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TESTICULAR CHANGES AND SPERM CHARACTERISTICS IN THE DIFFERENT DROMEDARY CAMEL BREEDS DURING THE BREEDING AND NON-BREEDING SEASONS

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ABSTRACT: Sixty- four male dromedary camel testes from different breeds (Fellahi, Maghrebi and Sudani) during the breeding and non –breeding seasons were used. The experimental work aimed to define the effect of breed and seasons on testicular measurements and sperm characteristics. The penetrating ability of spermatozoa into she-camel cervical mucus was also assessed. The obtained results revealed that, testes weight (g), testicular volume (cm^3), scrotal circumference (cm) and testes tone firmer score were significantly ($P<0.05$) higher during the breeding than during the non-breeding season, while insignificant differences between Fellahi and Maghrebi than Sudani camels were detected. Percentage of sperm motility and sperm-cell concentration ($x10^6$/ml) were significantly ($P<0.05$) higher, while the percentages of dead spermatozoa, abnormal spermatozoa, acrosomal damage and chromatin damage of spermatozoa were significantly ($P<0.05$) lower in the breeding than in the non-breeding season in Fellahi and Maghrebi camels as compared with Sudani ones. Penetrating ability of spermatozoa into she-camel cervical mucus was significantly ($P<0.05$) better during the breeding than non- breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels). The penetrating ability of spermatozoa into she-camel cervical mucus was not significant in the various breeds (Fellahi, Maghrebi and Sudanese camels). Moreover, the prolongation of incubation time at 37ºC for 4 hours significantly ($P<0.05$) decreased the penetrating ability of spermatozoa into she-camel cervical mucus either in the breeding or the non-breeding season with the different dromedary camel breeds. In conclusion, sperm characteristics and ability of Fellahi and Maghrebi camel spermatozoa to penetrate cervical mucus during the breeding season showed better performance than Sudani camel spermatozoa.

Key words: Camels, season, breed, testes, sperm characteristics.

INTRODUCTION

The camel (*Camelus dromedarius*) is an important livestock species that can uniquely adapted to live in hot arid areas. Four camel breeds are found in Egypt, Sudani, Maghrebi, Fellahi and Al-Mowalled. Al-Fellahi camel breed is dominated in the Nile Delta region, but not in desert environments, while Al-Mowalled camel breed is much more suitable as a farm and desert animal. Al-Sudanese and Al-Maghrebi camel breeds were raised for meat and milk production **(Wilson, 1997).**

In Egypt, increasing camel productivity can help to solve the insufficient amount of animal meat and milk and depends firstly and mostly on reproductive efficiency. A management strategy that promotes maximum reproductive efficiency depends, in turn, on an understanding of reproductive biology of the camel **(Abd El-Raouf *et al.*, 1975).**

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The breeding season called "rutting season" or "rut" occurs during the cool winter months of the year. Duration of daylight and temperature are the two major environmental factors affecting camel breeding season **(Farh *et al.*, 2018).**

Testicular sperm achieve fertilizing ability through the epididymis **(Bedford, 1975).** Although the process of sperm maturation is not clearly understood, it is believed that the epididymis provides a specific milieu **(Ariyaratna *et al.*, 1996).** This milieu results from interepithelial ion exchange and secretory and absorptive activities of the epithelium and is regulated by androgenic hormones **(Brooks** and **Higgins, 1980).**

From another point of view, achievement of high reproductive levels partially depends on the success of Artificial Insemination (AI) which in turn is dependent on the quality of semen obtained and its capacity for dilution and storage with minimum loss of fertilizing ability. Generally, the live of spermatozoa can be prolonged for several days on chilled state (2-5ºC). However, satisfactory fertility results are not always achieved after, as little as, one day of storage **(Zeidan *et al.*, 2001; Matter, 2019).**

Therefore, the present study aimed to investigate the effect of the breeding and non-breeding seasons with the different dromedary camel breeds (Fellahi, Maghrebi and Sudani) on testicular measurements and epididymal sperm characteristics. The penetrating ability of spermatozoa into she-camel cervical mucus during the breeding and non-breeding seasons with the different breeds was also assessed.

MATERIALS AND METHODS

The present study was conducted in the Department of Animal Production, Faculty of Agriculture, Zagazig University, belonging with the Animal Production Research Institute, Egypt. The experimental work was carried out in the Reproductive and Biotechnology Laboratory, Animal Production Research Institute, Giza, Egypt and a local Automated El-Bassatein Abattoris, Cairo near Giza Governorate, located in the South Western part of the Nile Delta (at distance of 21Km from the Laboratory), Egypt, during the period from January, 2016 till February, 2017.

