

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693

ISSN Online: 2617-4707

IJABR 2024; 8(9): 883-893

www.biochemjournal.com

Received: 20-07-2024

Accepted: 23-08-2024

Razafindrafara Mirantsoa Suzanne¹ National Center for Research,
Malagasy Institute of Veterinary
Vaccines, BP 04 Rue Farafaty
Ampandrianomby Antananarivo,
Madagascar² FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar**Rasoanomenjanahary Auldine**¹ National Center for Research,
Malagasy Institute of Veterinary
Vaccines, BP 04 Rue Farafaty
Ampandrianomby Antananarivo,
Madagascar² FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar**Razafinarivo Tsirinirina Donnah**FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar**Michelle Reine Lucie**FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar**Maminiaina Olivier Fridolin**¹ National Center for Research,
Malagasy Institute of Veterinary
Vaccines, BP 04 Rue Farafaty
Ampandrianomby Antananarivo,
Madagascar² FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar³ Department of Science Education
and Veterinary Medicine, Faculty of
Medicine, University of Antananarivo,
BP 04, Ambatobe Masinandriana
Ilafy, Antananarivo, Madagascar**Corresponding Author:****Razafindrafara Mirantsoa Suzanne**¹ National Center for Research,
Malagasy Institute of Veterinary
Vaccines, BP 04 Rue Farafaty
Ampandrianomby Antananarivo,
Madagascar² FOFIFA, Department of
Zootechnical, Veterinary and Fish
Researches, BP 1960 Rue Farafaty
Ampandrianomby, Antananarivo,
Madagascar

Goat genetic resources in Madagascar

Razafindrafara Mirantsoa Suzanne, Rasoanomenjanahary Auldine, Razafinarivo Tsirinirina Donnah, Michelle Reine Lucie and Maminiaina Olivier FridolinDOI: <https://doi.org/10.33545/26174693.2024.v8.i9k.2290>**Abstract**

Goats have always been considered very useful animals. As a result, local goat breeds that are renowned for their adaptation to difficult conditions deserve to be inventoried. The aim of this study is to draw up an inventory of domestic goats in Madagascar. The various existing breeds, the distribution of livestock, morphology and biometry are discussed. The study revealed that three types of breed are bred in Madagascar. Indigenous breeds, represented by two ecotypes: "Beroma" and "Fohivolo". The mixed breeds made up of Malagasy Angora and the exotic breeds made up of Alpine and Boer. These breeds are cosmopolitan in distribution, although a large herd is found in the south of Madagascar, particularly in the Menabe, Atsimo-Andrefana, Androy and Anosy regions. Native goats have highly variable coats, with long or short hair and short, horizontal ears that are pricked forward. The Malagasy Angora goat has a single-coloured coat with long hair and floppy ears. As for the exotic breeds, the Alpine goat is characterised by a buff coat and fairly closed upright horn-shaped ears, while the Boer goat has well-spaced horns on the head and gently curved backwards on the neck. Their ears are long and hang low on the head. In terms of biometry, the Malagasy Angora goat is higher than the two ecotypes 'Beroma' and 'Fohivolo', but lower than the two exotic goats 'Alpine' and 'Boer'. These results show that no selection has been made by Malagasy goat breeders since the goats were introduced to Madagascar. This work could therefore contribute to the implementation of genetic improvement or conservation strategies for Malagasy goat populations.

Keywords: Goat, breeds, morphology, biometrics**Introduction**

Animal genetic resources are an invaluable global asset. They provide around 30% of human needs in terms of food and agriculture. The use of these resources enables, among other things, the improvement of productivity, the quality of livestock products and the maintenance of animal health ^[1, 2]. The diversity of animal genetic resources is a source of adaptability and resilience in the face of climate change, emerging diseases, constraints in feed supply, and changes in market demand ^[3-5]. Indeed, many indigenous breeds have particular adaptive traits: resistance to disease, tolerance of the local climate, ability to accept poor-quality and reduced-quantity feeds ^[4, 6]. It is also likely that they have a particular aptitude for transforming a poor, low-protein diet ^[6].

In addition, human activities are depleting the planet's biological diversity ^[7]. For thousands of years, breeders have exploited animals domesticated by their ancestors on a small, local scale for specialized uses ^[6]. Biological cycles were therefore stable, and food production could continue unabated ^[6]. However, the pressure exerted by the growing human population and its need for food is upsetting the balance of natural resources used ^[6]. Indeed, recent trends in livestock production systems in developing countries to satisfy the demand for animal products, such as the introduction and increased use of exotic animals or their semen, uncontrolled crossbreeding or the intensification of production systems, are leading to poor management of animal genetic resources ^[4]. These attitudes lead to the genetic erosion of local breeds, which could eventually lead to the complete disappearance of these genetic resources. If they were to disappear, opportunities for genetic improvement of the species would also be lost. Given this situation, efforts to promote the sustainable use of these animal genetic resources must be stepped up as a matter of urgency ^[4].

Consequently, many countries are currently working to halt the erosion of their animal genetic resources by conserving their own resources ^[4].

In all regions of the world, livestock farming is an integral part of agriculture ^[8]. In regions characterized by extreme conditions unfavorable to agriculture, livestock is the only basis for human settlement ^[9]. In the case of goat farming, the livestock population has increased considerably since the 1960s, as climate change has limited the areas suitable for breeding ^[10]. In 2013, the world goat herd exceeded one billion head, an increase of over 34% since 2000 ^[11-13]. Africa is a major breeding area, accounting for a third of the world's goat population, with a greater distribution in the most arid regions ^[10, 14]. In fact, the African goat population represents 41% of the world population, and currently stands at around 423 million goats ^[11]. Arid zones are characterized by a high degree of random variability in time and space of natural forage resources. As a result, goats have always been considered the animal best suited to these precarious production conditions. In addition to their contribution to covering protein (meat and milk proteins), energy (fats, milk lactose), vitamin and mineral requirements, goats are raised for savings and income generation purposes ^[8]. Indeed, in difficult regions such as southern Madagascar, to survive each time drought wipes out most of their crops, poor and vulnerable families have given in to selling a large proportion of their goats, which are less sensitive to irregular rainfall than agriculture. In addition to milk, goat farming offers other benefits to owners: it provides raw materials for the craft and leather industries (skins, leather, hair, etc.), meat for households and fertilizer for farmers ^[10, 15].

