

## Water Intake in Omani Camels Fed Various Levels of Feed Under Intensive Management

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**Submitted:** October 12, 2025; **Accepted:** November 5, 2025; **Published:** June 15, 2026

### Abstract

This study was conducted to determine the water intake of Omani one-humped camels (*Camelus dromedarius*) fed different levels of feed under controlled feedlot conditions. Ten Omani camels were housed in individual pens and offered rations containing 60–80 % concentrate and 20–40 % Rhodes grass hay at three feeding levels corresponding to 1.0, 1.5, and 2.0 % of their body weight (BW). Water was provided *ad libitum*, and individual daily intakes were recorded for 14 weeks. The average daily water intake ranged from 17.0 to 30.4 l day<sup>-1</sup>, with a mean of 24.1 ± 4.7 l day<sup>-1</sup>, equivalent to 7.5–14.3 % of BW (mean 10.5 ± 1.8%). There was a clear trend of increasing water consumption with increasing feed intake level. Statistical analysis indicated a positive and curvilinear (polynomial) relationship between daily water intake and body weight. The regression model developed in this study provides a predictive tool for estimating water requirements of camels under intensive feeding systems. These findings offer baseline information for optimizing feeding and watering management of camels raised under feedlot or semi-intensive production in arid environments such as Oman, thereby contributing to improved animal performance, welfare, and resource use efficiency.

**Keywords:** *Camelus dromedarius*, water intake, feed level, feedlot management, Oman,

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### Introduction

Camels play a vital role in enhancing food security and promoting sustainability, especially in arid and semi-arid zones (Faraz, 2020). Their extraordinary ability to adapt to harsh conditions enables them to thrive in areas where other livestock struggle to survive (Faraz et al., 2019). The importance of camels is further heightened by the drastic environmental changes caused by progressive climate change and the instability of global economies. The production of milk and meat from camels generates fewer greenhouse gases compared to

cattle, thereby aiding in the creation of a cleaner, pollution-free environment because of camels' lower metabolism, better food and water efficiency, and lower methane emissions (Dittmann, 2014).

Camels make a significant contribution to the preservation of biodiversity in arid and dry regions (Al-Asaad, 2024). In traditional camel production systems, production costs are minimal (Kadim et al., 2008). This is mainly attributed to their resilience in enduring the most challenging intensive and extensive rearing systems to yield high-quality animal

protein. Additionally, they have low management expenses and effective utilization of lower-quality feeds that are not consumed by other livestock (Faraz et al., 2019). The costs associated with camel meat production are lower than those of other livestock because they are usually raised by nomadic herders in arid environments. Even in commercial settings, camels remain less expensive than other types of meat-producing animals. In Saudi Arabia, the production cost of camels varies from US\$618 to US\$875, depending on the size of the herd (Al Khamis and Young, 2006).

Camels tolerate high temperatures and low levels and quality of drinking water (Wilson, 1989). However, reduced water intake or increasing water salinity in the camel may reduce feed intake (Ayoub, 2006; Hashi et al., 1995). Water requirements of the camel in relation to body size and normal functions do not greatly differ from that of other farm animals (Wilson, 1989).

Camels deprived of water can drink very large volumes quickly (Faraz et al., 2021). This enables recovery after a long period of time without water (Schmidt-Nielsen, 1956). When water is available daily, water intake depends on the diet and environment. Lactating camels remain in the shade, maintain a low body temperature, and generate plasma vasopressin to decrease water losses and conserved water after drinking. Nevertheless, severe dehydration was noted during 8-day water deprivation, and recovery required a lengthy period following 16 days of water deprivation. Similar environmental conditions seem to suggest a watering interval of 4–7 days (Bekele et al., 2013).

Camels can tolerate losses of large body-water that may be up to 40% of body weight by allowing body temperature to rise during the day to reduce evaporative cooling, then dissipating heat at night (Bekele et al., 2013). This reduces water loss through

sweating/respiration (Schmidt-Nielsen, 1956). Camel kidneys concentrate urine efficiently and reduce obligatory water loss. Histological and molecular studies showed adaptive changes in aquaporins and solute carrier expression during dehydration/rehydration cycles (Damir et al., 2024). The camel's long nasal passages and vascular arrangements recover water from exhaled air; combined with limited sweating, this reduces respiratory and cutaneous water loss (Bekele et al., 2013).