The present experiment conducted to investigate the effect of the breeding (December to May) and non-breeding (June to November) seasons of the male dromedary camels with the different breeds on testicular measurements (testes weight, testicular volume, scrotal circumference and testes tone firmer score). Epididymal sperm characteristics, (percentage of sperm motility, dead spermatozoa, abnormal spermatozoa, acrosome damage of spermatozoa, chromatin damage of spermatozoa and sperm- cell concentration (x 10^6/ml)). Penetrating ability of camel spermatozoa into she- camel cervical mucus during the breeding and non- breeding seasons with the different breeds was also assessed.

Experimental Animals

Sixty-four testes of male dromedary camels (*Camelus dromedarius*) aging 6-10 years old and 500 $\pm$ 50 kg live body weight during each of the breeding and out of breeding seasons were used in the present study. The camels were divided into three experimental groups according to their breeds into Fellahi (n=24), Maghrebi (n=20) and Sudani (n=20). All camels were in healthy condition and clinically free from external and internal parasites with a sound history of fertility in their herd. Palpation of the external genetalia showed that they were typically normal. The testicular tone was glandular, epididymal regions were present. Both testes were approximately equal in size and moved freely up and down within the scrotal pouches.

The temperature–humidity index (THI) was estimated according to Livestock and Poultry Heat Stress Indices **(LPHSI, 1990)** using the following formula:

$$THI=db°F-(0.55-0.55\times RH/100)\ (db°F-58.00).$$

Where, db°F = dry bulb temperature in Fahrenheit and RH = relative humidity. The obtained values of THI were classified as follow: less than 72 = absence of heat stress, 72 to < 74 = moderate heat stress, 74 to < 78 = severe heat stress and over 78 = very severe heat stress. Minimum and maximum values of air temperature (ºC), relative humidity (%), temperature-humidity index (THI) and length of daylight (hours), during the breeding and non-breeding seasons are shown in Table 1.

Table 1. Means of meteorological data during the breeding and non–breeding seasons according to Egyptian Meteorological Authority

Season	Air temperature (°C)		Relative humidity (%)		Temperature-humidity index (THI)		Length of the daylight (hr)
	Min.	Max.	Min.	Max.	Min.	Max.	
Breeding	12.26[b] ±0.12	23.16[b] ±0.48	45.16 ±0.28	60.11 ±0.72	52.88[b]	70.23[b]	12.75
Non-breeding	19.40[a] ±0.17	30.97[a] ±0.35	40.86 ±0.73	58.71 ±0.84	63.93[a]	80.96[a]	14.64

[a-b] Values with different superscripts within a column are significantly different (P<0.05)

Testicular Measurements

Testes weight (g)

Main paired of the testes were weighed and recorded to the nearest gram after slaughtering in the different breeds during the breeding and out of breeding seasons using an ordinary balance.

Testicular volume (cm^3)

Main paired of the testicular volume has been calculated according to the method of **Weibel (1989**) using the following formulae:

$$\text{Testicular volume} = \frac{\pi \times L \times B \times T}{6}$$

Where: $\pi = 3.14$

- L= Length of the longitudinal axis of the testis
- B= Breadth of the testis
- T=Thickness of the testis

Main paired of the testicular volume (cm^3) has been calculated in the different breeds during the breeding and non-breeding seasons using an ordinary caliper as described by **Ismail (1979).**

Scrotal circumference (cm)

The measurement of scrotal circumference in centimeters was done using a flexible cloth tape around the greatest diameter of the testes and scrotum after pushing the testes firmly into the scrotum (**Mickelsen *et al.*, 1982)**.

Testes tone firmer (score)

Testes tone firmer (score) was measured in the different breeds during the breeding and non-breeding seasons using a manual palpation (scored from 1: very soft up to 9: very firm) according to **Wildeus and Hammond (1993).**

Camels Sperm Collection

Epididymal spermatozoa samples were collected immediately after slaughtering. A total number of 64 clinically normal testes were collected during the breeding season (n=32) and non-breeding seasons (n=32) in the different breeds (Fellahi, Maghrebi and Sudanese camels). The genitalia (epididymes attached to the testes) were removed from the carcass and transferred into a thermos flask containing a physiological solution (NaCl 0.9%) supplemented with 100 µg/ml streptomycin at 25°C during 2-3 hours after slaughtering to the laboratory for semen analysis as the method described by **Goto *et al.* (1989)**.