In rural areas of developing countries, the contribution of goats is highly valued. Indeed, goats are extremely intelligent, highly agile and independent animals, with a high level of disease resistance, compared to other ruminant species ^[12]. Despite the importance of the goat sector in Africa, the erosion of genetic heritage is leading to the

gradual disappearance of local goat breeds. The need to conserve these resources is therefore required in order to contribute to the conservation and maintenance of sustainable management ^[4]. However, in developing countries, animal genetic resources are made up of a multitude of often poorly characterized populations. In this review, we will attempt to draw up an inventory of these goat resources in Madagascar.

Domestic goat breeds and origins

The domestic goat or simply the goat does not belong to the primitive fauna of the large island and could not have been domesticated there ^[16]. In fact, the present-day goat, which belongs to the genus *Capra aegagrus hircus*, is a subspecies of *Capra aegagrus* domesticated from the wild goat (*Capra aegagrus creticus* - Schinz 1938 - Figure 1). It belongs to the animal family *Bovidae* and subfamily *Caprinae*.



Fig 1: Wild goat: kri-kri or *Capra aegagrus creticus* ^[17]

Goats were domesticated somewhere in the fertile crescent of the Middle East more than -10,000 years ago (Figure 2), and are among the first five farm animals domesticated by man ^[18-21].

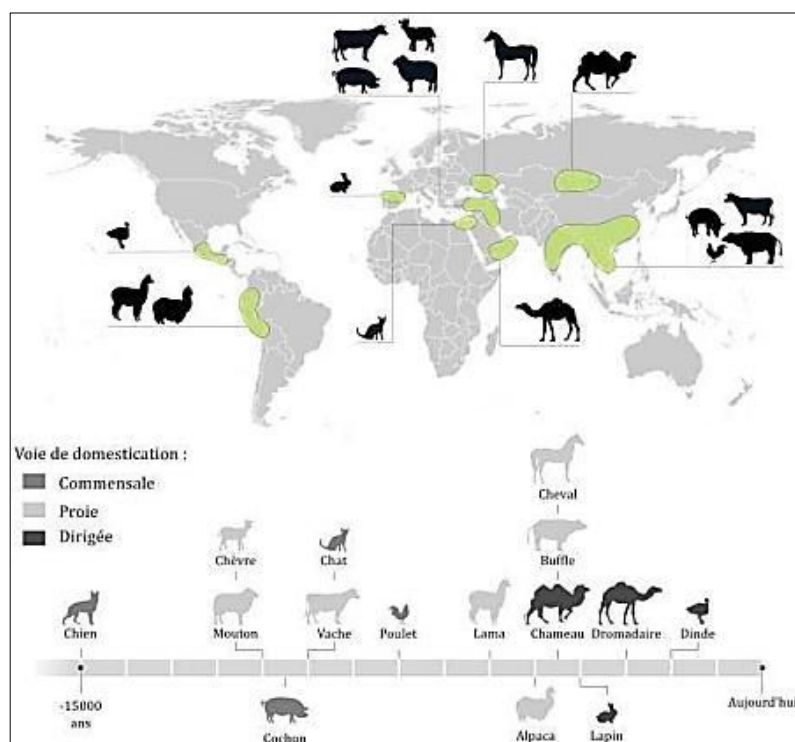


Fig 2: Places and dates of domestication of the main domestic animals ^[22]

Domesticated goats accompanied the first breeders, during their immigrations in the early (10,000-5,000 years BC) and late Neolithic (5,000-0 years) periods, in their quest for new

territories in Asia, Europe and Africa (Figure 3). Goats are robust and enduring species. They constituted a mobile supply of milk and fresh meat during their travels [23, 24].

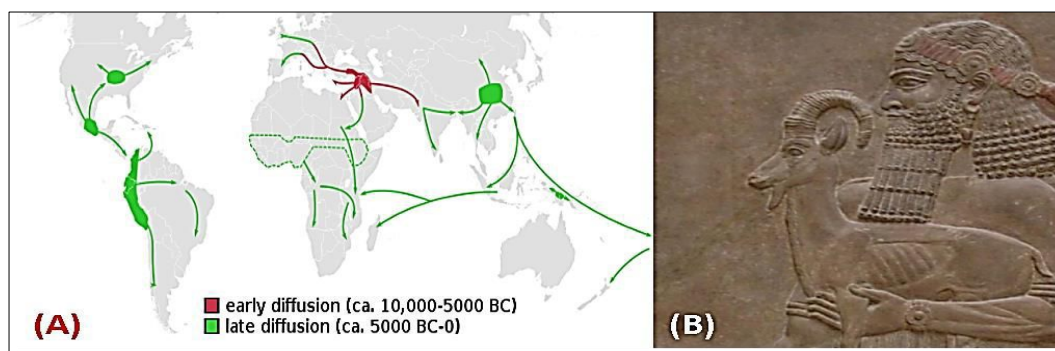


Fig 1: (A) Expansion and diffusion of agriculture and animal husbandry during the early and late Neolithic periods [25] (B) Mesopotamian stone sculpture of a man carrying a domestic or wild goat (Louvre Museum)

Like all the indigenous goats (marronnes) of the Indian Ocean islands [16, 26] on the route of the ancient navigators, Malagasy native goats could have been brought: either by Arab and Antalaotra navigators between the VI^{ème} century and XIII^{ème} century; or by Arab and African (Bantu) trading immigrants who were pastoral populations, taking advantage of the flourishing trade between the African coast and Madagascar [27-29].

Indeed, Arab navigators and the Antalaotra used goats as food during their voyages and/or during the long months of waiting for monsoon overturns aboard their dhows on the west coast of Madagascar [27, 29, 30]. Mixed with proto-Vezo,

these new immigrants (Bantus and Arabs) contributed to the settlement of pastoralists in western and southern Madagascar [31]. Goat breeding is developing in these regions, with a wide range of phenotypic diversity [32] but they are generally well adapted to the harsh environment in which they must survive and reproduce [32, 33].

