Determination of Some Body Measurements of Camels With Three Dimensional Modeling Method (3D)

Alkan çağlı

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Abstract

In this study, the use of three-dimensional modeling method was tested in taking some body measurements in camels with a practical method and was compared with other measurement methods. As the animal material of the study, 12 single humped dromedary female camels and 14 double humped *Camelus dromedarius* X *Camelus bactrianus*: F1 male camels, totally 26 camels, were used in three camel farms in Incirliova district of Aydin province. The body measurements taken from each animal by using different three methods, namely by Manuel Method (MM), by Photography Method (PM), and by Three Dimensional Modeling Method (3D) were the Cidago Height (CH), the Back Height (BH), the Rump Height (RH), the Body Length (BL), the Brisket Height (BRH), the Abdominal Height (AH), the Shoulder Width (SW) and the Rump Width (RW) and these values were compared with each other. As a result of this study, the mean values of MM and 3D measurement values were very close to each other and the difference between them was found to be statistically insignificant. ($P < 0.05$). The difference between the means of PM and MM/3D measurement values was found to be significant. ($P < 0.05$). In the measurements taken by MM, 3D, PM methods in male camels, the values obtained by MM and 3D methods for CH, BH, RH, BRH, AH, BL, and SW were very close to each other and the differences between them were found insignificant statistically ($p < 0.05$). On the determined regression graph, a linear was found between MM and 3D measurement values. As a result of this study, it has been determined that the 3D modeling method can be used as a remote and more practical method in determining the morphological features of large-scale animals such as camels more reliably, more easily and more practically.

Introduction

It is important to determine or to measure the morphological characteristics in defining species and the races within those species. Morphological characteristics are difficult to determine in farm animals. Besides, estimation of some physiological characteristics is difficult and time consuming for researchers and breeders in animal breeding studies. All these difficulties have created problems in the work of researchers. Studies have attempted to estimate the characteristics of populations or the identification of races from these criteria by taking measurements on a small number of animals. The use of body measurements technically and scientifically in the evaluation and breeding of farm animals at the end of the last century has further increased the importance of the subject (Zehender et al. 1996). Studies have been carried out for many years to develop practical and easily applicable methods to define morphological features and especially body measurements and to determine some physiological features in many animals (Wu et al. 2003; Tasdemir et al. 2011; Ozkaya, 2012).

In recent years, scientific studies on the use of digital technology in livestock for these purposes have gained importance. It was stated by Le Cozler et al (2019) that the three-dimensional (3D) imaging method can be used to monitor the morphology and growth of dairy cows, and to estimate indicators such as body volume, surface area and body weight. Kalkoohi investigated the possibility of estimating the weight of camels using digital image processing method and stated that this method could be a good alternative to weighing camels using a scale (Meghelli et al., 2020)

External appearance features are used as important selection criteria in all countries where systematic breeding programs are implemented. Various body measurements such as body height, rump height, body length, chest depth, withers height, chest width and circumference are the leading most important morphological characteristics used to determine the individual identities of animals, their structural capacities, their relationships with their yield levels, their morphological type assessments and most importantly for the registration of breeds (Tien and Tripathi, 1990; Velea et al. 1991). The use of digital technology is increasing day by day in animal husbandry as in every field. Efforts have intensified for the use and development of digital technology in different livestock sectors such as faster and easier animal breeding, animal nutrition and welfare, production and processing of animal products, and marketing. Especially with Agriculture 4.0, developed European countries attach importance to digital and robotic developments and smart agriculture practices (Ozdogan, 2017; Özkaya, 2017).