Recovery by cuts (swimming up) method

The processing of sperm samples was carried out, as soon as, possible directly at arrival to the laboratory. Genitalia were dissected, isolating the epididymis and vas deferens from its corresponding testes. Sperm recovery was carried out on 64 epididymis of the male dromedary camels.

The testes were thoroughly cleaned and the superficial blood vessels of the cauda were punctured, so that most of the blood could be wiped off. The epididymis was sectioned into three respective parts, caput, corpus and cauda using a sterile scalpel and forceps in three sterile petri dishes of 100 mm diameter. Longitudinal cuts were made using sterile disposable syringe in each epididymal segment using sterile sharp scalpel and

covered by 5 ml S-TALP medium **Parrish *et al.* (1988)**. The epididymal spermatozoa suspension was incubated for 10 minutes at 39°C in high humidity atmosphere with 5% Co_2 in a tilted position (45°angle) according to **Kaabi *et al.* (2003)**.

Epididymal camel sperm characteristics

Percentage of sperm motility

Generally, camel sperm motility (%) was detected as an oscillatory motion of flagellum, but not progressive due to the viscous materials. Sperm motility was estimated by adding one droplet of the diluted fresh semen with saline solution on dry, clean and pre-warmed (37°C) glass slide and covered with a warmed cover slip and immediately examined using high power magnification (400x). Sperm motility was estimated by observing the approximate percentage of spermatozoa moving forward motion across the field of vision with a normal vigorous swimming motion as the method described by **Plasson (1975)**.

Percentage of dead spermatozoa

The eosin/nigrosine staining procedure was carried out by dissolving 1.67 g eosin and 10 g nigrosine in distilled water up to 100 ml according to **Hackett and Macpherson (1965).**

Percentage of abnormal spermatozoa

The percentage of abnormal spermatozoa was evaluated in the same smears prepared for live/dead spermatozoa ratio.

Percentage of acrosomal damage

Assessment of the percentage of acrosome damage (%) was evaluated according to **Watson (1975).** The percentage of acrosomal damage was calculated for 100 spermatozoa observed randomly on each slide using phase contrast microscope.

Percentage of chromatin damage

Toluidine blue staining was performed as the method described by **Erenpreiss *et al.* (2004)**. Smears were fixed in ethanol-acetic acid glacial (3:1, *V/V*) for 1 min with 70% ethanol for 3 mins. Thereafter, smears were hydrolyzed for 20 min. in 1 Mm Hydrochloric acid, rinsed in distilled water and air-dried. One droplet of 0.025% Toluidine blue in Mcllvaine buffere (Sodium citrate- phosphate) at 4.0 pH was placed over each smear and then cover slipped. The percentage of chromatin damage was determined by evaluating 300 sperm-cell in each slide. Spermatozoa stained with green to light blue were considered to have normal chromatin, while spermatozoa stained with dark blue to violet were considered to have damaged chromatin.

Sperm-cell concentration ($\times 10^6$/ml)

The spermatozoa were counted using haemocytometer according to **Salisbury *et al.* (1978)**.

Sperm penetration (Score)

Sperm penetration into she-camel cervical mucus was assessed as the follows: Cervical mucus was obtained from she-camel. A portion of the mucus was sucked into polyethylene sealed tubes with 2 mm internal diameter to provide a column of 6 cm length. During the breeding and non-breeding seasons, camel semen was collected and extended with Lactose-yolk-citrate extender of the different breeds (Fellahi, Maghrebi and Sudanese camels) as described by **Salisbury *et al.* (1978)** and then placed into 2 ml cuvettes (1 ml each). The tubes containing the mucus were inserted (open end) into the cuvettes containing the extended semen and incubated at 37ºC for up to 4 hours. Sperm penetration was judged as the rank score as the method described by **Hanson *et al.* (1982)**.

Statistical Analysis

Data were statistically analyzed by Factorial design (ANOVA), using General Linear Model (GLM) procedure of SAS **(SAS, 2000)**. Duncan's New Multiple Range Test **(Duncan, 1955)** was used to detect significant differences among means. Percentage values were transformed to arc-sin values before being statistically analyzed. Penetration score was analyzed by Chi-square test.

The model used in the experiment was as follows:

$$Yijk = \mu + Si + Bj + (S\times B)ij + eijk$$

Where:

μ= overall mean,

S = effect of season,

B = effect of breed,

S × B = effect of interaction,

e = random error.

