Research Article

Reference Values for Hematological and Serum Biochemical Parameters of Dromedary Camel (*Camelus dromedarius*) in Sub-Tropical Climate of Bangladesh

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Abstract | Hemato-biochemical parameters are essential aid for disease diagnosis. The study was conducted to assess hematological and serum biochemical profile, along with their reference interval, of apparently healthy dromedary camel (*Camelus dromedarius*) at sub-tropical condition of Bangladesh. Hematological and serum biochemical analyses were made on 52 camel in Dhaka city, Bangladesh. Hemoglobin (Hb), Packed Cell Volume (PCV), Erythrocyte Sedimentation Rate (ESR), Total Erythrocyte Count (TEC), Total Leukocyte Count (TLC), neutrophil, eosinophil, basophil, monocyte, lymphocyte, glucose, Total Protein (TP), albumin, urea, Alanine Aminotransferase (ALT), Triglyceride (TG), and Aspartate Transaminase (AST) were determined by biochemical analyzer with their mean, median, range, standard error (SE) and 90% referrence interval (RI). The profile comparison were made between camel with good body condition score (BCS ≥3) and camel with poor BCS (<3); between adult (≥3 year) and juvenile (<3 year); between male and female. The reference intervals showed wide variation in their range. Significant differences were observed in the level of Hb, PCV, ESR, neutrophil, eosinophil, basophil, glucose and TP based on BCS. Adult and juvenile was showing significant variation only in the level of eosinophil and ALT. Among all the parameters, ESR and urea level in male and in female camel were significantly different. The study provides a preliminary report on hematological and serum biochemical parameters of camel in Bangladesh. It is the basis for future reasearch on camel blood as well as helpful for practitioners to interpret and compare the test results.

Keywords | Bangladesh, Biochemical parameters, *Camelus dromedarius*, Dromedary camel, Hematology

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INTRODUCTION

Camel is an even-toed ungulate under the genus *Camelus*. Three species of camel are found in the world- single humped camel (*Camelus dromedarius*), double humped camel (*C. bactrianus*) and wild Bactrian camel (*C. ferus*). Single humped camel is commonly known as Dromedary or Arabian camel. They are the smallest of the three species. The dromedaries are well-known for transportation, racing, milk, meat and fibre. They can adapt easily in desert region due to their ability to remain without drinking water for extremely long periods and having fluctuating body temperature (Fayed, 2001). They are well-equipped to survive, produce and work in harsh environment (Wu et al., 2014). Ninety four percent of the world's camel population is of dromedary type. Dromedaries are usually found in the Horn of Africa, Middle East and South Asia. The largest concentration of camel in the world is found in the Horn region of Africa alone (Bernstein, 2009). India and Pakistan have 70% of the camel population of Asia, among which most of them are found in the state of Rajasthan, India (Rosati et al., 2005). Although there is only one spe-

cialized camel farm in Bangladesh (Arif et al., 2017), but farmers also import camel from neighbouring countries for selling during religious festival. Camel is being reared in Bangladesh as a promising species of livestock for their easy adaptability. Study on camel is needed for understanding their physiology in sub-tropical climatic conditions like Bangladesh.

Clinical chemistry and hematology is important as disease diagnostic aid and also for research (Dessouky, 1992). Hematology and serum biochemical parameters are vital indicator of the animals' health status. Many researchers conducted study on camel hematology and also the influence of different season, age, health status, lactation stage on hematological and biochemical profile in Saudi-Arabia, Sudan and Iran (Al-Busadah and Osman, 2000; Babeker et al., 2013; Jalali et al., 2018). But to date, no research findings is available on camel hematological and serum parameters in sub-tropical climatic condition of Bangladesh. Besides, reference interval (RI) calculation of these parameters have not been done yet. For these reason, the present study estimated reference interval of hematological and biochemical parameters of camels in Bangladesh context as a baseline study.

MATERIALS AND METHODS

Ethical Approval

The study was approved by the Animal Ethical Experimentation review Committee of Chittagong Veterinary and Animal Sciences University, Bangladesh (CVASU/Dir (R&E) AEEC/2015/927) and University of California, Davis (IACUC #16048).

