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RESEARCH ARTICLE

INFLUENCE OF MORPHOLOGICAL TRAITS ON AGE-TYPE CONFORMATION AND LIVE BODY WEIGHT OF CAMEROON'S NATIVE GOAT

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ABSTRACT

The influence of qualitative characteristics on conformation and weight (BW) was assessed on 383 does of Cameroon native goats (CNG) from the Western highland (WHAZ) and bimodal rain forest (BRFAZ) agroecological zones. The study firstly aims at evaluating each characteristic. Secondly, at identifying morphometric markers of conformation and live body weight (BW). Qualitative traits included: dominant coat colour (DCC), dominant coat colour with rare colour location (DCCRL), coat colour pattern (CCP), rare colour location (RCL); presence of horn (PH), horn orientation (HO), horn tip orientation (HTO), horn quality (HQ); ear orientation (EO); presence of beard (PB) or wattles (PW) and supernumerary teat (SNT). The conformation consisted of: chest girth (CG), body length (BL) and height at wither (HW). To identify morphometric markers, the females were first described according to each criterion and two levels of doe's performances, low and high, were considered for CG, BL and HW. For the conformation traits and weight, the individual with a value inferior or equal (≤) to the mean value of the whole females of the same age was considered as low while those remaining were taken as high. The main results are as follow: For qualitative traits, 31 types of DCC have been recorded and the coat colour black/white is more represented (37.5%) while the Grey/black/white, Grey/white/brown, Red/brown/ white, Red/white, the White/fawn and the white/grey were the least represented (< 0.5%). 85 types DCCRL recorded, with black/white (15%). By this method, 98.7 % of the female colour had a frequency < 0.5%. 12 CCP were observed and the patchy type was so far the most represented with more than 70% while other types apart from the Black, the Roan and the Badger face,< 0.5%. 45 RCL were noted at different parts on body with frequencies varying from 0.26 to 35.88 %, the most frequent being the patchy type. No female studied has wattle. Beard was not present in 92.35 % and present in 7.65% of females. Horned animal displayed varieties of shapes, tip orientations and qualities. Specifically, 10 HO were observed: Backward (40.85 %), Straight (26.52 %), Backward/Lateral (14.06 %), Straight/Forward (7.7 %), Straight/Lateral (7.43 %), Forward (1.33%), Lateral (1.33 %), and Backward/ Straight (0.52%), Forward/Lateral whereas polled animal was scarce (0.26 %). Concerning HTO, 4 types were recorded namely the uniform (61.8%), the upward, (31.8%), the Lateral (5.04%) the least represented being the uniform/deviated (1.33 %). Four HQ were recorded, the normal (92.84 %), the abnormal (3.71 %), the Abnormal/stump (2.40 %) and the Normal/stump (1.06 %). EO was of two types, the horizontally (24.67 %) and the Erect (75.33 %). The SNT exists in the sample of does studied but in little proportion (1.3 %). The mean values (cm) for CG, HW and BL were 68.82 ±6.42, 50.48 ± 4.19 and 59.53 ± 6.21. The mean BW is 22.80 ± 5.43 kg. The association between the coat colour as well as the PB with the level of HW, BL, CG and the BW is not significant (P>0.05). Consequently, they can not be used as a criterion for the selection of female with high stature. HO is not significantly (P>0.05) associated with the HW but was significantly (P<0.05) associated with BL, CG and BW. For the BL, females with backward lateral HO are mostly found in the group of high than in low. The largest CG and heavier does have in majority backward and backward lateral, while those with the smallest chest girth and weight are most frequent in straight and straight Lateral HO groups. The association between the HTO with the level of HW, BL, CG and BW is not significant (P>0.05) and therefore is not useful for the selection of female with high stature. HQ is significantly (P<0.05) associated with the CG and BW but not significantly (P>0.05) associated with the HW and BL. Females with abnormal/stump have all smallest chest girth and the weight. EO is significantly (P<0.001) associated with the level of HW, the BL, CG and BW. The frequency of Lateral ear does was always greater in the group with the highest level of conformation and weight. Therefore, EO can be used as a selection criterion for conformation or growth in CNG. SNT is significantly (P<0.05) associated with the BL but not significantly (P>0.05) associated with the HW, the CG or BW. Females with extra teats were only found in high body length group. Finally, the study highlighted and proposed morphological traits that may be use to choose high quality does on farm. Examining the molecular determinism of such phenotypic relationships is recommended.

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INTRODUCTION

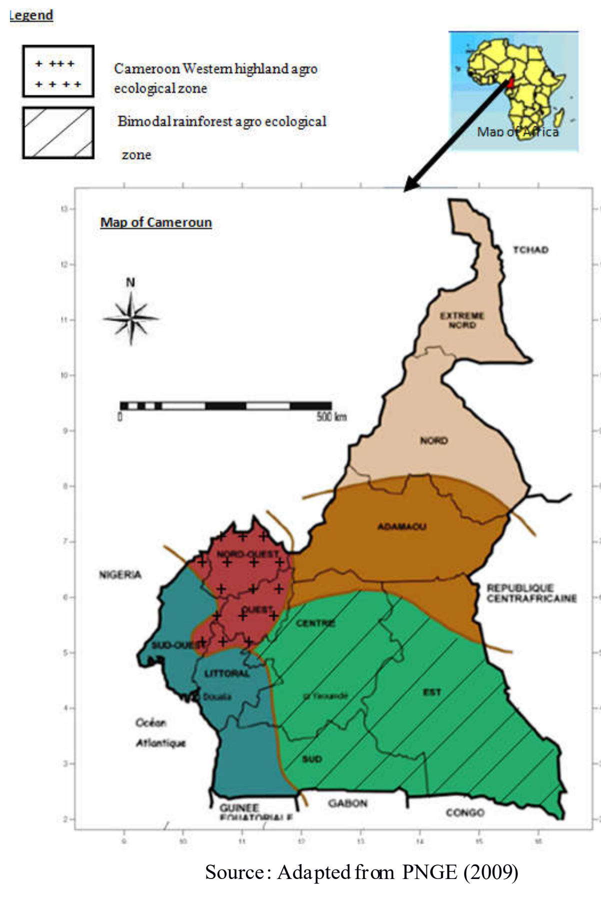
Base on current FAO data, there are nearly 1.2 billion goats around the world with almost 95 percent located in Asia and Africa. This numerical productivity is paradoxical to the production system, mostly extensive with less investment and care. It appears that the local breeds are specifically well adapted to their environment. In Africa, such specificity could have been used by decision markers as a pedestal to build up their strategies to address issues of animal protein deficiency and poverty alleviation. Improving the genetic ability of local breed is among the main step. Kosgey *et al.*, (2006) have suggested within-breed selection of the adapted indigenous genotypes as a viable option. Nowadays, the availability of pedigrees and the increasing amount of genomic information do not exclude the investigation of morphological markers considering its potential on-farm usefulness as efficient strategies to select best animals for reproduction especially in low selected population such endogenous breeds. Moreover, the first attempt to improve animals used the phenotype of animal for a specific trait as a tool for selection (Al-Samarai and Al-Kazaz, 2015). This application used external animal characteristics as a marker that called morphological markers such as udder shape, coat colour, body shape, skin structure, and anatomical characteristics (Van Wezel and Rodgers, 1996). After Yang *et al.*, (2013), it is still an effective method for the assessment of qualitative traits, for which it is easy to characterize phenotypic differences between individuals through direct observation and measurement.

