

# Housing Management of Male Dromedaries

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Housing systems that guarantee social interaction and physical activity are the most suitable housing management systems for captive male dromedaries during the rutting season.

Keywords: dromedary ; male ; behavior ; breeding system ; welfare ; breeding

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## 1. Introduction

Global climate changes, which are characterized by increasing desertification, high temperatures and drought, provide a driver to reconsider animal species that are bred in the livestock sector <sup>[1]</sup>. Animal species that can genetically adapt to such environmental conditions should be given more attentions. Dromedary camel (*Camelus dromedarius*) is one of the most adapted animals to harsh environmental conditions <sup>[2]</sup>. In many drought-prone arid and semi-arid regions, dromedaries play a great role in the livelihood as breeding of other animals under such conditions face several obstacles. Camel breeding in intensive farming systems has been increasingly established, since reconstitution of animal species used for meat and milk production has become a crucial demand under current drastic environmental changes. Compared to other livestock species, dromedaries have received less attention by the scientific community. Thus, understanding the physiological and behavioral properties of dromedaries facilitates ideal harness of their natural advantages under intensive farming systems.

Dromedaries are classified as seasonal breeders, with a restricted breeding season that varies from two to six months <sup>[3]</sup>. The breeding season extends from December to March in Egypt <sup>[4]</sup>, Tunisia <sup>[5]</sup>, Somaliland <sup>[6]</sup>, Pakistan <sup>[7]</sup>, India <sup>[8]</sup> and Sudan <sup>[9]</sup>. In Saudi Arabia and United Arab Emirates, the breeding season extends from October to April <sup>[10][11]</sup>. This relatively short breeding season limits reproductive performance and is considered one of the most constraints facing camel breeding <sup>[12][13][14]</sup>. Moreover, during the breeding season, male dromedaries exhibit aggressive behavior and substantial physiological, morphologic and behavioral changes negatively affecting animal performance <sup>[15]</sup>. In intensive farming systems, dromedaries are kept in captive conditions. Moreover, during the rutting season, male dromedaries are conventionally kept tied with ropes in small pens and/or kept in single stalls to avoid aggression toward other males and humans <sup>[16]</sup>. This breeding system may negatively affect animal welfare and increases negative effects of sexual activity-related peculiarities on animal performance. Padalino et al. <sup>[17]</sup> stated that male dromedaries showed both oral and locomotor stereotypy most frequently when the bulls were housed in single boxes for 24 h, indicating poorer animal welfare. In context, Fatnassi et al. <sup>[15]</sup> found that male dromedaries housed in a single stall for 22 h and 30 min, with one hour of paddock time and 30 min of exposure to a female camel herd had significantly higher sexual behavior scores, behavioral repertoires and decreased cortisol levels than those housed in a single stall for 24 h and those housed in a single stall for two to three hours with one hour free in the paddock. Skidmore <sup>[18]</sup> reports that male dromedaries kept in herds tended to start breeding earlier with longer rutting periods than that of confined males, confirming the relationship between housing system and sexual behavior. Farsi et al. <sup>[19]</sup> developed a highly reliable and sufficiently accurate scoring method to assess conveniently the locomotor activity rhythm and specific behaviors in camels. Accordingly, achieving the ideal housing system of male dromedaries during the rutting season can contribute to maximizing animal reproductive performance and reducing sexual-associated aggressiveness, thus improving animal welfare.

## 2. Effect on Behavioral Patterns

The effects of social contact (single or group), movement control (tied, fenced or exercised) and their interaction on frequency and duration of maintenance and posture behaviors of male dromedaries during the rutting season are presented in **Table 1**. Social contact with other animals significantly affected maintenance and posture behaviors. Group-housed male dromedaries expressed higher ( $p < 0.001$ ) frequencies of maintenance (ruminating) and posture (lying, standing and walking) behaviors than single-housed male dromedaries. Group-housed male dromedaries devoted longer times ( $p < 0.001$ ) for ruminating and walking than single-housed male dromedaries, whereas single-housed male

dromedaries devoted longer times ( $p < 0.001$ ) for lying and standing behaviors. Movement-control method significantly affected maintenance and posture behaviors. Compared to tied and fenced male dromedaries, exercised male dromedaries expressed higher frequencies and longer durations ( $p < 0.001$ ) of ruminating, standing and walking behaviors. On the other hand, tied male dromedaries gave preference ( $p < 0.001$ ) to lying behavior compared to fenced and exercised male dromedaries. Analysis of animal social contact by movement control showed that, regardless of social contact, male dromedaries that group housed in contact with other dromedaries, expressed higher frequencies and longer durations ( $p < 0.001$ ) of ruminating than male dromedaries in other housing systems. Male dromedaries in the tied housing system expressed higher frequencies and longer durations ( $p < 0.001$ ) of lying behavior than male dromedaries in other housing systems. Male dromedaries that were fenced or were exercised (single-fenced, single-exercised, group-fenced and group-exercised) expressed higher frequencies and longer durations ( $p < 0.001$ ) of standing and walking behaviors than male dromedaries in other housing systems.

