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Morphological and Functional Characteristics of The Azores Fighting Cattle – A Review

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Introduction

The existence of the fighting bull, exploited in the poor pastures in the interior of Terceira Island, allowed the preservation of the largest area of endemic a 20-million-year-old subtropical rainforest called Laurissilva (Pereira, [1]). The fighting bull is the symbol of the preservation carried out by some of these men, the cattle farmers (Albanez, [2]). The appearance of the first cattle in the Azores occurred in the 15th century, in line with the discovery and settlement by the Portuguese (Cartwright, [3]). In addition to being an important source of protein for emerging populations, interaction with cattle also took on a playful nature, taking advantage of the aggressiveness of these cattle raised in the interior of the islands, particularly on Terceira Island (Arruda, [4]). The aggressive cattle, which are the precursors of the Brava dos Açores cattle population, had and continue to play an important economic and socio-cultural role, particularly in maintaining the tradition of rope bullfight, called "Tourada à Corda", unique in the country and which is practically dispersed across 5 of the 9 islands from the Azores (Mendonça, [5]). The first Lydia's breeding bull has been originally from the main Portuguese land, particularly from Ribatejo, arriving in the Azores in 1910, to improve the quality of herds from different breeders (Crespo, et al. [6]).

Successive imports of these animals occurred throughout the 20th century, breeding these animals with the cattle existing on the island, giving rise to the Brava dos Açores population (Pacheco-Lima, et al. [7]), in which the soil and climate conditions of a region in the North Atlantic gave rise to an animal that was morphologically and behaviorally different from its predecessors (Correia, [8]). This bovine resulted from the crossing between specimens descended from those introduced into the settlement of the islands, and from successive crossings with imported animals, throughout the 20th century, which made the resulting descendants progressively similar to those of the Lidia Breed from the Iberian Peninsula (Martins, [9]). Brava dos Açores is actually recognized as a specific population belonging to Portuguese Lidia cattle breed. On May 6th of 2010, regional legislation was published approving the "Regulation of the Zootechnical Registry of the Wild Bovine Population of the Azores". This legislation considered (Department of Azorean Agriculture and Forestry [10]) that there is a population of cattle in the Azores, used in the various bullfighting events typical of the region, and their biological value must be maintained, making it necessary to know and record the genealogy of each animal (Gomes, [11]). The present paper aims to compile all existing information related to the Brava dos Açores cattle population in order to characterize it in terms of geographical distribution, morphology, aptitude and reproduction.

Geographical Distribution of the Brava Dos Azores Cattle Population

The animals that make up the population of this archipelago are distributed across six of the nine islands of the Azores, namely Terceira Island (municipalities of Angra do Heroísmo and Praia da Vitória), Graciosa (municipality of Sta. Cruz), São Jorge (Municipalities of Velas and Calheta), Pico (Municipalities of Madalena and São Roque), Faial (Municipality of Horta), São Miguel (Northeast Municipality) (A-Reis, et al. [12]) and mostly graze in the interior of the islands. In fact, throughout the archipelago, climate is temperate maritime, marked by abundant rainfall and mild temperatures (Mendes, et al. [13]), which, combined with soil fertility, promotes the prolific growth of pastures, essential for the sustenance of livestock (Quintero, [14]). After Azores' human colonization, there has been a systematic deforestation of indigenous forests to reuse the land, mainly for agricultural activities and pastures (Elias, et al. [15]). The pastures that developed after this deforestation are natural communities, neither artificially established nor maintained, and are dominated in their floristic and structural composition by spontaneous or even endemic herbaceous species from the Azores. These permanent pastures are typically over 20 years old (Dias, et al. [16]). Nonetheless, the yield of pasture is not steady throughout the year, with periods of low and occasionally the nutritional quality may be deficient (Moreira, [17]). The Azores archipelago serves as a paradigm of an area where pastures have been traditionally employed for animal nutrition, especially in the context of cattle farming (Cardoso, et al. [18]).

Over the years, cattle rearing in the Azores has developed without the requirement for ani-mal shelters (Morais, et al. [19]). Despite a recent trend towards intensification of production, the unique climatic conditions of the Azores mean that a significant proportion of cattle farming still involves some degree of grazing (J-Souto, et al. [20]).