So far, the constraints of breeding improvement of goat in smallholder production systems as addressed or reported by various authors (Peters, 1989**,** Wollny *et al.*, 2002) remains unchangeable. (Peters, 1989) reported Single sire flocks as an issue of confounding of sire and flock effects on farm study in traditional small ruminant breeding system while Wollny *et al.*, (2002) listed small animal populations, single sire flocks, lack of systematic animal identification, inadequate animal performance and pedigree recording, low levels of literacy and organizational shortcomings. Improvement attempts require good knowledge of the actual performances of animal even when the production system and the management practices are characterised by the lack of record. However, the small flock size tendency may be somehow advantageous when record keeping is absent. This is because most farmers can easily remind some information about their animal which when properly record may allow building up first initiatives. Collection of information from farmer is then an alternative around which first initiatives could be built up.

Phenotypic description of animal based on its body generally combines qualitative and quantitative traits also known as morphobiometric characteristics. Furthermore, morphology traits are frequently reported as result of adaptative mechanism to various environments. Odubote, (1994) was among the pioneer to investigate the effect of morphological trait on production in WADG. Sam *et al.,* (2017) observed a significant effect of beard and horn on morphometric traits and indicated that there may be important factors to consider in making selection and culling decisions in WAD goats. In Cameroon, many studies (Meutchieye, 2008; Katchouang, 2015 and Tangomo, 2015) on characterisation of goat using morphological criteria have been realised. Although the correlation between some body measurements related to conformation traits with the weight have been extensively used for barymetric equation, the relationship of those criteria as well as morphological trait with conformation and growth trait have never been assessed. On the contrary, the research on this topic, particularly in WADG is abundant in Nigeria. The general objective of this work is to improve knowledge to ease the selection of high potential does at the breeder level. Specifically, to present morphological specificities of CNG females and to analyse the association between the recorded morphological traits (coat colour, presence of beard and wattle, horn orientation, horn tip orientation and horn quality, earn orientation and presence of supernumerary teat) with the age type conformation traits (high at wither, body length, chest girth) and live body weight in order to proposed useful indicator traits.

MATERIALS AND METHODS

Study zone: Data was collected in the western highland and the bimodal rain forest agro ecological zone of Cameroon. The first zone is located between 5° to 8° latitude North and 9°45 to 11°15 longitude East and the second, 2° to 4° latitude North and 11°15 to 16 ° longitude East (ASEB Cameroon, 2010). Figure 1 gives the location of the study zone.



Source: Adapted from PNGE (2009)

Figure 1. Location of the study zone

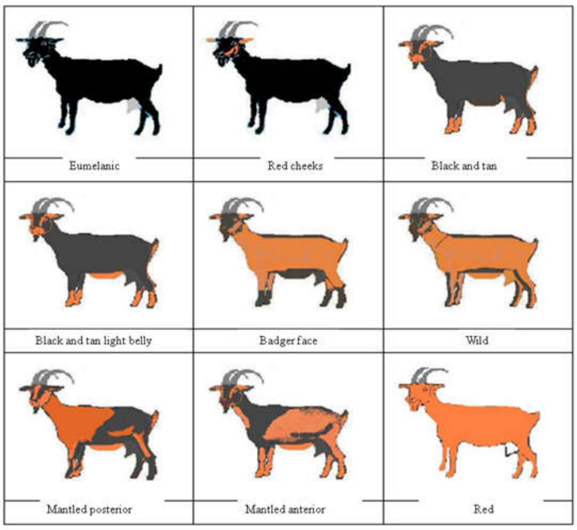
Geo-climatic condition: Data on the climate, vegetation and soil in these agroecological zone have been described by ASEB Cameroun, (2010) and PNGE, (2009).

Animal material and sampling: Field survey was carried on from October to December 2013 under the Goat project. A total of 383 females which have already given birth at least once from 196 goat keeper in 160 villages of the Western Highland and the bimodal rainforest agroecological zone of Cameroon were used. The females were kept under traditional breeding system mainly characterized by free range with modalities such as temporary confinement depending on farming activities. Feed is dominated by natural forage with irregular complementation made up of kitchen waste (Manjeli *et al.* (1994).

Collected data: All the records were done according to the USDA sampling protocol (USDA, 2013) adopted for the African Goat Improvement Network (AGIN) and completed by the FAO protocol (FAO, 2013). Age, the breed, three photos characterization (front, profile and back), body measurements (height at wither, body length and chest girth and live body weight) were collected.

Age of doe: This was estimated from dentition as describe by (FAO, 2013).