**Table 1.** Effects of social contact, movement control and their interaction on frequency (n/20 min) and duration (sec/20 min) of maintenance and posture behaviors of male dromedaries during the rutting season.

Factors	Variable							
	Maintenance		Posture					
	Ruminating		Lying		Standing		Walking	
	Frequency	Duration	Frequency	Duration	Frequency	Duration	Frequency	Duration
Social contact								
Single	6.97 <sup>b</sup>	78.50 <sup>b</sup>	2.44 <sup>b</sup>	139.08 <sup>a</sup>	5.89 <sup>b</sup>	118.75 <sup>a</sup>	3.33 <sup>b</sup>	54.89 <sup>b</sup>
Group	12.86 <sup>a</sup>	91.11 <sup>a</sup>	5.55 <sup>a</sup>	114.66 <sup>b</sup>	8.00 <sup>a</sup>	101.42 <sup>b</sup>	6.67 <sup>a</sup>	75.83 <sup>a</sup>
SEM	0.463	0.979	0.270	1.39	0.412	1.60	0.435	1.17
<i>p</i> value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Movement control								
Tied	7.83 <sup>b</sup>	79.00 <sup>c</sup>	6.50 <sup>a</sup>	154.63 <sup>a</sup>	3.50 <sup>c</sup>	88.75 <sup>c</sup>	1.50 <sup>c</sup>	50.25 <sup>b</sup>
Fenced	9.25 <sup>ab</sup>	85.25 <sup>b</sup>	3.33 <sup>b</sup>	115.00 <sup>b</sup>	7.67 <sup>b</sup>	116.00 <sup>b</sup>	5.00 <sup>b</sup>	62.33 <sup>b</sup>
Exercised	12.66 <sup>a</sup>	90.16 <sup>a</sup>	2.17 <sup>c</sup>	111.00 <sup>b</sup>	9.67 <sup>a</sup>	125.50 <sup>a</sup>	8.50 <sup>a</sup>	73.50 <sup>a</sup>
SEM	0.513	1.08	0.299	1.56	0.456	1.77	0.482	1.30
<i>p</i> value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Social contact × movement control								
Single-tied	7.25 <sup>cd</sup>	80.50 <sup>c</sup>	6.00 <sup>b</sup>	161.25 <sup>a</sup>	5.03 <sup>c</sup>	92.25 <sup>d</sup>	1.21 <sup>c</sup>	45.00 <sup>c</sup>
Single-fenced	5.33 <sup>d</sup>	73.73 <sup>d</sup>	2.33 <sup>cd</sup>	130.00 <sup>c</sup>	8.07 <sup>b</sup>	127.00 <sup>b</sup>	4.12 <sup>bc</sup>	57.67 <sup>b</sup>
Single-exercised	8.33 <sup>c</sup>	82.02 <sup>c</sup>	1.10 <sup>d</sup>	126.12 <sup>c</sup>	11.00 <sup>a</sup>	137.00 <sup>a</sup>	5.04 <sup>b</sup>	62.71 <sup>b</sup>
Group-tied	11.25 <sup>ab</sup>	90.00 <sup>b</sup>	9.00 <sup>a</sup>	148.00 <sup>b</sup>	2.00 <sup>d</sup>	85.25 <sup>d</sup>	2.93 <sup>c</sup>	55.50 <sup>b</sup>
Group-fenced	10.33 <sup>b</sup>	85.17 <sup>c</sup>	4.33 <sup>bc</sup>	100.07 <sup>d</sup>	7.33 <sup>bc</sup>	105.00 <sup>c</sup>	6.50 <sup>b</sup>	87.09 <sup>a</sup>
Group-exercised	17.00 <sup>a</sup>	98.33 <sup>a</sup>	3.33 <sup>c</sup>	96.25 <sup>d</sup>	8.33 <sup>b</sup>	114.00 <sup>c</sup>	12.00 <sup>a</sup>	85.10 <sup>a</sup>
SEM	0.70	1.5	0.54	2.5	0.63	2.69	0.79	2.1
<i>p</i> value	0.015	0.021	0.027	0.003	0.029	0.018	0.003	0.001

Means ± SEM in each column with no common superscript letter differ significantly ( $p < 0.05$ ).

