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The ovary of the Thomson's Gazelle

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Introduction

Thomson's gazelle, *Gazella thomsoni* Guenther, 1884, is a small wild ungulate within the group of antelopes (Brooks 1961). The female weighss approximately 23 kg., while the male weighs 29 kg. It is abundant in open grasslands of Kenya.

Breeding in Thomson's gazelle occurs throughout the year, but the highest number of pregnancies noted occurred between August and October during the short rains. This, however, coincided with the period during which most of the specimens were collected. Brooks (1961) and Hopcraft (1970) reported biannual breeding. Robinette and Archer (1971) observed two lambing peaks in May and November, while Brooks (1961) noted a peak in April.

At present, little information is available on the duration of gestation and on the birth weight of Thomson's gazelle. Hopcraft (1970) recorded a gestation period of three months and three weeks. Wehr (1971) observed a period of 222—224 days. The Thomson's gazelle is monotocous bearing only one offspring per gestation.

Materials and methods

The animals used in this study were collected from Kekopey Ranch 36°E, 1°S, Kajiado 37°E, 2°S and Maralal 37°E, 1.5°N in Kenya:

Ovaries used for histology were measured, weighed and fixed in Bouin's fluid, dehydrated, and embedded in paraffin wax. The reproductive tracts for gross anatomy were

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Animal Number	Age (Years)	Reproductive stage	Corpus Luteum (CL)	Fetus sex	Fetus length (CR) (cm)	Fetus weight (grammes)	Origin
1	7—8	Early Pregnancy	C.L.R.O.	—	—	—	Maralal
2	8—9	Pregnant	C.L.R.O.	Female	12.7	59.75	Kajiado
3	6—7	Pregnant	—	—	—	3000.00	Kekopey Ranch
4	6	Pregnant	—	—	—	—	Maralal
5	4	Pregnant	C.A.	—	—	—	Kekopey Ranch
6	4—5	(Preimplantation Early Pregnancy)	C.L.L.O.	—	—	—	Kajiado
7	4—5	Not Pregnant	—	—	—	—	Maralal
8	3	Pregnant	—	Female	32.6	974.90	Kekopey Ranch
9	5	Pregnant	C.A.	Male	11.4	41.30	Kekopey Ranch
10	4—5	Pregnant	—	—	—	—	Maralal
11	6	Pregnant	C.L.R.O.	—	—	—	Maralal
12	3	Pregnant	C.A.R.O.	—	—	—	Kekopey Ranch
13	2	Pregnant	C.L.R.O.	—	—	—	Kekopey Ranch
14	5	Not Pregnant	—	—	—	—	Kajiado
15	Adult	Pregnant	—	Female	40.0	2000.00	Kekopey Ranch
16	Adult	Pregnant	—	Male	40.0	1450.00	Kekopey Ranch
17	Adult	Preimplantation	C.L.R.O.	—	—	—	Kekopey Ranch
18	Adult	Pregnant	Well developed C.L.R.O.	—	2.6	2.50	Kekopey Ranch
19	Adult	Pregnant	C.A.	—	4.3	1800.00	Kekopey Ranch
20	7—8	Pregnant	—	Male	4.0	1.12	Kajiado
21	7—8	Pregnant	—	—	42.4	1350.00	Kekopey Ranch
22	4—5	Pregnant	Degenerating C.L.	—	14.5	—	Kekopey Ranch
23	7	Pregnant	C.L.L.O.	Male	3.0	0.88	Maralal
24	4—5	Preimplantation	C.L.R.O.	—	—	—	Maralal
25	Young	Pregnant	—	Not sexed	1.5	—	Kekopey Ranch
26	7—8	Pregnant	—	Male	22.5	350.00	Kajiado
27	8	Pregnant	—	Male	26.5	300.00	Kajiado
28	Adult	Pregnant	—	Male	20.0	300.00	Akira Ranch
29	Adult	Pregnant	C.L.L.O.	Not sexed	1.34	0.30	Akira Ranch
30	Adult	Pregnant	—	Female	16.5	145.50	Akira Ranch
31	Adult	Pregnant	C.L.R.O.	Male	3.58	3.80	Akira Ranch
32	7—9 months	Not Pregnant	—	—	—	—	Akira Ranch
33	Adult	Preimplantation	C.L.R.O.	—	—	—	Akira Ranch
34	7—8 months	Not Pregnant	—	—	—	—	Akira Ranch
35	3—4	Pregnant	C.A.L.O.	—	—	—	Kekopey Ranch
36	8	Not Pregnant	—	—	—	—	Kekopey Ranch
37	5—6	Not Pregnant (Lactating)	—	—	—	—	Kekopey Ranch
38	10	Implantation Pregnant	C.L.R.O.	Not sexed	Too small	—	Maralal
39	5—6	Pregnant	—	Female	38.4	1500.00	Maralal
40	Adult	Pregnant	—	Female	38.4	1250.00	Kajiado
41	Adult	—	—		—	—	Maralal
42	Adult	Pregnant	C.L.R.O.	Female	16.8	97.20	Kekopey Ranch

