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Preliminary biometric characteristics of Huacaya alpacas

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SUMMARY

The purpose of this study was to analyse and measure the biometrics of Huacaya alpacas. The results were compared with various animal species for which much more biometrics data is available, including horses, dogs and camels. Indexes used in other works on biometrics were calculated. Animals were divided according to sex and age – under 24 months old and older. The results provide preliminary information for further research on the biometrics of this species. Chest circumference was shown to be greater than the height at the withers, and their ratio, expressed by the massiveness index, is similar to that of the Felinski pony, a horse designed for riding. The eurysomia index in alpacas is high, far exceeding that of the one-humped camel. The greater limb length in males than in females in both age groups is also an interesting finding. Further studies are needed to obtain a complete set of biometric traits of alpacas. At this stage, the results may be useful for determining the correct conformation of species and for breeding selection purposes.

KEY WORDS: animal anatomy, comparative anatomy, alpaca, biometrics, Huacaya, breeding

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INTRODUCTION

In recent years, alpaca (Photo 1) breeding has been on the rise in Europe. Although domesticated about 5500–6500 BC (Burgin et al., 2020), alpacas have only functioned as companion animals for the last decade. Originally from South America, they are currently mainly used for agritourism, animal-assisted therapy, and fleece harvesting (Morales Villavicencio, 2010).

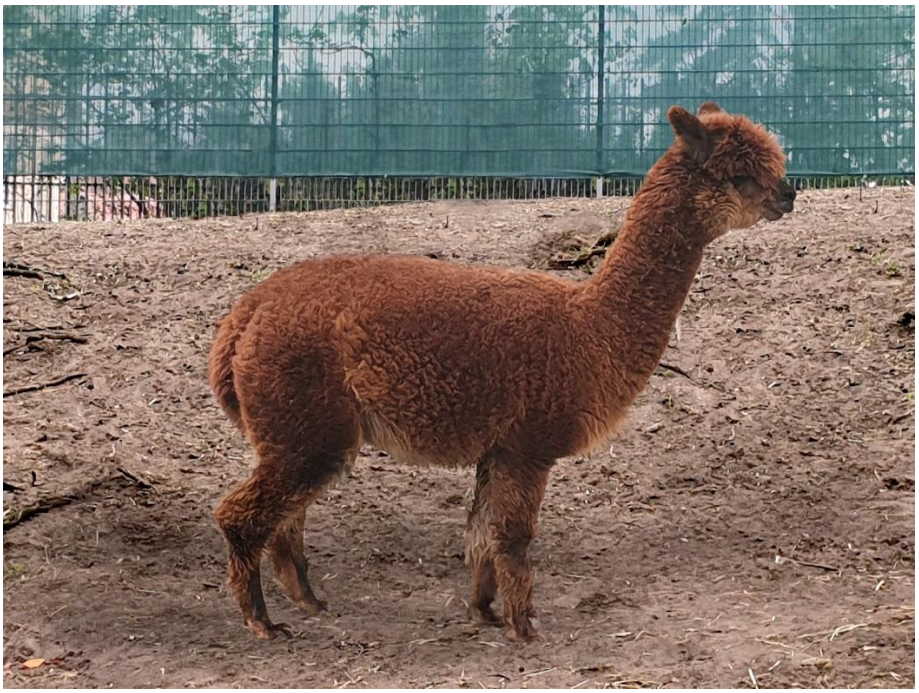

Photo 1: *Huacaya alpaca* (photo by: Agata Skalska)

Taxonomically, they belong to the camelids (Camelidae) along with the camel (*Camelus*) and the llama (*Lama*). The species was formerly commonly assigned to the genus *Lama*, but recent discoveries based on DNA have shown that domestication most likely originated with the vicuña (*Vicugna vicugna*). No subspecies are currently distinguished, but there are two breeds, Suri and Huacaya, differing mainly in hair coat (Groeneveld et al., 2010).

