Body weight, morphometric measurements and number of teats of Boer goat does, reared in Bulgaria

Dimitar Panayotov

Trakia University, Faculty of Agriculture, 6000 Stara Zagora, Bulgaria
E-mail: dpanayotov@uni-sz.bg

Abstract

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    The Boer goat is a goat breed new to Bulgaria, where it was introduced a few years ago. This study was conducted to evaluate the body weight (BW) and some morphological characteristics (body and head measurements and numbers of teats) in the first Boer goats, reared in Bulgaria – imported from different country (Austria and Germany) and the generation born in Bulgaria. Data were collected from 90 does kept in AGROUSTINA FARM in Plovdiv district, situated in the pre-mountainous territories of the Rhodope mountains. The does were divided into two age groups: 1.5 years and 2.5 years. Data were collected on 12 morphometrical measurements (MM) – Body weight (BW), Withers height (WH), Rump height (RH), Body length (BL), Rump length (RL), Rump width (RW), Chest width (CW), Chest depth (CD), Heart girth (HG), Cannon circumference (CC), Head length (HDL), Head width (HDL), Horns length (HoL). The BW of does was 44.70 – 47.46 kg at 1.5 years old and 57.10 – 64.58 kg at 2.5 years old; the WH was 64.21 – 65.63 cm at 1.5 years and 65.30 – 68.26 cm at 2.5 years old. Our results are close to recommended as optimal in the majority of Boer goat standards in the world. Other important MM, which was in relation with the truly meat type, was BL (79.0 to 82.0 cm at 1.5 years old and 83.4 to 87.1 cm at 2.5 years old) and HG (81.45 to 83.00 cm at 1.5 years old and 87.6 to 91.68 cm at 2.5 years old). With ANOVA was estimated the highest and most significant influences for factor "age" on all body measurements, body weight and head measurements (($p < 0.001$ and $p < 0.01$). The majority of correlation coefficients between BW and body measurements were high and significant ($P < 0.01$, $P < 0.001$) in both age groups but all were the highest at 2.5 years does. The highest and strongly positive correlation ($P < 0.001$) was recorded between BW and heart girth (0.94), chest width (0.87) followed by body length (0.84) and cannon circumference (0.79) for 2.5 years old goats. The studied goats were classified on the basis of the number of teats (2, 3, 4, 5, 6) by visual appraisal. The LS-means for number of teats in does born in Bulgaria and those born in Germany, was respectively 3.37 and 3.35 and the lowest was in does born in Austria (2.75). In the whole population of Boer does reared in Bulgaria we established a slight preponderance of four teats (48.89%) than two teats (46.67%) and equal share of does with three and five teats (2.22%). If we estimate the Supernumerary teats (SNT) of Boer does reared in Bulgaria, the biggest share had these born in Bulgaria (71.43%) followed by those born in Germany (70.00%) and the least – born in Austria (36.96%). In the Boer goat population reared in Bulgaria, the SNT was 53.33%. But if we compute the share of individuals with more than 4 teats (that was accepted in all Boer goat standards), only 2.22% of Boer goats introduced in Bulgaria had more than 4 teats (not acceptable).

Keywords: Boer goat; Breed standards; Body weigh;, morphometric measurements; number of teats

Introduction

During the last years the interest for goat meat worldwide has increased, including in developed countries. Goat meat assures high biological value proteins, a lean meat with low content of fat, a healthy meat due to a favorable proportion between the saturated and unsaturated fatty acids and a low content of cholesterol (Hogg et al., 1992; Mahgoub et al., 2002; Werdi Pratiwi et al., 2006).

Based on different classification methods, the number of goat breeds in the world has been reported to be 562 by Devendra (2007), 565 by Mason (1996), 1153 by FAO (2009) and 1156 by Devendra (2010). The developing countries owned about 95% of the goat population and 76% of the breeds, while Europe countries had 2.1% of the goat population and 33% of breeds (Devendra, 2010). Most of the world's goat population is used primarily for meat production, but consumers in devepoped countries prefer carcasses with good conformation and quality goat meat. The major factors involved in selection of meat goat breeds are their growth rate, feed efficiency, total edible and salable percentage of the animal, dressing percentage, carcass traits and meat quality including flavor, tenderness, juiciness, and cooking loss (Shrestha & Fahmy, 2005). In the west countries there is an orientation of the goat breeding to the meat production. There are being applied programs of goats genetic improvement for increasing the meat production and meat quality.

There are several specialized meat goat breeds (Gurung & Solaiman, 2010). Boer goat is considered as one of the largest desirable goat breed for goat meat production, well known worldwide for superior body conformation, high fecundity, fast growing rate, adaptability, resistance to diseases and higher meat quality compared to other exotic breeds (Casey & Van Niekerk, 1988; Malan, 2000).

The Boer goats were derived from the indigenous goats kept by Namaquo Hottentots and Southern Bantu tribes of South Africa although some genes were derived from goats from India and Europe (Casey & van Niekerk, 1988). The name Boer means "farmer" in Afrikaans. The highlight in the history of the Boer goat was when the Boer goat Breeders' Association of South Africa (SABBS) was founded on 4 July 1959 at Somerset East.