Study Design And Sample Collection

The study was conducted between September and October 2015 in Dhaka, Bangladesh. Fifty two blood samples (33 from an urban camel farm at Kamlapur, Dhaka and 19 were from an urban livestock market at Gabtoli, Dhaka, Bangladesh) were collected from dromedary camel. The selected farm was established with 06 imported camels from India in 2006. Since then the farmer is successfully breeding camels in our environment. Twenty two camel sampled from the farm were born in Bangladesh. Rest 11 camel were imported from India. But, most of the imported camels were adult and already spent >3 years in sub-tropical climate of Bangladesh (Table 1). In case of market, the owners import camel in their suitable time usually 5-6 months before Eid festival. The sampled animals were either born in Bangladesh or they passed a reasonable amount of time in Bangladesh. So, the selected animals were suitable for the study purpose. Besides, the number of sample represented the total camel population at the time of sampling. Because, the farm was the only camel farm in Bangladesh at that time and the selected livestock market was the only place where camels were kept for selling during the festival. So, all the camel present at that time were included in the study for sampling.

10 ml of blood was collected aseptically from the jugular vein of each animal- 5 mL in vials containing ethylene diamine tetraacetic acid (EDTA) as anticoagulant for hematology and the other 5 mL into plain vacuum containers for biochemical analysis. Serum samples were stored at -20^{0}c until analysis.

Table 1: Sampling of dromedary camel from farm and market of Dhaka, Bangladesh, 2015

Origin	Bangladesh		India		Total
	Adult	Juvenile	Adult	Juvenile	
Farm	17	5	9	2	33
Market	1	0	16	2	19
Total	23		29		52

Hematology

Routine hematological parameter values- Hemoglobin (Hb), Packed Cell Volume (PCV), Erythrocyte Sedimentation Rate (ESR), Total Erythrocyte Count (TEC), Total Leukocyte Count (TLC), neutrophil, eosinophil, basophil, monocyte and lymphocyte count were determined following the procedure described by Sharma and Singh (2000).

Biochemical Study

Serum samples were analyzed using automatic biochemical analyzer (Humalyzer-3000, USA). Glucose, Total Protein (TP), albumin, urea, Alanine Aminotransferase (ALT), Triglyceride (TG), and Aspartate Transaminase (AST) level were estimated for each sample. All samples were processed and tested at the biochemistry laboratory of the Department of Physiology, Biochemistry and Pharmacology, CVASU, Bangladesh.

Statistical Analysis

Data were collected on origin of the animal, age, sex and health status. Information about the origin of the animal were collected from the owner. A veterinarian in the study team assessed the health status of each animal. All the data were recorded using MS Excel (Microsoft Corporation, Redmond, WA 98052-6399 USA) and analyzed by STATA-13 (StataCorp, 4905, Lakeway Drive, College station, Texas 77845, USA). Reference intervals were calculated with 90% confidence interval (CI) by MedCalc Statistical Software version 17.5.5 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017) (Friedrichs et al., 2012). Variables which were not distributed normally, their RI's were calculated using Robust method. Animals were grouped according to age (Adult ≥3 year, Juvenile <3 year of age), sex (male and female) and health status (based on

Table 2: Reference values for different hematological and serum biochemical parameters of dromedary camel (*Camelus dromedarius*) (N=52) of Dhaka, Bangladesh, 2015.

