

Markovic, N., et al. (2021). "The last caravans in antiquity: Camel remains from Caricin Grad (Justiniana Prima)." *Journal of Archaeological Science-Reports* **38**.

Camels played an important role in caravan traffic and long-distance communication during the early Byzantine period as indicated by new findings from Caricin Grad. Excavations at the site revealed the remains of an important early Byzantine city, which has been identified with Justiniana Prima founded in the 530 s by Justinian I (527-565). The city, created ex nihilo, in a rural area in the north-west of the province of Dacia Mediterranea, represents a distinctive example of late urbanisation. Given the existence of the city for only 80 years and the fact that the nearby locality remained uninhabited until modern times, the site has yielded well-preserved monuments and remains of material culture. They allow for a detailed study of the urbanism, architecture, material culture and other aspects of daily life from the second quarter of the 6th century to the beginning of the 7th century. Here we investigate the camel remains discovered in five locations in Caricin Grad. Morphometric and proteomic analyses, including both collagen peptide mass fingerprint analysis (ZooMS) as well as in-depth sequencing, revealed that the majority originate from hybrids of the dromedary and Bactrian camels. Supported by written sources from the Early Byzantine period, it appears as though the use of the Caricin Grad camels was primarily for civilian purposes. These results highlight the complementarity of morphometric and proteomic approaches and their value in better understanding the impact of the early Byzantine economy.

Lau, S. K. P., et al. (2020). "Middle East Respiratory Syndrome Coronavirus Antibodies in Bactrian and Hybrid Camels from Dubai." *Mosphere* **5**(1).

So far, dromedary camels are the only known animal reservoir for Middle East respiratory syndrome (MERS) coronavirus (MERS-CoV). Previous published serological studies showed that sera of Bactrian camels were all negative for MERS-CoV antibodies. However, a recent study revealed that direct inoculation of Bactrian camels intranasally with MERS-CoV can lead to infection with abundant virus shedding and seroconversion. In this study, we examined the presence of MERS-CoV antibodies in Bactrian and hybrid camels in Dubai, the United Arab Emirates (where dromedaries are also present), and Bactrian camels in Xinjiang, China (where dromedaries are absent). For the 29 serum samples from Bactrian camels in Dubai tested by the MERS-CoV spike (S) protein-based enzyme-linked immunosorbent assay (S-ELISA) and neutralization antibody test, 14 (48%) and 12 (41%), respectively, were positive for MERS-CoV antibodies. All the 12 serum samples that were positive with the neutralization antibody test were also positive for the S-ELISA. For the 11 sera from hybrid camels in Dubai tested with the S-ELISA and neutralization antibody test, 6 (55%) and 9 (82%), respectively, were positive for MERS-CoV antibodies. All the 6 serum samples that were positive for the S-ELISA were also positive with the neutralization antibody test. There was a strong correlation between the antibody levels detected by S-ELISA and neutralizing antibody titers, with a Spearman coefficient of 0.6262 ($P < 0.0001$; 95% confidence interval, 0.5062 to 0.7225). All 92 Bactrian camel serum samples from Xinjiang were negative for MERS-CoV antibodies tested using both S-ELISA and the neutralization antibody test. Bactrian and hybrid camels are potential sources of MERS-CoV infection. IMPORTANCE Since its first appearance in 2012, Middle East respiratory syndrome (MERS) has affected >25 countries, with >2,400 cases and an extremely high fatality rate of >30%. The total number of mortalities due to MERS is already greater than that due to severe acute respiratory syndrome. MERS coronavirus (MERS-CoV) has been confirmed to be the etiological agent. So far, dromedaries are the only known animal reservoir for MERS-CoV. Previously published serological studies showed that sera of Bactrian camels were all negative for MERS-CoV antibodies. In this study, we observed that 41% of the Bactrian camel sera and

55% of the hybrid camel sera from Dubai (where dromedaries are also present), but none of the sera from Bactrian camels in Xinjiang (where dromedaries are absent), were positive for MERS-CoV antibodies. Based on these results, we conclude that in addition to dromedaries, Bactrian and hybrid camels are also potential sources of MERS-CoV infection.

Pares-Casanova, P. M., et al. (2020). "Lower palatine developmental instability in hybrid Old World camelids." *Journal of Advanced Veterinary and Animal Research* 7(4): 663-668.