In the development of Boer breed during the late sixties and early seventies there were five types of Boer goats recognized in South Africa according to SABBS: 1) the *ordinary Boer goats* are animals with good meat conformation, short hair and a variety of color patterns; 2) the *long hair Boer goats* have heavy coats and coarse meats; 3) the *polled Boer goats* are hornless with a less desirable confirmation; 4)

the *indigenous Boer goats* have long legs, variable and poor conformation and a variety of color patterns; 5) the *improved Boer goats* are the primary line which breeders have been selected for (Lu, 2001).

Breed standards and selection guidelines were formulated when SABBS was established (SABBS: https://www.boerboksa.co.za/Breeds-BoerStandards.htm). As it mentioned "the aim of the breeding standards is to improve the breed and to increase the economic value". Casey & Van Niekerk (1988) underlined that the "first phase" is adoption of breed standards, which developed uniformity of type, color, hair and body conformation. It also united breeders with a common purpose and identity. The improved Boer goat was recognized as the desirable type and a number of goat breeders commenced with directional selection and a well-defined breeding policy that resulted in the modern SA Boer goat found in commercial and other farming systems today (Visser & van Marle-Koster, 2017).

Performance testing of Boer goats started in 1970 under South African Mutton and Goat Performance and Progeny Testing Scheme (Casey & Van Niekerk, 1988) with five phases of determination. This was "the second phase" important for the development of the Boer goat breed. Combination of breed standards and performance testing is likely to be the better approach for the effective selection and improvement of Boer goats (Lu, 2001). The incorporation of Boer goat into the Testing Scheme makes this breed the only known goat breed (at that time) involved in a performance test for meat production.

The Boer goats are distributed widely throughout the world being used to upgrade indigenous goats and improve meat production. Total population might be about 5 million, about 2.2 million of which are known as "improved Boer" (DAGRIS, 2020). The distribution of Boer goats over countries has risen in the last years: in 2003 they were found in 48 countries (FAO, 2004) but in 2021 were found in 66 countries (FAO, 2022). The number of countries reporting population data was 23 with estimated population size 119 656, including 3 countries in Africa with 52 478 total Boer goats, 6 countries in Americas with 55 408 Boer goats and 15 countries in Europe with 11 770 Boer goats. The largest population was reported in South Africa (36 787), USA (28 619) and Namibia (14 691). In Bulgaria were reported 450 Boer goats.

In Europe, the Boer goat was first imported in 1977 in Germany (Barry & Godke, 1997). In 1980 a German herd book was established after first imported frozen Boer embryos. Then the Germans began to grade up their meat goat by crossing German goat breeds with Boer bucks (Porter et al., 2016). In 1987 the German Boer came to Britain and the British Boer goat Society was formed (British Boer goat So-

ciety). Since then the Boer has found its way to other European countries, incl. Austria, France, Denmark, Netherlands, Norway, Poland (Kawecka & Pasternak, 2020), Hungary (Nemeth et al., 2008) and others.

From the early 1990s Boer goat were being introduced to many countries in the world as meat goats, often for crossing to improve indigenous goats for meat and for creating new meat breeds. Exports from South Africa were stopped by an outbreak of foot-and-mouth disease in 2000 but between 1994 and 2000 about 18 000 live Boer goats had been exported (Porter et al., 2016), mainly to Malaysia (Ariff et al., 2010; Azhani et al., 2011), Thailand and China (Shilin, 2006; Ding et al., 2010), Indonesia (Elieser et al., 2012). The first full-blooded Boer goat was introduced to the USA and Canada through New Zealand and Australia in 1993. After that the American Boer Goat Association (ABGA) was established. The ABGA is an incredibly active force behind the increase in meat goat production in the US and continues to be the largest registry for Boer goats (Amundson, 2019).

After the first Boer goat Breed standard was established in South Africa, all other Boer Breeders Associations came to create own standards. The goal was to make a basis for all breeders to have certain criteria in order to improve breeding and profitability and to follow when selecting breeding stock, herd replacements and show stock. In general, all breed standards are very close or similar to the original SA Boer standards. Breed standards stipulate the ideal color of Boer goats to be white with a red head and a blaze, a limited number of red patches are allowed. A pigmented skin is preferred, particularly in areas with no hair cover. Furthermore, Boer goats must be robust, with good conformation and have a Roman nose and pendulous ears. Legs must be short, well fleshed with good thighs and hindquarters (Campbell, 1984), which is important for good carcass characteristics. Faults for culling are a hollow forehead, narrow mouth, folded ears, under-shot jaws, hollow back, weak pasterns, front x-shaped legs, small testes, hooves turning in or out, long, rough and furry hair covering, thick, big teats, no more than two separate functional teats per side and less than 25% pigmentation. No performance criteria are stipulated such as semen quality, growth rate, feed conversion, fertility, mothering ability, milk production, or carcass quality characteristics (Casey & van Niekerk, 1988). Widely known are the Boer goat breed standards of American Boer Goat Association (2019); Boer Goat Breeder's Association of Australia (2020); Netherlands Boer goat Organization (2020) and others. There are several Boer breed standards that mentioned specific figures about body weight (BW) and height of withers (HW) for does and bucks. Canada recommended as optimal HW respectively 54-77 cm and 68-95 cm and BW respectively 62-70 kg

and 67-75 kg (Canadian Meat Goat Association, 2014). In Czech Republic was published HW respectively 50-60 cm and 70-80 cm and BW respectively 55-75 kg and 90-130 kg (SCHOK, 2021). In Germany was recommended BW 50-70 kg for does and 80-90 kg for bucks (Boer goat in Germany, Bavaria).