At breed dog and horse exhibitions held around the world, expert judges evaluate the animals' presentation and conformation, in part on the basis of biometric tests. In the case of alpacas, there is little research on body proportions that could be used to conduct a correct and professional evaluation of these animals. The titles awarded to alpacas often determine whether a given animal can be used for reproduction and its breeding value.

The Alpaca Owners Association, Inc. (AOA), the largest alpaca owners association in the world, sets standards for each of the alpaca breeds. The breeding instructions on the association's website provide only general information on the appearance of alpacas. Ideal features include balanced proportions of the neck, body and legs, and erect, spear-shaped ears of appropriate length, balanced

with the head. The eyes should be clear and bright, free from congenital defects, and the nasal ducts should be symmetrical. The animal should have a smooth gait and balanced stride, with both toes pointing forward and the limbs in a straight line (Photo 2). The chest should be symmetrical to the whole, the hind limbs broad, with strong, well-muscled thighs and a rounded rump. The tail should be in the middle of the rump and felt as a natural extension of the spine. The tail should be straight, easy to bend, and long enough to cover the genitals (AOA Huacaya Breed Standard).

The above information is descriptive in nature and does not specify metric values to which an alpaca's exterior (conformation) standard should conform. The present study provides original biometric data collected from an analysis of measurements of a group of 69 individuals of the Huacaya alpaca breed. This can be useful for comparisons with the results of measurements of other populations of these animals, and eventually may help to improve the standard of Huacaya alpacas.

The purpose of this study was to perform a statistical and substantive analysis of the results of biometric measurements of Huacaya alpacas.

Photo 2: *Huacaya alpaca* in motion (photo by Anna Demkowicz-Czerwińska)

MATERIALS AND METHODS

Measurements were taken on Huacaya alpacas from Polish breeding farms, including 17 females and 9 males from the Alpaka-Team farm in Jankowo Gdańskie and 24 females and 19 males from the Dobronianka farm in Dobroń. Both farms currently belong to the Polish Alpaca Breeders Association (PZHA 2023). The males were aged from 15 to 95 months, and the females from 16 to

139 months. The tests were performed on animals showing no disease symptoms (basic veterinary medical examination by a DVM). All measurements were taken on alpacas standing on a level, rigid and stable surface, on the left side of the body (Figure 1).

