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Article

Body Measurements and Body Condition Scoring in Bactrian Camels

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Simple Summary

Body measurements and body condition score are common tools used by different stakeholders to assess the phenotypes and the global conditions of farm animals. If few references of body measurements were published, scoring of body condition was not available for Bactrian camel. After giving some information on the effect of age on body measurements, the present paper proposes a grid to evaluate the status of the animal by using a 6-points scoring from very emaciated Bactrian camel to very fat ones. This scoring is based on the observation of 12 anatomical points from side and from behind. It will be necessary, anyway, to validate the reproducibility and repeatability of the method.

Abstract

Body measurements were used regularly to describe phenotypes or the weight of the animal. However, few data described the age effect on the different measurements. In the present paper, 477 Bactrian camels (7-180 months old) were measured, and their growth was modeled by using Beta-Growth equation. The body condition scoring is widely used in farm animals as indicator of their feeding, health and welfare status. If the body condition score was available for dromedary, there was no specific grid for Bactrian camel. Starting from typical examples taken from photos in different conditions, including extreme ones, a representation of a scoring in 6 points from very emaciated (score 0) to overweighted Bactrian camel (score 5) was proposed in the form of drawings from right side, back and three-quarter rear. To complete the drawings a descriptive grid was built as a base for training stakeholders in relation to Bactrian camel farm management. However, the seasonal change in the fleece abundance, the variability of the humps' shape, and the presence of crossbreed with dromedary camel require to adapt the scoring accordingly.

Keywords: Bactrian camel; hump; body condition assessment; body measurements; feeding management; animal welfare

1. Introduction

Body measurements (BM) which are used to differentiate animal phenotypes are widely proposed in dromedary camel [1–5], but more rarely in Bactrian camel [6–8] and generally on limited number of animals. BM was used also to estimate the weight of the Bactrian camel [9].

The body condition score (BCS) is a low cost-effective method tool used by scientists and technical advisors worldwide to assess the nutritional status of farm animals. Indeed, it is considered that the body condition can reflect the importance of fat reserve and, indirectly, the nutritional balance of the diet, health status and reproductive capacity. The interest of BCS was emphasized for assessing the animal conditions during the important physiological steps of their life cycle: breeding, parturition, beginning of lactation, physical activities (agricultural works, competition, etc...). It is also useful as indicator of the availability and quality of the natural resources, to assess their adequacy with the requirements of the animal, especially in extensive pastoral systems during drought [10]. The modern alternative methods such as imaging techniques or ultrasonography are not necessarily easy to be used in pastoral conditions and are most costly [11].

The scoring grid was set up for long time for European *Bos taurus* [12], or tropical *Bos indicus* [13], more recently for tropical *Bos taurus* [14]. It was also proposed for other farm animals as sheep [15], goat [16], horse [17], donkey [18] and even buffalo [19]. A recent review proposed also a standardized scoring system in tropical farm animals [20], notably because the number of scoring levels, the visual anatomical zones to be assessed or the additional investigations as palpation were heterogenous. Regarding camelids' family, BCS was applied in alpacas and llamas [21].

Regarding camel, the only BCS in dromedary (*Camelus dromedarius*) was published [22,23] and used in different publications in Australia [24] and in Spain [25]. At our knowledge, there was no equivalent for Bactrian camel (*Camelus bactrianus*). Compared to the other farm animals, the large camelids have a specificity leading to the impossibility to apply the classical grid used for bovine: the presence of one (dromedary) or two humps (Bactrian) where are concentrated the main part of the fat reserves [26]. Moreover, the behavior of the hump in case of important weight loss is different according to species: the hump of the dromedary is melting while the humps of Bactrian are "falling". Besides, the only slight appreciation of fat condition in Bactrian camel which was published was based formerly by the status of the hump observed backward [27]. In this reference, only 4 levels were described: (i) very fat camel with well-raised hump, (ii) medium fat camel with hump slightly leaning on the side, (iii) poor fat camel with hump leaning at 90°, and (iv) meagre camel with empty hump placed on the side of the body. However, such classification is not sufficient to describe the full condition status of the animal.

Thus, the objective of the present paper was to set up of grid and propose a body condition scoring based on the observation of hundreds Bactrian camels with highly variable fat status.

2. Materials and Methods

2.1. Body Measurements

The body dimensions of the Bactrian camels were measured by a standard meter ribbon. The following measurements were achieved between spring 2023 – autumn 2025: (i) length of the head from nose to occipital (HeadL); (ii) length of the neck (lower part) from base of head to the chest (NeckL); (iii) circumference of the neck at the middle of the neck (NeckC); (iv) height at the withers (HeightW); (v) girth circumference in front of the hump (ChestC); (vi) length of the front leg (LengthFL) from shoulder point to foot; (vii) length of the body (BodyL) from shoulder point to ischium point. As the whole, 477 Bactrian camels (from 7 months to 16 years old) were measured. They were shared in 4 groups of age, namely young camel (YC) between 7 months and 2 years (n=117), subadults (SA), 3-4 years old (n=63), adults (AD) between 5 and 10 years (n=201), and old adults (OA) more than 10 years old (n=96). The animals belonged to 4 different camel farms from Kazakhstan in 3 very contrasted regions: one farm from Zhetisu region in the eastern part of the country (n=207), one farm in Turkistan region in the southern part (=55), and two farms in Atyrau region in the north-west part, named Atyrau1 and Atyrau2 (n =108 and 107 respectively). The maximal distance between the farms in Zhetisu and Atyrau region was around 3800 km.

2.2. Bactrian Camel Observation for BCS

Most of the observed Bactrian camels for assessing their body condition were in the same farms from Atyrau, Turkestan, and Zhetisu regions. In all farms, the farming system was under extensive management with mainly pastoral feeding. The assessment of the body condition of Bactrian camels was achieved in the frame of a monitoring of the Kazakh camel phenotypes which included dromedaries (Aruana breed) and hybrids between Bactrian female (*Camelus bactrianus*) and dromedary (*Camelus dromedarius*) male [28]. To get a large variability of the body condition, the observations were achieved at different seasons, as the access to natural resources could change throughout the year, and the potential feed supplementation highly variable between farms and regions [29]. However, it was not possible to observe the animals at wintertime due to the hard climatic conditions and the difficulties to reach the farms. In addition, few photos of Bactrian having extreme BCS, originate from other countries were considered to get a total panel of possible scores.