### 3. Effect on Sexual Activity

The effects of animal social contact (single or group), movement control (tied, fenced or exercised) and their interaction on sexual behavior of male dromedaries during the rutting season are presented in **Table 2**. Animal social contact significantly affected the sexual behavior of male dromedaries. Male dromedaries housed in groups expressed higher frequencies of sexual desire-related behaviors (teeth grinding, opening legs, flapping tail, extruding dulla, blathering and

urinating) than those individually housed. Movement control significantly affected sexual behavior; fenced and exercised male dromedaries expressed higher frequencies of sexual desire-related behaviors than tied male dromedaries. Animal social contact by movement control interaction revealed that male dromedaries that controlled by tying whether in contact with other animals or in groups single-tied and group-tied expressed lower ( $p < 0.05$ ) sexual desire-related behaviors than camel in other housing systems.

**Table 2.** Effects of social contact, movement control and their interaction on sexual behavior of male dromedaries during the rutting season.

Factors	Sexual Behavior Parameters					
	Teeth Grinding	Leg Opening	Tail Flapping	Dulla Extruding	Blathering	Urinating
Social contact						
Single	5.33 <sup>b</sup>	3.56 <sup>b</sup>	2.33 <sup>b</sup>	2.67 <sup>b</sup>	2.53 <sup>b</sup>	5.08 <sup>b</sup>
Group	7.00 <sup>a</sup>	5.22 <sup>a</sup>	3.33 <sup>a</sup>	4.67 <sup>a</sup>	3.75 <sup>a</sup>	6.19 <sup>a</sup>
SEM	0.435	0.393	0.381	0.362	0.313	0.350
<i>p</i> value	<0.001	<0.001	<0.001	0.009	0.002	<0.001
Movement control						
Tied	2.50 <sup>c</sup>	1.50 <sup>c</sup>	1.00 <sup>c</sup>	2.50 <sup>b</sup>	1.75 <sup>b</sup>	2.75 <sup>b</sup>
Fenced	7.00 <sup>b</sup>	5.00 <sup>b</sup>	2.50 <sup>b</sup>	4.00 <sup>a</sup>	3.33 <sup>a</sup>	6.83 <sup>a</sup>
Exercised	9.00 <sup>a</sup>	6.67 <sup>a</sup>	5.00 <sup>a</sup>	4.50 <sup>a</sup>	4.33 <sup>a</sup>	7.33 <sup>a</sup>
SEM	0.482	0.504	0.422	0.401	0.347	0.387
<i>p</i> value	0.017	0.004	0.005	0.001	0.01	0.041
Social contact × movement control						
Single-tied	2.23 <sup>c</sup>	1.05 <sup>c</sup>	1.20 <sup>c</sup>	2.50	1.25	2.25 <sup>c</sup>
Single-fenced	6.47 <sup>b</sup>	4.06 <sup>b</sup>	2.00 <sup>bc</sup>	3.17	2.33	7.00 <sup>b</sup>
Single-exercised	8.05 <sup>ab</sup>	5.67 <sup>ab</sup>	4.2 <sup>ab</sup>	3.00	4.00	6.00 <sup>b</sup>
Group-tied	3.21 <sup>c</sup>	2.00 <sup>c</sup>	1.07 <sup>c</sup>	3.20	2.25	3.25 <sup>c</sup>
Group-fenced	8.20 <sup>ab</sup>	6.00 <sup>ab</sup>	3.00 <sup>ab</sup>	5.52	4.33	6.67 <sup>b</sup>
Group-exercised	10.42 <sup>a</sup>	7.67 <sup>a</sup>	6.20 <sup>a</sup>	6.00	4.67	8.67 <sup>a</sup>
SEM	0.68	0.58	0.60	0.54	0.50	0.57
<i>p</i> value	0.029	0.023	0.033	0.255	0.603	0.039

Means ± SEM in each column with no common superscript letter differ significantly ( $p < 0.05$ ).