Objective: In this research study, we explore the fluctuating asymmetry (FA) of palate *Camelus hybrids and their parental species (dromedary and Bactrian)*. Materials and Methods: We studied a sample of pictures from 27 adult skulls of pure *Camelus dromedarius* (n = 13), *Camelus bactrianus* (n = 7), and their crosses (n = 7), from two different collections. A set of 11 semilandmarks was located on the palatal region and was studied by means of geometric morphometric methods. The asymmetric variation was analyzed and evaluated for allometric effects, and variation among these three groups was studied using a canonical variates analysis. Results: Among hybrids, there appeared a significantly lower amount of FA in comparison to the parental species, which may reflect the lower levels of genetic stress and higher levels of directional asymmetry, which may suggest the presence of strongly transgressive mastication compared to pure species. Conclusion: Camel hybrids would present increased developmental stability and better adaptation over those of parenteral lines.

Ryskaliyeva, A., et al. (2018). "Combining different proteomic approaches to resolve complexity of the milk protein fraction of *dromedary, Bactrian camels and hybrids*, from different regions of Kazakhstan." *PLoS One* 13(5).

Nutritional suitability of milk is not only related to gross composition, but is also strongly affected by the microheterogeneity of the protein fraction. Hence, to go further into the evaluation of the potential suitability of non-bovine milks in human/infant nutrition it is necessary to have a detailed characterization of their protein components. Combining proven proteomic approaches (SDS-PAGE, LC-MS/MS and LC-ESI-MS) and cDNA sequencing, we provide here in depth characterization of the milk protein fraction of *dromedary and Bactrian camels, and their hybrids*, from different regions of Kazakhstan. A total 391 functional groups of proteins were identified from 8 camel milk samples. A detailed characterization of 50 protein molecules, relating to genetic variants and isoforms arising from post-translational modifications and alternative splicing events, belonging to nine protein families (K-, alpha(s1)-, alpha(s2)-, beta-; and gamma-CN, WAP, alpha-LAC, PGRP, CSA/LPO) was achieved by LC-ESI-MS. The presence of two unknown proteins UP1 (22,939 Da) and UP2 (23,046 Da) was also reported as well as the existence of ap-CN short isoform (946 Da lighter than the full-length beta-CN), arising very likely in both genetic variants (A and B) from proteolysis by plasmin. In addition, we report, for the first time to our knowledge, the occurrence of a alpha(s2)-CN phosphorylation isoform with 12P groups within two recognition motifs, suggesting thereby the existence of two kinase systems involved in the phosphorylation of caseins in the mammary gland. Finally, we demonstrate that genetic variants, which hitherto seemed to be species-specific (e.g. beta-CN A for Bactrian and beta-CN B for dromedary), are in fact present both in *Camelus dromedarius* and *C. bactrianus*.

Ruiz, E., et al. (2015). "Diagnostic single nucleotide polymorphism markers to identify hybridization between dromedary and Bactrian camels." *Conservation Genetics Resources* 7(2): 329-332.

The technique to produce hybrid Tulu or Nar camels from crosses between dromedary and Bactrian camels is common throughout Middle Eastern and Central Asian countries. Formerly,

these hybrids were highly valued as strong and persistent pack animals but today are bred to improve milk or wool quality in the respective species and for camel wrestling. We developed a diagnostic single nucleotide polymorphism (SNP) panel to identify cryptic ancestry in F(1) hybrids and their backcrosses by selecting loci from whole genome data, which were fixed for different alleles in either dromedary or domestic and wild Bactrian camel. With this SNP panel we are able to identify the hybridization patterns in camels with uncertain origins, support hybrid breeding management and to detect potential rare dromedary introgression in the last wild Bactrian camels in Mongolia and China.

Raiymbek, G., et al. (2015). "Discriminant amino-acid components of Bactrian (*Camelus bactrianus*) and Dromedary (*Camelus dromedarius*) meat." *Journal of Food Composition and Analysis* **41**: 194-200.

Dromedary (*Camelus dromedarius*) and Bactrian (*Camelus bactrianus*) camels are close species and their hybrids fertile, but until now no comparative data on the nutrient composition of their meat has been available. Six muscle samples were collected from nine Bactrians and 10 dromedaries from Kazakhstan and the Sultanate of Oman, respectively. They were used for amino-acid pattern determination. The essential amino-acid index was higher for all muscles in the dromedary meat than in Bactrian meat with a mean value of 216.9 and 191.6, respectively, which is high compared to other red meats. The between-muscle variability was higher in dromedary than in Bactrian meat and was more important than the between-species variability. However, the two species were well discriminated on the second factor of the linear factorial discriminant analysis with 93.14% well-classed meat based on 7 discriminant amino-acid including 4 essential ones. The Bactrian camel meat was richer in proline and leucine and the dromedary camel meat in serine, tyrosine, histidine, threonine and arginine. In spite of these differences, both meats were characterized by their richness in methionine and leucine. Consequently, the dromedary and Bactrian meats could provide an excellent source of high-quality proteins for human consumers. (C) 2015 Elsevier Inc. All rights reserved.