Growth may be defined as an increase in weight until a mature size has been reached, and maintenance is the constancy in weight or other measurement of growth. Any increase in body weight, size, shape, form, composition or structure over time may be considered to be growth. Usually body weight is an major factor in determination of growth because it is measured easily than the other body changes (Mc Milin, 2010). To increase meat yield from goats requires genetic improvement of the body weigth of the breed. Growth in animals is usually determined with several morphometric measurements (MM), such as length, height, width, or circumference of the body and head. Morphological measurements are very important method used to evaluate and assess the characteristics of various breeds of animals (especialy meat breeds) and can help to provide the basic information on the suitability of the animals towards their selection (Martins et al., 2009; Yakubu, 2010). Measurements of phenotypic traits also enables the breeder to recognize early maturing and late maturing animals of different size and to be used as selection criterion for breeding animals. In goats, objective means (body measurements), which describe and evaluate body size and conformation characteristics, would overcome many of the problems associated with subjective method – visual evaluation and assessment (Okpeku et al., 2011). Body weight and measurements are important data sources in terms of reached breeds standards and are also important in giving information about the morphological structure and development ability of the animals (Alderson, 1999).

Breed differences, genetics within breeds, nutrition, health and disease, breeding age and management systems will cause differences in growth rates and body weights at any given time (Mc Milin, 2010). The BW of Boer yearling doelings are 45-65 kg and mature goats weight are 80-100 kg (Lu, 2001). According to AGTR, body weight of replacement does in highly selected Boer populations at 18 month age are 50 kg and at maturing age are 51-80 kg. Campbel (2003) showed BW for Boers does in South Africa (in very good condition) 64 kg at 18 month age and respectively 83.3 kg and 94.0 kg at 24 and 36 month age.

Martins et al. (2009) and Yakubu (2010) reported that the BW and morphological measurements may help to supply the basic information on the suitability of the animals towards their selection and can be used as a management tool to promote the productivity of goats (Abd-Allah et al.,

2019). They are used for several purposes including prediction of genetic improvement, growth rate, conformation and carcass traits (Slippers et al., 2000; Lambe et al., 2008). Body weight and morphometric characterization of livestock is essential for planning improvement, sustainable utilization and breeding programs of a breeds (FAO, 2012), including development of several specialized meat breeds and introduction of some breeds to different country of the world.

Azhany et al. (2011) reported that, there is a positive and significant relationship between the BW and MM (body length, withers height and hearth girth) in Boer goats and a practical way to estimate the BW of goats by measuring the hearth girth of the goats. A study for other goat breed (Alemayehu et al., 2012) emphasized that body weight has relatively highest relationship with heart girth (0.73-0.89) as compared with the other body measurements – body length (0.46-0.82) and withers height (0.53-0.83). Heart girth was high and positively correlated to withers height, body length and rump height (r=0.888**; r=0.865** and r=0.671**), respectively (Berhe, 2017). Madumetja & Thobela (2021) found that body weight of does had a highly positive significant correlation with body length (r = 0.727**), cannon circumference (r = 0.642**) and heart girth (r = 0.564**).

Udder and teats structure are of critical importance for meat goats because they have direct relation with the abilities of kids to nurse unassisted. Ideally, does would have one functional teat per side. The most common physical abnormality is some sort of extra teat (supernumerary) that is specific for the species. Supernumerary teats (SNT) are common in many mammalian species and the frequency varies considerably between species and even between breeds (Brka et al., 2002; Brka et al., 2007). Therefore, SNT can be functional (i.e., with emission of milk) or not and are not restricted to females but can also be observed in males.

Does from meat breeds, especially Boer goat, usually have more (than two) numbers of teats. All Boer breed standards (SABBS: https://www.boerboksa.co.za/Breeds-BoerStandards.htm; American Boer Goat Association, 2019; Boer Goat Breeder's Association of Australia, 2020; Netherlands Boer goat Organization, 2020, Canadian Meat goat Association, 2014) give special attention to udder and teats: does should have no more than two functional teats for each side of the udder, when each teat should possess only one orifice. The structure of the udder have to be such that the offspring can nurse unassisted. Animals with pendulous udders, bulbous or over-sized teats should be culled. According Sayer (2010) the South African (SA) farmers who developed today's Boer goat, selected for does with four functional teats. Such does, they reasoned, were more able to raise multiple kids successfully than does with only two teats. Some American breeders prefer

four-teated stock, others are breeding back to two-teatedness. Both sets of breeders want fully functional, easy-to-nurse teats with single orifices.

Supernumerary teats (SNT) is a congenital condition associated with combination of some genes with incidence as high as 100% in recessive homozygous genes (Brka et al., 2000). In goats, the heritability was 0.34 (Brka et al., 2007) to 0.40 – 0.44 (Martin et al., 2016). There were reported several additional economical loses because of SNT. Clinical and subclinical mastitis is often overlooked in the meat goat herd, yet can result in decreased growth rates of kids and overall loss of productivity. Other is losses for culling does – mastitis (48%) and failure to rear a kid (39%). The last one can be because of unacceptable udder and teat structure (Nogueira et al., 2015). In comparative study on 5 indigenous goat breeds and 3 exotic breeds, including Boer goat, Ghaffarilalch et al. (2022) found that Boer goat (4.43%) and Saanen goat (5.75%) have larger litter size and at the same time highest frequency of SNT's. Hoffman & Cawtborn (2014) found the number of doe teats and reproductive ability are positively correlated.