RESULTS AND DISCUSSION

Temperature-Humidity Index (THI)

The THI estimated in Table 1 indicate that the experimental camels during the non-breeding season were exposed to very severe heat stress. Changes in both air temperature and temperature–humidity index (THI) were significantly (P< 0.01) increased during the non-breeding season as compared with the breeding season.

Testicular Measurements

Testes weight (g)

The testes weight of the dromedary camels (Table 2) was significantly (P<0.05) higher during the breeding as compared with the non-breeding season. Similarly, **Zeidan *et al.* (2001) and Allam (2011)** in Fellahi dromedary camels found that the testes weight was significantly (P<0.01) increased during winter and spring as compared with summer and autumn. **Zeidan and Abbas (2004)** in Fellahi dromedary camels also, found that testes significantly (P<0.05) increased in winter season and decreased significantly (P<0.05) in summer season. These findings may be due to the increase in the amount of interstitial contents and spermatogenesis processes and the growth of the soft palate that takes place during the breeding season. On the other hand, the significant reduction observed in the testes weight during the non-rutting season (summer) may be due to exposure to heat stress which due to degeneration in the germ cells and to a partial atrophy in the seminiferous tubules **(Chou *et al.*, 1974).**

Testicular volume (cm^3)

The testicular volume of the dromedary camels (Table 2) was significantly (P<0.05) higher during the breeding than the non-breeding season. Similar findings were observed by **Charnot (1965)** who found that the size of the testes was greatly increased due to the increase in the development of interstitial tissue during the breeding season. Furthermore, **Gherissi *et al.* (2017)** found that the maximal testicular size was observed during the rutting season. **Zeidan *et al.* (2001)** observed also that the testicular volume in Fellahi dromedary camels was significantly (P<0.01) higher during winter and spring than during summer and autumn. **Zeidan and Abbas (2004) and Allam (2011)** found also**,** that testicular volume was significantly (P<0.01) higher during the rutting as compared with the non- rutting season in Fellahi dromedary camels. The increase of testicular volume during the breeding season may be attributed to the increase of spermatogenesis processes. In addition, the increase of testicular measurements was associated with the increase in the amount of the interstitial tissue and its components including blood vessels, Leydig cells, and conjunctive tissue **(Gherissi *et al.*, 2017).** Moreover, the testicular dimensions increased during the rutting season reflecting higher spermatogenesis in activity affected by the high levels of the testosterone and development of interstitial tissues.

Scrotal circumference (cm)

The scrotal circumference of the dromedary camels (Table 2) was significantly (P<0.05) higher during the breeding season than the non-breeding one. The present findings are in agreement with those of **Zeidan and Abbas (2004) and Allam (2011)** in Fellahi dromedary camels. Similar trends were reported by **Gherissi *et al.* (2017)** who found that the scrotal circumference was significantly (P<0.01) higher during the rutting season as compared with the non-rutting season. These differences may be attributed to the environmental factors, such as high temperature and relative humidity during summer causing a more pendulous arrangement of the scrotum with reduced scrotal wrinkling **(Zeidan *et al.*, 2001).**

Testes tone firmer (Score)

As shown in Table 2, the testes tone firmer score of the dromedary camels was significantly (P<0.05) better during the breeding than the non-breeding season. Similarly, **Ahmadi (2001), Zeidan *et al.* (2001) and Allam (2011)** observed that the testes tone firmer score in the dromedary camels was significantly (P<0.01)

Table 2. Effect of different seasons of the year and breeds on the testicular measurements of the male dromedary camels

Testicular measurement	Breeding season			Mean	Non-breeding season			Mean
	Breed				Breed			
	Fellahi	Maghrebi	Sudani		Fellahi	Maghrebi	Sudani	
Testes weight (g)	127.38^{a} ±2.11	123.24^{a} ±4.16	120.14^{a} ±3.15	123.60^{A} ±1.70	113.24^{a} +3.16	108.16^{a} ±4.13	106.11^{a} ±3.18	109.17^{B} ±1.73
Testicular volume (cm^3)	114.23^{a} ±4.51	116.27^{a} ±2.98	112.75^{a} ±4.82	114.41^{A} ±0.8 3	102.96^{a} +3.01	104.16^{a} ±2.78	99.17^{a} ±2.48	102.09^{B} ±1.22
Scrotal circumference (cm)	26.92^{a} ±0.46	28.76^{a} ±0.81	26.19^{a} ±0.38	27.29^{A} ±0.62	18.23^{a} +0.63	19.11^{a} ±0.47	17.22^{a} ±0.73	18.18^{B} ±0.44
Testes tone firmer (Score)	8.16^{a} ±0.16	8.72^{a} ±0.17	8.12^{a} ±0.18	8.33^{A} ±0.15	6.91^{a} +0.19	6.92^{a} ±0.14	6.32^{a} ±0.17	6.71^{B} ±0.16

Means bearing the different letters within the same classification, differ significantly (P<0.05).

higher during the breeding season (winter and spring) as compared with the non- breeding season (summer and autumn).