Galik, A., et al. (2015). "A Sunken Ship of the Desert at the River Danube in Tulln, Austria." *PLoS One* **10**(4).

Rescue excavations recovered a skeleton that resurrect the contemporary dramatic history of Austria in the 17th century as troops besieged Vienna in the second Osmanic-Habsburg war. Unique for Central Europe is the evidence of a completely preserved camel skeleton uncovered in a large refuse pit. The male individual of slender stature indicates a few but characteristic pathological changes revealing not a beast of burden but probably a valuable riding animal. Anatomical and morphometrical analyses suggest a hybrid confirmed by the ancient DNA analyses resulting in the presence of a dromedary in the maternal and a Bactrian camel in the paternal line.

Nurseitova, M., et al. (2014). "Comparison of dairy performances between dromedaries, bactrian and crossbred camels in the conditions of South Kazakhstan." *Emirates Journal of Food and Agriculture* **26**(4): 366-370.

The aims of the work compare similarly the yield and the composition. In this work determined the Camel milk composition (fat content, dry matter, density) and milk yield of Dromedaries, Bactrians and Hybrids in South-Kazakhstan condition in same farm, same time and repeated same animals. The milk sampled of 20 camel's milk, where 6 Bactrians (B), 5 dromedaries (D), 2 hybrids F1 Iner (I), 4 hybrids F1 Nar (N), and finally 3 hybrids F2 Kospak (K) with repeated 3 times (days). The milk of Bactrian camels contained significantly more DM and the same tendency was noted for the fat content. In the same time, the milk yield tended to be lower

even if no significance threshold was reached. Contrarily, the milk of dromedaries was not so rich in absence of any significant difference to F1 and F2 hybrids except an increased density. F1 hybrids (Nar-maya and Iner-maya) had a slight but not significant tendency of increased milk yield but a more or less reduced contents and density. This difference seems to be extenuated for F2 (Kospak) animals. The effect of calving year was illustrated by significantly lower milk yields in the second year of lactation (3.8 versus 2.8 L/d, $P < 0.05$), slightly increased contents of fat (4.9 versus 4.2 g/L, $P < 0.10$) and Dry matter (14.0 and 13.8 g/L, NS) and also density (1030.0 versus 1032.3 g/L).

Cakirlar, C. and R. Berthon (2014). "Caravans, camel wrestling and cowrie shells: towards a social zooarchaeology of camel hybridization in Anatolia and adjacent regions." *Anthropozoologica* **49**(2): 237-252.

Hybrid camels, intentional crosses between dromedaries and bactrian camels, are prized for their robustness and endurance. They were the prime vehicles of short and long distance caravan trade in a large area between Greece and Mongolia until the whole-scale introduction of motorized transport. This paper proposes a model for the zooarchaeological study of camel hybridization as a culture-historical phenomenon based on ethnographic and ethnohistoric observations of camel wrestling. Camel wrestling spectacles involve large audiences who gather in large arenas to watch first generation male hybrid camels wrestle during the mating season. While Anatolia was chosen as a case region for testing the model, it can be applied to all regions where hybrids are expected to occur in the archaeological record.

Iniguez, L., et al. (2014). "Characterization of camel fibers in regions of Kazakhstan and Uzbekistan." *Small Ruminant Research* **117**(1): 58-65.