## 4. Effect on Blood Serum Major Proteins and Energy-Yielding Metabolites

The effects of animal social contact (single or group), movement control (tied, fenced or exercised) and their interaction on concentrations of blood serum major proteins and energy-yielding metabolites of male dromedaries during the rutting season are presented in **Table 3**. Animal social contact did not affect the concentrations of blood serum major proteins and energy-yielding metabolites ( $p > 0.05$ ). Movement-control method significantly affected concentrations of blood serum major proteins, glucose and cholesterol. Tied male dromedaries had the highest ( $p < 0.001$ ) concentrations of blood serum total protein, followed by exercised and fenced male dromedaries. Tied male dromedaries had the highest ( $p < 0.001$ ) globulin concentrations compared to exercised and fenced male dromedaries, whereas concentrations of blood serum albumin followed an opposite trend. Tied male dromedaries had the lowest ( $p < 0.001$ ) concentrations of blood serum glucose and cholesterol, followed by exercised and fenced male dromedaries. The interaction analysis between animal social contact and movement control revealed that the single-tied and group-tied dromedaries had the highest ( $p < 0.001$ ) concentrations of blood serum total protein and globulin, followed by those in the single-exercised and group-exercised dromedaries, and the lowest values were in the single-fenced and group-fenced dromedaries. The single-

exercised and group-exercised dromedaries had the highest ( $p < 0.001$ ) concentrations of blood serum total protein and globulin, followed by those in the single-fenced and group-fenced dromedaries, and the lowest values were in the single-tied and group-tied dromedaries.

**Table 3.** Effects of social contact, movement control and their interaction on concentrations of blood serum major proteins and energy-yielding metabolites of male dromedaries during the rutting season.

Factors	Variables					
	Major Blood Serum Proteins (g/dL)			Energy-Yielding Metabolites (mg/dL)		
	Total Protein	Albumin	Globulin	Glucose	Cholesterol	Triglycerides
Social contact						
Single	6.91	3.14	3.69	82.83	53.55	54.67
Group	6.80	3.14	3.80	82.30	53.96	55.74
SEM	0.114	0.149	0.416	1.69	0.831	1.11
<i>p</i> value	0.579	0.989	0.842	0.828	0.735	0.502
Movement control						
Tied	7.26 <sup>a</sup>	2.65 <sup>b</sup>	4.91 <sup>a</sup>	68.38 <sup>c</sup>	39.45 <sup>c</sup>	54.75
Fenced	5.95 <sup>c</sup>	3.36 <sup>a</sup>	2.59 <sup>b</sup>	82.38 <sup>b</sup>	55.40 <sup>b</sup>	52.83
Exercised	6.75 <sup>b</sup>	3.41 <sup>a</sup>	3.85 <sup>b</sup>	96.95 <sup>a</sup>	66.43 <sup>a</sup>	58.03
SEM	0.146	0.18	0.431	1.87	1.06	1.41
<i>p</i> value	<0.001	0.014	<0.001	<0.001	<0.001	0.060
Social contact × movement control						
Single-tied	7.51 <sup>a</sup>	2.73	4.78 <sup>a</sup>	68.51 <sup>c</sup>	39.00 <sup>c</sup>	54.00
Single-fenced	5.91 <sup>c</sup>	3.28	2.63 <sup>c</sup>	81.67 <sup>b</sup>	52.00 <sup>b</sup>	54.67
Single-exercised	6.70 <sup>b</sup>	3.40	3.30 <sup>b</sup>	98.33 <sup>a</sup>	67.00 <sup>a</sup>	58.00
Group-tied	7.61 <sup>a</sup>	2.58	5.04 <sup>a</sup>	68.25 <sup>c</sup>	39.88 <sup>c</sup>	55.50
Group-fenced	5.98 <sup>c</sup>	3.4	2.55 <sup>c</sup>	83.10 <sup>b</sup>	56.13 <sup>b</sup>	53.67
Group-exercised	6.80 <sup>b</sup>	3.4	3.40 <sup>b</sup>	95.57 <sup>a</sup>	65.88 <sup>a</sup>	58.07
SEM	0.179	0.270	0.228	3.05	1.51	1.73
<i>p</i> value	<0.001	0.835	<0.001	<0.001	<0.001	0.905

Means ± SEM in each column with no common superscript letter differ significantly ( $p < 0.05$ ).