According to FAO (2017) statistical data, it has been stated that there are 34.83 million camels in the world and 47 countries breed camels. It has been reported that camel breeding has risen around the world and the numbers have doubled in the last 50 years. It was also stated that camel milk and meat production (totally 524.390 tons) rose due to this increase. Camels that are bred for milk, for meat and for mount in the world are bred in Turkey for camel wrestling and for prestige purposes. Camel breeding is done in the west of Turkey for mainly prestige purposes. In recent years, although they are in small numbers, some breeding enterprises

have started to breed camels for meat and milk production purposes. As in the world in general, sufficient studies have not been conducted in Turkey towards the identification of morphological and physiological characteristics of camels. In our country, it is necessary to define the morphological and physiological characteristics of both wrestling camels and camels whose breeding and production are desired. Too few researches have been conducted in Turkey to determine the morphological and physiological properties of wrestler camels (Yılmaz et al. 2013).

In this study, in order to measure the body measurements in camels with a practical method, the possibility of using the three-dimensional modeling method (3D) in camel and in similar cattle breeding where body measurements can be measured very difficultly and inconvenience of the method was tested by comparing it with other measurement methods.

Material And Methods

Material

As the animal material of the study, 12 single humped female dromedary camels at 5-12 years old and 14 *Camelus dromedarius* X *Camelus bactrianus* (F1) male camels, a total of 26 camels, were used in three breeding companies in Aydın Province in Turkey. This study was conducted in 3 farms breeding camels in Aydın Province in Turkey. In the study, totally 26 camels, 12 *Camelus dromedarius* female camels aged 5-12 years old and 14 F1 hybrid *Camelus Dromedarius* X *Camelus Bactrianus* male camels aged 6-16 years old that were bred by double humped Bactrian male and single humped Dromedar female and named as "Tulu", were used. Camel wrestling, located in 8 provinces in Turkey's western coast, has traditionally been held for many years. Although Dromedary camels were used in wrestling in the past, today wrestling is held between *Camelus Dromedarius* X *Camelus Bactrianus* F1 male camels called "tulu" (Manav et al. 2018; Koç et al., 2018).

Methods

In this study, various body measurements of *Camelus dromedarius* (females), Bactrian x Dromedar F1 hybrid male wrestling camels, 1- By hand, using a measuring stick and tape measure, 2-By the method of photographing using a camera, 3- using a three-dimensional (3D) camera, It was measured by three different methods and the results were analyzed. Measurements taken with a three-dimensional camera were compared with the other measurements taken by the other two measurement methods.

The body measurements taken were: Cidago Height (CH), Back Height (BH), Rump Height (RH), Body Length (BL), Brisket Height (BRH), Abdominal Height (AH), Shoulder Width (SW) and Rump Width (RW) (Bıyıkoglu, 1973).

Manual Method (MM): In the manual measurement method, body measurements were taken from each animal by the researchers using a tape measure and a measuring stick.

Photographing Method (PM): In this measurement method, the photographs of the animals were taken using a Nikon D3000 brand camera using a 10 * 10 centimeter square scale paper as a reference. While a photograph was taken by one person, a second person held the scale paper next to the camel, and it was shot from different angles. A total of three photographs of each camel were taken from the side, front and back. Body pixel measurements of camels were obtained from the obtained images using Adobe Photoshop CS6 (64 bit) Photoshop program. Pixel measurements determined with the help of a 10 * 10 centimeter square scale have been converted to centimeters. The following formula was used to determine body measurements from the photographs: Body size taken = (10 cm x pixels of body size to be determined) / pixels of the scale paper

The Three Dimensional Analysis method (3D): For the three-dimensional analysis in the study, Structure Sensor 3D scanner was used to transfer the models to digital environment. With this scanner, objects were scanned in 3D and the data obtained were transferred to digital media in real dimensions. In the Three-Dimensional Analysis method, the shooting was taken by a researcher around the calm and docile camels by turning from a distance of 1 to 2 meters and the process was completed in half a minute or one minutes. Behaviorally active and angry animals were kept by the owner and the shootings were completed within the same time. The obtained images were transferred to the Blender software of Autodesk Company and the measurements were evaluated in the Computer Engineering Department of Adnan Menderes University Faculty of Engineering.