C.L. = Corpus luteum, C.L.L.O. = Corpus luteum in the left ovary, C.L.R.O. = Corpus luteum in the right ovary, C.A. = Corpus albicans, C.A.R.O. = Corpus albicans in the right ovary, C.A.L.O. = Corpus albicans in the left ovary, C.R. = Crown — rump.

fixed in 10% formol saline. One animal was fixed in the standing position using the technique described by Hofmann (1966). This animal was carefully dissected and photographed at various stages to demonstrate the position of the female reproductive tract.

The paraffin sections were stained with H & E, Goldner (Romeis 1948), Heidenhain's Azan (Romeis 1948), the Gomori connective tissue impregnation technique (Romeis 1948), and the periodic acid Schiff-reaction. The diameters of the ovarian follicles and oocytes were measured from H & E stained specimens. The measurements were used for the determination of the relationship between the oocyte and follicle during growth.

Results

Position, shape, size, and weight of the ovary

The ovaries of the Thomson's gazelle were located in the dorsal part of the abdomen caudal to the kidneys. In the pregnant Thomson's gazelle, fixed in a standing position, the left ovary was situated below the body of the ilium adjacent to the acetabulum. The right one was resting on the *Ansa distalis* of the *Colon spiralis*. It was in a plane just caudal to the fifth lumbar vertebra. The ovaries were, therefore, outside the pelvic cavity.

The ovaries varied in shape from spherical to bean-shaped. They were slightly flattened dorsoventrally and, on the average, measured $12 \times 8 \times 7$ mm and weighed about 0.5 grams. The ovaries especially of immature females had a smooth outline. The corpus luteum protruded along the surface of the ovary in mature pregnant animals.

Histology

The ovaries were covered by a continuous sheet, usually single layered, of simple squamous to cuboidal epithelial cells supported on a thin basal lamina. The ovary was, on one occasion, covered by a stratified epithelium in one region (Fig. 1). The cells forming this epithelium had no consistent orientation in relation to the ovarian surface. The number of cell rows varied from two to four. The thickness of the