With regard to breeds, Table 2 showed that testicular measurements differences including testes weight (g), testicular volume (cm^3), scrotal circumference (cm) and testes tone firmer (Score) were not significantly varied among breeds (Fellahi, Maghrebi and Sudanese camels). Similar trends were reported by **Zeidan and Abbas (2004) and Allam (2011)** in Fellahi dromedary camels.

Epididymal Camel Sperm Characteristics

Percentage of sperm motility

Results in Table 3 show that, the percentage of sperm motility in Fellahi dromedary camels was significantly (P<0.05) higher during the breeding than non-breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels). In this respect, **Ahmadi (2001) and Zeidan *et al.* (2001)** found that the percentage of sperm motility in Fellahi dromedary camels was significantly (P<0.01) higher during winter than during spring, summer and autumn seasons. Similarly, **Ibrahim *et al.* (2016)** found that percentage of sperm motility of dromedary camels was significantly (P<0.01) higher in the rutting season as compared with the non-rutting seasons. Additionally, **Ali and Ibrahim (2014)** showed that the percentages of sperm motility were increased with the age progress in both seasons (rutting and non-rutting). **Fatnassi *et al.* (2014)** stated that, ejaculates collected during January and February (rutting season) showed good quality, especially in relation to sperm motility for artificial insemination programs. The present results may be due to the increase in the number of mature Leydig cells, as well as, spermatogenesis process during the breeding as compared with the non-breeding season. It is known that, the Leydig cells, are mainly responsible for testosterone production. So, an improvement in sperm quality is expected to happen during the breeding season **(Charnot, 1965).**

Percentage of dead spermatozoa

The percentage of dead spermatozoa of the male dromedary camels (Table 3) was significantly (P<0.05) higher during the non-breeding season than the breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels). These results are in agreement with those reported by **Ahmadi (2001) and Zeidan *et al.* (2001)** who found that the percentage of dead spermatozoa was significantly (P<0.01) higher during summer than autumn, winter and spring months. Similar results were reported by

Table 3. Effect of different seasons of the year and breeds on epididymal camel Sperm characteristics

Item	Breeding season			Mean	Non-breeding season			Mean
	Breed				Breed			
	Fellahi	Maghrebi	Sudani		Fellahi	Maghrebi	Sudani	
Sperm motility (%)	78.92^{a} ±1.12	76.19^{a} ±1.17	64.11^{b} ±1.30	73.07^{A} ±0.71	61.24^{a} ±1.10	60.78^{a} ±1.31	53.19^{b} ±0.97	58.40^{B} ±1.13
Dead spermatozoa (%)	12.61^{c} +0.10	18.72^{b} ±0.16	21.27^{a} ±0.11	17.50^{B} ±0.12	22.43^{c} ±0.18	28.51^{b} ±0.28	35.19^{a} ±0.14	28.79^{A} ±0.67
Abnormal spermatozoa (%)	6.32^{c} ±0.06	11.12^{b} ±0.08	16.29^{a} ±0.09	11.24^{B} ±0.05	16.38^{c} ±0.09	21.32^{b} ±0.12	30.28^{a} ±0.19	18.85^{A} ±0.09
Acrosome damage (%)	2.61^{c} ±0.04	5.34^{b} ±0.07	11.78^{a} ±0.08	6.57^{B} ±0.02	12.37^{c} ±0.07	14.20^{b} ±0.10	25.11^{a} ±0.13	17.22^{A} ±0.04
Chromatin damage (%)	3.01^{c} ±0.02	4.32^{b} ±0.06	7.01^{a} ±0.03	4.18^{B} ±0.06	6.03^{c} ±0.12	8.72^{b} ±0. 11	9.14^{a} ±0.08	7.96^{A} ±0.09
Sperm-cell concentration ($x10^{6}$/ml)	456.11^{a} ±12.60	461.17^{a} ±9.8 2	410.81^{b} ±10.15	442.69^{A} ±13.07	389.16^{a} ±8.12	380.11^{a} ±10.31	345.21^{b} ±9.14	371.49^{B} ±10.94

Means bearing the different letters within the same classification, differs significantly (P<0.05).