Body measurement values of CH, BH, RH, BL, BRH, AH, SW and RW obtained by MM were accepted as the Y property and the same values taken by PM and 3D were taken as the X property and the linear regression and co-t-test statistical methods were evaluated using SPSS 21.1 package program.

Results

In the study, MM values were compared with the other two measurement methods (PM and 3D) statistically and in terms of their practical use. When the practicality of application of all three measurement methods on animals was compared, MM was considered to be the most difficult method because it required two people to hold the animal stable and two people to take the measurements, a total of four people while measuring manually on the same animal. MM took between 15–20 minutes. Since the female camels are very mobile, some animals were given food during the measurement. In addition, another person tried to keep the animal stable. In the application of manual measurement method, measuring in animals has generally been difficult, dangerous and time consuming.

In the PM, while a photograph was taken by one person, a second person held the scale paper near the camel and the shots were taken from different angles. Another person kept the camel still during the shooting. A total of three people took part in the photo shooting and totally three photographs were taken from the side, front and back of each camel. The time taken for this process is approximately 3–5 minutes.

In the 3D Analysis method, the shooting was taken by a researcher around the calm and docile camels by turning from a distance of 1 to 2 meters and the process was completed in half a minute or 1 minutes. Behaviorally active and angry animals were kept by the owner and the shootings were completed within the same time.

The comparison of various body measurements of the female camels determined by all three methods according to the least squares averages is shown in Table 1.

For CH and BH measurement values, it was determined that MM and 3D Method measurement values were very close to each other and the difference between them was statistically insignificant ($p < 0.05$). For these measurements, the value obtained by the PM was found to be smaller. The difference between the measurement values determined by MM and PM ($p < 0.05$) was found to be significant. Measurement values of RH, BL, SW and RW were very close to each other in MM and 3D methods, and the differences were statistically insignificant ($p < 0.05$), but the difference between the measurement values determined by MM and PM ($p < 0.05$) was found significant (Table 1).

The values measured by 3D and PM methods for BRH and AH were close to each other and the difference was found to be statistically insignificant ($p < 0.05$), but the difference between MM measurement values of the same regions and the values obtained by other methods was statistically significant ($p < 0.05$). The reason for this is that the person who will do the measuring with MM has to go under the camel to measure AH and BRH values. It is thought that a very healthy measurement cannot be taken under these conditions because the person is afraid of going under the camel and this behavior is dangerous (Table 1).

RW was determined as 32.33 cm by MM, 33.00 cm by 3D, and 31.71 cm by PM. When the measurement values determined by MM, 3D and PM were compared statistically, the difference between the means ($p < 0.05$) was found to be insignificant (Table 1).

Table 1. Comparison of various body measurements of female camels by least squares means:

BMs	Groups					P
	N	MM	3D	PM		
CH	12	171.42±1.34 ^a	170.46±1.37 ^{ab}	165.54±2.22 ^b		*
BH	12	190.42±1.80 ^a	187.18±1.61 ^{ab}	183.17±2.91 ^b		*
RH	12	164.21±0.74 ^a	163.75±1.22 ^a	156.75±3.36 ^b		*
BRH	12	91.17±0.95 ^a	88.13±1.17 ^b	87.26±1.97 ^b		*
AH	12	91.00±1.25 ^a	86.67±1.83 ^b	85.42±2.41 ^b		*
BL	12	148.75±2.66 ^a	148.96±3.35 ^a	137.92±3.14 ^b		*
SW	12	40.33±1.52 ^a	40.25±1.39 ^a	34.38±0.83 ^b		*
RW	12	32.33±0.75 ^a	33.00±0.81 ^a	31.71±0.85 ^a		NS

a,b, Differences between means with different letters on the same line are statistically significant.

*=P<0.05; NS= Not Significant.