The Boer goat is a goat breed new to Bulgaria, where it was introduced a few years ago. There are only two studies on the productive characteristics of Boers in Bulgaria: on carcass characteristics (Panayotov, 2021a) and on chemical composition, fatty acid composition and technological quality of goat meat in Boer kids for producing "capretto" goat meat (Panayotov, 2021b). However there is lack of information on the exterior characteristics (body weight and measurements) and about the number of teats in the Boer goats following its introduction into Bulgaria.

The aim of this study is to evaluate the body weight and some morphological characteristics (morphological measurements and numbers of teats) in the Boer goat does, which originated from a different country and were reared in Bulgaria.

Materials and Methods

Study area and animal management
The data were taken from the first Boer goats imported from Germany and Austria and the first generation born in Bulgaria. The goats were kept in Agroustina farm in Plovdiv district, wich was the first farm in Bulgaria to raise purebreed Boer goat. It is situated in the pre-mountainous territories of the Rhodope mountains, at altitude 482 m. The territory refers to the Transitional Climatic Region and climate in the area is warm summers, milder winters with smaller annual temperature amplitudes. The average annual temperatures (12.7°C) are higher than those for the country. The monthly average air temperature show a maximum in August (23.7°C) and a minimum in January (0.8°C). Pre-

cipitation is lower than the national average, and the annual amount is about 550 mm. The average annual number of days with snow cover is between 35-40 days, and the average height of the snow cover is from 3 to 6 cm.

A total of 90 purebreed Boer goats were used in the study. The population included the following: first females imported in 2014 and 2015 from Germany (30 numbers) and from Austria (46 numbers) and their offspring born in Bulgaria (14 numbers). The does were divided into two age groups: 1.5 years and 2.5 years. They were reared in intensive production system, year-round in free-group boxes and constant access to food and water. Feeding was alfalfa and meadow food (at ratio 1:1) and concentrated feed meal with 15% Crude Protein, according to their body weight and physiological condition.

Morphometric measurements

Data were collected on twelve morphometric traits from the does – nine body measurements and three head measurements. All the measurements were taken by one person in order to avoid any measuring errors.

The FAO (2012) qualitative and quantitative goat/sheep breed descriptor list was followed to characterize the goat types phenotypically and morphologically as shown later:
- Body weight(BW) – measured using a weighting scale with accuracy of 100 g;
- Withers height (WH) – Measured as a distance from the surface of the platform to the withers of the animal by measuring stick;
- Rump height (RH) – Measured as a distance from the surface of the platform to the rump of the animal by measuring stick;
- Body length (BL) – The distance from the point of shoulder to the pin bone by measuring tape;
- Rump length (RL) – Measured as the distance from

the hip (tuber coxa) to the pin (tuber ischi) by dividers;
- Rump width (RW) – Measured as the horizontal distance between the extreme lateral points of the hook bone (tuber coxae) of the pelvis by dividers;
- Chest width (CW) – Measured as the widest point of shoulder by measuring stick;
- Chest depth (CD) – Measured from withers to the bottom brisket surface, just behind the elbow by measuring stick;
- Heart girth (HG) – Measured by taking the measurements of the circumference of the chest behind the forelegs by measuring tape;
- Cannon circumference (CC) – Measured as the circumference of the lower part fore canon bone or the smallest circumference of the foreleg by measuring tape;
- Head length (HDL) – The length of the front head from the middle of the top head to the end of the mouth by dividers;
- Head width (HDL) – The width of the front head from the base of left and right ear by dividers;
- Horns length (HoL) – The length of the horns from the base to the end of the horns by measuring tape;

All measurements were taken early in the morning prior to feeding. The age of the animals were obtained from the pedigrees (for imported goats) and from farm records (for goats born in Bulgaria).

Assessment of teats

The goats were classified on the basis of the number of teats (2, 3, 4, 5, 6) by visual appraisal. No special notice was taken on details about teats (if they function or not, placement of extra-teats toward primariy teats, sizes and etc.). The examples of Boer goat udders with different number of teats are shown on Figure 1.

a)

b)

c)

Fig. 1. Examples for Boer goat udders with different numbers of teats:
***a*) four teats; *b*) four teats (two normal sizes and two extra teats); *c*) three teats (it can be seen 2 teats at one half of the udder).** *Photos: D. Panayotov*

Statistical analisyss

All received results from the conducted studies were analysed with the program STATISTICA for Windows. Data was analyzed using descriptive statistics and ANOVA. The correlation coefficients between body weight and morphometric measurements were estimated. Results were presented in mean, standard error and coefficient of variation, LS-means, frequencies, percentages as appropriate.

Results and Discussion

Body weight (BW) and morphometric measurements (MM), such as length, height, width or circumference of the body and head, are important breeding signs, subject to a targeted selection in animals of specialized meat breeds directly related to their meat productivity. Body measurements (BW and MM) are important data sources in terms of reflecting the breeds standards and are also important in giving information about the morphological structure and development ability of the animals. The results obtained from the measurements of the BW of Boer goat does at 1.5 years age, according to country of birth, are presented in Table 1.