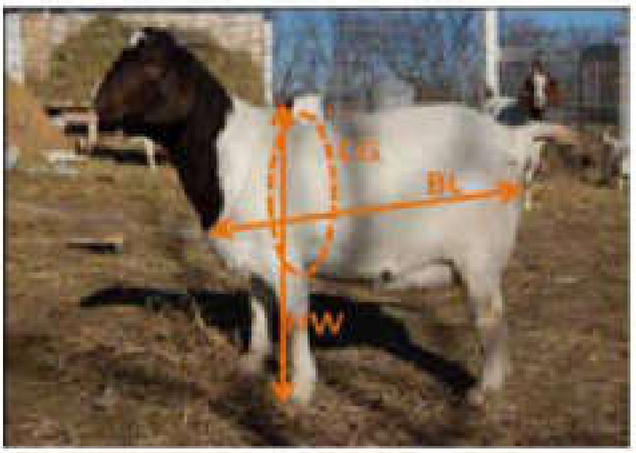
Morphological traits: The coat colour was described by one operator base on the above mentioned photos available for all the individuals. Coat colour was characterised by 4 criteria namely: the dominant coat colour; the dominant coat colour with rare colour location; the coat colour pattern and the rare colour location. The dominant coat colour was described according the FAO (2013). The dominant coat colour with rare colour location was adapted from the FAO (2013) in which the distribution of spotting on the body was combined to the dominant coat colour. The coat colour pattern was described according to the classification (figure2) proposed by Lauvergne (1982) and described by Danchin-Burge (2008). The last criteria focuses on the position of white marking (Adalsteinsson *et al.*, 1994) as well as others spotting type and was named the rare colour location. Here, a non-spotted animal (with no rare colour) was simply recoded according to its coat colour pattern. The presence of beard, presence of wattle and the presence the supernumerary teat were recorded by direct observation. Ear orientation, the horn orientation and the horn tip orientation were characterized as describe by the FAO (2013). The horn quality was also appreciated.



Source: Danchin-Burge (2008)

Figure 2. Main coat colour patterns in caprine.

Collection of zoometrics traits: The body measurements such as the ear length, the horn length, the body length (BL), High at withers (HW) and the chest girth (CG) were collected as describe on Figure 3. The body length and the chest girth (Figure 3) were taken using a measuring tape while the height at wither was taken by a height gauge. Each value was expressed in cm. The live body weight was determined by weighing the female with a 10^{-2}g electronic balance and expressed in kg.



CG= Chest girth, HW= Height at wither, BL = Body length
Source: FAO (2013) and USDA (2013).

Figure 3. Principal body measurements

Animal material and sampling: The entire 383 females pre-characterised output for the first objective was used. These females were grouped into modalities according to the nature of parameters and the type of associations to be examined. Table 1 gives details about the different type of association that have been examined.

Table 1. Different type of study associations

Parameter/ Characteristics	Conformation			Weight
	Height at wither	Body length	Chest girth	Live body weight
Coat colour (DCC, DCCRL, CCP, RCL)	X	X	X	X
Presence of horn	X	X	X	X
Presence beard	X	X	X	X
Presence of wattle	X	X	X	X
Horn orientation	X	X	X	X
Presence of supernumerary teat	X	X	X	X

Identification of morphological trait for conformation and live body weight: In order to analyse the influence of morphological character, the conformation (height at wither, the body length and the chest girth), live body weight and the reproduction parameter (maximum litter size, litter size at birth) were considered at different levels of performance depending of the trait.

Definition of the level of performance for conformation and live body weight: The females were share into two groups corresponding to two levels of performances low and high which have been defined. For this effect, an individual with a value inferior or equal (≤) to the mean of the whole females of the same age was considered as low. Otherwise, the individual is considered as high.

Data analysis: The description of female base on entire characteristics of the morphology, the zoometric and the prolificacy, sex ratio and the survival was analysed using the descriptive statistic. The effect of morphological trait (Coat colour, Presence of horn, Presence beard, Presence of wattle, Horn orientation, and Presence of supernumerary teat) on conformation and live body weight and the reproduction were assessed through association analysis by the contingency test using the software XLSTAT. However, the association between the presence of horn with the conformation, was not carried because only one polled doe was recorded. Similarly, association between the presence of horn on the conformation, live body weight and reproduction could not be carried as none of the doe had wattle.

RESULTS AND DISCUSSION

Morphological characteristics of Cameroon native goat does

Results of the descriptive statistics of doe's coat colour using different labelling methods.

Dominant coat colour: The bar chart of the dominant coat colour range in the decreasing order of frequency is shown on Figure 4.

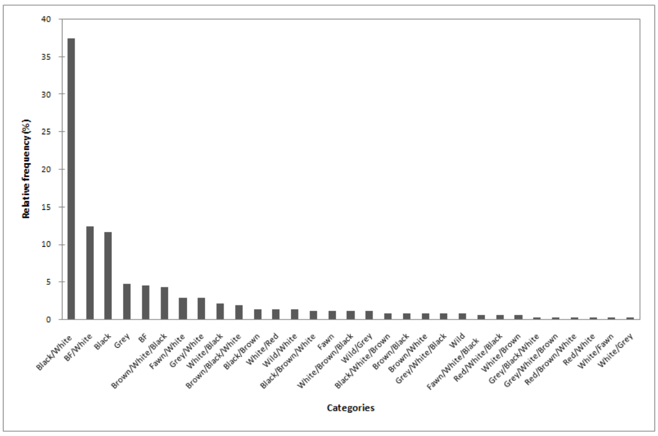


Figure 4. Coat colour of does using the dominant coat colour criteria

As shown by Figure 4, 31 types of dominant coat colour have been recorded. The coat colour black/white is the more dominant (37.5%) following by the Badger face/white (12.4%) while the Grey/black/white, Grey/white/brown, Red/brown/ white, Red/white, the White/fawn and the white/grey were the least represented with their individual value lower than 0.5%. This result is almost similar to that reported in WADG in Nigeria by Adedeji, (2012). He found that goats were predominantly black and suggested that this could be a feature of adaptation. The predominant animal with black and white coat colour may be the expression of the adaptation response to the environment. In fact, Odubote (1994) reported that the black coat colour may predispose the goat to high heat load, high metabolic rate and increased thyroid activity. In contrary, white coat colour animals were found to be more heat tolerant than other (Adedeji, 2012). Silanikove (2000) reported that coat colour has made it easy for the animals to survive in hot temperature region, the coat colour predisposes goat to high heat load and probably high metabolic rate and thyroid activity which consequently affects growth rate.