The comparison of the male camels according to the least squares means of various body measurements determined by three methods is shown in Table 2. MM and 3D values obtained for CH, BH, RH, BRH, AH, SW and BL in the measurements made with MM, 3D, PM methods were considered very close to each other and the differences between them were found to be statistically insignificant ($p < 0.05$). However, for these values, the differences between the values obtained by the MM and 3D methods and the values measured by the PM method were found to be statistically significant ($p < 0.05$). For the Rump Width (RW), the measurement values taken by the MM, 3D and PM methods were found to be close to each other and the differences between them were statistically insignificant (Table 2).

Table 2. Comparison of male camels by means of least squares of body measurements:

BM	Groups					P
	N	MM	3D	PM		
CH	14	183.21±1.46 ^a	183.68±1.41 ^a	168.43±2.71 ^b		*
BH	14	205.39±2.67 ^a	205.64±2.62 ^a	191.93±3.74 ^b		*
RH	14	165.36±1.95 ^a	164.36±1.78 ^a	152.36±3.59 ^b		*
BRH	14	92.46±1.04 ^a	92.57±0.97 ^a	86.51±2.11 ^b		*
AH	14	89.00±1.36 ^a	88.82±1.25 ^a	81.36±2.12 ^b		*
BL	14	168.39±1.33 ^a	168.43±1.23 ^a	148.46±3.79 ^b		*
SW	14	55.64±1.59 ^a	57.11±1.47 ^a	45.79±1.56 ^b		*
RW	14	39.10±1.37 ^a	39.71±1.18 ^a	36.50±0.69 ^a		NS

a,b, Differences between means with different letters on the same line are statistically significant.

*=P<0.05; NS= Not Significant.

Very high and significant positive correlations were found between the values obtained by MM and 3D methods in males and females. Correlation values between MM and 3D measurements of female camels are given in Table 3. There was a positive relationship between 3D-CH and MM-CH, 3D-CH and MM-BH ($p < 0.05$). A high positive correlation was found between 3D-CH and 3D-BH, 3D-CH and 3D-RH measurement values ($p < 0.01$). A high positive correlation was found between MM-CH and MM-BH ($p < 0.01$). The relationship between MM-CH and MM-RH was found to be significant ($p < 0.05$). A positive correlation was found between 3D-BH and MM-BH ($p < 0.05$). There was a high positive correlation between MM-BH and 3D-BL ($p < 0.01$), and a high positive correlation between MM-BH and MM-BL ($p < 0.05$). A positive ($p < 0.05$) relationship was found between 3D-RH and MM-RH and MM-RH and 3D-BRH. The relationship between 3D-RH and 3D-BRH ($p < 0.01$) was found to be positive. A positive ($p < 0.05$) relationship was found between MM-BRH and 3D-AH and 3D-AH and MM-AH. A positive correlation ($p < 0.01$) was found between 3D-BRH and 3D-AH and 3D-BL and MM-BL (Table 3).

Table 3: Correlation values of female camels between MM and 3D belonging to BMs (CH, BH, RH, BRH, AH, BL)

BM	3D-CH	MM-CH	3D-BH	MM-BH	3D-RH	MM-RH	3D-BRH	MM-BRH	3D-AH	MM-AH	3D-BL	MM-BL
3D-CH	1	0,690*	0,790**	0,633*	0,738**	0,513	0,511	0,215	0,176	0,084	0,267	0,156
MM-CH		1	0,339	0,717**	0,567	0,582*	0,555	0,497	0,264	0,224	0,302	0,318
3D-BH			1	0,687*	0,526	0,361	0,07	-0,199	-0,143	-0,245	0,548	0,455
MM-BH				1	0,386	0,528	0,04	0,131	-0,225	-0,15	0,765**	0,683*
3D-RH					1	0,643*	0,775**	0,468	0,499	0,568	-0,028	-0,034
MM-RH						1	0,593*	0,128	0,516	0,412	0,222	0,137
3D-BRH							1	0,443	0,790**	0,569	-0,263	-0,212
MM-BRH								1	0,634*	0,443	-0,193	-0,182
3D-AH									1	0,606*	-0,482	-0,388
MM-AH										1	-0,463	-0,453
3D-BL											1	0,943**
MM-BL												1