Zeidan and Abbas (2004), Ibrahim *et al.* (2016) and Matter (2019) in Fellahi dromedary camels. The percentage of live spermatozoa of camels (over 4 years) in cold season was significantly higher than those of 2-3 and 3-4 years in both seasons **(Ali and Ibrahim, 2014)**. These results may be attributed to the low temperature and short photoperiods during winter (rutting season) which have effect on the pituitary gland and activity of spermatogensis process and the critical temperature that inhibits spermatogensis **(Rhynes and Ewing, 1973).** In addition, heat stress during summer (non-breeding season) which can induce a disturbance in spermatogenesis process due to degenerative changes with reduce the number of mature spermatozoa or destruction or even death of spermatozoa **(Zeidan *et al.*, 2001)**.

Percentage of abnormal spermatozoa

The results presented in Table 3 show that, the percentage of abnormal spermatozoa in Fellahi dromedary camels was significantly (P<0.05) higher during the non-breeding season than the breeding one in the different breeds (Fellahi, Maghrebi and Sudanese camels). Similarly, **Ahmadi (2001) and Zeidan *et al.* (2001)** observed that the percentage of abnormal camel spermatozoa was significantly (P<0.01) higher during spring, summer and autumn than winter months. Similar results were found by **Zeidan and Abbas (2004)**, **Allam (2011), Ibrahim *et al.* (2016) and Matter (2019)** in Fellahi dromedary camels.

Percentage of acrosomal damage

The percentage of acrosomal damage of dromedary camels (Table 3) was significantly (P<0.05) higher during the non-breeding than the breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels). Similarly, **Zeidan and Abbas (2004) and Allam (2011), Ibrahim *et al.* (2016) and Matter (2019)** found that the percentage of acrosome damage in Fellahi dromedary camels spermatozoa was significantly (P<0.01) higher during spring, summer and autumn than winter month. The improvement in sperm quality observed in the current study during the breeding season as compared with the non-breeding one may be attributed to the increase in

the number of spermatogonia, spermatids and spermatozoa during the rut, also it was documented that the activity of the Leydig cells arrived the maximum level during the breeding season **(Marai *et al*., 2009)**, but are less active in the non-breeding season, consequently, reduction in steroidogenic activity by the testes **(El-Wishy, 1988)**. Furthermore, high levels of testosterone have been detected during the breeding season **(Agarwal and Khanna, 1990)**.

Percentage of chromatin damage

The percentage of chromatin damage of dromedary camels (Table 3) was significantly (P<0.05) higher during the non-breeding than the breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels).

With regard to breeds, percentage of chromatin damage was significantly (P<0.05) increased in Sudanese as compared with Fellahi and Maghrebi camels in the breeding and non-breeding seasons. Similarly, the percentage of chromatin damage was significantly (P<0.05) lower in Fellahi than Maghrebi and Sudani camels during the breeding and non-breeding seasons. Available literature studied the effect of the breeding and non-breeding seasons in the different breeds on percentage of chromatin damage of the male dromedary camels are lacking.

Sperm-cell concentration (x10^6/ml)

Sperm-cell concentration (x10^6/ml) of the male dromedary camels (Table 3) was significantly (P<0.05) higher during the breeding than non-breeding season in the different breeds (Fellahi, Maghrebi and Sudanese camels). The present results are in agreement with those reported by **Ibrahim *et al*. (2016) and Matter (2019)** in Fellahi dromedary camels. Sperm-cell concentration of cold season showed a significant increase than those of moderate-hot season in different ages **(Ali and Ibrahim, 2014).** They also added that sperm-cell concentration obtained from the epididymis was significantly (P<0.05) increased with the age progress in both seasons. The low sperm-cell concentration of the camel semen during the non-breeding season may attributed to the long daylength, as well as, heat stress which lead to reduction in the interstitial cells stimulating hormones, consequently, reduction in androgen production **(Sinha and Prasad, 1993).** A positive relationship between FSH level and spermatogenesis was reported by **Franchimont (1972).** Moreover, the sperm-cell concentration in semen is affected by numerous factors such as age of the male, frequency of services, intensity of sexual excitement and season of the year.