Dominant coat colour with rare colour location: Figure 5 show the different colour recorded using the dominant coat colour with rare colour location method. From Figure 5, it is found that among the 85 coat colour variants recorded, the black/white is the most present with a relative frequency of 15%. Moreover around 98.7 % of the female colour using this method shows a frequency lower than 5 %. This means that base on the coat colour, the population can be very diverse. Each animal turns to have its own specificity compared to standard breeds were the coat is uniform and differentiation between individual is only possible by good identification method. This diversity appears as a gold mine for breeding purposes.

Coat colour pattern: The different coat colour patterns observed in Cameroon native goat are given on Figure 6. Figure 6 reveals that 12 coat colour patterns were identified in the sample studied. The patchy type was so far the most represented with more than 70% of the females. All the other types apart from the Black, the Roan and the Badger face, had shown a frequency lower than 5%. All the coat colour patterns were proposed by Lauvergne (1983). These main groups of coat colour found in goat have been used before in characterization studies of Cameroon native goats. Most of these colours: eumelanic, red cheek, black and tan light belly, badger face, wild, mantled anterior, mantled posterior and red have been mentioned to derive from different expressions of well-known alleles of one gene, the agouti. The genetic mechanism of action of these alleles is still to be highlighted. However, for the Roan and the frosting, each of them displays two alleles at each locus and act in a dominant manner. Contrarily, Danchin-Burge (2008) reported that for the patchy type as well as for other colour dilutionvariants, no locus is known suggesting that many genes are probably responsible of that phenomenon. This result is different from that of Tangomo, (2015) in monomodal and Katchouang (2015) in high savana agroecological zone of Cameroon.

They reported that the "undetermined" type, mainly due to the irregular distribution of colour such as the white marking over the animal body, was the most dominant with respectively 39 % and 21 %.Their results were however not sex specific. However the black was like in our case the second most represented colour which is similar to finding of Katchouang (2015) but different to Tangomo (2015) where the black was the 4th represented behind the BF and the EFVC. The differences may be due to combination of factors namely: the locality, the number and the sex of surveyed animal as well as the recording ability which may vary from one operator to another. It is important to note that the unreadable type is quite rarely mentioned elsewhere by some other authors. However, the phaeomelanin is less present which is conform to Adalsteinsson *et al.*, (1994) who reported that the pattern with the most limited occurrence of phaeomelanin in goats is red cheeks, where only the cheeks are affected.

Taking globally, these results greatly vary according to criteria being used to define the coat colour phenotype. Patchy is predominant in CNG does. High level of variation was observed in coat colour among goats in the areas studied with black coat colour being the predominant (Ayodeji and Adeyemi 2018). However our result is somehow closer to those of Ayodeji and Adeyemi (2018) who reported BF as the third most represented colour.

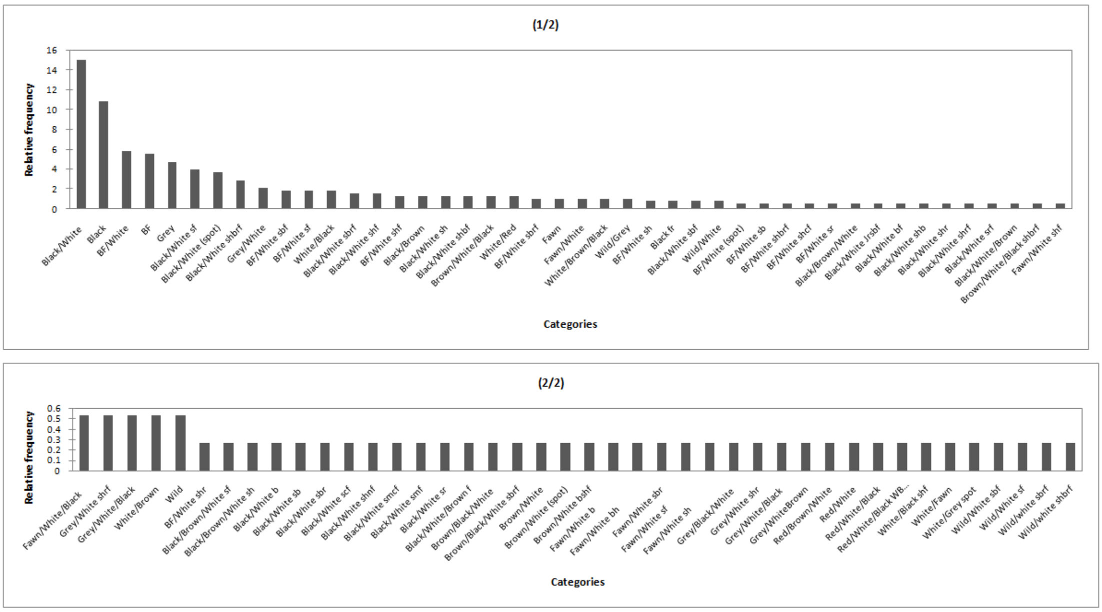


Figure 5. Coat colour of does using the dominant coat colour with rare colour localization criteria