Parameters	Mean	SE[a]	Median	Minimum	Maximum	Lower limit RI[b] (90% CI[c])	Upper limit RI[b] (90% CI[c])	Distribution
HB (g/dL)	10.4	0.2	10.2	7.2	13.2	7.98(7.5/8.5)	12.8(12.3/13.3)	Normal
PCV (%)	36.5	0.8	37.0	24.0	51.0	24.6(22.1/26.97)	48.4(45.95/50.8)	Normal
ESR (mm/8 hr)	7.9	0.1	8.00	7.00	9.7	6.5 (6.2/6.8)	9.4 (9.15/9.74)	Normal
TLC (thousand/ Cumm)	8.9	0.3	8.7	4.45	16.05	4.4 (3.5/5.3)	13.5(12.5/14.4)	Normal
TEC (million/ Cumm)	5.3	0.1	5.1	3.15	7.55	3.4 (2.99/3.8)	7.1 (6.7/7.5)	Normal
Lymphocyte (%)	48.6	0.6	48.5	40.0	59.0	39.5 (37.6/41.3)	57.8 (55.9/59.6)	Normal
Neutrophil (%)	33.5	0.7	34.0	24.0	45.0	23.7 (21.8/25.7)	43.2 (41.2/45.1)	Normal
Eosinophil (%)	5.4	0.2	5.00	3.00	9.00	1.97(1.28/2.66)	8.79 (8.1/9.48)	Normal
Monocyte (%)	4.04	0.2	4.00	2.00	7.00	1.5 (0.94/1.99)	6.6 (6.1/7.1)	Normal
Basophil (%)	0.44	0.07	0.00	0.00	1.00	0.00	1.000	Not normal
Glucose (mg/dL)	114.9	1.8	115.6	90.2	144.7	89.6 (84.5/94.7)	140.2(135.1/145.3)	Normal
TP (g/dL)	8.2	0.2	8.1	5.97	10.67	5.4 (5.03/5.95)	10.99(10.5/11.5)	Not normal
Albumin (g/dL)	4.4	0.2	4.7	1.22	7.75	1.3 (0.6/1.9)	7.6 (6.9/8.2)	Normal
Urea (mg/dL)	25.04	0.7	24.4	17.6	44.9	14.2(11.3/17.4)	34.3(31.2/37.1)	Not normal
ALT (u/L)	13.1	0.5	12.95	7.1	21.5	6.2 (4.8/7.6)	19.97 (18.6/21.4)	Normal
TG (mg/dL)	31.0	0.8	30.7	20.1	45.5	20.2 (18.0/22.4)	41.8 (39.6/44.0)	Normal
AST (u/L)	123.1	2.7	122.95	84.1	161.8	84.9 (77.2/92.7)	161.2(153.5/168.97)	Normal

[a]SE: Standard Error; [b]RI: Reference Interval; [c]CI: Confidence Interval

Table 3: Comparison of hematological and serum biochemical parameter according to body condition score, age and sex of camel (*Camelus dromedarius*) (N=52) of Bangladesh, 2015.

Parameters	n	Mean± SD[a]	Median	Min-Max	n	Mean± SD[a]	Median	Min-Max	P value
	BCS good				BCS poor				
HB (g/dL)	35	11.1± 0.9	10.8	10/13.2	17	9.1± 0.8	9.2	7.2/10.0	0.001
PCV (%)	35	38.1± 5.5	38	25/51	17	33.2± 5.9	33	24/45	0.006
ESR (mm/8 hr)	35	7.8± 0.6	7.6	7/9	17	8.4± 0.8	8.2	7.0/9.7	0.005
Neutrophil (%)	35	32.3± 4.8	32	24/40	17	35.8± 4.7	36.0	27/45	0.02
Eosinophil (%)	35	5.0± 1.7	5.0	3/9	17	6.1± 1.6	6.0	3/9	0.02
Basophil (%)	35	0.3± 0.4	0.0	0/1	17	0.7±0.5	1.0	0/1	0.04
Glucose (mg/dL)	35	118.6± 12.4	117.4	95.4/144.7	17	107.2± 10.5	107.3	90.2/128.7	0.002
TP (g/dL)	35	8.7± 1.2	9.1	6.2/10.7	17	7.2± 1.1	6.8	5.97/9.72	0.003
	Adult				Juvenile				
Eosinophil (%)	41	4.9± 1.5	5.0	3/9	11	7± 1.7	7	4/9	0.001
ALT (u/L)	41	13.8± 3.6	14.3	7.1/21.5	11	10.3± 1.4	9.7	8.5/12.7	0.003
	Male				Female				
ESR (mm/8 hr)	28	8.3± 0.6	8.2	7/9.7	24	7.6± 0.7	7.4	7/9.5	0.005
Urea (mg/dL)	28	24.2±4.6	23.4	18/39	24	26.1±5.2	25.4	17.6/44.9	0.06

[a]SD: Standard Deviation

Body condition score/BCS- <3 poor and >3 Good) for calculating mean values of different paramet-ers. If the data distributed normally, student t-test was used to examine the effects of age, sex and health status. If not, then Mann-Whitney test was used. P value <0.05 were regarded as significant.