2.3. The Principle of Scoring

The Bactrian camel was observed at distance (2 to 3 meters) on visual criteria, based on the assessment of the anatomical areas, usually taken in account in dromedary camel to assess the BCS [30]. It was not necessary to touch the animal, but sometimes, it could be helpful to confirm the visual judgment, especially when the fur of Bactrian camel becomes abundant and lead to overestimate the body condition. From back to front observations, the assessment included 12 main points (Figure 1):

- 1. The base of the tail and the ano-genital area
- 2. The bones of the pelvis (iliac crest and ischial spine)
- 3. The sacro-tuberal ligament
- 4. The thighs
- 5. The transverse apophyses of the lumbar vertebrae
- 6. The hollow of the flank
- 7. The groin crease
- 8. The spinous apophyses of the dorsal vertebrae
- 9. The ribs
- 10. The shoulder and notably the humerus joint
- 11. The neck
- 12. The state of repletion of the humps and the general appearance

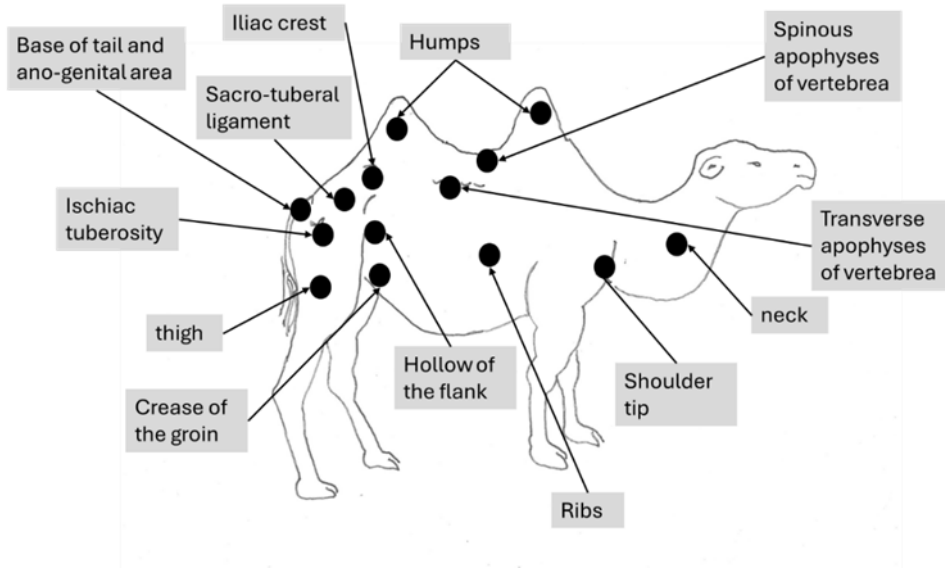


Figure 1. The main points to be observed for assessing a BCS in Bactrian camel.

Usually, a BCS score is attributed to the profile (right-side preferably) and the back of the animal, and an average of the two scores is provided but can be modulated according to the general appearance. The assigned note could vary from the note 0 (very emaciated animal) to 5 (overweighed animal), and it is possible to note by ½ point.

To get a homogenous scoring, only adult females were observed, notably because adult males have a different morphology and they are few in the herds (typically, one male for 30-40 females).

Then, a tentative of scoring in 6 points (from 0 to 5) similar to that is used for dromedary camel and bovine was proposed. One example of each note was taken in photo from side and from back, and a drawing was done to help the establishment of the scoring. Then, a fine description of the different anatomical areas was clearly reported in a grid to define the different scores.

2.4. Statistical Analysis

The statistical analysis involved body measurements only. The objectives of the analysis were (1) to assess the age effect on the body measurements, and (2) to assess the regional effect on the adult animals considering that their growth is stable. To achieve these objectives, the statistical procedure was as follows: (i) to apply a growth model (non-linear regression), several equations were tested: Gompertz, Beta-growth, exponential growth, logistic growth; (ii) to achieve a variance analysis (ANOVA) after homogenization of the variances for identifying the parameters significantly different between farms (only for adults and old adults animals and class of age for all the animals; (ii) Principal Components analysis (PCA) of the body measurements parameters of the adult camels by using farms and age as supplementary variables, (iii) Ascending Hierarchical Classification (AHC) to identify the homogenous groups of camels according to their body measurements and their relationships with the regions tested by Chi². To compare our results with those of the literature data, a data table including different Bactrian camel breeds of the world (as mean of individuals) and some common body measurements (as variables) was built and analyzed by PCA and AHC. The references used came from China [7], India [8,30], Mongolia [31] and Russia [32].

The software used was XLstat (Addinsoft®, 2024).

3. Results

3.1. Body Dimensions of the Bactrian Camels

Obviously, the age is the main source of variation of the different body parameters with increasing values from the group YC to OA. The relative changes in the dimensions of the different parameters were between 10.6 and 25% from the young group to the old adult group with higher changes observed for neck length, chest circumference and front leg length, the lowest being head length and body length (Table 1)

Table 1. Mean body measurements (in mm) of Bactrian camels in Kazakhstan at different group of age: young camel (YC), sub-adult (SA), Adult (AD), old adult (OA); n=477.

Agegroup	HeadL	NeckL	NeckC	HeightW	ChestC	LengthFL	BodyL
P							
OA	481.3 c	1136.9 d	909.1 c	1877.9 c	2235.7 d	1514.4 d	1463.3 c
AD	463.4 b	1095.8 c	884.4 b	1813.2 b	2121.3 c	1449.5 c	1356.6 b
SA	459.3 b	1018.7 b	882.1 b	1785.5 b	2016.8 b	1406.7 b	1395.7 b
YC	435.2 a	909.8 a	810.7 a	1680.3 a	1908.4 a	1316.2 a	1318.5 a
	459.6±46.	1048.3±139.	871.0±85.	1790.0±131.	2078.3±195.	1424.2±145.	1373.9±156.
Total	1	8	1	2	4	7	1
%	10.6	25.0	12.1	11.8	17.2	15.1	11.0
Increase							

P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
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^{a,b,c,d} The values with different subscripts in column differ significantly.