The lowest BW was shown in the does imported from Austria (44.70 kg), next are those born in Germany (45.10 kg) and the highest – those born in Bulgaria (47.46 kg). No significant differences were found. Our results are close to the reported by Madumetja & Thobela (2021) at yearling Boer goats in South Africa (aged between one and two years

old) – 46.51 kg ±1.28. Lu (2001) shows higher BW of Boer goats at 12-months age – 52 kg (45-65 kg)

Regardless of the lowest BW of the does imported from Austria (Table 1), they are highest in the withers (WH) and in the rump (RH), respectively 65.63 cm and 63.04 cm. The goats born in Bulgaria have similar values, respectively 64.21 cm and 62.50 cm. All groups have body proportions with higher withers than rump even with little value. Some authors (Chiemela et al., 2016) reported the opposite for Boer goats in Ethiopia – lower withers than rump.

With the largest body length (BL) are does born in Bulgaria (82.0 cm) and with the smallest – those born in Austria (79.0 cm). For the signs of rump – rump length (RL) and rump width (RW), the mean values in the studied groups varied in very narrow range (22.96 to 23.29 cm for RL and 15.41 to 15.71 for RW). Goats born in Bulgaria have relatively higher (but not significant) values of chest width (CW) – 20.14 cm, but lower chest depth (CD) – 25.93 cm in relation to the other groups. The does from Austria are with deeper but narrower chest. One of the most important traits for meat goat breeds is the heart girth (HG) because it is in relation with the truly meat type. The HG values are similar for the three groups – from 81.45 cm (born in Germany) to 83.00 cm (born in Bulgaria).

The mean values of measurements characterizing the size of the head – head length (HDL) and head width (HDW) have no significant differences between the three groups. They vary from 21.26 to 21.50 cm for HDL and from 12.41 to 12.90 cm for HDW. The horns length were found similar

Table 1. Body weight and morphometric measurements of does from Boer goat at 1.5 years of age according to country of birth

Traits	Imported from Austria (27 numbers)		Imported from Germany (20 numbers)		Born in Bulgaria (14 numbers)	
	$\overline{x} \pm Sx$	CV%	$\overline{x} \pm Sx$	CV%	$\overline{x} \pm Sx$	CV%
Body Weight, kg – (BW)	44.70 ± 1.416	16.46	45.10 ± 1.520	15.08	47.46 ± 2.004	15.80
Body measurements, cm						
Withers height (WH)	65.63 ± 0.562	4.46	63.65 ± 0.734	5.15	64.21 ± 0.556	3.24
Rump height (RH)	63.04 ± 0.505	4.16	61.95 ± 0.816	5.89	62.50 ± 0.532	3.18
Body length (BL)	79.00 ± 0.973	6.40	80.20 ± 1.128	6.29	82.00 ± 1.016	4.64
Rump length (RL)	22.96 ± 0.223	5.05	23.05 ± 0.394	7.64	23.29 ± 0.549	8.82
Rump width (RW)	15.41 ± 0.209	7.03	15.65 ± 0.233	6.65	15.71 ± 0.496	11.82
Chest width (CW)	17.89 ± 0.510	14.82	18.35 ± 0.425	10.35	20.14 ± 0.864	16.04
Chest depth (CD)	26.96 ± 0.299	5.77	26.00 ± 0.562	9.67	25.93 ± 0.963	13.90
Heart girth (HG)	82.74 ± 1.051	6.60	81.45 ± 1.219	6.69	83.00 ± 1.690	7.62
Cannon circumference (CC)	10.19 ± 0.160	8.19	10.45 ± 0.135	5.79	10.57 ± 0.251	8.87
Head measurements, cm						
Head length (HDL)	21.26 ± 0.415	10.16	21.40 ± 0.535	11.18	21.50 ± 0.228	3.98
Head width (HDW)	12.41 ± 0.144	6.02	12.90 ± 0.191	6.61	12.86 ± 0.206	5.99
Horns length (HoL)	19.48 ± 0.609	16.26	18.95 ± 0.749	17.67	20.21 ± 0.933	17.27

for the three groups – from 18.95 cm (goats born in Germany) to 20.21 cm (goats born in Bulgaria).

Comparing our results about body measurements with these from Chiemela et al. (2016) we can generalize that Boer goats reared in Bulgaria are longer, with less rump width and similar for rump height, heart girth and canon circumference than the Boer goats studied by the authors in South Africa. Accordingly, comparing the results of Visser & van Marle-Koster (2017) and our investigation, the South African Boer goats are taller and shorter, with less rump width and length and with smaller head (less length and width), similar in depth of chest but with biger heart girth than the firstly introduced Boer goats in Bulgaria. Compared with Abd-Allah et al. (2019) the Boer goats reared in Bulgaria are with biger BW, WH, CG, CC and HDL but with less BL and CD than the Boer goats reared in Egypt. Very big differences were established for Boer goat (2 years age) in Ethiopia where BW and all measurements of body and head were lower than our results (for does 1.5 years old).