RESULTS

Hematological and serum biochemical profile of 52 dromedary camel are listed in Table 2 along with their mean, standard error (SE), median, range, lower limit and upper limit of RI with 90% CI. The reference intervals showed wide variation in their range. Table 3 depicts the hematological and serum biochemical parameters of dromedaries which showed significant difference in their level based on BCS, age and sex. Significant differences were observed in the level of Hb, PCV, ESR, neutrophil, eosinophil, basophil, glucose and TP between camel with good body condition and camel with poor body condition. Adult and juvenile camel was showing significant variation only in the level of eosinophil and ALT. ESR and urea level in male and in female camel were significantly different among the parameters.

DISCUSSION

The study estimated the reference interval for different hematological and serum biochemical parameters. There is no published literature on reference values for camel hematology and serum chemistry in Bangladesh. So, this makes the study a unique one which will act as a guideline for interpreting the hemato-biochemical changes in camel in future. The reference intervals showed wide range and variation for different parameter. This variation may be due to diversity in animal selection, time and place of sampling, environment, sample transport and preservation procedure, laboratory techniques (AL-Busadah, 2007; Farooq et al., 2011).

The study also compared the estimated parameter between two age group (adult and juvenile), between sex (male and female) and between camel with good and with poor body condition. As there is no previous work on camel hematology and serum chemistry in Bangladesh, the estimated values were being compared to literature from other countries.

Red Blood Cell Values

The level of Hb, ESR and TEC in camel of this study are much lower than the previous studies (Banerjee et al., 1962; Majeed et al., 1980; AL-Busadah, 2007). Young Magaheim camels (3-4 months old) in Saudi Arabia had lower Hb level (9.3 ± 0.3 g/dL) (Al-Sultan, 2008) than our studied camel although the level was within the reference interval given by (Abdelgadir et al., 1979). Furthermore, another study reported lower level of PCV and TEC than our findings (Majeed et al., 1980). However, Hb and TEC profile was found at greater level in single humped camel of India (Narnaware et al., 2016). Similarly, Hb and PCV level were found to be higher in suckling camel calves whereas TEC was higher in weaning calves (Omer et al., 2006). Camel do not have reserve RBC in their spleen. So , the Hb and PCV level increase after exercise (Snow et al., 1988). Sometimes RBC markers are at peak level in camel during breeding season (Dec-Mar) (Jalali et al., 2018).

White Blood Cell Values

TLC count, eosinophil and lymphocyte count were in accordance with reference range stated by (Farooq et al., 2011) from Cholistan district of Pakistan. Monocyte and basophil count of the present study were in accordance with previously stated reference interval (Abdelgadir et al., 1979). Narnaware et al. (2016) found similar monocyte count like our study. TLC, neutrophil and eosinophil count of camel of this study are much lower, although monocyte and basophil level were relatively higher in the present study than the previous studies (Banerjee et al., 1962; Majeed et al., 1980). Alternatively, lymphocyte count found to be close to one previous literature (Majeed et al., 1980) although higher level was also reported (Banerjee et al.,1962). Suckling camel calves had greater TLC than weaning calves (Omer et al., 2006). The most predominant white blood cell in camel is lymphocyte, followed by neutrophil, monocyte, eosinophil and basophil (AL-Busadah, 2007). But in our study, eosinophil count was higher than monocyte. It was found that eosinophil and neutrophil increase but lymphocyte and monocyte decrease in pregnant camel (Ayoub et al., 2003). Neutrophil was the predominant white blood cell in young Magaheim camels of 3-4 months age from Saudi Arabia (Al-Sultan, 2008). Monocyte count is increased during rainy season (July) whereas lymphocyte, eosinophil and basophil count increase during rainy hot summer season (September) (Babeker et al., 2013).

Biochemical Profiles

The level of different parameters were not showing similarity with reference interval except for TP, albumin and urea (Abdelgadir et al., 1979). Dissimilarity with previous literature was also found in the level of TP, albumin, ALT, TG and AST (Narnaware et al., 2016). TP level were higher in suckling camel calves than weaned calves while ALT and AST level were greater in their lactating dam than their suckling calves (Omer et al., 2006). In pregnant camel, TP and albumin increase though ALT and AST decrease (Ayoub et al., 2003). Rainy season has an effect on increased level of ALT in camel also (Babeker et al., 2013). TG, TP and ALT level significantly increase in female camel during breeding season (Dec-Mar) (Jalali et al., 2018). Protozoal infection in camel can also increase the level of AST and ALT (Durrani et al., 2017).