Several growth equations were tested (Gompertz, Beta-growth, exponential growth, logistic growth). The most adjusted model with the minimum of residues was Beta-growth equation : $Y=pr1*(1+(pr2-X1)/(pr2-pr3))*(X1/pr2)\exp(pr2/(pr2-pr3))$ where pr1, pr2 and pr3 are the parameters of the model and X1 the age of the camel (in months). This model was applied for each measurement (Figure 2 and Table 2).

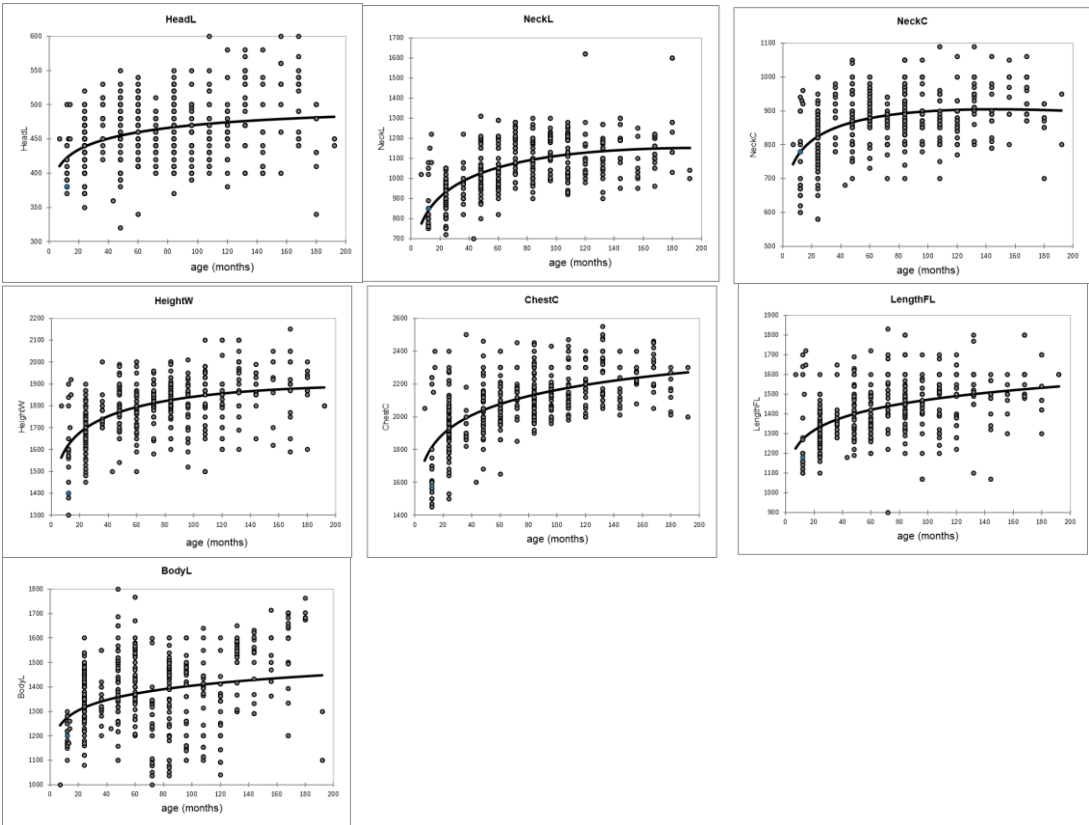


Figure 2. Growth curve of the body measurements in Bactrian camel according to the Beta-growth model.

Table 2. Beta-growth equations according to age for the different body measurements in Bactrian camel from Kazakhstan (ages between 7 months and 16 years).

Parameter	Beta-growth equation
HeadL	$HeadL = 488.7*(1+(399-age)/7040)*(age/399)^{0.056}$
NeckL	$NeckL = 1153,6*(1+(203-age)/1265)*(age/203)^{0.16}$
NeckC	$NeckC = 904*(1+(146-age)/1568)*(age/146)^{0.093}$
HeightW	$HeightW = 1892*(1+(271-age)/3856)*(age/271)^{0.070}$
ChestC	$ChestC = 2430.5*(1+(908-age)/10498)*(age/908)^{0.086}$
LengthFL	$LengthFL = 1871*(1+(7861-age)/112262)*(age/7861)^{0.070}$
BodyL	$BodyL = 1709*(1+(17451-age)/374834)*(age/17451)^{0.046}$

Except for headL and neckC which were relatively stable after 48 months, all other measurements continued to increase, rapidly up to 4 years approximately, then more or less slowly. The growth of chestC appeared the more continues. As the data regarding the groups YC and SA were mainly collected in the farm from Zhetisu region (94% of the camels from YC group and 62% of the sub-adult group came from this region, only 6% and 28.5 respectively from Atyrau while there

was no measurements of young group and only 9.5% of sub-adult group in Turkestan), the regional effect was assessed on body measurements of adults and old adults only (Table 3)

Table 3. Mean body measurements (in mm) of Bactrian camels from different regions in Kazakhstan (n=298).

Region	HeadL	NeckL	NeckC	HeightW	ChestC	LengthFL	BodyL
Zhetisu	494.9 ^b	1009.3 ^a	939.0 ^c	1816.2 ^a	2025.9 ^a	1394.0 ^a	1456.9 ^b
Atyrau1	490.4 ^b	1057.3 ^b	914.6 ^b	1894.9 ^b	2282.4 ^c	1581.5 ^b	1354.0 ^a
Atyrau2	448.0 ^a	1189.0 ^c	860.5 ^a	1810.0 ^a	2132.0 ^b	1426.6 ^a	1384.3 ^a
Turkesta	438.0 ^a	1175.5 ^c	854.7 ^a	1782.4 ^a	2122.4 ^b	1427.8 ^a	1399.0 ^{a,b}
	469.2±46.	1109.1±116.	892.4±71.	1834.1±115.	2158.3±14	1470.5±134.	1391.1±169.
TOTAL	6	5	4	9	5	8	1
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.003

a,b,c,d The values with different subscripts in column differ significantly

The correlations circle issued from PCA analysis have shown that all the parameters are correlated positively along the main factor, except LengthFL correlated to the second factor and NeckL correlated to the third factor (Figure 3). The Bactrian camel from Atyrau1 had long legs, higher size and large chest in opposite to those from Zhetisu region, while there was a proximity between camels from Turkestan and Atyrau2, projected close to the center of gravity of the main factorial plan (Figure 4). In these two farms, the Bactrian camels were characterized by their longer neck while those from Zhetisu had longer head, strong neck and shorter leg.