The coefficients of variation (CV) are the highest for the measurements horns length (16.26 – 17.67), BW (15.08 – 16.46) and chest girth (10.35 – 16.04). All other morphometric measurements have low CV and that means the first Boer goats population raised in Bulgaria has good homogeneity.

Descriptive statistics of body weight and morphometric traits of Boer does in second age group (2.5 years old) are shown in Table 2. The BW of goats from Austria was 64.58 kg and these from Germany – 57.10 kg. Despite the relatively large difference between those values (7.48 kg), confidence has not been established. The coefficients of variation

for both groups are slightly higher than those obtained for the goats' 1.5 year old.

For all body measurements, the mean values obtained for goats imported from Austria are higher and only rump length and cannon circumference are similar. The average values of any morphological traits in does according to country of birth are very similar. The differences are significant for WH only. All other differences are non significant. The head measurements (head length and head width) in both groups are very close. The horns length of goats from Austria are significantly larger (2.62 cm $p < 0.05$) than that of goats from Germany.

The obtained results in our study for 2.5 years Boer does reared in Bulgaria are close to recommended as optimal BW and WH in several Boer breed standards, respectively: in Canada 62-70 kg and 54-77 cm (Canadian Meat Goat Association, 2014); in Czech Republic 55-75 kg and 50-60 cm (SCHOK, 2021); in Germany 50-70 kg (Boer goat in Germany, Bavaria).

The estimated values of the quantitative characteristics of morphological measurements can be useful in developing appropriate selection criteria for future breeding standards and breeding programe of Boer goat in Bulgaria.

We investigated the influence of factors "country of birth" and "age" on the morphometric measuruments of Boer goat does, reared in Bulgaria (Tables 3 and 4). The whole model is highly significant ($p < 0.001$) but country of birth has a little influence on some body measurement – withers height ($p < 0.01$), girth width ($p < 0.005$) and girth depth ($p < 0.005$) (Table 3). This factor has no significant influence on all other body measurements, body weight and head measurements (Table 4).

Table 2. Body weight and morphometric measurements of does from Boer goat at 2.5 years of age according to country of birth

Traits	Imported from Austria (19 numbers)		Imported from Germany (10 numbers)	
	$\overline{x} \pm Sx$	CV%	$\overline{x} \pm Sx$	CV%
Body Weight, kg – (BW)	64.58 ± 3.363	22.70	57.10 ± 3.304	18.30
Body measurements, cm				
Withers height (WH)	68.26 ± 0.844	5.39	65.30 ± 0.633	3.07
Rump height (RH)	67.21 ± 0.833	5.40	65.20 ± 0.696	3.38
Body length (BL)	87.11 ± 1.447	7.24	83.40 ± 1.833	6.95
Rump length (RL)	25.11 ± 0.477	8.28	25.10 ± 0.657	8.28
Rump width (RW)	17.26 ± 0.489	12.34	15.70 ± 0.761	15.32
Chest width (CW)	21.32 ± 0.730	14.92	20.70 ± 0.932	14.23
Chest depth (CD)	30.47 ± 0.584	8.36	28.50 ± 0.734	8.14
Heart girth (HG)	91.68 ± 1.875	8.91	87.60 ± 1.881	6.79
Cannon circumference (CC)	11.05 ± 0.235	9.28	11.00 ± 0.211	6.06
Head measurements, cm				
Head length (HDL)	23.47 ± 0.686	12.73	22.50 ± 0.401	5.64
Head width (HDW)	15.16 ± 0.491	14.13	14.80 ± 0.742	15.86
Horns length (HoL)	24.42 ± 1.096	19.56	21.80 ± 0.998	14.47

Table 3. Analysis of variance for influence factors "country of birth" and "age" on some body measurements of the Boer goat does, reared in Bulgaria

Sources of variation	df	Withers height		Rump height		Body length		Rump length		Rump width		Chest width		Chest depth		Heart girth		Cannon circumference	
		F	p	F	p	F	p	F	p	F	p	F	p	F	p	F	p	F	p
Intercept	1	27430	***	26395	***	13868	***	10737	***	5237	***	3084	***	7267	***	10662	***	9477	***
Country of birth	2	5.72	**	2.05	–	1.28	–	0.15	–	0.62	–	3.02	*	2.98	*	1.30	–	0.87	–
Age	1	10.25	**	29.25	***	24.55	***	25.64	***	8.77	**	21.49	***	28.84	***	28.01	***	14.36	***
Error	86																		

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 4. Analysis of variance for influence factors "country of birth" and "age" on body weight and some head measurements of the Boer goat does, reared in Bulgaria

Sources of variation	df	Body Weight		Head length		Head width		Horns length	
		F	p	F	p	F	p	F	p
Intercept	1	1758	***	5769	***	5535	***	1980	***
Country of birth	2	0.96	–	0.17	–	0.31	–	1.49	–
Age	1	54.05	***	11.79	**	52.96	***	23.03	***
Error	86								

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

The highest and most significant influences were determined for the factor "age" on all body measurements, body weight and head measurements (($p < 0.001$ and $p < 0.01$). Probably these results are because of the not so large number of studied animals. Another reason is that imported Boer goats are a quite equalized population regarding exterior and morphometric traits.