Comparison Of Parameters Based On Body Condition, Sex And Age

Hb and PCV level were lower in camel with poor body

condition, which consequently showed higher ESR level. Poor body condition also influenced higher count of neutrophil, eosinophil and basophil; lower level of glucose and TP in camel. Malnourishment of studied camel may result in their poor body condition status and hemato-biochemical profiles are changed due to this condition (Farooq et al., 2011). Besides, parasitic infection can reduce the TEC, Hb, PCV level in camel (Rabana et al., 2011; Durrani et al., 2017). Glucose and TP level can be decreased due to heavy intestinal parasitic infestation also (Momenah, 2014; Durrani et al., 2017).

Juvenile camels showed lower eosinophil count than adult whereas adult showed higher ALT level than juvenile in this study. Young camel from Saudi Arabia had also significantly lower eosinophil level than adult dry and lactating camel (Al-Busadah and Osman, 2000). It was also found that white blood cell count in camel was highest at 1 month of age and thereafter it decreased gradually for 6 months (Hussein and Mogawer, 1992). Besides, eosinophil and ALT level in camel may increase due to parasitic infection like mange, gastro-intestinal parasite etc. (Momenah, 2014). But age has no significant effect on ALT level in camel (Metawie et al., 2000).

ESR is greater in male than female animal in this study. But previous report stated that female shows greater ESR than male (Majeed et al.,1980). Sex has significant effect on Hb level of camel (Hussein and Mogawer, 1992). Another explanation could be the more parasitic infection in male camel which resulted in high ESR (Rabana et al., 2011; Durrani et al., 2017). Urea level is higher in female than male in our study. Urea level increase in dromedary camel at the time of dry hot summer season (April) (Babeker et al., 2013).

No literature on camel hematology and serum chemistry is available in Bangladesh. So, this study provides a preliminary report on reference values of hematological and serum biochemical parameters of camel reared in sub-tropical climate of Dhaka city, Bangladesh. Age, sex and body condition had significant effect on some specific parameters. But, other factors like physiological condition, stress, environment, technical variation should be taken into account during the future studies.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

AUTHORS CONTRIBUTION

AI conceived and supervised the study; AI and SI collected the samples, SI, MKR and SA did the laboratory examination; AI, SI, JF and MKR did the formal data analysis; SI and JF wrote the original draft; SI, MMH and AI involved in reviewing and editing the manuscript.

REFERENCES

- Abdelgadir SE, Wahbi AG, Idris O (1979). Some blood and plasma constituents of the camel. In: Proceedings of Intl' foundation for science workshop on camels, Khartoum, Pakistan, 438-443.
- Al-Busadah K, Osman T (2000). Hematological parameters of adult dry, lactating and camel calves in Saudi Arabia. Pak. J. Biol. Sci. 3: 1749-1751. https://doi.org/10.3923/pjbs.2000.1749.1751
- AL-Busadah KA (2007). Some biochemical and hematological indices in different breeds of camels in Saudi Arabia. Sci. J. King Faisal Uni. (Basic and applied sciences). 8(1): 1428H.
- Al-Sultan S (2008). Studies on hematological and certain serum biochemeical values in young Magaheim Dromedary camels at Al-Ahsa Province. Vet. Res. 2(3): 34-37.
- Ariful I, Epstein J, Rostal M, Islam S, Rahman M, Hossain ME, Uzzaman MS, Munster V, Peiris M, Flora M, Rahman M, Daszak P (2017). Middle East Respiratory Syndrome Coronavirus (MERS-CoV) antibodies in dromedary camels. Emer. Inf. Dis. 24(5): 926-928.
- Ayoub M, El-Khouly A, Mohamed T (2003). Some hematological and biochemical parameters and steroid hormone levels in the one-humped camel during different physiological conditions. Emirat. J. Food Agri. 44-55.https://doi.org/10.9755/ejfa.v15i1.5281
- Babeker E, Elmansoury Y, Suleem A (2013). The influence of season on blood constituents of dromedary camel (*Camelus dromedarius*). Online J. Anim. Feed Res. 3(1): 1-8.
- Banerjee S, Bhattacharjee RC, Singh TI (1962). Hematological studies in the normal adult Indian camel (*Camelus dromedarius*). Amer. J. Physiol.-Legacy Conten. 203(6): 1185-1187. https://doi.org/10.1152/ajplegacy.1962.203.6.1185
- Bernstein WJ (2009). A splendid exchange: How trade shaped the world. Grove/Atlantic Inc.
- Bush RM, Smith EE (1980). Clinical chemistry and hematology as diagnostic aids in zoological medicine.
- Dessouky MI (1992). Studies on the hemogram and blood biochemical constituents in camel in health and disease. Proceedings of the Training course on camel diseases. 333-344