Goat herd and geographical location

In Madagascar, the goat herd continues to grow (Table 1; Figure 4). In 2012, goat breeding was estimated at around 2,327,270 head [34].

Table 1: Goat livestock trends in Madagascar's 22 regions: 2010, 2011 and 2012 (Source: SAIGS/MINEL)

Area	2010	2011	2012
Analamanga	7 210	6 900	15 500
Itasy	7 410	350	400
Bongolava	2 790	2 900	3 300
Vakinankaratra	10 730	13 160	8 200
Antananarivo	28 140	23 310	27 400
Diana	22 420	56 500	60 200
Sava	8 570	2 300	2 600
Antsiranana	30 990	58 800	62 800
Matsiatra Ambony	19 000	12 400	21 000
Vatovavy fitovinany	1 220	260	200
Atsimo Antsinanana	-	100	100
Amorony Mania	5 710	1 800	2 540
Ihorombe	2 350	1 500	2 900
Fianarantsoa	22 570	14 260	24 200
Boeny	39 340	19 000	18 500
Sofia	136 580	67 000	22 000
Melaky	8 300	2 200	2 250
Betsiboka	12 270	15 300	16 000
Mahajanga	196 490	117 760	82 950
Antsinanana	-	-	-
Analanjirifo	-	90	130
Alaotra Mangoro	18 560	15 000	8 500
Toamasina	18 560	15 090	8 630
Menabe	56 470	152 000	185 000
Antsimo Andrefana	912 880	865 000	907 210
Andoy	713 670	858 000	820 000
Anosy	167 700	153 000	204 000
Toliara	1 850 720	2 028 000	2 116 210
Madagascar	2 153 180	2 260 820	2 327 270

More than 80% of the national livestock population is concentrated in the following regions: Atsimo-Andrefana,

Menabe, Androy and Anosy (Table 1; Fig 4).

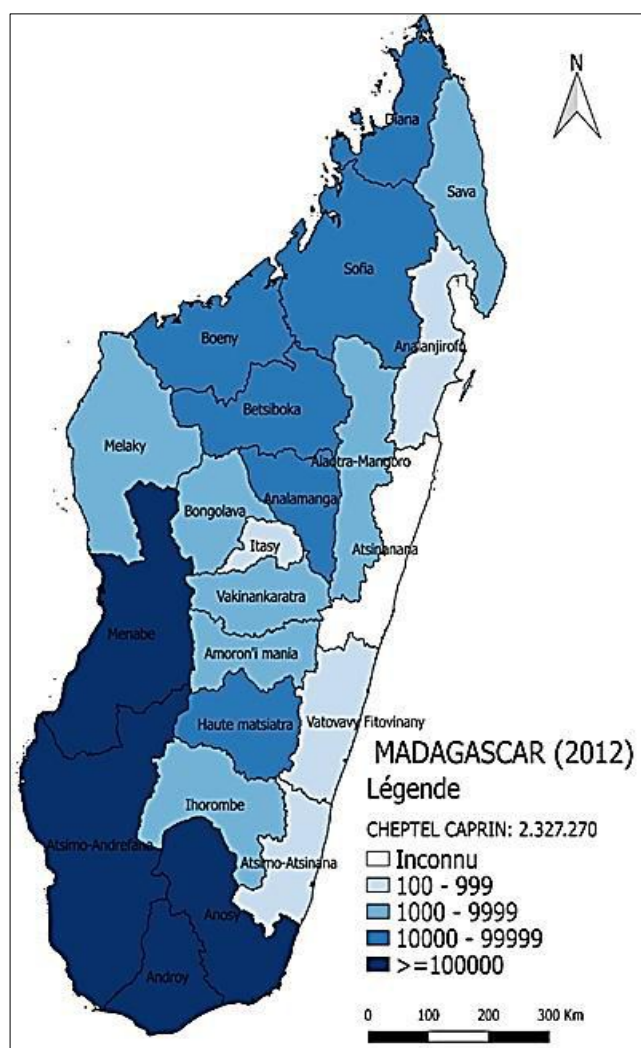


Fig 4: Goat population in Madagascar's 22 regions

Since animal genetic resources constitute the basic biological heritage for livestock development, various countries are investing in studies of their resources (Table 2)

in order to obtain exhaustive information on existing breeds.
^[35]

Table 2: Distribution of mammal species worldwide (FAO, 2008)

Mammal species	Africa	North America	Latin America and the Caribbean	Asia	Europe and Caucasus	South-West Pacific	Near and Middle East
% of countries in a region reporting information on breeds of the species							
Cattle	98	100	94	96	100	77	75
Buffalo	8	0	27	57	25	8	25
Yak	0	0	0	32	2	0	0
Goat	96	100	94	96	93	69	83
Sheep	92	100	91	86	100	31	100
Pig	70	100	91	82	91	92	8
Donkey	38	50	39	46	36	8	50
Horse	46	100	64	93	91	23	58
Bactrian camel	0	0	0	25	5	0	0
Dromedary	32	0	0	25	2	8	58
Alpaca	2	0	12	0	0	8	0
Lama	0	0	15	0	0	0	0
Guanaco	0	0	9	0	0	0	0
Vulture	0	0	12	0	0	0	0
Deer	2	50	9	25	14	15	0
Rabbit	38	0	48	39	39	0	8
Guinea pig	8	0	15	0	0	0	0
Dog	2	0	0	7	5	0	0

Goat breeds bred in Madagascar

Native Malagasy goats are made up of two very distinct ecotypes: the short-haired (*Fohivolo* goat) and the long-haired (*Beroma* goat) shown in Figure 5 [16, 32]. In 1914 and 1924, Angora goats from Africa were introduced in the

vicinity of the province of Tuléar, where they developed strongly [16]. In addition to the local population, there are also a number of imported goat breeds, such as the Alpine and Boer breeds [16].



Fig 5: (A) Beroma long-haired goat and (B) Fohivolo short-haired goat

Native goats: *Fohivolo* and *Beroma*

Morphology: The native Malagasy goats *Beroma* and *Fohivolo* (Figure 5 and 6) all have horns, a concave or

straight nasal bridge and short, horizontal, erect ears. Horns are virtually present in both sexes (Figure 6).