Camels fed moist forage use significantly less drinking water because browse plant species like acacia or succulent plants provide substantial amounts of water. However, camels who consume high-salt forages, such as *Atriplex*, will need more water in order to eliminate salts. Thus, the content of the feed alters the amount of water that camels need to consume. Although it responds favourably to superior fodder from wet-season or irrigated pasture, the camel is generally a browser with a low water need and may survive on subpar diet (Knoess, 1977).

The objective of this research is to measure water intake in general and specifically to study the effect of feed intake on water intake in feedlot camels.

## Materials & Methods

Ten 6–8-month-old Omani male camels of  $203.5 \pm 15.5$  kg average body weight (BWT) were purchased from Dhofar (south Oman) and transported to Sultan Qaboos University (SQU) Agricultural Experiment Station (AES). Upon arrival animals were quarantined for two months during which they were treated for internal and external parasites and some skin infection. Camels were then housed in partially shaded pens equipped with individual concentrate and hay troughs as well as automatic water troughs (Figure 1).



**Figure 1:** Camels individually housed and fed



**Figure 2:** Water meters used for measuring water intake

Camels were fed a concentrate and Rhodes grass hay (RGH) diet. The concentrate feed was a 14% crude protein (CP) pelleted feed manufactured by the National Livestock Development Company, Salalah, Sultanate of Oman. The feeding period continued for 162 days at the end of which those camels were slaughtered. Mineral blocks were offered *ad*

*libitum*. The concentrate and RGH chemical composition are given in Table 1. Camels were randomly allocated into three groups: two, four and four camels received a feed intake equivalent to 1.5, 2.0 and 2.5% of body weight, respectively with 60:40 concentrate:RGH ratio for 14 weeks.

**Table 1.** Chemical composition of the concentrate feed and Rhodes grass hay used for feeding camels.

| Feed             | DM%   | CP    | EE   | Ash   | CF    | ADF   | NDF   |
|------------------|-------|-------|------|-------|-------|-------|-------|
| Concentrate      | 92.46 | 14.35 | 1.8  | 12.12 | 19.34 | 24.06 | 51.28 |
| Rhodes grass hay | 91.52 | 9.43  | 1.08 | 9.59  | 30.62 | 35.82 | 68.32 |

Water meters were fitted to automatic water troughs (Figure 2). Readings were made on these meters every day in the morning and water intake was measured. Water intake was adjusted for evaporation using pan system.

### Statistical Analyses

Data were subjected to analysis of variance using the General Linear Models procedure of SAS (1991) for effects of level of feed intake, using the diet as a class in the GLM statement in a completely randomised experimental

design. Significant treatment means were assessed using LsMEANS command on the (SAS (1991)). Significant differences were accepted if  $P < 0.05$ .

