.98	2.98-5.50
annular ring number	3.40 ± 0.55	3.00-4.00
Anterior Vagina		
length	10.26 ± 5.18	4.46-16.00
Posterior Vagina		
length	2.56 ± 0.79	1.62-3.50
Vulva		
length	1.30 ± 0.43	0.95-1.20
Anogenital Distance	15.01 ± 1.57	12.45-16.57

as 3-5 mm in height. This papilla was rich in muscle tissue and formed a sphincter muscle at its apex. The uterus was bicornuate (Fig. 1, A and B). It was small and contained entirely within the pelvic cavity. It had no distinct uterine body and the cervix had two internal openings that corresponded to each horn. There was no significant difference in both left and right uterine horn length and width between cycling and not-cycling animals. The endometrium of the uterine horn contained caruncles (Fig. 1C**).** The cervix had between 3 and 4 annular mucosal cartilaginous rings (Fig. 1E) and the number of cervical rings was similar between cycling and not-cycling animnals. There was no significant difference in length of the cervical canal between cycling and not-cycling animals. The cervix protruded caudally into the vaginal cavity forming a fornix of variable depth. The size of the protruded vaginal portion of the cervix and the actual position within the vaginal cavity varied among animals.

Table 2 – Measures of formalin-fixed reproductive organs of cycling and not-cycling female Arabian Oryx (cm, except for annular ring number).

Organ	Mean ± SD, cycling	Mean ± SD, not cycling
Right Ovary		
Length	2.15 ± 0.37	1.01 ± 0.17
Width	0.16 ± 0.04	0.52 ± 0.11
Height	0.53 ± 0.57	0.53 ± 0.34
Left Ovary		
Length	1.69 ± 0.02	1.08 ± 0.11
Width	0.14 ± 0.04	0.52 ± 0.07
Height	0.67 ± 0.09	0.64 ± 0.37
Right Oviduct		
length	11.35 ± 0.49	10.3 ± 4.29
Width	0.37 ± 0.04	0.3 ± 0.12
Left Oviduct		
Length	10.75 ± 0.35	10.37 ± 4.24
Width	0.38 ± 0.08	0.30 ± 0.15
Right Uterine Horn		
length	15.00 ± 0.28	13.87 ± 3.36
width	1.05 ± 0.11	1.19 ± 0.24
left Uterine Horn		
length	15.9 ± 0.85	14.17 ± 4.38
width	1.17 ± 0.16	1.34 ± 0.06
Cervix		
Length	4.45 ± 1.48	3.44 ± 0.43
No. annular rings	3.5 ± 0.71	3.33 ± 0.58
Anterior Vagina		
Length	15.75 ± 0.35	6.60 ± 1.85
Posterior Vagina		
Length	3.35 ± 0.21	2.03 ± 0.43
Vulva		
length	1.71 ± 0.37	1.03 ± 0.14
Anogenital Distance	15.1 ± 0.42	14.94 ± 2.19

Anatomy of external genitalia

The vagina comprised of a posterior part, vestibule, and an anterior part (vagina proper). It was lined by many longitudinal folds (Fig. 1H). There was a significant difference in the length of the vagina between cycling and not-cycling animals ($P<0.05$). The vagina proper and the vestibule were separated by a strong band of tissue (sphincter muscle of the vestibule) (Fig. 1H). The vulva (Fig. 1G) opened directly below the anus, with no difference between cycling and not-cycling animals. The clitoris was very small and there was no distinct clitoral fossa. The urethra was also short and the urinary meatus small. A suburethral pouch was noted just below the urethral opening.