*= $P < 0.05$, **= $P < 0.01$

Correlation values of female camels between MM and 3D belonging to BMs (BL, SW, RW) were given in Table 4. A high positive correlation ($p < 0.01$) was found between 3D-BL and MM-BL and between 3D-BL and MM-SW. The relationship between 3D-BL and 3D-SW, 3D-BL with 3D-RW and 3D-BL and MM-RW ($p < 0.05$) was found to be positive and significant. A high positive correlation ($p < 0.01$) was found between MM-BL and 3D-SW, MM-BL with MM-SW, MM-BL and 3D-RW, MM-BL and MM-RW (Table 4). A high positive correlation ($p < 0.01$) was found between 3D-SW and MM-SW; between 3D-SW and 3D-RW; between 3D-SW and MM-RW; between MM-SW and 3D-RW; between MM-SW and MM-RW and between 3D-RW and MM-RW (Table 4).

Table 4
Correlation values of female camels between MM and 3D belonging to BMs
(BL, SW, RW)

BMs	3D-BL	MM-BL	3D-SW	MM-SW	3D-RW	MM-RW
3D-BL	1	0,943**	0,668*	0,743**	0,627*	0,578*
MM-BL		1	0,767**	0,777**	0,763**	0,750**
3D-SW			1	0,883**	0,801**	0,852**
MM-SW				1	0,665*	0,734**
3D-RW					1	0,817**
MM-RW						1

*=P < 0.05, **=P < 0.01

The correlation values between MM and 3D measurements of male camels are given in Table 5. A positive correlation ($p < 0.01$) was found between 3D-CH and MM-CH, 3D-BH and MM-BH. A positive correlation ($p < 0.01$) was found between 3D-RH and MM-RH, 3D-RH and 3D-AH. The relationship between 3D-RH and 3D-BRH, 3D-RH and MM-AH ($p < 0.05$) was found to be positive. A positive correlation ($p < 0.01$) was found between MM-RH and 3D-BRH, MM-RH and 3D-AH. The relationship between MM-RH and MM-BRH, MM-RH and MM-AH ($p < 0.05$) was found to be positive. A high positive correlation ($p < 0.01$) was found between 3D-BRH and MM-BRH, 3D-BRH and 3D-AH, 3D-BRH and MM-AH, MM-BRH and 3D-AH. A high positive ($p < 0.01$) correlation was found between MM-BRH and MM-AH. A positive correlation ($p < 0.01$) was found between 3D-AH and MM-AH, 3D-BL and MM-BL. As seen in Table 5, the relationship between 3D and BMs with MM was generally found to be significant.

Table 5
Correlation values of male camels between MM and 3D belonging to BMs (CH, BH, RH, BRH, AH, BL)

BMs	3D-CH	MM-CH	3D-BH	MM-BH	3D-RH	MM-RH	3D-BRH	MM-BRH	3D-AH	MM-AH	3D-BL	MM-BL
3D-CH	1	0,953**	0,177	0,163	0,36	0,416	0,19	0,227	0,484	0,451	0,477	0,154
MM-CH		1	0,32	0,322	0,396	,538*	0,218	0,258	0,491	0,454	0,47	0,306
3D-BH			1	0,995**	-0,091	0,163	0,038	0,104	-0,044	-0,132	0,239	0,3
MM-BH				1	-0,077	0,198	0,062	0,121	-0,023	-0,109	0,238	0,335
3D-RH					1	0,871**	,619*	0,494	,691**	0,578*	-0,08	-0,111
MM-RH						1	0,705**	0,641*	0,729**	0,625*	-0,006	0,037
3D-BRH							1	0,948**	0,795**	0,748**	-0,031	-0,106
MM-BRH								1	0,761**	0,710*	-0,094	-0,16
3D-AH									1	0,977**	0,253	0,105
MM-AH										1	0,132	0,195
3D-BL											1	0,780**
MM-BL												1