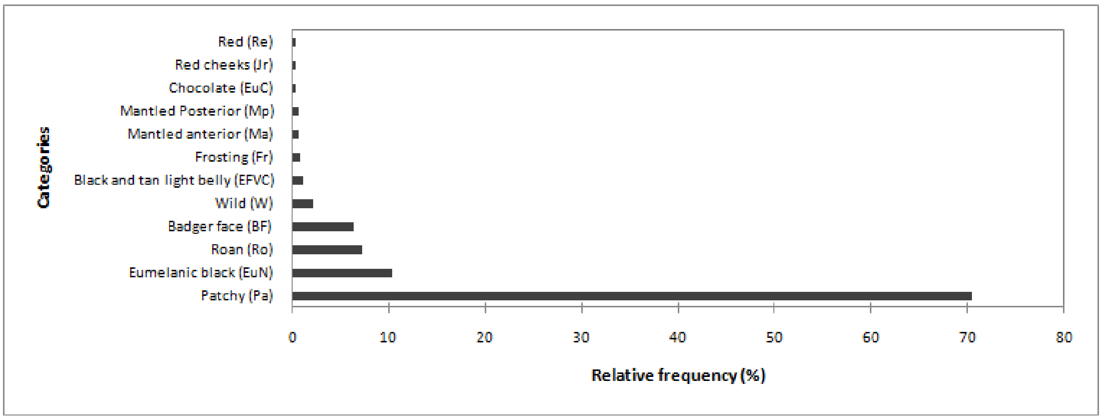
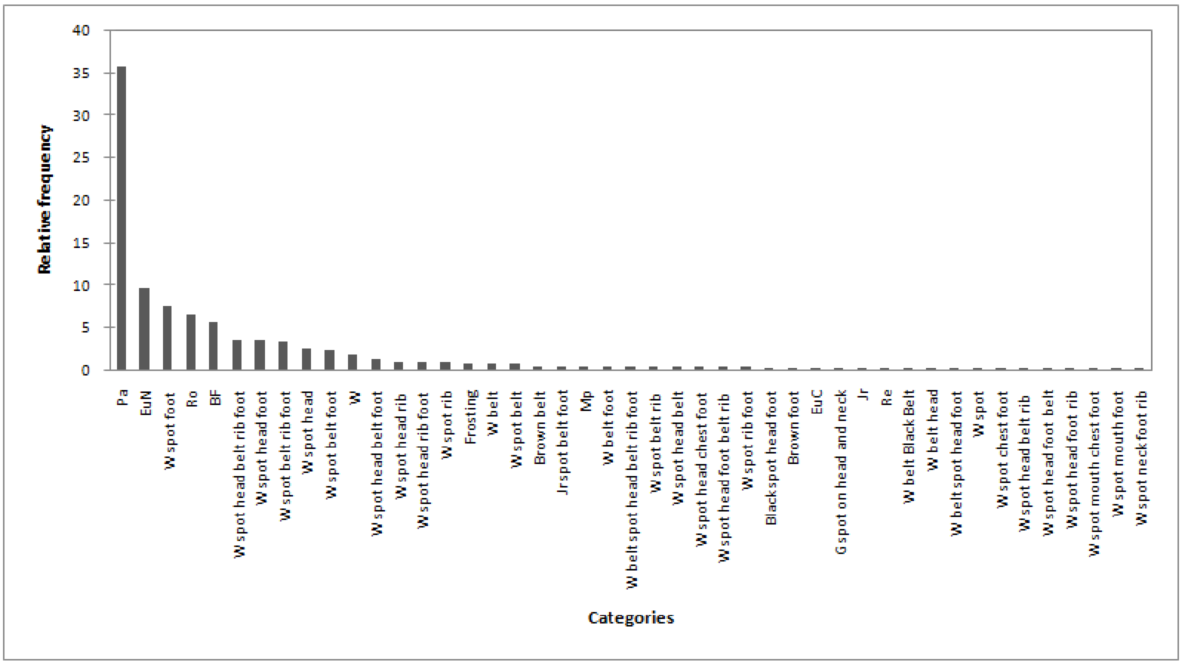


Figure 6. Coat colour pattern of does



NB: W= white, G = Grey

Figure 7. Coat colour of does using name of rare colour location criteria

Finally these results show that in contrary to the Nigeria flock where the black colour is predominant, the CNG have undergoes more dilution which may suggest specific adaption to their environment. Danchin-Burge (2008) reported that the genetics determinism of the patchy colour or white marking is yet to be established. Indeed, goats may have many different patterns of white spotting, and each of these is totally independent in terms of genetic control (Bemji *et al.*, 2012). Coat colour and type are known to adapt animals to different climatic zones and have a considerable influence on the performance of various stocks (Odubote, 1994; Okpeku *et al.*, 2011).

Coat colour pattern with name and location of rare colours

Figure 7 gives the name of rare colour observed on the females with their distribution site across the body. As observed on Figure 7, 45 rare coat colours with their specific position on body of the animal were identified. Their relative frequencies vary from 0.26 to 35.88 %. The most frequent type was the patchy type. The white was the main concerned rare colour displaying different distribution site on the body of the females.

This might indicate that some other marks such as red are generally well fixed on the body and that most of the variation simply the advent of the white. The name and the relative position of spot especially the white have not been reported in literature. Like patchy type, it is not known if this advent is incidental or not. Unfortunately, the transmission pattern of such variant is still to be studied. This study also recorded incidence of other types of spotting such as red, black and brown almost similar to those reported by Ayodeji and Adeyemi (2018).

Results of the descriptive statistics of Presence of beard and wattle

Presence of beard: Figure 8 show the distribution of the presence of beard in the females. The majority of does do not have beard (Figure 8). This trait seems to be rare in females. In Western highland, Meutchieye (2008) reported frequency of (14.56%) while Tangomo (2015) mentioned a frequency of (26%) in the coastal monomodal rainfall agroecological zone. But their observations were not specific to females which may explain the differences. Sam *et al*. (2017) reported 13.3 % of female with beard and independently to the sex, goats with beard had significantly ($p<0.05$) wider heart girth, longer height at wither and larger body depth but no significant effect on body weight, body length and rump height.

Presence of wattle: None of the female studied has wattle. It is possible that this characteristic is very rare in the population. Thus, might not have anymajor impact on the conformation trait in CNG. In Cameroon population, the previous work reported relative low frequencies of wattle. 1.50 % (4/262) of wattle (Tangomo, 2015).

But the highest value of 3,61 % on 249 individuals have been reported by Katchouang (2015) in the soudanoguinean agroecological zone, closer to the driest and warm zones of Cameroon may reinforce their adaption to heat. Goats can have zero, oneor two wattles, but actual reported data on Cameroon goat show that existing wattle are found in pair.

Results of the descriptive statistics of horns

Presence of horn: Only one polled female (0.26%) has been observed. Then the main focus on those having horns regards the shape, the tip orientation and the general quality the horns. Horn is a binary trait with a clear distinction among individuals. It appears at relatively early age. According to Ricordeau *et al.*, (1969), horning became evident at 28 days at the latest, and the goats had to attain at least that age before the number of horned animals in a population could be correctly estimated but future horned animals may be detected earlier by determination of whorls of hair at the site of the horn buds. But the frequency by sex was not given. Katchouang (2015) reported in the soudanoguinean zone, 1 polled individual over 249 but it is not known whether the animal was a male or female as the sex modality was not taken into account in their study. Similarly, in a sample of 262 goats, Tangomo (2015) reported no polled animal in the coastal monomodal rainfall agroecological zone in Cameroon. These observations suggest that polledness animals are rare in Cameroon goat population. According to Meutchieye, (2008) this is the indication of non-selection population. But such animal may be for some raison less suitable to the milieu.