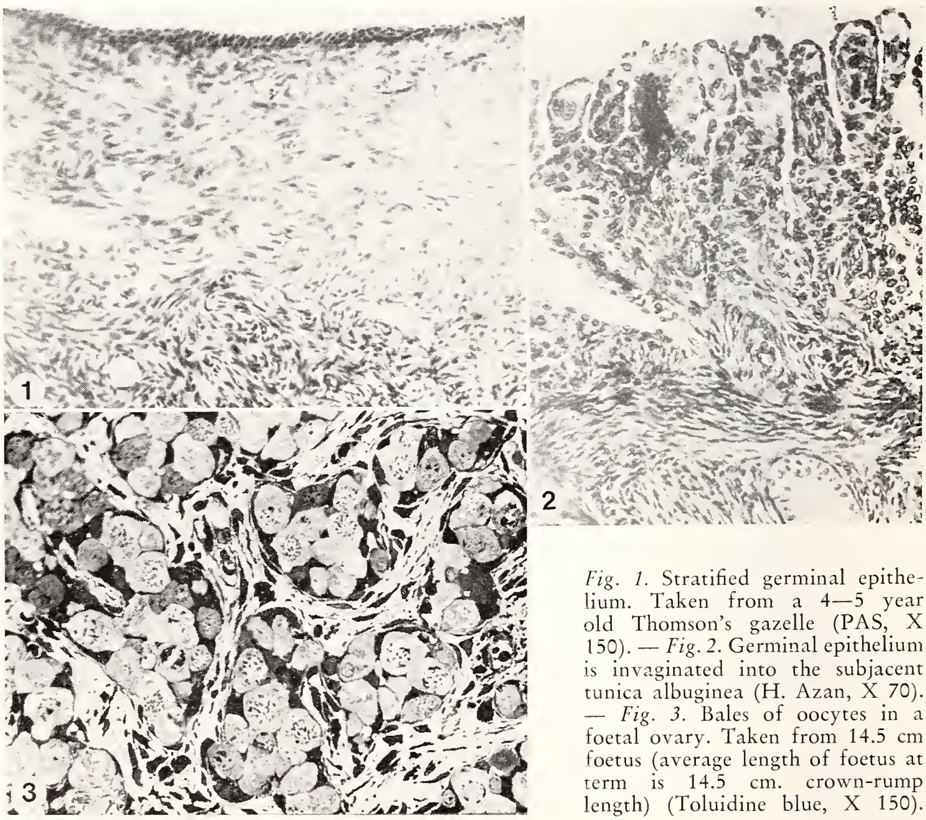

Fig. 1. Stratified germinal epithelium. Taken from a 4—5 year old Thomson's gazelle (PAS, X 150). — *Fig. 2.* Germinal epithelium is invaginated into the subjacent tunica albuginea (H. Azan, X 70). — *Fig. 3.* Bales of oocytes in a foetal ovary. Taken from 14.5 cm foetus (average length of foetus at term is 14.5 cm. crown-rump length) (Toluidine blue, X 150).

germinal epithelium ranged from 3.5 µm, in simple squamous epithelium to 20 µm in the multilayered epithelium.

In two of the animals studied, the germinal epithelium was invaginated into the subjacent *tunica albuginea* to form pits (Fig. 2). In a few cases, the ovarian surface was slightly indented at the tip of a large tertiary follicle.

Beneath the germinal epithelium was the tunica albuginea which was well developed and helped to impart a smooth outline to the ovarian surface. It contained collagenous fibers arranged in a three dimensional system. On the average, it was 67 µm deep, ranging from 18 µm to over 250 µm in a few isolated regions.

The ovary was subdivided into an outer zona parenchymatosa, immediately below the tunica albuginea and an inner zona vasculosa. The zona parenchymatosa, or ovarian cortex was occupied mainly by stroma ovarii and follicles. Smooth muscle cells were occasionally found amongst the stroma ovarii and theca externa cells. These smooth muscle cells were larger than the stroma ovarii cells. The majority of the reticular fibers ran perpendicular to the ovarian surface in the zona parenchymatosa. As they approached the tunica albuginea, they fanned out to run parallel to the ovarian surface. The orientation of the oocytes and follicles appeared to be influenced by the course of the reticular fibers.

The follicles presented a wide range of sizes corresponding to the various stages of their development. They were numerous in the late fetus and the young juvenile animal (Fig. 3). A rapid reduction in the number of follicles was noted as the animal matured. Relatively few follicles were found in the adult gazelle compared to other ungulates, for instance, the impala (Kayanja 1969). Primordial follicles were situated in the periphery of the zona parenchymatosa just beneath the tunica albuginea where they were relatively numerous in the Thomson's gazelle.

It was rare to find a naked oocyte in the mature Thomson's gazelle. The primordial follicles sizes ranged from 30 to 40 µm, while their oocytes measured 25 to 40 µm in diameter. The primary follicles measured 40 to 72 µm, while their oocytes were 25 to 45 µm. The secondary follicles were 65 to 285 µm and contained oocytes of 30 to 120 µm in diameter. The tertiary follicles ranged from 300 µm to over 3 mm, while their oocytes ranged from 65 to over 90 µm.

The growth of follicle relative to that of the contained oocyte was biphasic, as has been proved in other species (Parkes 1931).

The linear regression lines (Fig. 4) were calculated from the following formulae:

1. $y = 21.1 + 0.277x$, where y is the diameter of the oocyte in µm and x is the diameter of the follice between 20 and 266 µm and
2. $y = 89.4 + 0.02x$, where y is the diameter of the oocyte in µm and x is the diameter of the follicle between 266 and 700 µm.

The oocyte contained a complete epithelial covering at about 30 µm diameter. The majority of oocytes had a double layer of epithelial cells by the time they reached 45 µm in diameter. The theca interna appeared when the follicle was about 200 µm in diameter. At this stage, the zona pellucida appeared as a faint PAS-positive line.