*=P < 0.05, **=P < 0.01

The correlation values between MM and 3D of BL, SW and RW measurements of male camels are included in Table 6. A high positive correlation ($p < 0.01$) was found between 3D-BL and MM-BL, 3D-SW and MM-SW, 3D-RW and MM-RW.

Table 6
Correlation values of male camels between MM and 3D belonging to BMs (BL, SW, RW)

BMs	3D-BL	MM-BL	3D-SW	MM-SW	3D-RW	MM-RW
3D-BL	1	0,780**	-0,27	-0,322	0,139	-0,14
MM-BL		1	0,14	0,121	-0,098	-0,344
3D-SW			1	0,984**	0,144	0,247
MM-SW				1	0,082	0,225
3D-RW					1	0,909**
MM-RW						1

*=P < 0.05, **=P < 0.01

Cidago Height

3D-CH and MM-CH (green line) in female camels were found to be positively linear as shown in the graph in Fig. 1. There was no linear between 3D-CH and PM-CH (blue line). Likewise, PM-CH and MM-CH (red line) were also not linear.

For female camels, the R^2 between MM-CH and 3D-CH was found as 0.48, the R^2 between MM-CH and PM-CH as 0.18 and the R^2 between 3D-CH and PM-CH as 0.07.

In male camels, 3D-CH and MM-CH (green line) were found to be positively linear as shown in the graph in Fig. 2. There was no linear between 3D-CH and PM-CH (blue line). Likewise, PM-CH and MM-CH (red line) were also not linear.

In male camels, the R^2 between MM-CH and 3D-CH was found as 0.91, the R^2 between MM-CH and PM-CH as 0.09 and the R^2 between 3D-CH and PM-CH as 0.08.

Back Height

In female camels, 3D-BH and MM-BH (green line) were found to be linear as shown in Fig. 3. However, 3D-BH and PM-BH (blue line) and PM-BH and MM-BH (red line) BMs were not linear.

In female camels, the R^2 between MM-BH and 3D-BH was found as 0.30, the R^2 between MM-BH and PM-BH as 0.09 and the R^2 between 3D-BH and PM-BH as -2.49.

3D-BH and MM-BH (green line) were found to be linear in male camels as shown in Fig. 4. However, 3D-BH and PM-BH (blue line) and PM-BH and MM-BH (red line) BMs were not linear.

In male camels, R^2 between MM-BH and 3D-BH was found as 0.99, R^2 between MM-BH and PM-BH as 0.24 and R^2 between 3D-BH and PM-BH as 0.21.

Rump Height

In female camels, 3D-RH and MM-RH (green line) were found to be linear as shown in Fig. 5. However, 3D-RH and PM-RH (blue line) and PM-RH and MM-RH (red line) were not linear.

In female camels, R^2 between MM-RH and 3D-RH was found as 0.41, R^2 between MM-RH and PM-RH as 0.07 and R^2 between 3D-RH and PM-RH as 0.34.

In male camels, 3D-RH and MM-RH (green line) were found to be linear as shown in Fig. 6. However, 3D-RH and PM-RH (blue line) and PM-RH and MM-RH (red line) BMs were not found to be linear.

In male camels, the R^2 value between MM-RH and 3D-RH was found as 0.76, the R^2 value between MM-RH and PM-RH as 0.04 and the R^2 value between 3D-RH and PM-RH as 0.001.

Brisket Height

In female camels, 3D-BRH and PM-BRH (blue line) and PM-BRH and MM-BRH (red line) were found to be linear as shown in Fig. 7. However, 3D-BRH and MM-BRH (green line) BMs were not linear.