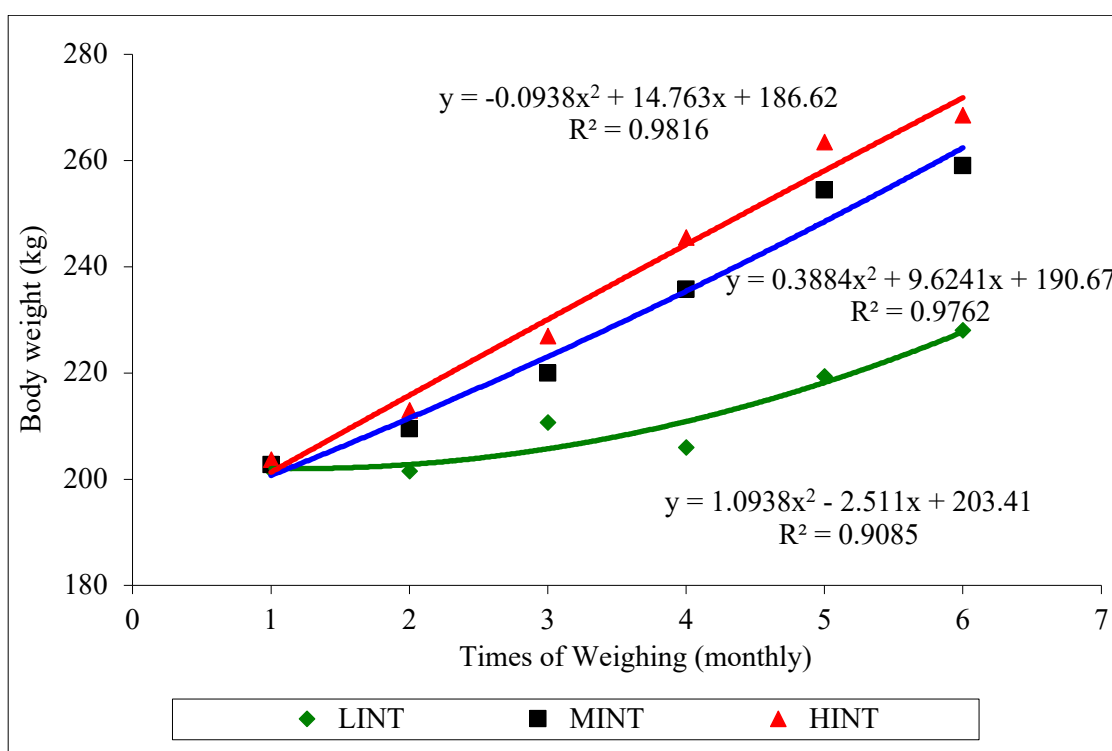
### Results and Discussion

#### *Feed Intake and Body Weight Growth*

The camel's initial weight averaged 203.5 kg whereas their mean final body weight was  $256.6 \pm 32.3$  kg (range 218-322 kg). The camels on the 2.5% BW intake gained more weight

(64.5 kg) over the study period followed by those on the medium intake (56.3 kg). The camels on the low feed intake (1.5% BW) grew at the slowest rate but did not lose weight gaining 11.5 kg over the experimental period (Table 2). The average daily gain was 71, 347 and 400 g/d for the animals given low, medium and high intake (Table 2). Figure 3 describes the growth curves of the camels in various treatment groups. Camels on the 2.5% BW

intake grew at a much higher linear pattern indicating a greater growth potential and they were closely followed by those on the medium intake allowance (2.0% BW). Animals on the lowest feed intake grew at a much slower rate with a trend of increasing growth rate after the 3rd month. This was coinciding with the increase of the concentrate:hay ratio from 3:2 to 4:1.



**Figure 3:** Body weight growth of the three groups of camels fed low, medium and high intake

**Feed Intake and conversion**

The camels on the high feed intake obviously consumed more concentrate feeds than the other 2 groups. The 2.5% BW intake group feed intake was more than double that consumed by camels on the low intake (Table 2). Both animals on the medium and high intake consumed more hay than those on low intake

but there was no difference between the 2.0 and 2.5% BW groups in hay intake (Table 2). This indicates that high concentrate intake will be accompanied by low hay intake at this level. This most probably was because of the high fibre content in the concentrate diet (Table 2). The average daily feed intake (concentrate+hay) was 2.522, 4.232 and 5.157 kg, for the low, medium and high feed intake.

**Table 2.** Body weight growth parameters, feed intake and feed conversion in Omani camels maintained on 3 levels of feed intake.

| Parameter                             | Experimental Group |        |        |       |        |       | Treatment effect |
|---------------------------------------|--------------------|--------|--------|-------|--------|-------|------------------|
|                                       | Low                |        | Medium |       | High   |       |                  |
|                                       | Mean               | SE     | Mean   | SE    | Mean   | SE    |                  |
| Average daily concentrate intake (kg) | 1.451              | 0.228  | 2.520  | 0.198 | 3.487  | 0.198 | ***              |
| Average daily hay intake (kg)         | 1.071              | 0.077  | 1.712  | 0.066 | 1.670  | 0.066 | ***              |
| Average daily total intake (kg)       | 2.522              | 0.263  | 4.232  | 0.227 | 5.157  | 0.227 | ***              |
| Total feed Intake (kg)                | 408.5              | 42.53  | 685.6  | 36.83 | 835.46 | 36.83 | **               |
| Intake (% BW)                         | 1.20               | 0.004  | 1.84   | 0.003 | 2.19   | 0.003 | ***              |
| Initial BW (kg)                       | 204.0              | 17.021 | 202.8  | 14.74 | 203.75 | 14.74 | NS               |
| Final BW (kg)                         | 228.0              | 22.600 | 259.0  | 15.98 | 268.50 | 15.98 | NS               |
| Total BW gain (kg)                    | 11.50              | 6.000  | 56.25  | 4.243 | 64.50  | 4.243 | **               |
| Average daily gain (g/d)              | 71                 | 37.0   | 347    | 26.2  | 400.0  | 26.2  | **               |
| Feed conversion ratio (FCR)           | 35.48              | 0.590  | 12.21  | 0.590 | 12.96  | 0.590 | *                |

