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Shortened daily photoperiod during the non-breeding season can improve the reproductive performance of camel bulls (*Camelus dromedarius*)

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ABSTRACT

The effects of a shortened photoperiod on the reproductive performance and hormones of mature dromedary camel bulls (*Camelus dromedarius*) were evaluated. A group of 6 bulls were blindfolded to induce a daily photoperiod that was ~2.55 h shorter than the natural day length (10.83L:13.17D), whereas 6 others served as the control group. The trial started in June and continued for 10 weeks during the non-breeding season. The reproductive performance of all animals was evaluated weekly during this time and also during the breeding season, starting in December and continuing for 10 weeks. Camel bulls in the treatment group showed a significant ($p < 0.05$) increase in testicular volume, scrotal circumference, sexual desire, reaction time, and mating ability scores, and serum melatonin and testosterone concentrations, relative to the control group, during the non-breeding season. In addition, sexual desire and reaction time and mating ability scores were significantly ($p < 0.05$) higher in the treatment group than in the control during the breeding season. There was no significant difference between the treatment groups in both seasons and the control group in the breeding season regarding semen volume, sperm cell concentration, total motility, progressive motility, plasma membrane integrity, and viability. Shortening the daily photoperiod by blindfolding can improve the reproductive performance of dromedary camel bulls during the non-breeding season and the following breeding season. This simple, inexpensive, and easily applicable method can enable breeders to collect semen of acceptable quality during the non-breeding season.

1. Introduction

Camels are short-day breeders (October–April) in Saudi Arabia (Abdel-Rahim et al., 1994). While, in Egypt (Shalash and Nawito, 1965), in Sudan (Musa and Abusineina, 1978), in Somaliland (Mares, 1954), in Tunisia (Minoia et al., 1992), in Morocco (Sghiri and Driancourt, 1999), Pakistan (Yasin and Wahid, 1957), and in India (Matharu, 1966), the breeding season extends from December to

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March. The reproductive seasonality of camels (*Camelus dromedarius*) is an obstacle to improving their reproductive and productive efficiency (Bhakat et al., 2005; Skidmore, 2005; Marai et al., 2009). If a female camel does not give birth early in the breeding season, she may miss conceiving during the following breeding season (Vyas and Sahani, 2000). Therefore, the extension of the camel breeding season would be very valuable because the semen can be collected and processed from males and the embryos can be produced from females (Dholpuria et al., 2012). Reproductive seasonality in mammals is controlled by photoperiod via suprachiasmatic nuclei that send multi-neuronal circuits to the pineal gland, which secretes melatonin during the night. The circadian rhythm of melatonin secretion changes with the duration of the night and therefore the duration of melatonin changes seasonally. Through this variation of the nocturnal picture of melatonin, the signal of photoperiod is integrated by the body. Seasonal photoperiod control of reproduction occurs mainly through the seasonal variation of melatonin. Recently, two non-melatoninergic pathways to control seasonality of reproduction have been discovered in hamsters (Milesi et al., 2017). A first pathway is deiodinase 3 dependent and might trigger hypothalamic–pituitary–gonadal reactivation via a thyroid hormone spike. The second pathway is thyroid stimulating hormone, deiodinase 2 and neuropeptide (Kisspeptin and RFamide related peptide) dependent. This pathway is triggered after the first one to sustain and stabilize the reactivation (Milesi et al., 2017).

Camels have the ability to monitor and assimilate photoperiodic variations through changes in melatonin concentration through the seasonal variation in the picture of plasma melatonin concentrations (El Allali et al., 2005, 2013). Melatonin concentration is high during the night and low during the day (Arendt et al., 1985; Reiter, 1985a, b). The pattern of melatonin secretion in camels also shows a significant seasonal variation corresponding to photoperiodic changes of the year in temperate regions. The long duration of melatonin peak during a short day stimulates the reproductive hormones release and mating behavior during the breeding season (Vyas et al., 1997; El Allali et al., 2018).

Elongation of the breeding season can be achieved in two ways. The first is direct injection of melatonin, which modifies the hypothalamic–pituitary–gonadal endocrine function (Chemineau et al., 1988, 1992). Melatonin implants improve follicle growth in lactating camels and increase the libido of camel bulls during the non-breeding season (Dholpuria et al., 2012; Swelum et al., 2017; El Allali et al., 2018). These studies mimicked reducing photoperiod by melatonin implants. Few trials of decreasing the photoperiod have been conducted in females and none in males. The reduction of the photoperiod during the non-breeding season by placing a mask over the eyes, for 6 h daily for a period of 1–2 months, produced follicular activity in a high proportion of female camels (Agarwal and Khanna, 1998; Vyas et al., 2008).

To the best of our knowledge, the influence of a shortened photoperiod on the reproductive performance of camel bulls has not been studied. The present study aimed to evaluate the effect of a shortened photoperiod on the reproductive performance and hormones of dromedary camel bulls during the non-breeding season and the following breeding season.

2. Materials and methods

2.1. Camels and management

The study animals were 12 mature dromedary camel bulls (aged 6–8 years, body weight 800–900 kg). The animals were housed individually in open yards at the Experimental Farm, Department of Animal Production, King Saud University, Riyadh (latitude 24° 48` N and longitude 46° 31` E), Saudi Arabia. The animals were fed alfalfa hay and concentrate and had free access to fresh water and mineralized salt blocks. The camel-bulls had a good reproductive history and appeared healthy and free from diseases, including those of a reproductive nature (anatomical, pathological or infectious diseases). The experimental protocol regarding the care and handling of camels was approved by the Ethics Committee of the king Saud University, Riyadh, Saudi Arabia.

2.2. Experimental design

The camel bulls were randomly assigned to two groups of 6 camels each. The control group experienced natural day length. The camels in the other group were subjected to a daily shortened photoperiod using the light-dark cycle 10.83L:13.17D by having their eyes blindfolded ≈2.55 h before sunset. The eye-cover was made manually from palm fronds and tested using a light-meter (DLAF-8000, MANNIX, Taiwan) to be sure that the illuminance under the cover was 0 lx (Fig. 1). The eye-cover blocked the camel's vision; however, there was no observed evidence of compromised health or behavior during the experiment. The illuminance outside the eye-cover ≈2.55 h before sunset was < 9000 lx; it decreased gradually and reached 0 lx directly after sunset. The trial was carried out during the non-breeding season starting between June and August when the natural day length ranged from 12.78 to 13.68 h (mean 13.38 ± 2.03) and the reproductive performance of all animals was evaluated weekly for 10 weeks. The control and treatment groups during the non-breeding season were described as the CNB and ENB groups, respectively. During the breeding season (December–February), the natural day length ranged from 10.68 to 11.32 h (mean 10.83 ± 1.52), and again the reproductive performance of all animals was evaluated weekly for 10 weeks. The control and treatment groups during the breeding season were described as the CB and EB groups, respectively.

2.3. Scrotal circumference and testicular volume calculation

The scrotal circumference and left testicular length, width, and height were measured at the maximum dimension in a sitting position at one-week intervals using a coulter scrotal tape and caliper. The left testicular volume was calculated using the following formula: volume = length × width × height × 0.5236 (Ghoneim et al., 2012).