To generate information on Central Asian camel fiber quality, fiber samples of 712 camels from Kazakhstan and Uzbekistan were characterized. Fixed effects involved geographical location, animal age, sex, coat color and species. Camel species are Bactrians (*Camelus bactrianus*), dromedaries (*Camelus dromedarius*) and crosses between both species, hereafter referred as hybrids. Fiber traits included clean fine fiber yield (CY), mean fine fiber diameter (MFD), mean fine fiber diameter coefficient of variation (MFD CV), fine fiber curvature (Curv) and fine fiber staple length (SL). The arithmetic averages of CY, MFD, MFD CV, Curv and SL were respectively 37.3%, 18.0 μm , 30.6%, 87.7 degrees/mm and 46.0 mm for Bactrians; 29.1%, 21.2 μm , 30.3%, 78.2 degrees/mm and 52.7 mm for dromedaries; and 42.7%, 17.9 μm , 29.5%, 89.9 degrees/mm and 47.2 mm for hybrids. Significant age by species interaction was detected for all traits. Overall, Bactrian camels had higher CY, lower MFD, higher Curv and lower SL than dromedaries ($P < 0.05$). The geographical locations significantly differentiated CY and Curv but not the other traits; thus, for the locations studied little could be gained by looking into location variability when planning genetic improvement programs. There were no significant sex differences for all the studied traits, whereas significant differences due to the color of the coat were found only for Curv. The residual phenotypic correlations among CY, MFD and Curv were all high and would be favorable for selection purposes. Likewise, the residual phenotypic correlations between each of these variables with SL would be unfavorable if selection targets an increased SL. The study detected heterogeneity for most fiber quality traits, suggesting that a base is in place for fiber quality improvement. (C) 2013 Elsevier B.V. All rights reserved.

Akhmetsadykova, S., et al. (2014). "Microflora identification of fresh and fermented camel milk from Kazakhstan." *Emirates Journal of Food and Agriculture* **26**(4): 327-332.

In Kazakhstan where **Bactrian camel, dromedary camel and their hybrids** are cohabiting within same farms, the consumption of camel milk is very popular because its medicinal and dietary properties. This milk is consumed under fermented form, called shubat. Shubat is still very often made on a small scale in the steppe with a fermentation step driven by wild bacteria. Camel milk and shubat were sampled from 4 regions with high number of camel population. As the whole, 26 samples were obtained from 13 selected farms representing the variability of the farming system. Isolated LAB strains were identified by method of a polymorphism determination of 16S ribosome DNA. PCR with using two different pairs of amorces (338f/518r; W001/23S1) was done. Majority of microflora were cocci in a both milk products. The following microorganisms were identified: *Enterococcus durans*; *Enterococcus faecalis*; *Enterococcus faecium*; *Lactobacillus casei*; *Lactobacillus casei* subsp. *casei*; *Lactobacillus curvatus*; *Lactobacillus kefir*; *Lactobacillus paracasei*; *Lactobacillus sakei*; *Lactococcus lactis* subsp. *lactis*; *Leuconostoc mesenteroides*. Diversity of microorganisms in a both products was similar, but percentage of each microorganism changed during fermentation process. Yeast biodiversity in shubat was studied by using denaturing gradient gel electrophoresis (DGGE). Target DNA bands were identified according to the reference species scoring. Comigrating bands present in the DGGE profiles were resolved by species-specific PCR. The dominant yeasts in both products included *Kazakhstania unispora*, *Saccharomyces cerevisiae* and *Kluyveromyces marxianus*. Frequently isolated yeast species were *Dekkera bruxellensis* and more rarely *Galactomyces geotrichum*. The results of microflora identification in these products provide a theoretical foundation for developing starter cultures.

Faye, B., et al. (2010). "Variability of urea concentration in camel milk in Kazakhstan." *Dairy Science & Technology* 90(6): 707-713.

Urea is a part of non-protein nitrogen in milk The variability of its concentration was never reported in camel milk The present communication aimed to give some reference values on urea content in camel milk and to explore some interpretable variation factors In 102 milk samples collected in Kazakhstan, at four seasons of the year, in four distant regions and in different species (***Camelus dromedarius Camelus bactrianus and their hybrids***), urea was determined in the raw milk The mean value of urea concentration was 81.6 +/- 60.4 mg L⁻¹ with a range of 0-290.5 mg L⁻¹ values changed significantly (P < 0.001) according to season, the highest concentration being observed in spring when the grass contained the highest soluble nitrogen The milk urea was positively correlated to the total protein concentration in milk On average, those values were lower than in cow milk

Faye, B., et al. (2008). "Discriminant milk components of Bactrian camel (*Camelus bactrianus*), dromedary (*Camelus dromedarius*) and hybrids." *Dairy Science & Technology* 88(6): 607-617.