### Water Intake

The average daily water intake in camels in the current study ranged between 17 to 30.4 l/d with a mean  $24.1 \pm 4.7$  l (Table 3). This corresponded to 7.5-14.3% of body weight (mean  $10.5 \pm 1.8\%$  BW). Reports in the literature on camel water intake vary greatly as it is affected by ambient temperature (season), type of feed and body weight (Faraz et al., 2021). For instance, Basmaeil et al. (2012) reported a daily water intake of 11.65 to 12.96 l day<sup>-1</sup> in Saudi camels of mixed breeds ranged in

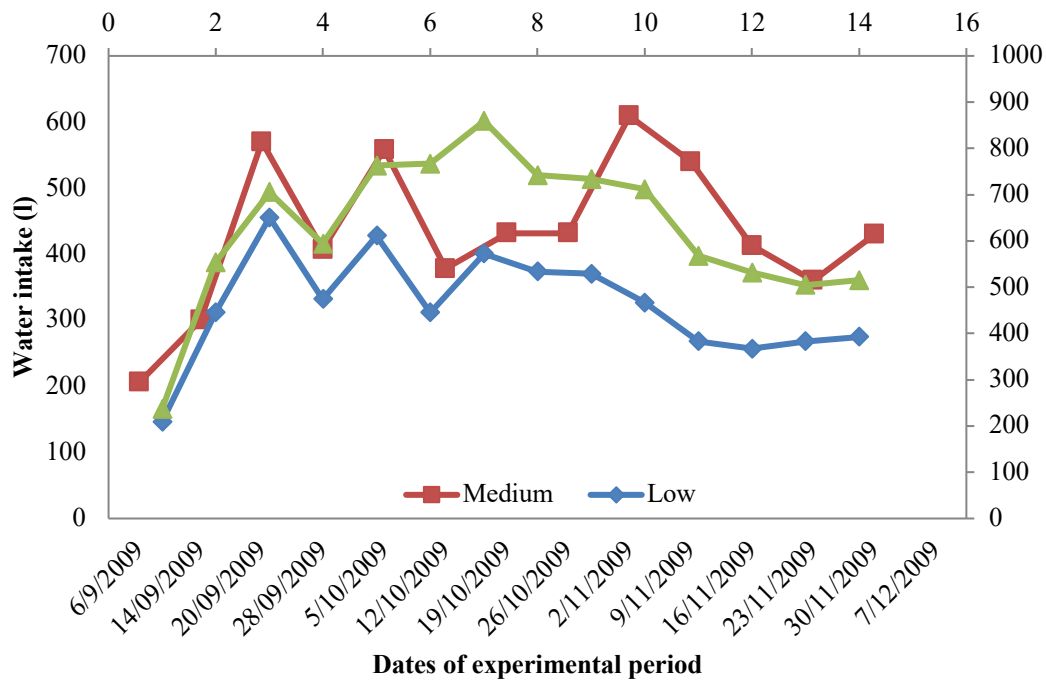
BW between 270-292 kg. This corresponds to 4.4-5.6% BW. The season had a significant effect on water intake by camels. Hermas (1990) reported a daily water intake of 23, 55, 40 and 16 l day<sup>-1</sup> in spring, summer, autumn and winter in Libyan camels. These figures are more relevant to those of the current study (mean 24 l day<sup>-1</sup>). Faraz et al. (2021) reported a mean values of daily water intake of  $82.9 \pm 1.34$  l in dairy camels with higher values for camels deprived from water for 6 days having higher intakes than those deprived for 1- 4 days.

**Table 3:** Water intake in Omani camels.

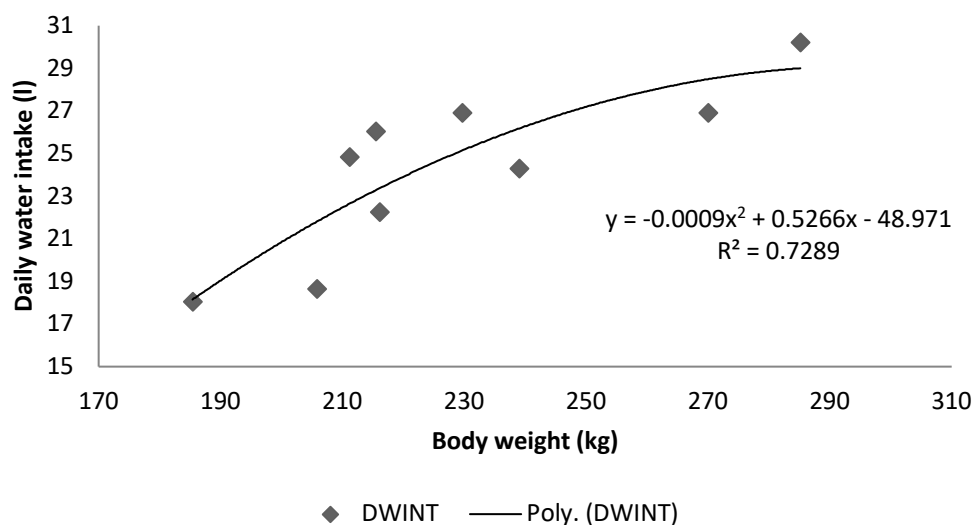
| Measurement                        | Mean   | SD     | Median | Maximum | Minimum |
|------------------------------------|--------|--------|--------|---------|---------|
| Total water intake over 14 weeks   | 8084.8 | 1561.0 | 8319.6 | 10184.6 | 5697.6  |
| Daily water intake (l/d)           | 24.1   | 4.7    | 24.8   | 30.4    | 17.0    |
| Daily water intake/body weight (%) | 10.7   | 1.79   | 10.3   | 14.3    | 7.5     |