With regard to breeds, sperm-cell concentration (x10^6/ml) was significantly (P<0.05) increased in Fellahi and Maghrebi as compared with Sudani camels during the breeding and non-breeding seasons. While, sperm-cell concentration (x10^6/ml) was significantly (P<0.05) lower in Suadni than Fellahi and Maghrebi camels (Table 3). Similar trends were partially in agreement with those of **Zeidan and Abbas (2004), Allam (2011) and Matter (2019)** in Fellahi dromedary camels. Few literatures about the effect of different breeds of the male dromedary camels on semen characteristics, during the breeding and non-breeding seasons.

Generally, variations in reproductive traits are caused by physiological changes such as body development and release of sexual hormones and by environmental conditions such as daylength, ambient temperature, relative humidity, availability of feed and nutritional conditions. Usually there is a time log between these causes and their effects on reproductive traits. In fact, the present study showed that, the best values of sperm quality parameters (sperm motility, sperm concentration, abnormal spermatozoa, acrosome damage of spermatozoa and chromatin damage of spermatozoa) were better in Fellahi and Maghrebi than Sudani camels during the breeding and non-breeding seasons. Similar findings were recorded by **Zeidan and Abbas (2004) and Matter (2019)** in the male dromedary camels.

Sperm Penetration into She-Camel Cervical Mucus in the Breeding and Non-Breeding Seasons with the Different Breeds, during Incubation at 37ºC

The penetrating ability of spermatozoa into she-camel cervical mucus was significantly

(P<0.05) better during the breeding than the non-breeding season, while did not differ significantly among various breeds (Fellahi, Maghrebi and Sudanese camels). However, the advancement of incubation time at 37ºC for up to 4 hours significantly (P<0.05) decreased the penetrating ability of spermatozoa into she-camel cervical mucus during the breeding and non-breeding seasons in the different breeds (Fig. 1). **Aitken *et al.* (1983)** found a close correlation between human spermatozoa movement and their penetrating ability into cervical mucus. **Murase *et al.* (1990)** reported that, the duration of sperm motility and penetration distance in the mucus closely correlated to the pregnancy and conception rate. Similar findings were recorded by **Zeidan *et al.* (2002), Allam (2011) and Matter (2019)** in the dromedary camels.

With regard to breeds, the penetrating ability of spermatozoa into-she camel cervical mucus was not significantly different among Fellahi, Maghrebi and Sudani camels (Fig. 1). While, the advancement of incubation time at 37ºC for 4 hours significantly (P<0.05) lower the penetrating ability of spermatozoa into–she camels cervical mucus in the different breeds (Fellahi, Maghrebi and Sudanese camels). Similar trends were partially reported by **Aitken *et al.* (1983), Zeidan *et al*. (2002) and Matter (2019)** in the dromedary camels.

In the available literature there is lake about the effect of the breeding and non-breeding seasons with the different breeds on penetrating ability of camel spermatozoa into she-camel cervical mucus.

Based on the previous obtained results, it can be conclude that epididymal camel spermatozoa was better during the breeding season of the dromedary camels than out of breeding season. Moreover, epididymal spermatozoa was better in Fellahi and Maghrebi than Sudanese camels indicated by better quality of camel spermatozoa and penetrating ability of spermatozoa into she-camel cervical mucus.