Horn orientation: The Figure 9 gives the relative frequency of different types of horn orientation found in the female population.

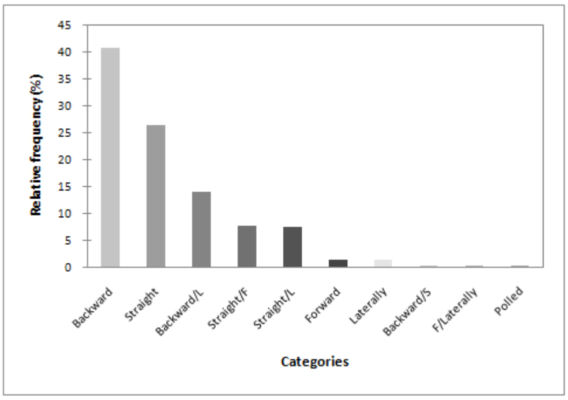


Figure 9. Type of horn orientation of does and relative frequencies

As from Figure 9, the backward has shown the highest frequency (40.8%) while the backward/straight, Forward/Lateral and the polled were the least represented and even scarce. The shape is not a good criterion to describe the horn type in CNG female. According to the FAO, (2013) the horn shape in goat can be either scurs, straight, curved, spiral, corkscrew. These were unable to characterize all the forms observed on the field, which were no scurs, no spiral and no corkscrew and sometime neither obliquely, nor simply curved (backward), but were forward nor laterally curved. Then only the horn orientation, the horn tip orientation and the horn quality which were able to capture all these variations have been used.

Horn tip orientation: Figure 10 shows the distribution of different horn tip orientation found. As shown on the bar chart (Figure 10), 4 horn tip orientations were recorded. The most common horn tip orientation was the uniform (61.8%) type follow by the upward (31.8%), the least represented being the uniform/deviated (1.3%).

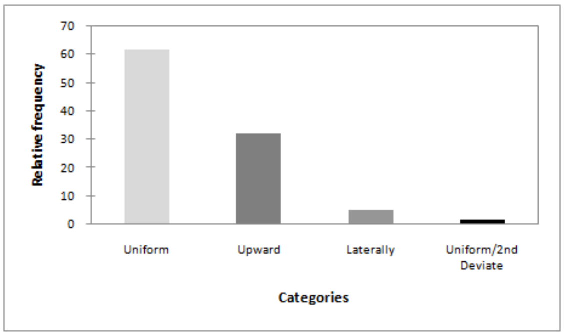


Figure 10. Type and relative frequency of horn tip orientation in does

Horn quality: Figure 11 shows the distribution of different horn quality which had been observed. The appreciation of the horn quality reveals 4 types. The normal type (92.8%) was the most represented while the least represented was the normal/stump (1%).

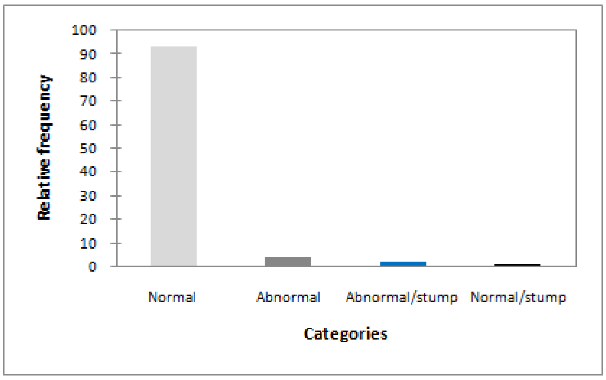


Figure 11. Type and relative frequency of horn quality

Results of the descriptive statistics of ear orientation and presence of supernumerary teat

Ear orientation: Figure 12 gives the type and the frequency of ear orientation in CNG.

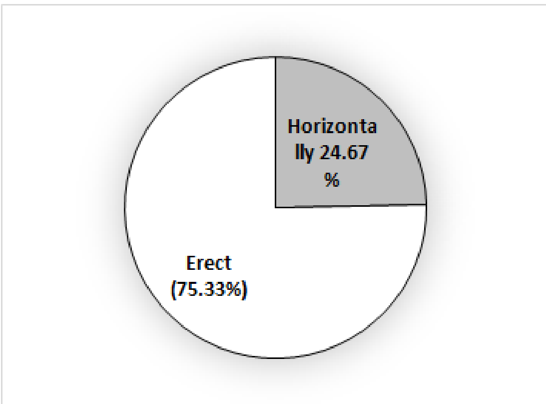


Figure 12. Type and frequency of ear orientation in CNG does

From Figure 12, the majority of does show erect ears. Ear is a widely used organ in the characterisation of livestock species from which qualitative aspects and quantitative values are described. This paedomorphic traits is retained by adults of some breeds in many domesticated mammals including dogs, cattle, goats and rabbits (Boyko *et al*., 2010).

Apart from its main relevant function in hearing, ear morphology has also been reported as an adaptive mechanism. In goat, ear structure is variable with implications for adaptation to heat stress (Paim *et al.* 2018). Results of characterisation studies in Cameroon suggest different ear carriage and length. In the monomodal agroecological zone, Tangomo (2015) reported that the ear carriage was erected, horizontal and floppy with respective frequency (%) of 28.20, 64.90 and 6.90 while the ear length (cm) was 10.73 ±1.12. In the Soudanoguinean zone, 4 types of ear carriage erected (79.90 %), horizontal (13.30 %), semi pendulous (1.20 %) and floppy (5.6%) with an overall mean length (cm) of 11.02 ±1.41 have been recorded (Katchouang, 2015).

Presence of supernumerary teats: Figure 13 shows the proportion of supernumerary teat in CNG does.