Water intake by the different experimental groups over the study period is given in Figure 4. There was a trend of increasing water intake with increasing feed intake. However, the lines representing medium and high feed intakes overlap which indicates no differences between the two groups. Regressing average daily water intake with camel body weight indicated a significant relationship ( $R^2=0.73$ ) and generated a polynomial equation to predict water intake from camel body weight (Figure 5).

Water intake analysis helps in optimizing feed efficiency. Water intake is intrinsically linked with feed intake; cattle that drink less tend to eat less, which can directly affect milk production in dairy cows or weight gain in beef cattle (Pires et al., 2022). Consequently, by monitoring these metrics, farmers can adjust diets and management practices.



**Figure 4:** Water intake in Omani camels fed low, medium and high feed intake



**Figure 5:** Average daily water intake in Omani camels regressed with body weight

Therefore, from a practical point of view, if water access is intermittent, camels should have free access at rehydration as camels can safely drink large volumes but more rapidly when previously deprived. Stocking density, water trough capacity and water quality, especially salinity, should be monitored because these drive both intake and health. There is need for more frequent watering and attention for electrolyte balance in lactating and working animals. Although camels naturally rehydrate quickly, it is sometimes recommended to gradually reintroduce water after extreme dehydration in clinical settings. Feed intake in camels is usually reduced during dehydration (Faraz et al., 2021),

### Recommendations based on study findings

#### 1. *Water Provision:*

Camels in intensive or feedlot systems should have continuous access to clean, fresh water, as their daily consumption can reach up to 30 l depending on feed level and environmental temperature. Intermittent or restricted watering should be avoided to prevent dehydration and reduced feed intake.

#### 2. *Feed–Water Balance:*

Since water intake increases with higher feed intake, especially when diets contain more concentrates, ration formulation should always consider water availability. Feeding levels of 1.5–2.0% of body weight requires adequate water supply to maintain rumen function and thermoregulation.

#### 3. *Environmental Management:*

Water intake is strongly affected by ambient temperature and humidity. Provision of shaded housing, ventilation, and watering during cooler hours can reduce stress and conserve water.

#### 4. *Monitoring and Prediction:*

The polynomial regression model developed in this study can be used to estimate water needs of camels under different body weights and feed levels. Such predictive tools should be incorporated into management plans for efficient resource use.

#### 5. *Future Research:*

Further studies should assess seasonal variation, salt intake effects, and breed differences in water-use efficiency to refine water-requirement estimates for camels across production systems in Oman and similar arid regions.

## Conclusions

This study provided for the first-time data on Omani camel water intake and its relation to feed intake. The results of this study demonstrate that water intake in Omani camels is closely influenced by feed level and body weight under intensive management conditions. Average daily water consumption ranged between 17.0 and 30.4 l, corresponding to 7.5–14.3% of body weight, with a mean of  $24.1 \pm 4.7$  L ( $10.5 \pm 1.8\%$  BW). A consistent increase in water intake with higher feeding levels was observed, reflecting the physiological link between feed dry-matter intake and water requirements. The polynomial regression model developed provides a useful predictive relationship between body weight and daily water intake for feedlot-reared camels. These findings supply essential baseline data for designing water-management strategies and ration formulation in intensive camel production systems. Efficient water and feed management based on such relationships will contribute to improved productivity, animal welfare, and sustainable camel husbandry in arid environments such as Oman.

## Acknowledgement

This work was based on a project funded by Sultan Qaboos University (Project #: IG/AGR/ANSC/08/01).

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