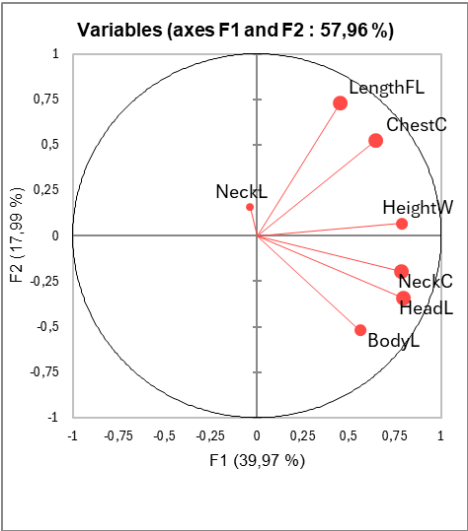


Figure 3. Correlations circle of the body measurements of the adult Bactrian camels on the two first factors of the PCA.

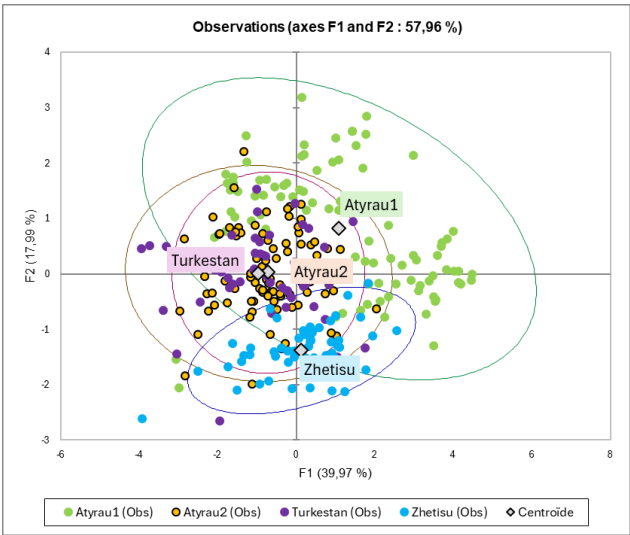


Figure 4. Main factorial plan (1,2) of the PCA with the regions in supplementary variables showing the distribution of the observations colored according to the farm origin.

The automatic classification confirmed the regional differences in body measurements: four main groups of animals can be identified and described by the mean values of the measurements and the farm origin (Figure 5 and Table 4).

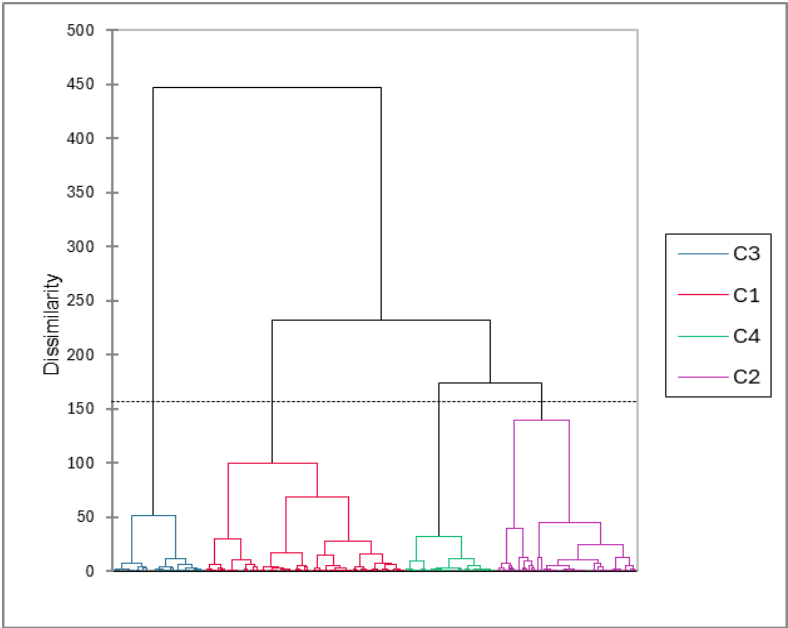


Figure 5. Dendrogram issued from the automatic classification (AHC) of the 278 adult Bactrian camels in Kazakhstan according to their body measurements.

Table 4. Mean values of the body measurements of the 278 adult Bactrian camels in the four groups issued from the automatic classification (tested by ANOVA) and distribution of the farms in the different groups (the values in bold tested by χ^2 test were significantly higher).

Class Parameter	Class3 n=53	Class1 n=113	Class4 n=52	Class2 n=79	P<
HeadL	533.4 ^c	441.6 ^a	455.0 ^b	449.2 ^{a,b}	<0.0001
NeckL	1055.5 ^b	1120.4 ^c	962.4 ^a	1192.7 ^d	<0.0001
NeckC	971.9 ^c	868.4 ^b	858.4 ^{a,b}	843.8 ^a	<0.0001

HeightW	1965.1 ^d	1783.8 ^b	1739.4 ^a	1829.7 ^c	<0.0001
ChestC	2340.8 ^d	2180.6 ^c	1958.8 ^a	2107.1 ^b	<0.0001
LengthFL	1519.6 ^b	1551.9 ^b	1359.8 ^a	1366.8 ^a	<0.0001
BodyL	1535.9 ^d	1261.1 ^a	1368.3 ^b	1443.0 ^c	<0.0001
Atyrau1	45.8%	52.1%	0%	2.1%	<0.0001
Atyrau2	1.1%	41.5%	3.2%	54.3%	<0.0001
Turkestan	2.0%	49.0%	0%	49.0%	<0.0001
Zhetisu	12.1%	0%	84.5%	3.45%	<0.0001

a,b,c,d The values with different subscripts differs significantly.