## 5. Effect on Hormone Levels and Mineral Balance

The effects of animal social contact (single or group), movement control (tied, fenced or exercised) and their interaction on concentrations of blood serum hormones and minerals of male dromedaries during the rutting season are presented in **Table 4**. Animal social contact significantly affected the concentration of blood serum cortisol. Single-housed male dromedaries had higher ( $p = 0.004$ ) cortisol concentrations than group-housed male dromedaries. Movement-control method significantly affected concentrations of blood serum cortisol, testosterone and T3. Tied male dromedaries had the highest significant concentrations of blood serum cortisol and T3; while, fenced male dromedaries had the highest concentrations of blood serum testosterone. The single-tied and group-tied dromedaries had highest ( $p < 0.001$ ) concentrations of blood serum cortisol and T3, followed by those in the single-exercised and group-exercised dromedaries while those in the Single-fenced and group-fenced dromedaries had the lowest values. The group-fenced dromedaries had the highest concentrations of blood serum testosterone, whereas the group-exercised dromedaries had the lowest values, and male dromedaries in the other groups had intermediate values. Serum mineral concentrations were not affected by animal social contact, movement control and their interaction. Except the significant increases in magnesium concentrations ( $p = 0.005$ ) in the fenced and exercised groups and potassium concentrations ( $p = 0.026$ ) in fenced group. The group-fenced dromedaries had higher ( $p = 0.020$ ) concentrations of serum magnesium than in the single-tied group.

**Table 4.** Effects of social contact, movement control and their interaction on concentrations of blood serum hormones and minerals of male dromedaries during the rutting season.

Factor	Variables						
	Hormones			Minerals			
	Cortisol (nmol/L)	Testosterone (ng/mL)	Triiodothyronine (ng/mL)	Calcium (mg/dL)	Phosphorous (mg/dL)	Magnesium (mg/dL)	Potassium (mg/dL)
Social contact							
Single	66.89 <sup>a</sup>	2.05	1.09	2.42	2.27	0.914	3.67
Group	62.54 <sup>b</sup>	2.41	1.08	2.54	2.31	1.04	3.87
SEM	0.707	0.190	0.044	0.078	0.033	0.051	0.017
<i>p</i> value	0.004	0.113	0.728	0.361	0.765	0.106	0.162
Movement control							
Tied	89.81 <sup>a</sup>	1.69 <sup>b</sup>	2.03 <sup>a</sup>	2.55	2.31	0.796 <sup>b</sup>	3.55 <sup>b</sup>
Fenced	44.12 <sup>c</sup>	2.91 <sup>a</sup>	1.68 <sup>b</sup>	2.40	2.29	1.13 <sup>a</sup>	4.05 <sup>a</sup>
Exercised	53.52 <sup>b</sup>	2.09 <sup>ab</sup>	1.91 <sup>b</sup>	2.47	2.25	0.998 <sup>a</sup>	3.88 <sup>ab</sup>
SEM	0.783	0.116	0.056	0.078	0.033	0.064	0.091
<i>p</i> value	<0.001	0.002	<0.001	0.613	0.807	0.005	0.026
Social contact × movement control							
Single-tied	91.00 <sup>a</sup>	1.95 <sup>bc</sup>	2.03 <sup>a</sup>	2.48	2.25	0.78 <sup>c</sup>	3.48
Single-fenced	46.63 <sup>c</sup>	2.67 <sup>ab</sup>	1.68 <sup>c</sup>	2.37	2.30	1.07 <sup>ab</sup>	3.90
Single-exercised	55.00 <sup>b</sup>	1.53 <sup>c</sup>	1.90 <sup>b</sup>	2.40	2.28	0.90 <sup>bc</sup>	3.70
Group-tied	88.63 <sup>a</sup>	2.23 <sup>bc</sup>	2.05 <sup>a</sup>	2.63	2.38	0.82 <sup>bc</sup>	3.62
Group-fenced	41.60 <sup>c</sup>	3.15 <sup>a</sup>	1.70 <sup>c</sup>	2.43	2.29	1.20 <sup>a</sup>	4.20
Group-exercised	52.03 <sup>b</sup>	1.85 <sup>bc</sup>	1.92 <sup>b</sup>	2.55	2.23	1.10 <sup>ab</sup>	3.86
SEM	1.07	0.24	0.06	0.14	0.09	0.07	0.15
<i>p</i> value	<0.001	0.009	<0.001	0.953	0.668	0.020	0.091

Means ± SEM in each column with no common superscript letter differ significantly ( $p < 0.05$ ).

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