The correlation coefficients between body weight (BW) and morphometric measurements are shown in Table 5. Because of the high significant influence of age on morphometric traits, shown above, we estimate the relationship by age groups of the goats. It is clear that the majority of correlation coefficients between BW and body measurements were high and significant ($P < 0.05$ till $P < 0.001$) in both age groups but all were the highest at 2.5 years does.

The highest and strongly positive correlation ($P < 0.001$) was recorded between BW and heart girth (0.94), chest width (0.87) followed by body length (0.84) and cannon circumference (0.79) for 2.5 years old goats. On the other hand, lower estimates were recorded for the correlation of BW with all head measurements wherever correlations are lower in older group (2.5 years old) than younger does. Several studies on Boer goats were in accordance with our results for the most reliable measurements regardless of their orders. Azhani et al. (2011) reported correlations between BW and HG, BL and WH respectively 0.97, 0.93 and 0.91 and concluded that HG is the most high predictor of BW. Madumetja & Thobela

Table 5. Correlations between body weight and morphometric measurements of Boer goat does at 1.5 and 2.5 years of age

Morphometric measurements	Age of does	
	1.5 years of age *(n = 61)*	Over 2.5 years of age *(n = 29)*
Body measurements, cm		
Withers height (WH)	0.32*	0.50***
Rump height (RH)	0.45*	0.69**
Body length (BL)	0.70**	0.84 ***
Rump length (RL)	0.76***	0.69**
Rump width (RW)	0.39*	0.61**
Chest width (CW)	0.61**	0.87***
Chest depth (CD)	0.49**	0.76***
Heart girth (HG)	0.83***	0.94***
Cannon circumference (CC)	0.58**	0.79***
Head measurements, cm		
Head length (HDL)	0.47**	0.38
Head width (HDW)	0.53*	0.38
Horn length (HoL)	0.60**	0.40

n – number of animals; * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

(2021) indicate that BW of Boer does in South Africa had a highly positive significant correlation with BL (0.727**), CC (0.642**) and HG (0.564**). Authors concluded that heart girth (HG) and age played a crucial role on BW in female goats. Some other authors shows similar results for

Table 6. LS means for number of teats in Boer goat does according to country of birth and age at assessment

	n	LS-means	SE
Born in Austria	46	2.75	0.148
Born in Germany	30	3.35	0.185
Born in Bulgaria	14	3.37	0.290
Age of 1.5 years	61	3.22	0.131
Age of 2.5 years	29	3.10	0.212

n – number of animals

several goat breeds – Abb-Allah et al. (2019) for Shami goats in Egipt; Karna et al. (2020) for Ganijam goats, Celik (2019) for Pakistan Goats.

From the findings of our study and the similar results of mentioned authors we can advise that by improving heart girth, chest width, body length and cannon circumference in Boer goat does body weight may also be influenced positively. In conclusion, since the body measurements, mentioned above, had high correlation with the body weight, this may be used as selection criteria. Further research is needed to investigate present situation with maximum number of observations.

Does from goat meat breeds, especially Boer goat, often have more (than two) numbers of teats. The extra teats (more than usual for the species) described as supernumerary teats (SNT). SNT can be functional (with emission of milk) but can be not functonal. Some authors supposed that SNT are typical for multiparous breeds and for animals with larger liter size and that is biological possibility for more numbers of kids to be nursed.

Table 6 presents the LS means for number of teats in Boer does reared in Bulgaria. Very similar are LS-means for number of teats in does born in Bulgaria and those from Germany, respectively 3.37 and 3.35 but the lowest – does from Austria (2.75). LS-means for number of teats of does at 1.5 years and 2.5 years are so very similar, respectively 3.22 and 3.10. Analysis of variance shows that country of birth have a significant ($p < 0.05$) influence on the number of teats but the factor "age" has no significant influence.

Percentage individuals with different numbers of teats by country of birth and in the Boer goats population reared in Bulgaria are shown at Figure 2.

The biggest share of Boer does with two teats was determined in these born in Austria (63.04%), less was in does from Germany (30.00%) and in those born in Bulgaria (28.57%). Boer goats with an odd number of teats were registered as follows: three teats only in does born in Germany (6.67%) and five teats in does from Austria (2.17%) and
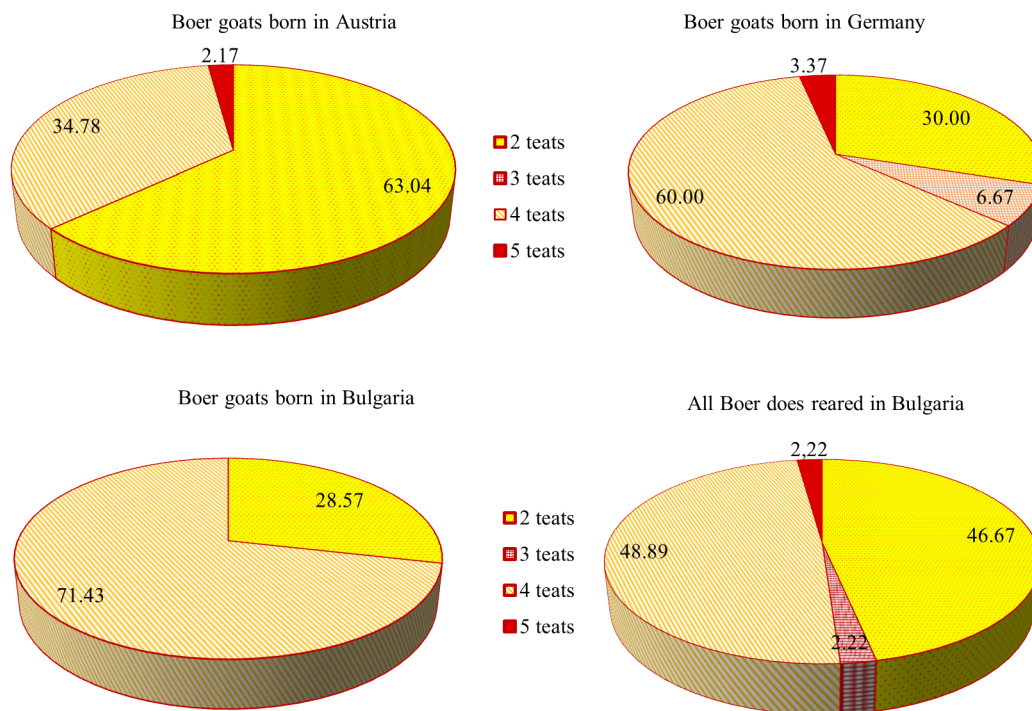