Thus, the Bactrian camels from Atyrau1were almost equally distributed in class1 and 3, corresponding to animals with long legs but differentiated by all other parameters, especially the body length. The animals from Atyrau2 were more present in class2 (small head, long and fine neck, short leg and medium values for the other parameters). A part (41.5%) was gathered in class1 (chi2 non-significant) characterized by shorter head, long and fine neck and very short body length and long legs. Camels from Turkestan were distributed as the previous one, confirming the proximity of these two farms regarding the global conformation of their camels. At reverse, the camels from Zhetisu were mainly (84.5%) in class 4 and are characterized by short and fine neck, shorter height, chest circumference and legs.

The comparison with other published results was limited as few references were available: One reference in China including 6 breeds, 2 references in India regarding Ladakh breed, one Mongolian reference and one Russian reference only. The automatic classification applied on the table of the mean values of body measurements gave a clear distinction between the Bactrian from Kazakhstan, Russia and Sunit breed from China in one side, and the others breeds from China, Mongolia and India on the other side (Figure 6)

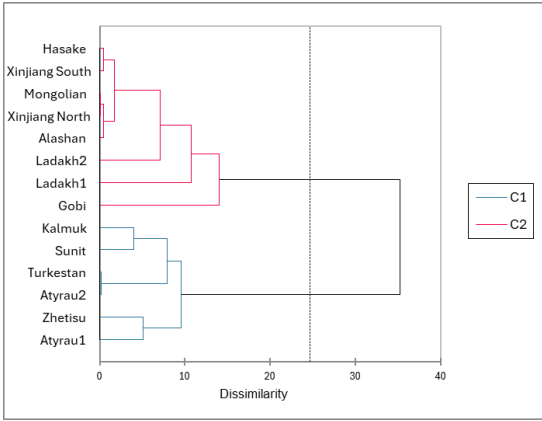


Figure 6. Dendrogram issued from the automatic classification (AHC) of the 10 groups of Bactrian camels reported in the literature in addition of the present results.

Bactrian from the first group (Kazakh, Kalmuk and Sunit breeds) had on average bigger size for all parameters, except the body length (Figure 7).

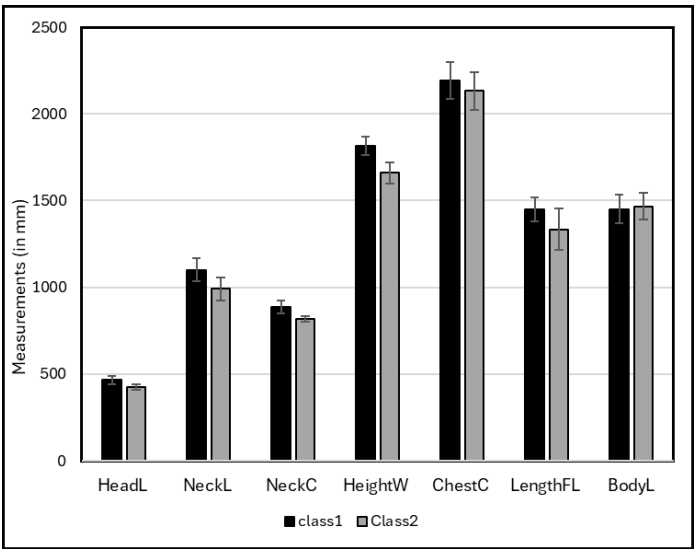


Figure 7. Mean and SD values of body measurements in Bactrian camels from Kazakhstan (class1) and from other countries (class2).

3.2. Body Condition Scoring

3.2.1. Photos of the “Examples” Corresponding to the Expected Scoring

The scoring was built by starting from 6 prototypes of photos representing the six BCS notes from deeply meagre animal (note 0) to highly fat animal (note 5). The six photos are displayed below. Four of them were taken in Kazakhstan, the two others in Europe (Figure 8).

- Example note 0:
This photo was taken in France, in a deeply parasitized camel coming from a circus. We can observe an important muscular melting with alopecia, lack of humps, deep hollow of the flank and empty stomach. The animal has “the skin on the bones”.
- Example note 1
The camel was taken in a Kazakh farm in Turkistan region. The ribs are still highly visible and the humps completely absent. The bones of the back are highly prominent but compared to the former prototype, the hole of the flank is not well visible, and the belly is more rounded, probably because the camel was watering recently.
- Example note 2
This camel came from the same farm as previously. If the ribs are still visible, the tuberosities of the basin are less visible and the shoulder more replenished. However, the two humps are small and still flexed, showing a very small fat reserve.
- Example note 3
It is a typical “medium” animal, coming from Kazakhstan. The ribs and the tuberosities both in shoulder and basin are not visible, but the fat reserves in the humps are still limited although the humps can be erected.
- Example note 4
This camel from Kazakhstan is in very good conditions with well erected humps, basin, shoulder and thorax well covered. It is not easy to see any part of the skeleton.
- Example note 5
It is a very fatty camel from Sweden with all body widely covered of fat and very big humps, especially the rear one with fat covering the basin. All parts of the skeleton are not visible.



Figure 8. Examples of Bactrian camels corresponding to the expected BCS scoring.

3.3. Representation opf the Scoring by Draws

From these 6 examples, it was possible to get drawings from side and back (Figure 9). Each drawing is commented in order to propose a descriptive scoring proposed in the table below (Table 1).