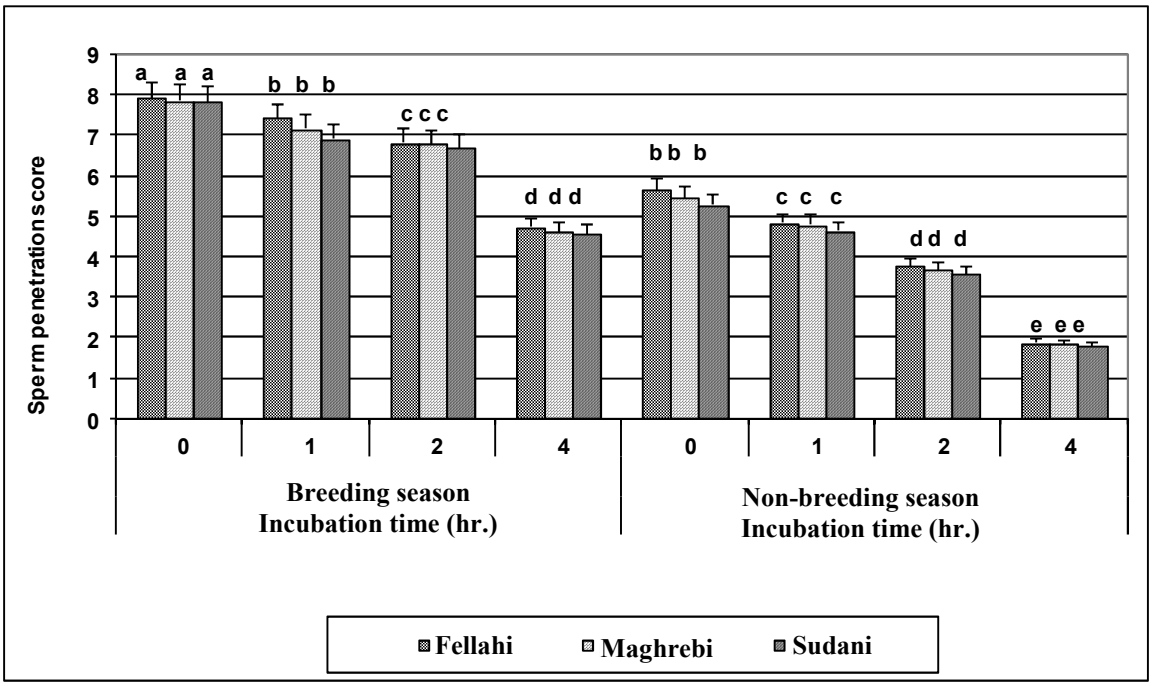

Fig. 1. Penetration score values of the male dromedary camel spermatozoa into she-camel cervical mucus in the breeding and non breeding seasons with the different breeds

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التغيرات الخصوية وصفات الحيوان المنوى في سلالات الجمال العربية المختلفة خلال موسمي النشاط والخمول الجنسي

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أجريت هذه الدراسة على عدد ٦٤ خصية من سلالات مختلفة من ذكور الجمال العربية (الفلاحي والمغربي والسوداني) أثناء موسمي النشاط والخمول الجنسي، وقد هدفت الدراسة إلى معرفة تأثير مواسم (النشاط الجنسي والخمول الجنسى) وسلالات الجمال (الفلاحي ن=٢٤، المغربي ن=٢٠، السوداني ن= ٢٠) المختلفة على معرفة قياسات الخصية وصفات الحيوان المنوى. كذلك تم قياس مقدرة الحيوانات المنوية على اختراق مخاط عنق الرحم للنوق، وقد أوضحت النتائج أن هناك زيادة فى وزن الخصيتين (جم)، حجم الخصيتين (سم^{٣})، محيط كيس الصفن (سم) وملمس كيس الصفن معنويا (على مستوى ٠,٠٥) خلال موسم النشاط الجنسى عن موسم الخمول الجنسي، بينما كانت الصفات غير معنوية فى الجمال الفلاحي و المغربي عن السوداني، كما وجدت زيادة في النسبة المئوية لحركة الحيوانات المنوية وتركيز الحيوانات المنوية (×١٠^{٦}/ مل) معنويا (على مستوى ٠,٠١) ، بينما تلاحظ حدوث انخفاض معنوي (على مستوى ٠,٠١) في النسبة المئوية للحيوانات المنوية الميته والشاذة وشذوذ الاكروسوم وشذوذ الكروماتين في الحيوانات المنوية فى موسم النشاط الجنسى عن موسم الخمول الجنسى وكذلك فى الجمال الفلاحي و المغربي مقارنة بالجمال السوداني. تحسنت مقدرة الحيوانات المنوية على النفاذية داخل مخاط عنق الرحم فى النوق معنويا (على مستوى ٠,٠٥) أثناء موسم النشاط الجنسى عن موسم الخمول الجنسى وذلك في سلالات الجمال المختلفة (الفلاحي والمغربي والسوداني). لم تتأثر معنويا مقدرة الحيوانات المنوية على النفاذية داخل مخاط عنق الرحم فى سلالات الجمال المختلفة (الفلاحي والمغربي والسوداني)، هذا بالإضافة إلى انخفاض مقدرة الحيوانات المنوية على النفاذية داخل مخاط عنق الرحم معنويا (على مستوى ٠,٠٥) سواء فى موسم النشاط أو الخمول الجنسى وذلك في سلالات الجمال العربية المختلفة مع تقدم فترة التحضين على درجة حرارة ٣٧ درجة مئوية لمدة ٤ ساعات، نستخلص من هذه الدراسة أن صفات السائل الحيوان ومقدرة الحيوانات المنوية للجمال الفلاحي والمغربي علي النفاذ داخل مخاط عنق الرحم أثناء موسم النشاط الجنسي أفضل من الحيوانات المنوية للجمال السوداني وكذلك في موسم الخمول الجنسي.

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