Fig 6: Ears horizontal and erect, chamfer straight (a) and concave (b), with horns [32]

Their coats are highly variable, with 8/9 possible pigment patterns between black or eumelanic pigment (Figure 7) and red or phaeomelanic pigment (Figure 7) [32]. These coat colors are controlled by 13 genes, including the ASIP

(Agouti Signaling Protein Gene), controlling these pigment patterns and other genes controlling variegation and pigment alterations [36].

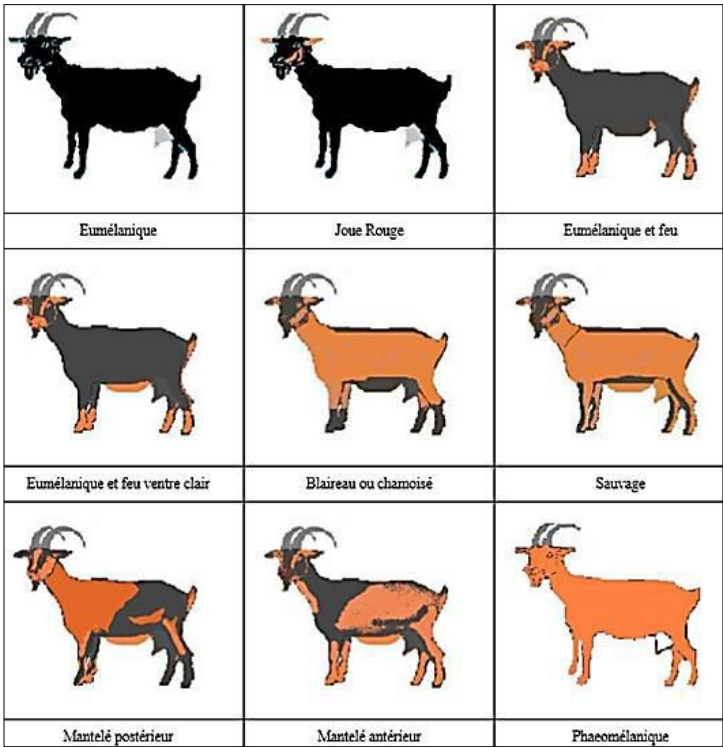


Fig 7: The nine (09) pigment patterns in goats [37]

However, the dominance of the pigment pattern eumelanin (locus agouti allele Aa: black and brown - Figure 8), Badger or buff (locus agouti allele Atb- Figure 8) and wild (locus agouti allele A+ - Figure 8) was observed [32]. What's more, these pigment patterns are sometimes hidden by variegations or alterations (Figure 8).



Fig 8: Example of pigment patterns found in native Malagasy goats: (A) with eumelanin pigment (black); (B) with pheomelanin pigment (red); (C) "Badger or chamois" longhaired goat; (D) "Wild" short-haired goat; (E) pheomelanin longhaired goat with variegation (White); (F) eumelanin longhaired goat with pigment alteration (Grey) [32]

Biometrics

To compare the biometric parameters of native Malagasy goats, the Substernal Gracility Index or SGI [38] and live weight estimation using the method of Traoré *et al.* [39] are used. On the one hand, the IGs is defined by the ratio

between the substernal void (SSV) and the breast width (BW). On the other hand, SSV is equal to the difference between height at withers (HW) and BW (Formula 1). On the other hand, live weight is estimated using chest circumference (CC) and height at the withers (HW) measured with a master tape, according to the procedure described by Katongole's team [40]. A multiple linear regression equation established by Traoré's team [39] is then used to estimate the live weight of Malagasy goats (Formula 2).

Formula 1:

$$IG_s = \frac{SSV}{BW} = \frac{HW - BW}{BW}$$

Formula 2 [41]:

$$Y = 1,33 \times TP - 0,93 \times HG - 0,23.$$

If we consider the substernal gracility index (IGs=0.94 and 0.98 - less than 1 - Table 3), the two Malagasy ecotypes are among the Brevipedic goats like its cousin the *Small East African* (SEA goat). Indeed, these Malagasy goats have visible phenotypes very similar to SEA, but have higher biometric variables (Table 3). Using live weight estimates, both Malagasy ecotypes appear heavier (Table 3) than their SEA cousin (adult male: 30-40 kg and female: 25-30 kg). Comparing the two Malagasy ecotypes, *Fohivolo* goats appear taller and heavier than *Beroma* goats. Compared with the average weight and height at withers (HW) of *Beroma* goats, those of *Fohivolo* are generally higher. Nevertheless, *Beroma* goats have longer bodies than *Fohivolo* (Table 3). The values of primary indices in segregation with respect to "visible effect loci" (IPa values of s=1.00) and agouti loci (IPa=0.88), reflect well the primary or traditional population status of native Malagasy goats [42]. It seems that no selection has been made by Malagasy native goat breeders since their introduction to Madagascar.

Table 3: Weight, Index and biometric parameters of Beroma, Fohivolo and Angora goats

Variables		Goat (N=150)			Goat SEA
		Fohivolo (n=76)	Beroma (n=49)	Angora (n=25)	
Biometrics (in cm)	LB	67 [62,2-71,8]	69,6 [61,5-77,7]	66,9 [61,8-72]	-
	HW	64,7 [60,3-69,1]	64,1 [59,6-68,6]	63,5 [57,7-69,3]	64,1 [59,6-68,6]
	CC	81,5 [70,4-92,2]	76,2 [67,2-85,2]	82 [75,8-88,2]	64,1 [59,6-68,6]
	BW	33,4 [29,4-36,4]	32,4 [30,7-34,5]	34,7 [32,9-36,5]	-
IGs		0,94	0,98	0,83	-
IPs		1	1	0,29	-
IPa		0,88	0,88	0,22	-
Adult male weight [1-2 years (Kg)]		52,5 [46,12-54,4]	45,3 [38,2-51,7]	50,6 [47,7-52,6]	36,5 [36-37]
Adult female weight [1-2 years (Kg)]		47,2 [40,8-53,6]	43,7 [37,4-50,8]	48,9 [46,9-51,8]	35,2 [35-35,5]

* SEA goat: Small East African Goat [43]

*LB: Length of body; HW: Height at withers; CC: Circumference of chest; BW: breast width (BW);

* Substernal gracility index or IGs=(HW-BW)/BW;

-if IGs ≤ 1 ==> Goat brevipedes, -if IGs ≥ 1.5 ==> Logopedic goat.