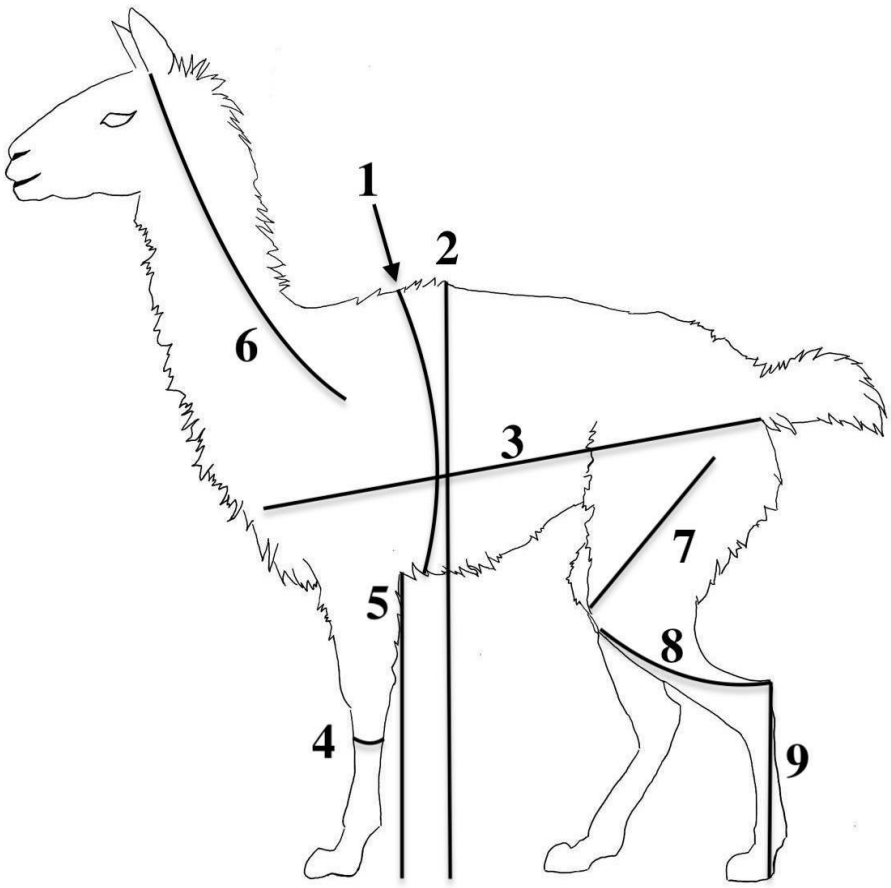

Figure 1. Sites where measurements were made on the body (illustration by Agata Felska): 1. circumference of the chest, 2. height at the withers, 3. oblique length of the trunk, 4. girth of the metacarpus, 5. length of the zeugopodium and autopodium of the thoracic limb, 6. length of the neck, 7. length of the thigh, 8. length of the cruris, 9. length of the foot

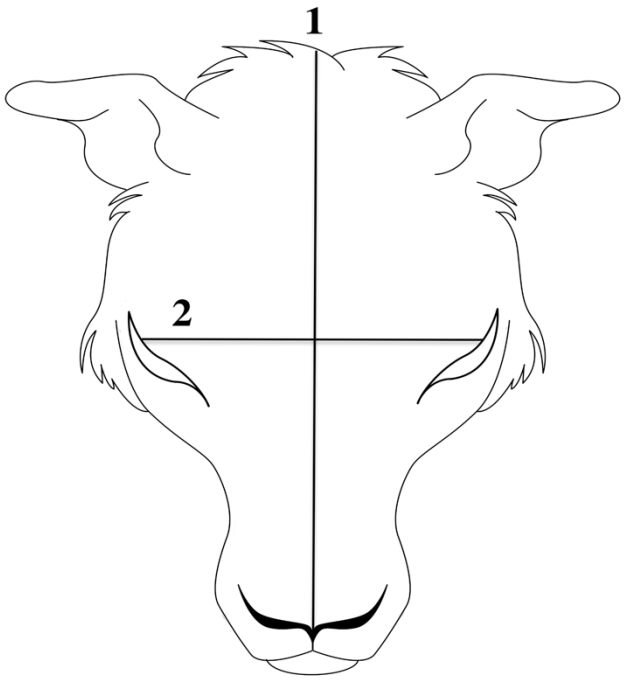

Figure 2. Sites where measurements were made on the head (illustration by Agata Skalska): 1. length of the head, 2. width of the head

A flexible tailor's tape accurate to within 1 mm was used for the measurements. The chest girth was measured by stretching the tape measure between the withers and the body of sternum (*corpus sterni*). The length of the forelimb was measured from the olecranon (*olecranon*) of the ulna (*ulna*) to the ground, with the limb straight. The circumference of the cannon (metacarpus) and the height at the withers were measured as well. Diagonal body length was measured between the greater tubercle of the humerus (*tuberculum majus ossis humeri*) and the ischial tuberosity (*tuber ischiardicum*). The pelvic limb was divided into three parts: the thigh (from the greater trochanter (*trochanter major*) to the base of the patella (*basis patellae*); the cruris (from the *apex patellae* to the *tuber calcanei*); and the foot (from the *tuber calcanei* (*basipodium posterius*) to the *tuberculum flexorium* (*acropodium posterius*)). The length of the neck was measured from the cranial angle of the scapula (*angulus cranialis scapulae*) to the base of the auricle, and the length of the head from the external occipital crest (cris*ta occipitalis externa*) to the line joining the lower angles of the nostrils (*nares*) (Figure 2). Then the width of the head at the furthest possible points of the supraorbital arches (*arcus supraorbitalis*) was measured with a zoometric compass to within 0.5 cm.