Fig. 2. Share of the does with different numbers of teats according to country of birth and in the Boer goat does population reared in Bulgaria

from Germany (3.37%). The biggest share of does with four teats was determined in those born in Bulgaria (71.43%), followed by born in Germany (60.00%) and least of all was in goats from Austria (34.78%).

When we investigate the whole population of Boer does reared in Bulgaria we established a slight preponderance of four teats (48.89%) than two teats (46.67%). Very small and equal are the share of does with odd number of teats – three and five teats (2.22%). Similar to our results but with higher figures was reported by Famakinde et al. (2019) – 58.82% of individuals with four teats. Our results are less than reported by Bemji et al. (2016) for Kalahary Red goats, than percent of 3, 4 and 5 teats was respectively 15.2%, 57.6% and 9.1%.

Most researchers note the extra-teats (that are more than the usual for goats two teats) as Supernumerary teats (SNT) and classify the goats according this in SNT-1 (with 3 teats), SNT-2 (with 4 teats), SNT-3 (with 5 teats) and etc. But all Boer breed standards (mentioned above) recommended that "does should have no more than two functional teats for each side of the udder". If we estimate the SNT of Boer does reared in Bulgaria, the biggest share had these born in Bulgaria (71.43%) followed by those born in Germany (70.00%) and the least – born in Austria (36.96%). In the Boer goat population reared in Bulgaria, the SNT was 53.33%. But if we compute the share of individuals with more than 4 teats (that was accepted in Boer goat standards), only 2.22% of Boer goats introduced in Bulgaria had more than 4 teats (not acceptable).

Some authors had an opinion that more important was not the number of teats rather than if they ware functional (give milk). Since the occurrence of number of teats has been linked with some recessive homozygous genes that can be passed down from one generation to another, researchers and breeders should evaluate a type and conformation of Boer goat animals with special attention to udder and teats. Such Boer goats with not accepted teats (according to the number and structure) should be screened out and not to be selected for breeding purposes. In the future researches it is necessary to examine the structure of teats and theirs functionality in the present population of Boer goat in Bulgaria. In addition to the base economicaly important traits (reproduction, growt rate, carcass traits, quality of meat, etc.) the teats characteristics are also important to include in breeding programs when introducing the Boer goat breed in Bulgaria.

Conclusions

Body weight (BW) and morphometric measurements (MM) are important data sources in terms of reaching the breeds standards and are also important information about the morphological structure and development ability of the breeding animals. In the Boer does reared in Bulgaria at 2.5 years old are estimated the BW 57.10 – 64.58 kg and the Withers height (WH) 65.30 – 68.26 cm. Our results are close to the recommended as optimal in the majority of Boer goat standards in the world. Other important MM, which are in relation with the truly meat type, are established in Boer does at 2.5 years old: Body length (BL) 83.4 – 87.1 cm and Heart girth (HG) 87.6 – 91.68 cm. The estimated values of the morphological measurements can be useful in developing appropriate selection criteria for future breeding standards and breeding programme of Boer goat in Bulgaria.

The highest and strongly positive correlation (P < 0.001) was recorded between BW and HG (0.94), CW (0.87) followed by BL (0.84) and CC (0.79) in goats at 2.5 years. From the findings of our study we can advise that by improving heart girth, chest width, body length and cannon circumference in Boer goat does, the body weight may also be influenced positively. Since the body measurements, mentioned above, had high correlation with the body weight, this may be used in breeding estimation and in breeding programme.

In the population of Boer does reared in Bulgaria we established a slight preponderance of four teats (48.89%) than two teats (46.67%) and equal share of does with three and five teats (2.22%). The Supernumerary teats (SNT), that means more than 2 teats, was 53.33% in all Boer does. But if we compute the share of individuals with more than 4 teats (that was accepted in Boer goat standards), only 2.22% of Boer goats introduced in Bulgaria had more than 4 teats (not acceptable). Since the number of teats has been genetically determined and so economicaly important, Boer goat researchers and breeders should evaluate the teats characteristics and should include them in the selection programme when introducing the Boer goat breed in Bulgaria.

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