Malagasy Angora goat

Morphology and geographical distribution

Angora goats (*Capra hircus angoremis*) are native to Asia Minor, where there are around four million of them. The most famous are found in the goat-breeding region of

Beybazar, the center of the Angora district [44]. In general, Angora goats wear a single-colored, long-haired coat and floppy ears [45]. The coat is generally white, although various colors such as black, gray, yellow and even red can be observed. The Angora breed has flattened, laterally spiral

horns. These animals are no taller than 0.65 m, and their long, silky hair is made up of long, straight or curly strands. This hair, called mohair, is used to make carpets and fabrics [44].

Asian Turkey, Australia, America and South Africa all have large herds of Angora goats. As a result, the Angora breed was introduced to Madagascar in several stages from South Africa and Turkey (1890, 1914) [16, 44] and Australia (2008). The Angora goat has been introduced to various regions of the French Union, but has been most successful in Madagascar [44]. Initially, a few Angora goats were introduced to indigenous breeders in the Ampanihy district (Atsimo-Andrefana region, Madagascar). This was the start of further cross-breeding with native goats to perfect the breed. The effect of the cross-breeding, which spanned four generations, resulted in a billy-goat capable of transmitting the mohair trait to its offspring. However, other traits, notably uniformity of beige or gray color, pus-white color, lengthening of the hair, extension of the mohair over the entire body and disappearance of the jarre appeared successively in the offspring [44]. Multiple crosses between Angora goats and indigenous Malagasy goats gave rise to the Malagasy Angora goat (figure 9), known to breeders as the Boda goat [32]. The latter, which is the result of crossbreeding, is similar to the pure breeds, apart from a few details. Their size is slightly larger, but they are better adapted to local geoclimatic conditions than pure Angora. Because of their stability, they are referred to as the "Malagasy Angora breed" [44].

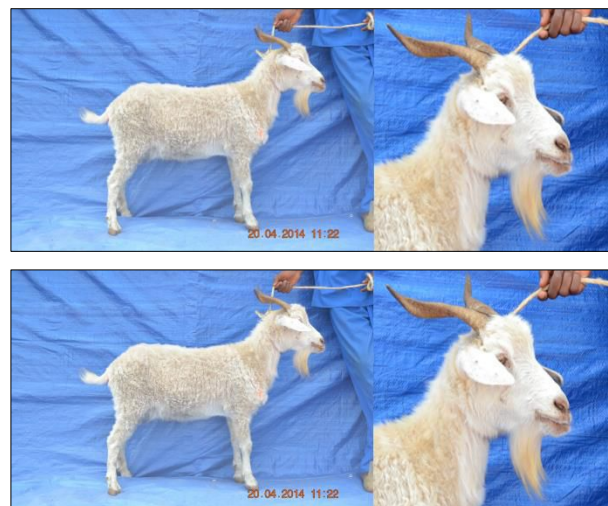


Fig 9: Madagascar Angora goat (boda goat) [32]

The largest population of the Malagasy Angora breed is currently found between the Atsimo-Andrefana (Ampanihy district) and Androy (Beloha district) regions, on both alluvial banks of the Menarandra River (Figure 10). However, a population of pure-bred Angora from the former and the latest introduction in 2008 has been kept on the Ankilimary state farm (Betiooky district - Atsimo-Andrefana region - Figure 10).

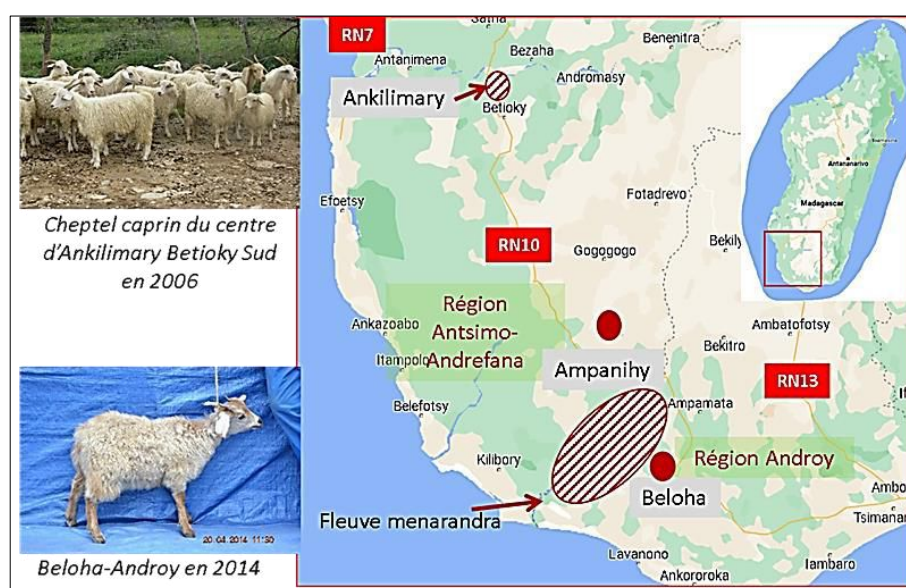


Fig 10: Malagasy Angora goat "Boda goat": from Ankilimary in 2006 [46] Beloha in 2014 [32]

The Angora goat has been known for its hair (mohair wool) as a raw material in the manufacture of mohair carpets between Ampanihy and Beloha (Figure 11).



Fig 11: Creation of mohair carpets at Ampanihy [47]

Biometrics

In terms of biometric values, the Malagasy Angora goat is higher than the two ecotypes *Beroma* and *Fohivolo* (Table 3, p.11), but these values remain within the current purebred standard (Female: HG=65cm and 30-40 Kg; Male: HG=70 cm and 40-60 Kg). Considering the four categories: wild species, traditional population, standardized breed and selected line, according to the evolutionary classification of farm animals proposed by Lauvergne [48] Malagasy Angora populations still belong to the standardized breed category, with primarity indices $IP_s=0.29$ and $IP_a=0.22$ (Table 3, p.11).