In female camels, the R^2 between MM-BRH and 3D-BRH was found as 0.20, the R^2 between MM-BRH and PM-BRH as 0.36 and the R^2 between 3D-BRH and PM-BRH as 0.32.

In male camels, 3D-BRH and MM-BRH (green line) were found to be linear as shown in Fig. 8. However, 3D-BRH and PM-BRH (blue line) and PM-BRH and MM-BRH (red line) BMs were not linear.

In male camels, the R^2 between MM-BRH and 3D-BRH was found as 0.90, the R^2 between MM-BRH and PM-BRH as 0.11 and the R^2 between 3D-BRH and PM-BRH as 0.19.

Abdominal Height

In female camels, 3D-AH with PM-AH, MM-AH with PM-AH and 3D-AH with MM-AH were found to be linear as shown in Fig. 9.

In female camels, the R^2 between MM-AH and 3D-AH was found as 0.37, the R^2 between MM-AH and PM-AH as 0.60 and the R^2 between 3D-AH and PM-AH as 0.48.

In male camels, 3D-AH and MM-AH (green line) were found to be linear as seen in Fig. 10. However, 3D-AH and PM-AH (blue line) and PM-AH and MM-AH (red line) BMs were not linear.

In male camels, the R^2 between MM-AH and 3D-AH was found as 0,96, the R^2 between MM-AH and PM-AH as 0,12 and the R^2 between 3D-AH and PM-AH as 0,07.

Body Lenght

In female camels, 3D-BL and MM-BL (green line) was found to be linear as shown in Fig. 11. However, 3D-BL/PM-BL (blue line) and PM-BL/MM-BL (red line) were not linear.

In the female camels, the R^2 between MM-BL and 3D-BL was found as 0.89, the R^2 between MM-BL and PM-BL as 0.15 and the R^2 between 3D-BL and PM-BL as 0.05.

In male camels, 3D-BL and MM-BL (green line) were found to be linear as seen in Fig. 12. However, 3D-BL and PM-BL (blue line) and PM-BL and MM-BL (red line) were not linear

In male camels, the R^2 between MM-BL and 3D-BL was found as 0.61, the R^2 between MM-BL and PM-BL as 0.10 and the R^2 between 3D-BL and PM-BL as 0.23.

Shoulder Width

In female camels, 3D-SW and MM-SW (green line) were found to be linear as shown in Fig. 13. However, 3D-SW and PM-SW (blue line) and PM-SW and MM-SW (red line) were not linear.

In female camels, the R^2 between MM-SW and 3D-SW was found as 0.78, the R^2 between MM-SW and PM-SW as 0.001 and the R^2 between 3D-SW and PM-SW as 0.002.

In male camels, 3D-SW and MM-SW (green line) were found to be linear as shown in Fig. 14. However, 3D-SW and PM-SW (blue line) and PM-SW and MM-SW (red line) BMs were not found to be linear.

In the male camels, the R^2 between MM-SW and 3D-SW was found as 0.97, the R^2 between MM-SW and PM-SW as 0.02, R^2 between 3D-SW and PM-SW as 0.02.

Rump Width

In female camels, 3D-RW and MM-RW (green line), 3D-RW and PM-RW (blue line) and PM-RW and MM-RW (red line) were found to be linear as shown in Fig. 15.

In female camels, the R^2 between MM-RW and 3D-RW was found as 0.67, the R^2 between MM-RW and PM-RW as 0.41 and the R^2 between 3D-RW and PM-RW as 0.31.

In male camels, 3D-RW and MM-RW (green line) were found to be linear as seen in Fig. 16. However, 3D-RW and PM-RW (blue line) and PM-RW and MM-RW (red line) BMs were not found to be linear.

In male camels, the R^2 between MM-RW and 3D-RW was found as 0.83, the R^2 between MM-RW and PM-RW as 0.07 and the R^2 between 3D-RW and PM-RW as 0.03.