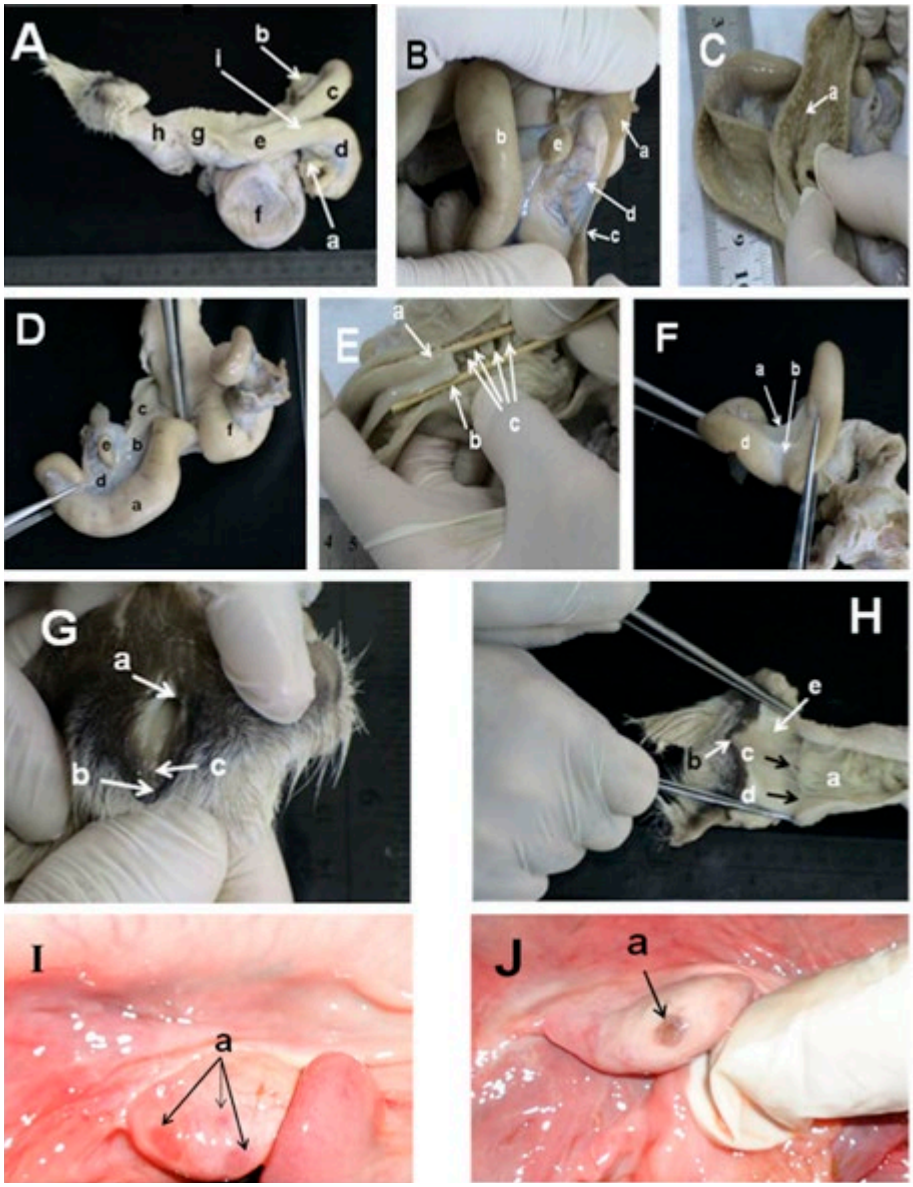

Fig. 1 – A, whole excised reproductive tract of Arabian oryx: a, right ovary; b, left ovary: c, left uterine horn; d, right uterine horn; e, cervix; f, urinary bladder; g, anterior vagina; h, posterior vagina; i, bifurcation of uterus. B: a, fimbria; b, uterine horn; c, uterotubal junction; d, oviduct; e, ovary. C: a, caruncles. D: a, right uterine horn; b, mesovarium; c, mesometrium; d, mesosalpinx; e, ovary; f, left uterine horn. E: a, right internal ostium of the cervix; b, left internal ostium of the cervix; c, cartilaginous rings of the cervix. F: a, left uterine horn; b, dorsal intercornual ligament; c, ventral intercornual ligament. G: a, anterior vagina (vagina proper); b, ventral commissure of vulva; c, urethral opening; d, vestibulovaginal junction; e, posterior vagina. H: a, dorsal vulvar comissure; b, ventral vulvar comissure; c, clitoris. I, Ovary: a, follicles. J, Ovary: a, corpus luteum. Note: I and J were taken before fixing the tracts in formalin.

Discussion

Aspects of the female oryx reproductive tract are similar to those in small ruminants and the cow (Dyce *et al.*, 2002; Kong and Liebich, 2007). However, female oryx has no distinct uterine body and the cervix has two internal ostia immediately communicating with the respective uterine horn.

Based on ultrasonographic examination of the pregnant oryx, Delhomme and Ancrenaz (1994) have reported that the placentation of the oryx is similar to that of ruminants (cotyledonary). Animals studied in the present study were not pregnant; however, close examination of the endometrium revealed the presence of a caruncular surface suggesting a cotyledonary placentation as reported by Delhomme and Ancrenaz (1994).

No evidence of follicles or corpora lutea was seen in not-cycling animals at gross examination. This could be due to physiological inactivity of the ovaries (anestrus) during winter months or to regression or dysfunction because of disease. Seasonality has not been reported in this species as births occur throughout the year. On the contrary, there were follicles and corpora lutea on the surface of the ovaries of cycling animals.

The cervix of the female Arabian oryx has 3 to 4 cartilaginous rings as in other domestic ruminants (Senger, 2003), which makes penetration of the cervix and pipetting a difficult process. In addition, the cervix bifurcates at its junction with the uterus to form two internal ostia which give access to the respective horn directly. Therefore, before attempting artificial insemination, the active ovary with maturing follicles should be determined to decide on which side to deposit the semen. Deposition of semen in the contra lateral uterine horn might not result in fertilization, an issue – however – still to be investigated. For artificial insemination, if determination of follicular activity is not performed, deposition of semen on both sides would be necessary to increase chances of successful insemination.

Analysis of reproductive problems depends on access to the reproductive tract; however, the small size of this tract and the length of the rectal wall make most of the of the female oryx reproductive tract inaccessible, thus hampering many reproductive procedures. Clinicians should also note that a suburethral diverticulum exists in the oryx, as in the domestic cow. The suburethral diverticulum is a blind pouch located ventral to the opening of the urethra and exists in the cow and sow (Dyce *et al.*, 2002; Kong and Liebich, 2007). Clinically, its significance arises when one has to introduce instruments into the vagina (for artificial insemination procedures or pipetting the reproductive tract): one should direct the device upperward to avoid entering the bladder or the blind pouch. This is also important when attempting to collect the urine using a catheter.

Conclusion

It could be concluded from this study that the anatomy of female Arabian oryx reproductive system share some anatomical characteristics with that of domestic ruminants with few peculiarities. Defining these peculiarities will help in the development of appropriate reproductive techniques in order to propagate this endangered species and control its reproduction. Nonetheless, further studies using larger

numbers when possible of animals may be of help to further detail the characteristics of this animal species.

Declaration of conflicting interests

The authors declare that they have no conflicts of interest with respect to their authorship or the publication of this article.

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