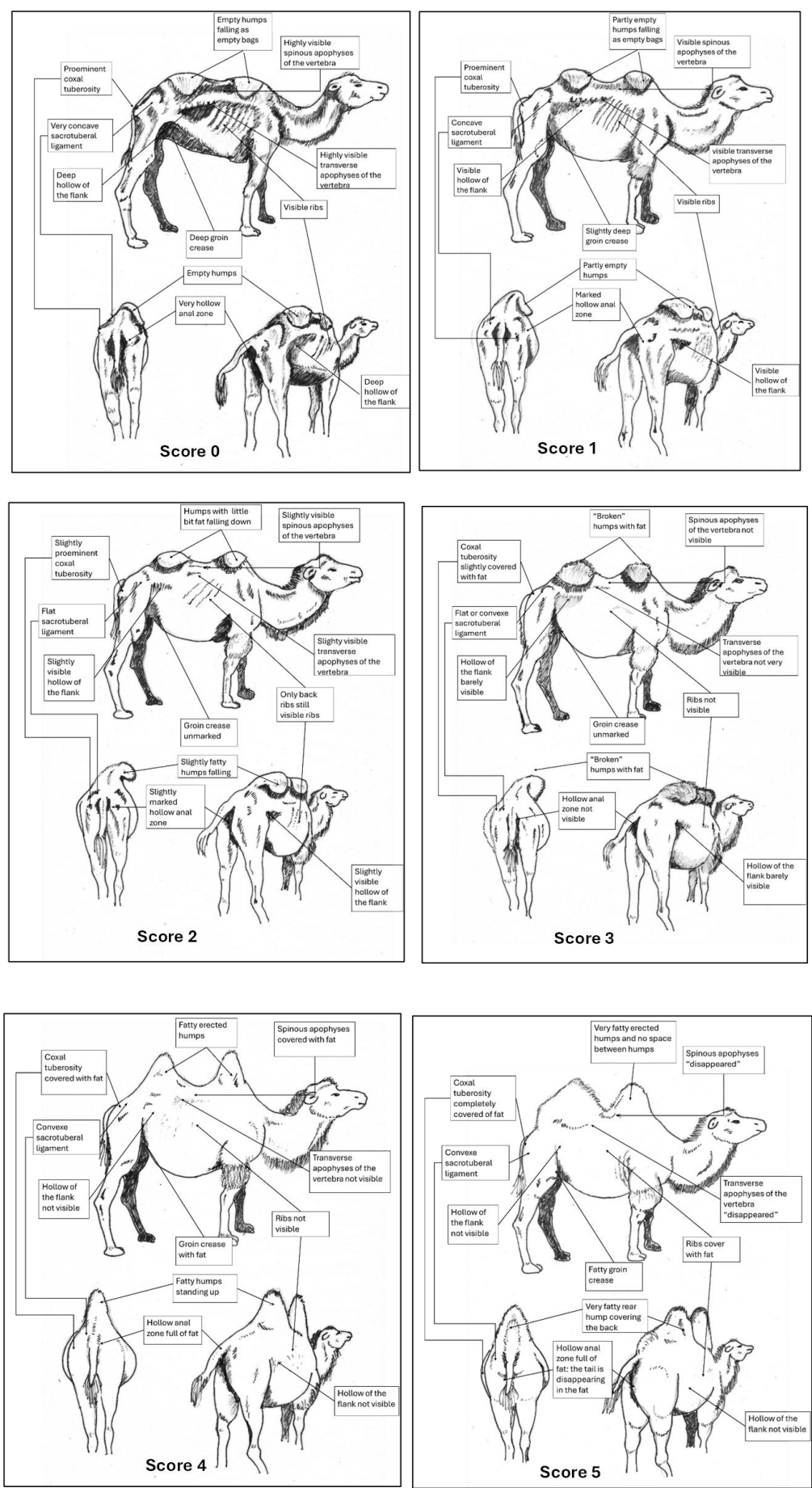


Figure 9. The drawings of the 6 levels of BCS scoring for Bactrian camel with the main comments.

3.4. Description of the Scoring

The grid proposed in the Table 5 is a detailed description of the scoring based on the field observations partly adapted from the grid already established for dromedary camel [33].

Table 5. Grid of the body condition scoring for Bactrian camel.

Scores	Back					Flanc				
	Ano-genital region	Ischial spine	Iliac crest	Sacro-tuber-al ligament	Thigh	Hollow of the flank	Transverse apophyses	Spinous apophyses	Crease of groin	Ribs
0	Very deep at the base of the tail	Very prominent	Completely visible	Very concave	Deeply concave	Very deep	All prominent	All visible even under the humps	Deep crease of groin completely dry	All visible (« skin on bones »)
1	Deep, base of the tail still prominent	Well visible	Still visible	concave	Still concave	Clearly apparent	Still prominent	Still visible on the back	Slightly deep and dry crease	Clearly visible
2	Visible hollow	Well visible	Slightly visible	Flat	Flat	visible	Slightly visible	Slightly visible on the back	Unmarked crease	Back ribs slightly visible
3	Slight hollow	Visible, slightly covered of fat	Slightly covered of fat	Flat to convex	Slightly convex	Very slight	Not very visible	Not very visible	Unmarked crease but with small quantity of fat	Invisible
4	Filled	Hardly visible and covered with fat	Covered of fat	convex	convex	Almost invisible	Invisible	Well covered by fat	Fatty crease	Covered of fat
5	The base of tail is covered by fat	Disappeared in fat	Disappeared in fat	Strongly convex	Well-rounded	Totally invisible	Invisible and rounded back	Rounded back	Crease completely covered of fat (rounded surface)	Presence of intercostal fat

4. Discussion

The differences in the body measurements observed in Kazakhstan could express partly the breed diversity. Globally, three Kazakh Bactrian breeds were described in the country: *Oralobokeliki* mainly present around the Caspian Sea and close to Kalmuk breed from Russia, *Kyzylorda* in the central part of the country and *Ontustik-Kazakhstan* in the south [34]. In the farms in Atyrau region, the breed *Oralobokeliki* are dominant, while in Turkestan, the *Ontustik* breed is more present. The case of the farm in Zhetisu is specific: indeed, although it was in the eastern part of the country, the camel herd was formed with male from Kyzylorda region and mixed with females from different regions. Unfortunately, there were few references regarding Bactrian camel body measurements and the methodology used by the different authors was not necessarily homogenous. Thus, the comparison with the data from the literature should be taken with caution.