The animals were divided into four groups, according to sex and separating individuals that had not yet reached sexual and breeding maturity, i.e. before the age of 24 months (11 females and 10 males), and adults above 24 months (30 females and 18 males) (Hafez and Hafez, 2000). Statistical analysis of the results was then carried out, and indices used in biometric studies were calculated. Pearson correlations were calculated for the traits analysed, and the significance of differences between males and females was determined using Student's t-test (Ściesiński, 2009; Komosa and Purzyc, 2013; Komosa et al., 2013; Horoszewicz et al., 2015; Frąckowiak et al., 2021a; Frąckowiak et al., 2021b).

- Body length index = $\frac{diagonal\ body\ length}{height\ at\ withers}$
- Boniness index = $\frac{circumference\ of\ the\ cannon}{height\ at\ withers}$
- Massiveness index = $\frac{chest\ girth}{height\ at\ withers}$
- Eurysomia index = $\frac{chest\ girth}{diagonal\ body\ length}$
- Head size index = $\frac{width\ of\ head}{height\ at\ withers}$
- Thigh length index = $\frac{thigh\ length}{length\ of\ pelvic\ limb}$
- Cruris length index = $\frac{cruris\ length}{length\ of\ pelvic\ limb}$
- Foot length index = $\frac{Foot\ length}{length\ of\ pelvic\ limb}$

Some authors present these indexes as percentages (%). In this study, it was decided not to convert the values to percentages.

RESULTS AND DISCUSSION

Morphological standards based on biometric studies are the primary indicator for determining the characteristic features of species and breeds of animals. Biometrics is used to monitor populations of living beings and the variability of organisms. Based on mathematical analysis, biometrics has applications in fields such as anthropology, physiology, genetics, medicine, veterinary medicine, animal science, and palaeontology. In zootechnical practice, for example, it is used to determine the conformation of horses, dogs, and cats, as well as livestock such as domestic cattle (Abramowska, 1973; Ściesiński and Kaleta, 1989; Brzeski and Kulisa, 1993; Redlicki, 1996; Ściesiński, 1997; Ściesiński, 2002; Cieśla et al., 2010; Firuta, 2019).

Biometric measurements of camelids are a relatively new field of research. Biometric analyses of camels have been performed, but there is still a lack of publications on new world camelids (Mostafa and Khalil, 2018; Al-Hazmi et al., 1994; Ehsaninia, 2020). The present study is one of the few articles presenting preliminary research on alpaca biometrics. Authors of papers on camel biometry have focused on limb length and angles and the length of the neck, facial part, tail, and ears, as well as parameters such as the distance of the eyeballs from each other and other structures. Interest in testing in the species mentioned above largely stems from the fact that dogs, horses and camels

are all used in several sports, and biometric analyses are used to classify them in terms of speed, jumping ability or other parameters desired by breeders, including appearance and breed-specific morphological characteristics. Alpacas are not currently used in sports; however, biometric criteria provide a basis for rational selection and for choosing animals for breeding and husbandry.

Height at the withers in the mature individuals averaged 91.93 cm in females and 87.24 cm in males (Table 1). The average height in young animals was 92.70 cm in males and 84.40 cm in females (Table 2). Tamburini et al. (2012), in a study conducted on 45 females and 18 males of the Huacaya alpaca breed, reported average values of 86.5 cm for females and 83.4 cm for males. These average values indicate that female alpacas were higher at the withers than males. Most notable in the study is the difference in chest circumference between adult females and males; it was significantly larger in females. It would be interesting to compare the results of biometric measurements of the Huacaya and Suri alpaca breeds, but this is difficult, mainly due to the lack of data. Therefore there is a need for further research in this area. Although the height at the withers and the oblique length of the trunk were greater in females, males showed higher average values for some measurements, such as thoracic and pelvic limb lengths. There were no statistically significant differences in other traits.

Table 1
Average values of biometric traits of mature alpacas (over 24 months of age).