The columnar epithelial cells of the primary follicle entered a phase of proliferation coincidental with the enlargement of the oocyte. The oval to rod-shaped nuclei of the columnar cells became spherical. They had relatively little heterochromatin and had a distinct nucleoulus. Their cytoplasm was not intensely eosinophilic and the limiting membranes were indistinct. Later on in proliferation process, the limiting cell membranes began to show. The bigger the follicle became, the more loosely the cells were arranged. Spaces formed in between them were occupied by an amorphous, almost nonstaining substance traversed by a network of PAS-positive threads. This point was regarded as the end of the secondary follicular stage. The

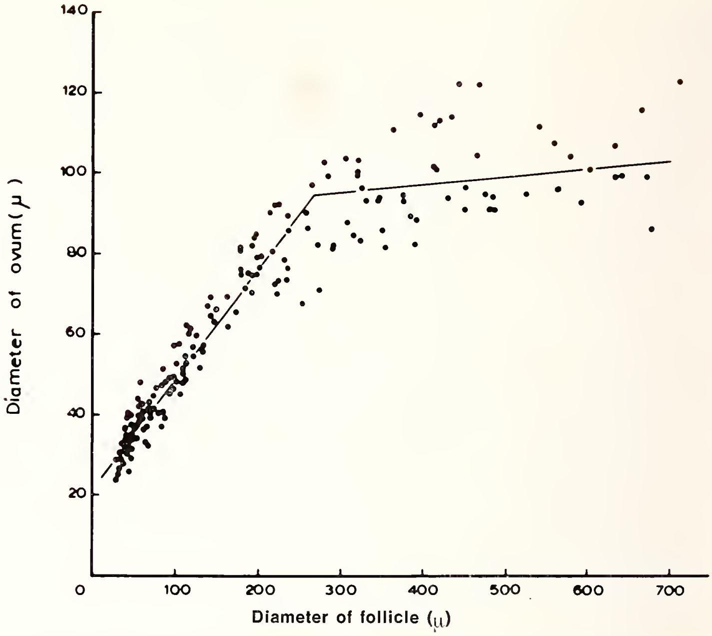

Fig. 4. The relationship between the growth of ovum and follicle in the Thomson's gazelle

peripheral granulosa cells formed a row of columnar cells with their nuclei basally situated toward the membrana propria. The cells next to the zona pellucida formed a row of cuboidal cells containing spherical nuclei. Mitotic figures were seen frequently in the granulosa cells during follicular growth.

The membrana propria was identified as a distinct PAS-positive line separating the membrana granulosa from the thecal coat. The cells of the theca interna were initially pleomorphic. They differentiated from the surrounding stromal tissue. The Gomori stain showed that reticular fibers surrounded each cell and that the majority of the fibers ran concentrically around the follicle. As the spaces (initial stages of antrum formation) between the granulosa cells developed into a common large cavity, the thecal cells began to acquire their typical appearance. Some of them enlarged and assumed a polygonal shape with oval to rod-shaped nuclei.

The tertiary follicles increased rapidly in size due to the accumulations of liquor folliculi. Confluence of the secretion in the intercellular spaces between the granulosa cells led to the formation of a single antrum. During this process, the oocyte became eccentric in position. As they approached maturity, the tertiary follicles almost occupied the full thickness of the ovarian cortex.

The granulosa cells were loosely arranged especially those of the cumulus oophorus. They were columnar immediately next to the membrana propria, while those adjacent to the zona pellucida were cuboidal with round nuclei as in the secondary follicles.

The zona pellucida had increased in thickness to about 7 μm. It formed a thick dense layer surrounding the oocyte. The thecal layer had already differentiated into a theca interna and a theca externa. The theca interna cells enlarged and assumed a polygonal shape with nuclei containing one or more nucleoli. The nuclei were spherical to oval and stood out clearly. The cytoplasm was faintly stained and the cell boundaries were indistinct. A number of mitotic figures were observed in the cells.

Scattered in the theca externa were smaller cells, stellate or pyriform in shape with thin long nuclei. Immediately beneath the membrana propria they formed a row of thin long cells. Blood capillaries of various sizes were encountered in this region. Some were near the membrana propria. These vessels, together with the theca interna cells were enmeshed in a reticular fiber network. The theca interna maintained equal thickness around the follicles except in cone formation. In the region of the cone, there was an increase in the number of thecal cells except at the tip. The cells merged smoothly into the theca externa.

The theca externa was composed of loosely arranged connective tissue cells concentrically surrounding the follicle. It contained large blood vessels. This layer merged gradually with the stroma ovarii from which it was distinguished only by its rich vascularity and its concentric arrangement. Smooth muscle cells were seen in the region between theca externa and stroma ovarii.