BCS is regarded as a better indicator of the fat storage than the live weight, which depends on the water and feed repletion, or of the pregnancy stage. It is a useful tool, especially around parturition to detect the critical nutritional status of the camel, and to adjust the diet facing the specific requirements when the lactation is starting or for mating [22]. Its implementation is interesting at herd level to detect the feeding problem or the management mistakes, but also at animal level to detect especially the parasitized camels or other health problems. Indeed, the emaciation is an important consequence of the default of nutriment absorption and a symptom of many troubles as parasitism, specific deficiencies or loss of appetite due to different metabolic or infectious diseases. In dairy cattle for example, BCS was used in the prevention of metabolic diseases [35], to evaluate their relationships with the reproduction performance [36] or with mastitis and other diseases [37]. BCS was used also in cattle and dromedary camels to detect trypanosomiasis considering that

animals with poor BCS was more susceptible to this disease leading to the use of BCS in large scale epidemiological studies [38]. In Nigeria, Woma et al [39] had investigated the relationships between BCS and the exposure of camels to the Peste des Petits Ruminants detected by serology. At reverse, very fatty animals (score 5) could be an indicator of the excess of feeds and a lack of optimization of the resources which can impact the farm economy.

BCS could be also fully integrated into welfare recommendations, as it can serve as an indicator of animal well-being, reflecting good management practices, including adequate feeding and proper health care, including camel [40–42]. In dromedary camel, BCS was also a parameter involved in the assessment of reproductive performances [43] as ovarian activity [44] or reproductive abnormalities [45]. The relationships between BCS and meat quality of dromedary camel was also investigated [46].

Obviously, the proposed scoring requires to be validated to assess its reproducibility (ability of different assessors to assign the same score to a given animal) and repeatability (ability of each assessor to assign the same score several times for a given animal). The field application should require specific training of the stakeholders (practitioners, technicians, scientists, farmers) in case of monitoring, survey or surveillance of camel herds. Such training is necessary for a better understanding of the assignment and to get a homogenous point of view.

The application of the BCS in field would reduce the subjectivity of the stakeholders and it is interesting to appreciate the homogeneity or heterogeneity of the body conditions within a herd, giving an appreciation of the farm management.

In the present paper, three supports were used: the selection of photos as examples of expected scoring, a unique representation of each score by drawings and a detailed grid. The photos were an illustration of different “archetypes” for a specific score, but some differences could occur between breeds or ecotypes, and generally, the choice of drawing is regarded as a better representation and uniformity in the assessment of the different anatomical landmarks [20]. Drawings were widely used for the establishment of BCS in other species such as Holstein cows [47] and different tropical species as zebu, sheep, goat or donkey [20]. The grid is especially useful for training and are regarded as a complementary tool for drawings. This grid can be distributed with the drawings in brochures adapted for breeders as it was done for the dromedary in the reference cited above [33].

However, the assessment of the BCS for Bactrian camel faces to different pitfalls: (i) the seasonal abundance of wool; (ii) the behaviour of the humps; (iii) the importance of hybridization. Contrary to dromedary camel, the Bactrian camel has abundant fur, especially in winter. In spring, the animal moults, loses its fleece which is generally collected by combing, and the wool gradually grows back until the following winter. In such conditions, the scoring appears difficult in winter time, and not only because the climatic conditions (Figure 4).

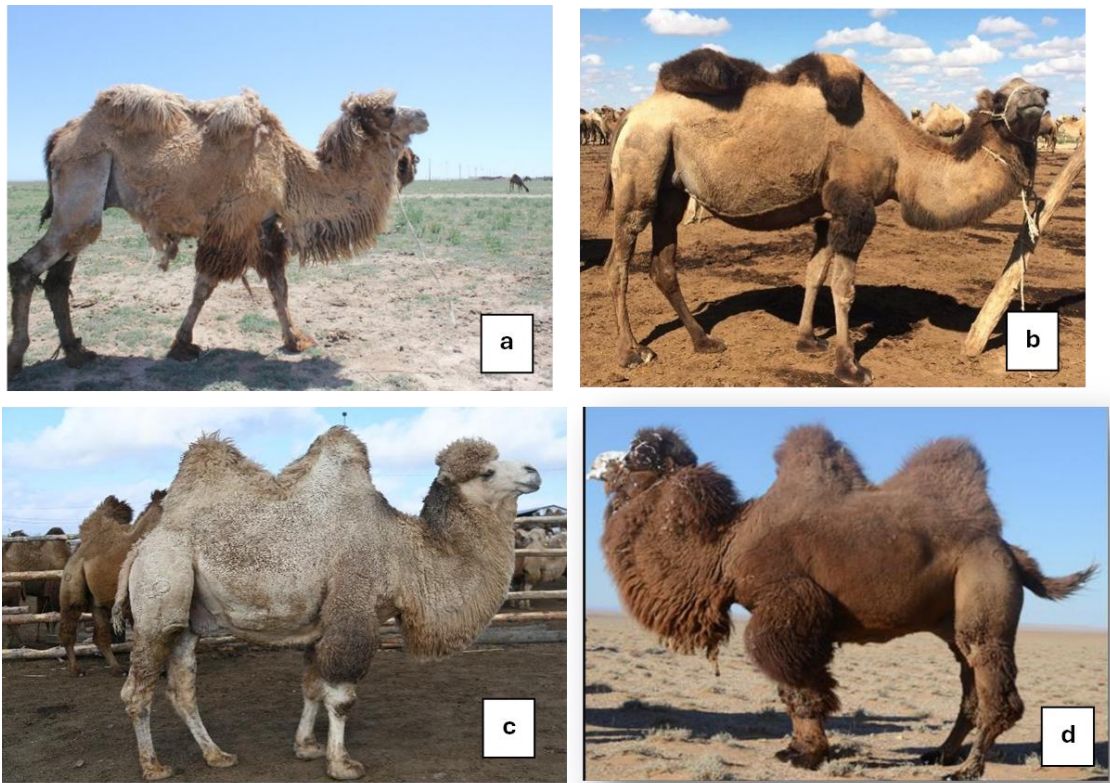
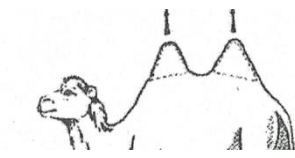
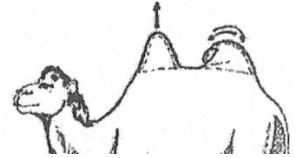


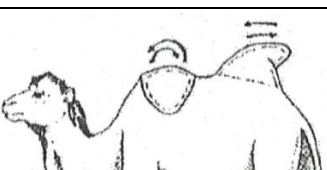
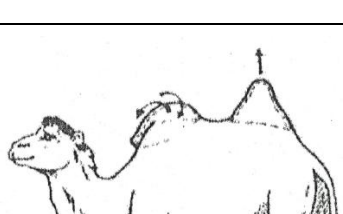
Figure 4. The seasonal change of Bactrian camel’s fleece: (a) in Spring, moulting period), (b) in summer, (c) in autumn, (d) in winter.