Genetic study of the Malagasy Angora breed

Observed and expected heterozygosity rates were calculated for each Angora breed from different countries under the Hardy-Weinberg equilibrium hypothesis ^[49-51]. Table 4 shows the genetic diversity of the Madagascan Angora breed compared with others worldwide. Indeed, the expected and observed heterozygosity for the Malagasy Angora breeds (ANG-MG: $H_e = 0.3478$; $H_o = 0.3496$) was

slightly higher than those from South Africa (ANG-ZA: $H_e = 0.3396$; $H_o = 0.3246$) and lower than those recorded from France (ANG-FR: $H_e = 0.3546$; $H_o = 0.3454$) as well as Argentina (ANG-AR: $H_e = 0.3866$; $H_o = 0.3847$) ^[52]. These differences can be attributed to differences in effective population size, duration of isolation and selection practices in the different production systems.

Table 4: Genetic diversity of Madagascan Angora goats compared with others worldwide ^[52]

Breed code by country	Breed name	Continent	Country	N. ind. - raw	N. ind. - QC	N. ind. - WD	n. polym. loci	Ho	He	Fis
ANG_MG	Angora	Worldwide	Madagascar	7	7	7	42621	0.3496	0.3478	0.0008
ANG_AR			Argentina	332	217	50	47299	0.3847	0.3866	0.0258
ANG_FR			France	26	26	26	46635	0.3454	0.3546	-0.0059
ANG_ZA			South Africa	48	48	48	47158	0.3246	0.3396	0.0439

WD: working dataset; n.polym.loci: number of polymorphic loci; HE: expected heterozygosity
HO: observed heterozygosity; Fis: inbreeding coefficient

Exotic goats: Alpine and Boer

Madagascar's exotic goat breeds are mainly represented by Alpine and Boer. While the Alpine breed is best known for producing milk for cheese-making, the Boer breed is bred for meat production.

Alpine goat morphology

The Alpine goat (Figure 12) is a breed of goat native to the Alps (Switzerland and France). In 1928, a small herd of Alpine goats from France was placed in the Ankaratra at the Vavavato station, where the animals thrive and reproduce ^[16]. The French Alpine breed features a long, slightly triangular head, a broad, concave forehead, protruding eye sockets and a broad, rounded neck. The ears are long, thin and straight. The back is narrow and protruding, the chest is narrow, high and deep, and the belly is well developed. The udders are short and large. The coat is light buff with glossy highlights. The coat is short and a little coarse ^[53].



Fig 12: French Alpine goat ^[54]

A few pairs of this breed have also been introduced to Madagascar by a cheese producer from the Mid-West in Analavory and from Haute-Matsiatra in Analatsara - Ambohimahasoa (Figure 13).



Fig 13: Alpine goat raised for cheese production in Analatsara, Madagascar (Photo FOFIFA-DRZVP in 2016)

Boer goat morphology

The Boer goat is a goat breed originally from South Africa. Its butchery qualities have earned it international renown ^[54]. Indeed, it is considered the best meat goat breed in the world ^[55].

The Boer goat has a strong head with a Roman nose making a continuous curve from the mouth to the extension of the nose. The horns are well spaced on the head and slightly curved back on the neck. The ears are long, reaching at least to the nose, and hanging down from the head. The neck is muscular and in proportion to the length of the body. The shoulders are broad and rounded (Figure 14). The coat is short, white on the body and red on the head and neck ^[56, 57]. A herd of 1,600 head of this breed was imported from Australia in 2008.



Fig 14: Boer goat ^[54]

Biometry of Alpine and Boer goats

Biometric values of the Alpine goat^[58] and the Boer goat^[57, 59-61] are higher than local breeds (*Beroma* and *Fohivolo* ecotypes) and Malagasy Angora (Table 3, p.11 and 5).

Table 5: Biometry of Alpine and Boer goats

Biometric variables	Alpine	Boer
Live weight (Kg)	50-60	90-100
HW (cm)	70-90	60-70
LB (cm)	80-90	75-85
CC (cm)	80-100	81

Conclusion

Knowledge of the diversity of genetic resources is essential in designing sustainable strategies for their conservation and use. Farm animal diversity originates from wild ancestors and has been successively shaped by mutation processes, genetic drift and human and natural selection. However, only part of the ancestral species diversity has survived in domestic offspring. The present study characterizes the domestic goat breed using morphological and biometric characteristics. Goat breeding has multiple purposes: the production of meat, which is highly prized for its organoleptic quality, and the production of milk used in cheese-making. The production of mohair wool, which is used in the manufacture of carpets and fabrics. Today's domestic goats originate from the domestication of wild goats by immigrant herders during the early and late Neolithic periods in their quest for new territories (Africa, Europe and Asia). Goats do not appear in the primitive faunas of Madagascar, but may have been brought by various tribes: Arab navigators, Antalaotra, Arab and African (Bantu) traders. In fact, thanks to their sturdiness and endurance, they were a mobile fountain of milk and a source of fresh meat for immigrants on their travels. In Madagascar, goats are bred almost everywhere. However, a high percentage of goats (over 80%) is concentrated in the south: the Atsimo-Andrefana, Menabe, Androy and Anosy regions. The Malagasy goat herd is made up of animals from local, mixed-breed and exotic populations. The population of local goat breeds represents the *Beroma* and *Fohivolo* ecotypes. The animals are characterized by short and long hair, and their coats are highly variable, with 8/9 existing pigment patterns. The Malagasy Angora population is the result of crossbreeding Angora breeds with local breeds. The population of imported breeds is mainly represented by the Alpine and the Boer. The biometric relationship between weight and height expressed by height at withers and chest circumference proposed by Traoré is used to compare the two local Malagasy ecotypes with African goats. In the present study, the effect of height on weight is assessed, but this study requires further studies with increased sample size to clarify the influence of height on animal weight in Malagasy goats. In other words, the aim is to find out whether this relationship applies to all Malagasy goats, or whether the latter are more specific. In addition, Traoré's method needs to be supplemented by a morpho-biometric study that considers other measurements (body length, thorax depth, etc.) to obtain a more exhaustive mapping of Madagascar's goat genetic resources that will enable the identification of the main ethnic groups. Analysis of molecular data could provide the genetic basis for the appearance of morphological traits such as hair length and coat color, as well as biometric traits in Malagasy goats.