In Kazakhstan, the **cohabitation of Bactrian camels, dromedaries and their hybrids** is a common feature even within farms. The physico-chemical composition of 147 milk samples from 57 Bactrians, 70 dromedaries and 20 hybrids was determined. The samples came from 4 different regions and were collected at 4 different seasons within a year. Compared with dromedary, Bactrian camel milk had significantly higher fat (6.67 vs. 5.94%), vitamin C (177 vs. 152 mg.L⁻¹), calcium (1.30 vs. 1.16 g.L⁻¹) and phosphorus (1.07 vs. 0.91 g.L⁻¹). The iodine index value was significantly higher in dromedary (16.69) than in Bactrian milk (14.99). To distinguish Bactrian milk from dromedary milk, a discriminant analysis was carried out after discarding seasonal and regional variability. The discriminant parameters were phosphorus (linear discriminant coefficient = -1.00), pH (-0.408), vitamin C (-0.377) and fat content (-0.226), in higher concentrations in Bactrian than in dromedary milk. The iodine index (0.287) was higher in

dromedary milk. After quadratic discriminant analysis, milk composition can predict species, with 75.4% well-classed. The milk composition of the hybrids was intermediary but with a low discriminant power.

Konuspayeva, G., et al. (2008). "Fatty acid and cholesterol composition of camel's (*Camelus bactrianus*, *Camelus dromedarius* and hybrids) milk in Kazakhstan." *Dairy Science & Technology* **88**(3): 327-340.

The fatty acid composition and cholesterol content of 22 camel's milk samples from different regions of Kazakhstan were determined, in different seasons and with different camel species (*Bactrian*, *dromedary* and *hybrids*). Camel milk fat differed from mammalian fats by its high content of the long-chain fatty acids C14:0, C16:0, C18:0 and C18:1. Great differences in fatty acid composition occurred between regions. Short-chain fatty acids (C8:0 and C10:0) were in higher proportion in spring and long-chain fatty acids (C17:0 and C17:1) in autumn. Dromedary milk had a higher proportion of C17:0iso and C18:1 than Bactrian milk. The ratio of unsaturated saturated acid was more favorable in camel's milk compared with that of cows or other mammals. All of these parameters gave a nutritional advantage to camel's milk, although it had a higher content of cholesterol (37.1 mg.100 g⁻¹) than cow's milk. Multivariate analysis allowed the identification of four types of fatty acid profiles with a clear opposition between the samples rich in short-chain fatty acids and the samples rich in long-chain fatty acids. These results confirmed that environmental and farming conditions allowed modulation of the lipid composition of camel's milk.

Konuspayeva, G., et al. (2007). Variation factors of some minerals in camel milk. NATO Advanced Research Workshop on Impact of Pollution on Animal Products, Almaty, KAZAKHSTAN.

In four regions of Kazakhstan (Atyrau, Aralsk, Shymkent and Almaty), a survey on camel farms was achieved in order to study the variability of the physico-chemical composition of camel milk both in *dromedary (Camelus dromedarius)* and *Bactrian (Camelus bactrianus)* camel as well as *their hybrids*. As the whole, 163 milk samples were analyzed for calcium, phosphorus and iron determination. In order to maximize the variance, the samples were done in four different seasons which expressed the feeding change and the physiological stage changes as the calving season was concentrated in few months. The mean values were respectively 1.232 +/- 0.292 g/l, 1.003 +/- 0.217 g/l and 2.02 +/- 1.24 mg/l for calcium, phosphorus and iron. No species, season or region effect was observed on iron content in the milk. Calcium and phosphorus change significantly according to season and species, but only phosphorus was linked to region effect. Especially phosphorus content is high in Aralsk region (1.156 +/- 0.279 g/l). Globally, it is noticeable to observe the high level of phosphorus in the camel milk of Kazakhstan compared to the literature's results.

Narmuratova, M., et al. (2006). "Fatty acids composition of dromedary and bactrian camel milk in Kazakhstan." *Journal of Camel Practice and Research* **13**(1): 45-50.

The fatty acid composition is probably linked to one of the health effects attributed to camel milk. In the present paper, the fatty acid compositions of *dromedary camel*, *bactrian camel* and *hybrids* are analysed in Kazakhstan where all these species cohabit. The results confirm the higher quantity of unsaturated fatty acids compared to cow milk. Palmitic acid, stearic acid, oleic acid and miristic acid are the most important part of the camel milk fat. As our sampling method included 3 variation factors (species, season, regions) with not more than one sample per case, only general trends were observed. The milk samples collected in summer, on bactrian camel and in the Caspian region (Atyrau, Aralsk) tend to be richer in long-chain fatty acids. At

reverse, the milk samples taken in winter, on hybrids or dromedary and from the southern part of Kazakhstan seem richer in short-chain fatty acids.