Consequently, it is preferable to assess the BCS after the moulting or the shearing, up to the middle of autumn especially since the palpation is difficult unless it is possible to approach the animals in milking corridor when it exists (and only lactating females). Usually, palpation is an easy observation for small ruminants as sheep and goat, but it requires specific logistic conditions for big animals as Bactrian, sometimes not easy to approach, especially the dried females having spent the season in the steppe.

As said above, the Bactrian humps can be “broken” despite its replenishment with fat and this can be an individual specificity. Moreover, when the hump is flexed as more or less empty bag, it could be on one side or another, each hump independently. Besides, for example in Mongol tradition, there is a specific name according to the side and the shape of the humps as well as their movements at walking (Table 6).

Table 6. The different positions and movements of the Bactrian camel humps and their names in the Mongol tradition [48].

Hump shape	Description	Denomination	Translation
	Two humps well erected	<i>Tyг ууpээ</i>	<i>Tug chyrée</i>
	Raised front hump Rear hump flexed on the right side	<i>coëo</i>	<i>Soyo</i>

	Front hump flexed forward and rear hump flexed backward	Солбин ширээ	<i>Solbyn chirée</i>
	The two empty humps flexed on the left side	Зэв Буруу лөг	<i>Zev Bourou leg</i>
	The two humps flexed on the right side	Ханан	<i>Khanan</i>
	Front hump flexed backward and rear hump flexed forward	Дотогуйоо чачир	<i>Dotoguyoo chachyr</i>
	Front hump flexed forward and rear hump flexed backward	Гадагчаа чачир	<i>Gadagchaa chachyr</i>
	Front empty hump flexed forward and asymmetric erected rear hump	Хойт бөх чачир	<i>Khoyt bokh chachyr</i>
	Font hump moving forward and symmetric erected rear hump	Урд бөх чачир, хойт чирээ	<i>Ourd bokh chachyr, khoyt chirée</i>
	Front empty hump flexed on the right side and rear erected hump, flexed backward	Урд бөх лөг, хойт бөх Ханан	<i>Ourd bokh leg, khoyt bokh khanan</i>
	Front empty hump flexed on the right side and well erected rear hump	Солбын соёо чирээ	<i>Solbyn soyo chirée</i>
	Front erected hump flexed forward and empty rear hump flexed on the left side	Урд бөх солбын, хойт бөх лөг	<i>Ourd bokh solbyn, khoyut bokh leg</i>

Since the “filling” of the humps with fatty tissue may appear different for the front one and the back one, the final score should be adjusted to take these variations into account. For example, in case of one hump well erected and one appearing empty, the score can be reduced by half a point. In dromedary, the estimation of the hump volume and weight was proposed by considering it as a semi-ellipsoid measurable with the formula

$V = \frac{1}{2} (4/3 \pi * rL * rW * rH)$ where rL , rW and rH are respectively the radius of length, width and height of the hump, the weight being estimated from charts obtained on slaughtered animals by the formula $\sqrt{P(kg)} = 1.59 + 0.0836 H (cm)$ [49,50]. However, in Bactrian, the hump asymmetry is common, especially on very fat animals leading to an underestimation of the hump fat reserve. This limit of the method to assess the hump fat reserve is accentuated in hybrids.

Indeed, if in China and Mongolia, only Bactrian camels are reared [51,52], in central Asia, the hybridization between dromedary and Bactrian camel is common [53], especially in Kazakhstan [54]. The fat reserve in the humps of the hybrids become more difficult to assess because a high variety of hump's shape can be observed (Figure 5)



Figure 5. Different forms of the hybrids' humps at different level of hybridization.

The BCS proposed for Bactrian could be used for hybrids but with the necessary adaptation to the hybridization level, the two humps being completely fused or more or less separated according to the type of crossbreeding (father Bactrian or dromedary) and generation (F1, F2, F3).

In Kazakhstan, a state-regulated grading system is applied to all farm animals to establish conformity with recognized pure breed standards. For camels, grading assessments are conducted at 2.5 and 5 years of age. The evaluation is based on a set of parameters encompassing phenotypic traits, zootechnical characteristics, and selected genetic indicators. Due to complexity of body condition scoring (BCS), it could serve as a valuable additional criterion to be incorporated into future revisions of the camel grading standards.

In the future, it should be useful to use 3D-imaging device-although for which remarkable progresses were done. This technology was tested on dairy cow with interesting results allowing to measure morphological parameters, volume of body and model the complete shape of the animal [55,56]. However, the scoring of body condition could contribute to a better interpretation of such model. Moreover, such device could more useful in a context of research than in field conditions.

In camel, both in dromedary and in Bactrian, some studies were focused on the use of digital technology, notably 3D-modeling method, compared to manual body measurements and photographing method, to determine the morphological features of camels [57]. However, even if this methodology is easy and practical, it is useful to get accurate body measurements and eventually to estimate the weight of the animal [58], but not yet to evaluate the body condition score.

5. Conclusions

A better standardization of body measurements should be proposed to have a clear idea of the diversity in Bactrian camel populations leading to easier geographical comparison. Elsewhere, the use of a BCS as a tool for assessing the feeding management or the health status of Bactrian camel can be developed easily. But it requires training by regular practical sessions to have experienced technicians and veterinarians, able to transmit their know-how. It is useful also for scientists to assess the relationships between BCS and different production and health performances, or the links with the feeding practices and availability of resources.

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Abbreviations

The following abbreviations are used in this manuscript:

AD Adult

AHC Ascending Hierarchical Classification

BCS Body Condition score

BM Body measurement

OA Old adult

PCA Principal Components Analysis

SA Subadult

YC Young Camel

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