Measurement	Female N=30		Male N=18	
	$\bar{x}$	S	$\bar{x}$	S
Height at withers	91.93[a]	3.68	87.24[b]	14.75
Diagonal body length	65.60[a]	5.36	58.97[b]	3.68
Chest girth	107.70[a]	10.55	100.92[b]	7.23
Length of the zeugopodium and autopodium of the thoracic limb	53.37	3.52	54.86	2.57
Circumference of the cannon	12.19	1.56	12.22	1.95
Length of pelvic limb	101.02	6.74	105.47	6.98
Thigh length	30.75	3.41	31.61	3.31
Cruris length	36.88	2.62	38.08	3.76
Foot length	33.38	2.33	35.78	3.02
Neck length	63.58	5.19	61.81	3.75

Head length	31.25	1.73	32.47	2.49
Head width	12.07	0.85	12.24	0.49

Different letters indicate statistically significant differences ($P \leq 0.05$).

The trend of taller females than males is not confirmed in young animals. The average height of young females at the withers was 84.40 cm, while it was 92.70 cm in males. This is most likely due to the disproportion of limbs in females and males. The length of every limb section examined was greater in males. Young males had significantly longer thoracic and pelvic limbs and a highly significantly greater height at the withers and larger thoracic circumference than young females. This is most likely due to the presence of epiphyseal cartilage (*cartilago epiphysialis*), which is the site of bone growth for length. In humans, the epiphyseal plate is present only in children and teenagers; in adults, who have stopped growing, the plate is replaced by the epiphyseal line, which, according to current knowledge, has no specific function. This replacement is known as growth plate fusion. Complete fusion occurs no earlier than about 12 years of age in girls (most often at 14–15 years) and 14 years in boys (most often at 15–17 years) (Crowder and Austin, 2005). Given the evolutionary convergence of mammalian organ systems, it can be assumed that similar mechanisms are at work in alpacas, hence the greater height of young males due to a different rate of juvenile bone growth in length than in females. Also, the thoracic circumference in young males is larger than in young females, which changes when they reach breeding maturity. In contrast, the oblique length of the trunk in both juvenile and adult males is statistically smaller than in females.

Table 2
Average values of biometric traits of young alpacas (under 24 months of age)

Feature/measurement	Female N=11		Male N=10	
	$\bar{x}$	S	$\bar{x}$	S
Height at withers	84.40^{A}	7.13	92.70^{B}	1.72
Diagonal body length	62.80^{a}	13.35	58.60^{b}	4.94
Chest girth	86.45^{A}	10.56	93.60^{B}	3.01
Length of the zeugopodium and autopodium of the thoracic limb	49.45^{a}	3.50	53.10^{b}	2.29
Circumference of the cannon	10.00	1.02	11.20	1.12
Length of pelvic limb	93.20^{a}	7.75	100.70^{b}	5.12

Thigh length	27.00	2.92	29.10	1.93
Cruris length	33.75	2.93	36.40	2.92
Foot length	32.45	2.97	35.20	1.81
Neck length	59.05	4.95	56.70	5.83
Head length	28.21	2.28	29.90	1.50
Head width	11.05	1.19	11.90	1.11

Different lower case letters (a, b) indicate statistically significant differences ($P \leq 0.05$). Different capital letters (A, B) represent highly significant differences ($P < 0.01$).