Acknowledgments

This work was carried out by the FOFIFA-DRZVP team in collaboration with the DRA (MAEP) and jointly funded by FOFIFA-DRZVP, FAO, Goat ADAPTmap Project, AGIN and USDA. The authors thank these organizations.

References

1. FAO. The global strategy for the management of farm animal genetic resources: executive brief. Rome: FAO; c1999.
2. Rakotondravao R, Ravelotahiana JA, Rafaliarison J, Ranarison J, Razafindraibe H, Rasambainarivo JH, *et al.* RAPPORT NATIONAL sur l'Etat des Ressources génétiques Animales. Antananarivo: Centre National de Recherche Appliquée au Développement Rural; c2003.
3. Boettcher PJ, Hoffmann I, Baumung R, Drucker AG, McManus C, Berg P, *et al.* Genetic resources and genomics for adaptation of livestock to climate change. *Front Genet.* 2015;5:191.
4. FAO. Deuxième rapport sur l'Etat des Ressources Zoogénétiques pour l'Alimentation et l'Agriculture dans le Monde. Rome: FAO; c2015.
5. Jarvis A, Upadhyaya HD, Gowda C, Aggarwal PK, Fujisaka S, Anderson B. Plant genetic resources for food and agriculture and climate change. Rome: FAO; c2015.
6. Hodges J. Les ressources zoogénétiques. *Impact.* 1990;158:165.
7. Cheever F. Human population and the loss of biological diversity: two aspects of the same problem. *Int J Environ Pollut.* 1997;7(1):62-71.
8. Niango MAJ. Importance socio-économique de la chèvre du Sahel burkinabé et amélioration de sa productivité par l'alimentation. Thèse de doctorat en développement rural. Bobo-Dioulasso: Université Polytechnique de Bobo-Dioulasso; c2008.
9. Peters JK. Élevage et sécurité alimentaire: Quelles conséquences pour l'environnement ? *Agriculture + Développement Rural.* 1999;1:41-46.
10. Miller BA, Lu CD. Current status of global dairy goat production: an overview. *Asian-Australas J Anim Sci.* 2019;32(8):1219-32.
11. Onzima R, Gizaw S, Kugonza D, van Arendonk JA, Kanis E. Production system and participatory identification of breeding objective traits for indigenous goat breeds of Uganda. *Small Ruminant Res.* 2018;163:51-9.
12. Capote J. Sustainable goat breeding and goat farming in the Central and Eastern European countries. In: Kukovic S, editor. *European Regional Conference on Goats*; c2014 Apr 7-13; Debrecen (Hungary) and Oradea (Romania). Rome: FAO; c2014. p. 297. Available from: <http://www.fao.org/3/a-i5437e.pdf> [Accessed: May 13, 2022].
13. FAO. Food and Agriculture Organization of the United Nations statistical databases. Available from: <http://faostat.fao.org/>. 2019.
14. Missohou A, Ba AC, Dieye PN, Bah H, Lo A, Guye S. Ressources génétiques caprines d'Afrique de l'Ouest: système de production et caractères ethniques. In: 7e Conférence internationale sur les caprins; c2000 May 15-18; Tours, France. p. 932-935. INRA.