The zona vasculosa harboured the main blood vessels of the ovary. It contained many muscular arteries and large valved veins. Two varieties of unusual tissues were observed in the ovarian medulla. One type formed cords of cells and short tubes (Fig. 5). These cells were either cuboidal or columnar or polygonal being epithelial in character. They had spherical or oval distinct nuclei which were centrally located. The cytoplasm was hardly stained by the routine staining techniques, and the cell boundaries were indistinct. A thick line, red-staining with eosin, surrounded the cell cords. Adjacent to and external to the thin line was a row of flat cells with dark staining nuclei. The cell cords were encountered in ten animals. These were young animals below five years of age.

Fig. 5. Cords of cells in the ovarian medulla in a 4-year old Thomson's gazelle (H and E, X 150). — *Fig. 6.* Tubular structure in the ovarian medulla. The tubules are lined by a ciliated columnar epithelium. The ovary was taken from a 4-year old Thomson's gazelle (H and E, X 200).

The second type of unusual tissue tended to form tubular structures. This form had a high columnar epithelium bearing kinocilia (Fig. 6). The nuclei were situated basally. The cells lay against a basal lamina which stained positively with the PAS-reaction. The nuclei stained dark purple, while the cytoplasm was eosinophilic with H and E stain.

Discussion

A multilayered germinal epithelium was noted in one ovary of the Thomson's gazelle. This was also reported in the impala ovaries (Kayanja 1969) in which the germinal epithelium was in some areas composed of three layers and was prevalent in the region near the hilus. Pits of varying depths were observed in the germinal epithelium of some of the Thomson's gazelles ovaries. These formations were reported to be well developed in Pinnipedia by Harrison et al. (1952) and Laws (1956) and in Proboscidea by Perry (1953). The above authors observed an increase in the number and extent of the surface crypts probably associated with the oestrus cycle. This was not observed in the Thomson's gazelle.

The tunica albuginea was comparatively thick and tended to give a smooth contour to the ovary as suggested by Harrison (1948) in the goat and by Kayanja (1969) in the impala.

The adult female Thomson's gazelle had few follicles and even fewer naked oocytes. This may be due to a high rate of follicular atresia.

The growth of follicles was biphasic. This has been demonstrated in many mammalian species: in the ferret, rabbit, and pig (Parkens 1931), bank vole (Brambell and Rowlands 1936) and impala (Kayanja 1969).

Harrison (1948) and Kayanja (1969) recorded the occurrence of "thecal cones" on goat and impala follicles, respectively. The present author has observed the same structures on Thomson's gazelle follicles. Harrison (1948) suggested that "thecal cones" were related to the migration of follicles into the depth of the cortex. Kayanja (1969) indicated that these structures were basically due to the pattern of reticular fibers going round the follicle and coming together at a peak before fanning out in the outer zone of the cortex.

The unusual structures observed in the medulla are most likely vestigial tissue. The cords and short tubes observed are probably the rete ovarii. Rete ovarii have been reported as vestiges in several species. In man, Arey (1960) reported the existence of rete ovarii vestiges. Mossman and Duke (1973) suggested that the rete ovarii are probably always present and are usually rather conspicuous in sections of the area of the hilus near the cephalic end of the ovary. The same authors demonstrated an epithelium of low cuboidal cells and a network of lumina, sometimes locally dilated or even grossly cystic. The cords in the medulla of the ovary of the Thomson's gazelle did not appear to form cysts and the appearance of lumina was very rare. Hadek (1958) reported the presence of vestiges of the rete ovarii in the ovarian medulla of sheep.

The rete-type interstitial gland tissue of the tentbuilding bat *(Vroderma bilobatum)* closely resembles the cords seen in the Thomson's gazelle ovarian medulla. The rete-type cords of the Thomson's gazelle differ slightly from those reported by Archibald et al. (1971) in heifers. The distinction of rete-type cords from medullary cords is needed in the Thomson's gazelle.

The second type of unusual tissue observed in some ovaries of the Thomson's gazelle bears resemblances to epoophoron tubules described in a tent-building bat *(Vreoderma biloatum)* by Mossman and Duke (1973).

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Summary

The histology of the ovary of the Thomson's gazelle is described. The mature ovary contains relatively few primordial and primary follicles. Unusual structures were observed in the medulla. It is being suggested that these are likely to be vestigial tissue, rete ovarii and epoophoron.

Zusammenfassung

Das Ovar der Thomsongazelle

Die Histologie des Ovars der Thomsongazelle wird beschrieben. Der vollentwickelte Eierstock enthält relativ wenige Primordial- und Primärfollikel. In der Medulla werden ungewöhnliche Strukturen gefunden, die vermutlich Anhangsgewebe (Rete ovarii und Epoophoron) darstellen.

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