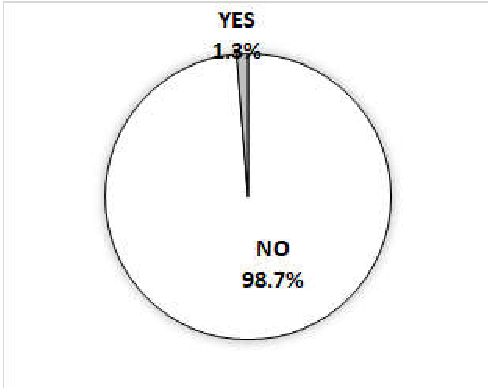


Figure 13. Presence of supernumerary teat

In the population studied, teats in females occur essentially in pair. In a few proportion of those having extra teats, it was either 3 or 4 in 50% of case. But it was not possible to know whether extra teats were functioning or not. Such an information is of great importance as it can increase the capacity of does to milk more than two kids at once. This might positively impact the preweaning growth and the kid's survival at weaning. The effort of the goat breeder during the rotational feeding of kids from high litter will be reduced. Such trait appears as usefulness and its introduction as a new trait in the breeding goal of meat type goat is not unrealistic. This trait has never attracted any particular attention in Cameroon. However, some investigations on SNT have been carried out in various goat breeds elsewhere.

In WADG, Oppong and Gumedze (1982) reported a frequency of 29.7% in a sample of 142 does. In the same breed, and Oseni *et al.*, (2006) recorded a frequency of 23.0% among 84 does of one village in South western Nigeria and the types of extra teats were 3 (7.0%) , 4 (15.0%) and 5 (1.0%) . A frequency of 4% in Alpine and Saanen Goats have been reported by Martin *et al.,* (2016). In addition, it is a high heritable trait Brka *et al.*, (2007) reported a value of 34% in Saanen Goats.However, the determinisms of SNF are still to be highlighted. Different factors have been suggested. According to Oppong and Gumedze (1982), the relatively high occurrence of supernumerary teats in the goats investigated is attributed to inbreeding. On the contrary, intrauterine hormone has been suggested in sheep (Brka *et al.*, 2002) with the acting pattern similar to that of freemartin in cattle. In Alpine and Saanen females, Martin *et al.,* (2016) reported high estimates of SNT heritability (0.4 and 0.44 respectively).

Table 2. Results of the Chi square test of the coat colour, the presence of bear, the horn orientation, the horn tip, the horn quality, the Ear orientation the presence of extra teat with the level of height at wither (LHW), body length (LBL), chest girth (LCG) and weight (LBW).

Variables	Dominant coat Colour	Dominant with rare colour location	Colour pattern	Rare colour location	Presence of Beard	Horn orientation	Horn tip	Horn quality	Ear orientation	Presence Extra Teat
Modality	31	85	12	45	2	10	4	4	2	2
LHW	ns	ns	ns	ns	ns	ns	ns	ns	***	ns
Sig (p-value)	0.99	0.377	0.518	0.567	0.766	0.153	0. 529	0.67	0.000	0.164
N	379	379	379	379	377	377	377	377	377	377
DF	30	84	11	44	1	9	3	3	1	1
Chi-square (obs.)	40.301	87.456	10.144	41.792	0.088	13.213	2.216	7.163	19.837	1.940
Chi-square (theo.)	43.773	106.395	19.675	60.480	3.841	16.919	7.814	7.814	3.841	3.841
LBL	ns	ns	ns	ns	ns	*	ns	ns	**	*
Sig (p-value)	0.576	0.388	0.193	0.428	0.053	0.041	0.415	0.196	0.008	0.04
N	280	280	280	280	278	278	278	278	278	278
DF	26	67	11	37	1	8	3	3	1	1
Chi-square (obs.)	23.993	69.653	14.772	37.907	3.755	16.131	2.852	4.689	7.019	4.221
Chi-square (theo.)	38.885	87.108	19.675	52.192	3.841	15.507	7.814	7.814	3.841	3.841
LCG	ns	ns	ns	ns	ns	*	ns	**	***	ns
Sig (p-value)	0.357	0.233	0.416	0.150	0.356	0.034	0.760	0.01	0.001	0.136
N	379	379	379	379	377	377	377	377	377	377
DF	30	84	11	44	1	9	3	3	1	1
Chi-square (obs.)	32.220	93.100	11.327	53.696	0.853	18.095	1.170	11.313	11.780	2.222
Chi-square (theo.)	43.773	106.395	19.675	60.480	3.841	16.919	7.814	7.814	3.841	3.841
LBW	ns	ns	ns	ns	ns	*	ns	**	***	ns
Sig	0.357	0.233	0.416	0.150	0.356	0.034	0.760	0.01	0.001	0.136

ns = non significant (p>0.05); *, **, *** = significant at 0.05, 0.01 or 0.001 respectively

This maybe a good indication of the high potential of the additive genetic effect of responsible genes to be inherited. Thus, the inbreeding will surely increase its frequency particularly in small flow with high degree of relatedness between individuals. Recent works such as those of Martin *et al.,* (2016) are probably among the first published works on the genetic architecture study of supernumerary teats (SNT) using GWAS with 52K goat SNP chip (Illumina Inc., USA).

Identification of morphological indicator traits of zoometric traits (Factors affecting the zoometric traits)

The effect of the coat colour, the presence of bear, the horn orientation, the horn tip, the horn quality, the Ear orientation the presence of extra teat on conformation traits and weight. The summary of the chi square test of morphological trait at different modalities with the level of the conformation and the weight are given in table 2.

The analysis was done under the following hypothesis:

H0: Variation in each morphological trait and the level of conformation and growth are independent