The biometric indexes used in this study were calculated based on formulas given in publications, mainly concerning dogs and horses. The body length index (diagonal body length/height at withers) was 0.714 in adult females and 0.676 in males, respectively (Table 3). In a study conducted by Komosa and Purzyc (2009), the body length index of the Polish horse was 78.8, and that of the Hucul horse was 78.7. In our study, the average index for mature alpacas was 69.5. While some authors present the indexes as percentages (%), in this study, we chose not to convert the values. Holmström and Philipsson (1993) report that the femur is the most important conformation index in biometric studies of horses. Its length and obliquity improve balance and facilitate the function of the horse's hind legs. According to Komosa and Purzyc (2009), the thigh length index of the Polish Konik horse was 29.72, and that of the Hucul horse was 27.7. In the case of alpacas, these values are 30.4 for females and 30 for males. Based on a study conducted by Mostafa and Khalil (2018) on a group of 208 one-humped camels (*Camelus dromedarius*), we can calculate the thigh length index of this species to be 30.7. This means that the proportions in alpacas may be similar. Frąckowiak et al. (2021b), in a biometric study on Border Collie dogs, present the length of segments of the pelvic limbs, so that we can calculate the proportion of the length of each section, i.e. the thigh, cruris and foot, to the total limb length. This shows that the thigh length index was 32.88 for males and 33.96 for females. Therefore in the case of the thigh length index, the value in the one-humped camel comes closest to that obtained for the alpaca. The eurysomia index (chest girth/diagonal body length) was 1.642 for females, and 1.711 for males. This means that the thoracic circumference of females is about 64% larger than the diagonal body length, and the corresponding difference in males is similar, at 71%. For comparison, Al-Hazmi et al. (1994), in their study of the biometry of various breeds of the one-humped camel, provide values which can be used to calculate indexes. The results for the eurysomia index for the breeds are as follows: Meghem 1.27; Sawahli 1.385; Gamra 1.247; and Awadi 1.248. The boniness index (circumference of the cannon/height at the withers) in female alpacas is 0.133, the same as in the Polish Konik. In males, on the other hand, the boniness index of 0.14 is similar to the Hucul horse's value of 0.1392 (Komosa and Purzyc, 2009). The massiveness index (chest girth/height at withers) indicates that the chest girth of both sexes is greater than the height at the withers. Kolstrung (2006), in a study on the biometry of Felinski ponies, reported a massiveness index of 1.1783; for female alpacas, based on our research, this index is 1.172.

Table 3
Value of indexes of adult individuals

Feature/measurement	Female N=30	Male N=18
Body length index	0.714	0.676
Boniness index	0.133	0.140
Massiveness index	1.172	1.157
Eurysomia index	1.642	1.711
Head size index	0.131	0.140
Thigh length index	0.304	0.300
Cruris length index	0.365	0.361
Foot length index	0.330	0.339

In our opinion, objective evaluation of young animals is only applicable in comparison with mature alpacas to analyse changes occurring during ontogeny. Unfortunately, the lack of studies on the biometry of young alpacas, llamas or camels makes it impossible to make a meaningful, statistically significant comparison. The boniness and massiveness indexes are higher for adult individuals. This implies a predominance of increasing chest girth relative to height at the withers and a faster increase in height at the withers relative to the circumference of the thoracic limb cannon. According to our research, the eurysomia index indicates a dominant increase in the diagonal length of the body compared to the girth of the chest. Comparison of head size indexes shows that they are identical to those of mature individuals. We can see a significant difference in the index of foot length relative to the entire pelvic limb (Table 4). Comparing these values, we can assume greater growth of the foot relative to the whole limb in the first 24 months of the alpaca's life. The remaining results and the calculations based on them do not represent data of statistical importance.

Table 4
The value of indexes of young individuals

Feature/measurement	Female N=11	Male N=10
Body length index	0.744	0.632
Boniness index	0.118	0.121
Massiveness index	1.024	1.010
Eurysomia index	1.377	1.597
Head size index	0.131	0.140
Thigh length index	0.290	0.289
Cruris length index	0.362	0.361
Foot length index	0.348	0.350

In conclusion, the biometric analysis of statistical data of alpaca individuals up to 24 months of age and older ones provides preliminary information for further research into the biometrics of this species. Chest girth is greater than height at the withers, and their ratio, expressed as the massiveness index, is similar to that of the feline pony, a horse designed for riding performance (Kolstrung, 2006). The eurysomia index in alpacas is high, far exceeding that of the one-humped camel. The greater limb length of males compared to females in both age groups is also an interesting parameter. Further studies are needed to obtain a complete set of biometric traits of alpacas. The results, at this stage, may be useful for determining the correct conformation of the species and for breeding selection purposes.

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