15. Zhongming Z, Linong L, Xiaona Y, Wangqiang Z, Wei L. Adaptation to climate change in semi-arid environments: experience and lessons from Mozambique. 2012.
16. Dechambre E. Origine des animaux domestiques de Madagascar. *Rev Écologie Terre Vie*. 1951;4:187-96.
17. Roy's farm. Kri-Kri Goat characteristics, origin & uses. Available from: <https://www.roysfarm.com/kri-kri-goat/>. 2022.
18. Zeder MA, Hesse B. The initial domestication of goats (*Capra hircus*) in the Zagros mountains 10,000 years ago. *Science*. 2000;287(5461):2254-7.
19. Papadopoulos MC. Evaluation of Theodorou Island as a habitat for the conservation of the Cretan wild goat (*Capra aegagrus cretica* Schinz 1938) and the impact of grazing on vegetation. *Z Jagdwissenschaft*. 2002;48(1):130-9.
20. Naderi S, Rezaei HR, Pompanon F, Blum MG, Negrini R, Naghash HR, *et al*. The goat domestication process inferred from large-scale mitochondrial DNA analysis of wild and domestic individuals. *Proc Natl Acad Sci USA*. 2008;105(46):17659-64.
21. Taberlet P, Coissac E, Pansu J, Pompanon F. Conservation genetics of cattle, sheep, and goats. *Comptes Rendus Biol*. 2011;334(3):247-54.
22. Larson G, Fuller DQ. The evolution of animal domestication. *Annu Rev Ecol Evol Syst*. 2014;45:115-36.
23. Vigne JD, Peters J, Helmer D. The first steps of animal domestication: new archaeozoological approaches. 2005.
24. Zeder MA, Emshwiller E, Smith BD, Bradley DG. Documenting domestication: the intersection of genetics and archaeology. *Trends Genet*. 2006;22(3):139-55.
25. Joey R. Map of the world showing approximate centres of origin of agriculture and its spread in prehistory. Available from: <http://www.essential-humanities.net/history-overview/stone-bronze-iron-ages/>. 2010.
26. Questel K. La chèvre marronne. In: *Les vertébrés terrestres introduits en outre-mer et leurs impacts: Guide illustré des principales espèces envahissantes*. Paris: Comité français de l'UICN, ONCFS; c2011. p. 54-55.
27. Domenichini JP. Le peuplement de Madagascar: des migrations et origines mythiques aux réalités de l'Histoire. *Tsingy*. 2013;16:17-44.
28. Phillipson DW. L'expansion bantoue en Afrique orientale et méridionale: les témoignages de l'archéologie et de la linguistique. In: *L'expansion bantoue: Actes du Colloque de Viviers*; c1977 Apr 4-16. Paris: Société d'Etudes Linguistiques et Anthropologiques de France; c1980. p. 649-84.
29. Sanchez SF. Navigation et gens de mer dans le canal de Mozambique: les boutres dans l'activité maritime de Nosy Be et de l'Ouest de Madagascar au XIXe siècle. *Karthala*; c2007.
30. Aubaile-Sallenave F. La mousson, pluie des agriculteurs et vent des marins. *Rev Ethnoécologie*. 2014;5.
31. Deschamps H. Histoire de Madagascar. Paris: Berger-Levrault; c1972. 358 p.
32. Maminaiaina OF, Rakoto-Alison V, Ralambomanana N, Raliniaina M. Caractérisation phénotypique et l'environnement de production des chèvres autochtones malgaches. Annexe I rapport de projet FAO-USAID - AGIN. 2014.
33. Mataveia GA, Visser C, Siteo A. Smallholder goat production in Southern Africa: a review. In: Kukovics S, editor. *Goat Science - Environment, Health and Economy [Working Title]*. London: IntechOpen; c2021 [cited 2022 May 13]. Available from: <https://www.intechopen.com/online-first/76608> doi: 10.5772/intechopen.97792.
34. Ministère de l'élevage. Données statistiques. SAIGS/DSI. Antananarivo, Madagascar; c2012.
35. FAO. Commission de ressource génétique. L'état des ressources zoogénétiques pour l'alimentation et l'agriculture dans le monde. Rome; c2008.
36. Dong Y, Zhang X, Xie M, Arefnezhad B, Wang Z, Wang W, *et al*. Reference genome of wild goat (*Capra aegagrus*) and sequencing of goat breeds provide insight into genic basis of goat domestication. *BMC Genomics*. 2015;16(1):431.
37. Lauvergne JJ. Utilisation du principe d'homologie interspécifique pour l'étude du déterminisme héréditaire de la couleur du pelage des ruminants domestiques: l'exemple du locus Agouti. *Bull Soc Zool France*. 1983;108(2):231-43.
38. Bourzat D, Souvenir-Zafindrajaona P, Lauvergne JJ, Zeuh V. Comparaison morpho-biométrique de chèvres au Nord Cameroun et au Tchad. *Rev Elev Med Vet Pays Trop*. 1993;46:667-74.
39. Traoré A, Tamboura HH, Kaboré A, Yaméogo N, Bayala B, Zaré I. Caractérisation morphologique des petits ruminants (ovins et caprins) de race locale "Mossi" au Burkina Faso. *Anim Genet Resour Inf*. 2006;No. 39:39-50.
40. Katongole JBD, Sebolai B, Madinabe MJ, editors. Morphological characterisation of the Tswana goat. In: *Proceedings of the third Biennial Conference of the African Small Ruminant Research Network*; c1994; UICC, Kampala, Uganda.
41. Traoré A, Tamboura H, Kaboré A, Yaméogo N, Bayala B, Zaré I. Caractérisation morphologique des petits ruminants (ovins et caprins) de race locale "Mossi" au Burkina Faso. *Anim Genet Resour*. 2006;39:39-50.
42. Lauvergne J, Bourzat D, Souvenir Zafindrajaona P, Zeuh V, Ngo Tama AC. Indices de primarité de chèvres au Nord Cameroun et au Tchad. 1993.
43. Nguluma AS, Msalya G, Chenyambuga SW. Phenotypic variation among four populations of small East African goats of Tanzania. *Livest Res Rural Dev*. 2016;28. #136. Available from: <http://www.lrrd.org/lrrd28/8/ngul28136.html>.
44. Guillermo L. La chèvre angora à Madagascar. *Rev Elev Méd Vét Pays Trop*. 1949;3(3):123-32.
45. Sponenberg DP, Alexieva S, Adalsteinsson S. Inheritance of color in Angora goats. *Genet Sel Evol*. 1998;30(4):385-95.
46. Maminaiaina OF, Rakotonindriana JS. Mission d'enquête et d'étude sur les maladies inconnues dans les districts d'Ampanihy Ouest, Betioky Sud et de Sakaraha. Rapport de mission dans le cadre du Programme de développement de l'élevage dans le sud-ouest (DELSO) - FED n°8 apc mag 046. 2007.

47. Gyre A. Le tapis mohair malagasy. Available from: <https://agir-avec-madagascar-over-blog-com/2015/07/le-tapis-mohair-malagasy.html>. 2015.
48. Lauvergne J, editor. Genética en poblaciones animales después de la domesticación, consecuencias pour la conservation de las razas. Proceedings of the 2nd World Congress on Genetics Applied to Livestock Production; c1982; Madrid.
49. Boyer SH. Classic papers on genetics. Science. 1963;142:1646.
50. Hardy GH. Mendelian proportions in a mixed population. Science. 1908;28(706):49-50.
51. Stern C. The Hardy-Weinberg law. Science. 1943;97(2510):137-8.
52. Colli L, Milanesi M, Talenti A, Bertolini F, Chen M, Crisà A, *et al.* Genome-wide SNP profiling of worldwide goat populations reveals strong partitioning of diversity and highlights post-domestication migration routes. Genet Sel Evol. 2018;50(1):58.
53. Saraza OR. La chèvre laitière en France: la souche alpine. Le Lait. 1956;36(358):481-6.
54. Capgenes. La race Alpine française. Available from: <https://www.capgenes.com/les-races-caprines/race-alpine-francaise/>. 2022.
55. Dieter N. La biodiversité agricole en Afrique de l'Ouest. Situation actuelle, expériences et perspectives. Bamako: FAO; c2003.
56. Le Gal O, Planchenault D. Utilisation des races caprines exotiques dans les zones chaudes: contraintes et intérêts. 1993.
57. Sambraus HH. A Colour Atlas of Livestock Breeds: 220 breeds in words and pictures. 1992.
58. Caprigene. Races caprines françaises. Paris: Fédération France de contrôle laitier; c2004.
59. Abd-Allah S, Salman FM, Shoukry MM, Abd-El Rahman HH, Mohamed M, Abedo A. Study of some morphological characteristics of Boer goat raised in Egypt. Adv Anim Vet Sci. 2019;7(10):88-97.
60. Mathapo M, Cyril T, Thobela L. Prediction of body weight of yearling Boer goats from morphometric traits using classification and regression tree. Am J Anim Vet Sci. 2021;16(2):130-5.
61. Quittet E. La chèvre: guide de l'éleveur. Paris: La Maison Rustique; c1977. p. 18-20.