- Durrani AZ, Bashir Z, Rasheed I, Sarwar NU (2017). Epidemiological study of common diseases and their risk factors in camels in South Punjab, Pakistan. Microb. Pathogene.108: 6-12. https://doi.org/10.1016/j.micpath.2017.04.011
- Farooq U, Samad H, Khurshid A, Sajjad S (2011). Normal reference hematological values of one-humped camels (*Camelus Dromedarius*) kept in Cholistan desert. J. Anim. Plant Sci. 21(2): 157-160.
- Fayed RH (2001). Adaptation of the camel to desert environment. Proceedings of the ESART 11th annual conference.
- Friedrichs KR, Harr KE, Freeman KP, Szladovits B, Walton RM, Barnhart KF, Blanco Chavez J (2012). ASVCP reference interval guidelines: determination of de novo reference intervals in veterinary species and other related topics. Vet. Clin. Pathol. 41: 441-453. https://doi.org/10.1111/vcp.12006
- Hussein M, Mogawer H (1992). The haeiviatology of growing camels (*Camelus dromedarius*) during the first year of life.
- Jalali SM, Hasani YN, Darabifard A, Mavadati AH (2018). A study of hematologic and biochemical profile in female dromedary camels during the breeding and non-breeding seasons. Compar. Clinica. Pathol. 1-5. https://doi.org/10.1007/s00580-018-2645-1
- Majeed M, Hur G, Rahman Z, Ahmad A (1980). Effects of sex and season on 10 hematological values of normal adult one-humped camel. Rev. Livest. Vet. Med. Tropic. 33(2): 135-141.
- Metawie R, Mohamed O, El-Bagoury A, Ezzo O (2000). Some hematological and serum biochemical changes in camel calves during the first 8 months of age. Egyptia. J. Agri. Res.78(2): 1311-1321.
- Momenah MA (2014). Some blood parameters of one humped she-camels (*Camelus dromedarius*) in response to parasitic infection. Life Sci. J.11(5): 118-123.
- Narnaware S, Ranjan R, Sawal R, Nath K, Patil N (2016). A comparative study on hematological and blood biochemical profile of double humped (*Camelus bactrianus*) and single humped camel (*Camelus dromedarius*). J. Camel Practic. Res. 23(1): 109-110. https://doi.org/10.5958/2277-8934.2016.00017.5
- Omer S, Khougali SM, Agab H, Samad H (2006). Studies on some biochemical and hematological indices of Sudanese camels (*Camelus dromedarius*).
- Rabana JL, Kumshe HA, Kamani J, Hafsat G, Turaki UA, Dilli HK (2011). Effects of parasitic infections on erythrocyte indices of camels in Nigeria. In: Vet. Res. For. 2(1): 59-63.
- Rosati A, Tewolde A, Mosconi C (2005). Animal production and animal science worldwide. Wageningen Academic Publishers.
- Sharma IJ, Singh HS (2000). Students laboratory manuals of veterinary physiology, 1st edition, kalyani publisher, new delhi, India.
- Snow D, Billah A, Ridha A (1988). Effects of maximal exercise on the blood composition of the racing camel. Vet. Rec.123(12): 311-312. https://doi.org/10.1136/vr.123.12.311
- Wu H, Guang X, Al-Fageeh MB, Cao J, Pan S, Zhou H, Zhang L, Abutarboush MH, Xing Y, Xie Z (2014). Camelid genomes reveal evolution and adaptation to desert environments. Nat. Comm. 5: 5188. https://doi.org/10.1038/ncomms6188