Discussion

Many studies have been conducted to find practical and easy methods for taking body measurements of farm animals. Taşdemir et al. 2011, conducted studies on Holstein cows using MM and PM and Wu et al., 2003, studied on pigs using multiple cameras. Numerous studies have been conducted on image processing, mostly with photography, video processing, thermography and thermal image analysis methods (Tözsér et al., 2000; Wu et al., 2004; Stajniko et al., 2008). The results of these studies, which were carried out for 3D imaging using numerous cameras and equipment, were found to be successful; however, there was not enough improvement in the practical use of these measuring methods. With the development of digital technology and the use of industry 4.0 in the field of agriculture, it is seen that 3D imaging and image processing methods in livestock farming have been used in studies to determine the morphological and physiological characteristics of animals in the last two years. In a study, it was reported that a full body scan was performed by placing five three-dimensional (3D) imaging devices on a fixed platform to capture images from all angles to monitor the morphology and growth of 64 heads of Holstein cows (Le Cozler et al. 2019). In this study, a full body scan was performed by rotating 360 ° around the animal with a single three-dimensional imaging device. With this method, in which we used on the basis of the operator and in extensive conditions without the need for a platform or a large number of cameras, body measurements of animals can be taken easily. There are few studies on the measurements of morphological and physiological characteristics in camels (Iglesias et al., 2020; Meghelli et al., 2020).

Instead of using many cameras and different imaging systems and platforms for three-dimensional images, it has been seen in our study that all measurements can be determined using a single three-dimensional imaging device and a computer program.

Conclusion

As a result of this study, it has been revealed that the measurement of morphological characteristics of large animals such as camels with easy and practical three-dimensional modeling method from a distance is a reliable, easy and practical method. As a result of this study, it has been observed that with the 3D measurement method, it is easily achieved to take the desired body measurements in a very short time with a small number of people in many animals and to follow the body parts.

The 3D method is a measurement method that can enable to take measurements in large farm animals without touching them, without causing stress to them and without fear for the researcher or breeder who takes the measurements. In addition, considering the difficulties in monitoring the general situation of cattle breeding (camel, cattle, buffalo, horse) enterprises, the ease of the use of the 3D measurement method will also provide time and economic gain by supporting herd management.

A single three-dimensional camera can be used to determine the relationship or abnormalities between the body parts of animals and to detect damages such as lesions and injuries, etc. in the body, as in this study. The results of this study demonstrated that more studies should be conducted on taking measurements with the 3D method, and this method should be tested and developed in different breeds as well. It is thought that this method will become widely used in taking morphological measurements of animals in animal breeding and studies for scientific purposes in the near future.

Declarations

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Figures

Figure 1

Regression graph of CH measurements taken by three methods in female camels

Figure 2

The Regression graph of CH measurements taken by three methods in female camels

Figure 3

Regression graph of BH measurements taken by three methods in female camels

Figure 4

Regression graph of BH measurements taken by three methods in female camels

Figure 5

Regression graph of RH measurements taken by three methods in female camels

Figure 6

Regression graphic of RH measurements taken by three methods in male camels

Figure 7

Regression graph of BRH measurements taken by three methods in female camels

Figure 8

Regression graph of BRH measurements taken by three methods in male camels.

Figure 9

Regression graph of AH measurements taken by three methods in female camels.

Figure 10

Regression graph of AH measurements taken by three methods in male camels

Figure 11

Regression graph of BL measurements taken by three methods in female camels

Figure 12

Regression graph of BL measurements taken by three methods in male camels

Figure 13

Regression graph of SW measurements taken by three methods in female camels.

Figure 14

Regression graph of SW measurements taken by three methods in male camels.

Figure 15

Regression graph of RW measurements taken by three methods in male camels.

Figure 16

Regression graph of RW measurements taken by three methods in male camels