The association between the coat colour with the level of HW, BL, CG and BW is not significant (P>0.05). Consequently, the coat colour can not be use as a criterion for the selection of female with high stature. The effect of the coat colour have been assess for the first time in Cameroon. However, there have been no clear reports on the impact of coat pigmentation on morphometric indicators in recent literatures. Shoyombo *et al.* (2018) suggested that coat colour moderately influence body morphometric measures and its effect varied between breeds, gender and ages of Nigerian indigenous goats. In WADG does, they observe that in one year old, body length and the heart girth were significantly influenced by the coat colour with highest value in BR/W type but with no effect on the HW and the BW. HW and BW were in contrary significantly influenced by the coat colour in female between 1-2 years with the respective highest value obtain in R and in BR/W. Surprisingly Shoyombo *et al.,* (2018) observed no effect of coat colour on all traits tested in does over 2 years old. It is important to note that these authors tested a maximum of 9 coat types which vary from one age group to another. In our case, all the analyses have been carried on using the entire colour being observed. A different effect was observed by Olfaz *et al.*, (2011) who reported that there was no significant effect of coat colour factor on milk production and kid growth in Turkish hair goat. But our result agree with findings of Oke and Ogbonnaya (2011) who reported insignificant differences in live weight and heart girth among different colour groups even though black sheep had the highest values for these traits. However, different results have been reported in literature.
Dark-coloured animals (various livestock species studied) grow faster in the tropics and subtropics, and survival and growth are less in lighter colored animals (Kinne, 1998). Conversely, lighter colored sheep in the tropics seem to have increased milk yield. This does not agree with the findings of Ayodeji and Adeyemi (2018) who reported a significant effect of coat colour genes on body weight of West Africa bucks and with finding of Odubote (1994) in his various studies of intensive and extensive reared West African dwarf goats of Nigeria. The observed difference may be the result of the sampling and the number of the categories of the coat colour used by those authors in the studied population. It is therefore difficult when a trait is so variable such as the coat colour in CNG that some valuable marker could be identify. This may be possible only after the selection of these colours and the evaluation of their performance in a separated flock. The presence of beard is not associated with the level of height at wither, the body length, the chest girth and the weight is not significant (P>0.05). Consequently, this criterion is not useful for the selection of female with high stature. Horn orientation is not significantly (P>0.05) associated with the level of HW

but was significantly (P<0.05) associated with level of the body length, the chest girth and the weight. For the Body length, the number of female with horn orientation backward lateral is significantly greater in the group of high than in low body length. Whilst the largest chest girth and heavier does have in majority backward and backward lateral, those with the smallest chest girth and weight are significantly more frequent in straight and straight Lateral horn orientation groups. The association between the horn tip with the level of HW, the body length, the chest girth and the weight is not significant (P>0.05). Consequently, this criterion is not useful for the selection of female with high stature.

Horn quality is significantly (P<0.05) associated with level of the chest girth and the weight but not but not significantly (P>0.05) associated with the level of HW and the body length. The females with abnormal/stump have been only found in the group with the smallest chest girth and the weight. Abnormalities in horn might have significant effect on the level of growth of the chest and the weight. Ear orientation is highly significantly (P<0.001) associated with the level of HW, the body length, the chest girth and the weight. The frequency of Lateral ear oriented does was always greater in the group with the highest level of conformation and weight. Therefore, Ear orientation can be used as a selection criterion for conformation or growth in CNG. This orientation may affect the metabolism in goat. It is known that ear size is associated with heat tolerance; thus, animals with larger ear are expected to be more adapted than other. In our study it has been shown by further analysis (data not publish) that ears size is larger in Lateral oriented goats than in other even if the analysis of variance was not significant (p>0.05). Heat is a major constraint on animal productivity in the tropical belt and arid areas and one of the homeostatic responses to thermal stress in mammals include decreased feed intake (Silanikove, 1992). Cameroon is located in the tropical zone which is hot. It is guest that the feed intake in Lateral oriented ear does is more important under this hot environment than in other with positive incidence on their development. The presence of extra teat is significantly (P<0.05) associated with the LBL but not significantly (P>0.05) associated with the level of HW, neither the CG nor the weight.

Female with extra teats was only found in high body length group. However, the low frequency (1%) of supernumerary animal in the sample is not enough for reliable conclusion. But selection toward functional SNT may have potential usefulness in meat type animal especially for high litter size natural feeding. The SNT are also known as polythelia or hyperthelia. Polythelia is common abnormality of the udders of some livestock species (Palacios *et al.*, 2014). This conception is widely spread in milk industries. In human being it is also considered as pathology. Compared to milk industry and reproduction, less attention has been previously paid on the potential effect of SNT on the conformation traits and weight in the available literature. None of the does sampled had wattle. This suggests that wattle may not play any major role on the linear growth in the population and cannot be used as a morphological marker. In goat, the effect of wattle on conformation, production and reproduction traits have been studied. Recently, Sam *et al*. (2017) reported a frequency of 0.52 % in female and no wattle was present in males with no effect on morphometric traits of WADG. On contrary, Ozoje and Kadri (2001) observed that WAD sheep with wattle were superior to those without wattle in all the morphometric traits measured. Similarly, Shongjia *et al.*, (1992) reported that litter size and milk yield of Wattled Saanen does were significantly higher than non-wattle does.Recent findings of Beber *et al.*, (2015) support earlier assumptions that wattles are rudimentary developed extremities. So far, caprine wattles are supposed to be caused by an autosomal dominant W allele, and earlier studies indicate that there is no linkage between the W locus and the loci for horns or sex (Ricordeau, 1967). Similar finding have been reported by Reber *et al.* (2015) showing that the presence of wattles is not correlated with sex or with the presence of horns or beard. However, their real physiological role is still doubtful. Hypothesis suggests that it should be an adaptative mechanism to heat. Wattle possession in goats could have thermoregulatory functions and this could be translated to one of the adaptative features of wattle goats in the humid environment (Odubote, 1994). Adedeji (2012) observed that bilateral wattled goats (WW) had the lowest rectal temperature and beats/minute while the highest RR was recorded in the male goats. He suggested that together with coat colour, wattle types of WAD goats could be used as indirect and affordable selection criteria in the tropical environment for the heat tolerance trait. Moreover, bilateral wattled goats (WW) had the lowest RT and beats/minute while the highest RR was recorded in the male goats. Wattle can also be aesthetic but this has not yet been reported in the available literature.

Conclusion

CNG does are diverse in term of morphological characteristic offering a wide potential of selection purposes. The study highlighted and proposed morphological traits that may be used to choose high quality does on farm. Examining the molecular determinism of such phenotypic relationships is recommended.

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Author contributions

Jaures Kouam Simo contributed to data collection, analyzed the data and wrote the paper; Felix Meutchieye contributed to the experimental design, coordinated the field survey and supervised the first author; Yacouba Manjeli supervised the first author; Patrick Wouobeng contributed to field survey. All authors reviewed the manuscript.

Ethical clearance

Sample collection for this work was performed in close collaboration with the Directorate of Veterinary services of the

MINEPIA. During sampling no animal sacrifice was carried out. The bioethical approval procedure for livestock research in Cameroon only includes cases of animal sacrifice, surgery, or medical trials. Hence, no ethical approval was needed for the sampling in this research. The permission of each goat owner was required prior to sampling.

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