Breed Valorization

The production of animals from the Brava dos Açores population is oriented towards behavior that includes specific characteristics of the shows where cattle are used (Barradas, [21]). Nonetheless, their conformation and body development allow their carcasses to be used for meat when they reach the age of 30 months or more. Similar to what happens with the Lidia Bovine breed in the Iberian Peninsula (Narciso, et al. [22]), the meat of animals from the Brava population of the Azores has high levels of antioxidants, which is a key factor in the valorization of this product, with currently low consumption rates. The levels of vitamin E (alpha-tocopherol) and beta-carotene are high, indicators of animals raised on pasture and sufficient to delay lipid oxidation to which the meat is exposed after the animal is slaughtered (Ferreira, [23]), and its huge appreciation can be a financial asset for their breeders (Santos, [24]). Traditionally, its use in bullfighting is the main objective, but the valorization of residual animals, for example cows that do not pass the functional selection test or bulls that do not present the appropriate behavioral characteristics, presents itself as a monetary bonus for the exploration, increasingly important (Correia, et al. [25,26]). The number of animals slaughtered from this population has a notable increase from November and March (Herrera, [27]) and this is due to the lack of bullfighting shows in the Azores in those months since the traditional season takes place from May 1st to October 15th.

During the closed season, the cattle herds are reformulated, choosing breeders and using meat products from animals that are considered unsuitable in behavioral terms (Lomillos-Pérez, et al. [28]). In 2015, the economist Domingos Borges conducted a study on "Bullfighting by Rope as an Economic Activity Indicator in the Region" (Borges, [29]). In this study, both direct and indirect costs related to traditional bullfighting by rope were considered, along with the number of bullfights that typically take place between May 1st and October 15th the study concluded that the financial impact of bullfighting on Terceira Island in the Azores corresponds to 2.47% of the Azores Gross Domestic Product (GDP) and 11.4% of Terceira's Island GDP. This research highlights the significant contribution of preserving animals from the Brava population in the Azores to the regional economy (Lima, et al. [30]).

Breed and Breeding's Characteristics

The morphological characteristics of these animals are quite variable due to the great diversity present in this population, a fact that is not unrelated to the diversity of their origins (Correia, [31]). They are characterized by being very rustic animals and highly adaptable to the fluctuating climatic conditions of the areas where they graze inland (especially in Terceira Island). They adapt easily to different types of pastures and can be produced without great environmental pressure, in a sustainable manner (Ferreira, [23,32]). In the Azores about 40 hectares are dedicated to pastures for this livestock, representing on Terceira Island 3.5% of the island's total area within the natural park, distributed among around 49 active owners (Lima, et al. [30]). These are included in the Serra de Santa Barbara-Pico Alto, a protected area integrated into the Natura 2000 Network Sector Plan (ICNF, [33]). This area, which has a high level of interest in environmental protection, presents adverse soil and climatic conditions, affecting the nutritional value of the grazing areas Ázera (Ázera, [34]) covering the Geological Natural Reserve of Algar do Carvão, Biscoito da Ferraria, Serra de Santa Barbara and Mistério Negro, which represent one of the largest concentrations of valuable elements of natural heritage, as they have a high number of endemic and rare species (wet formations of forested peatlands of Juniperus brevifolia, shagnum peatlands; Laurifólia Forests - predominance of laurus azorica; Ilex Forests; Zimbral - endemic element of the A.R. formed by cedar forests in high mountain areas; Erical - areas with dominance total of Erica azorica) (Furtado, [35]).

In the wild fauna, a diverse bird fauna stands out, with emphasis on the presence of migratory birds and resident species (Wood Pigeon - Columba palumbus azorica, Kite - Buteo rothschildi, Woodcock - Scolopax rusticola, etc.). Some mammals also appear, including the Weasel or Comadrinha (Mustela nivalis), bats such as the Myotis Borkhausen, Nyctalus azoreum Thomas, Hedgehog (Erinaceus europaeus) and the Wild Rabbit (Oryctolagus cuniculus) (Borges, et al. [36]). In this area, there are still other agricultural activities with limited expression, namely small ruminants and some small beef herds. Maintaining cattle from this population on extensive farms allows for high levels of animal welfare, preserving biodiversity. Cattle populations, specifically the Brava dos Açores and its progenitor, the Iberian Peninsula's Lidia Cattle, which are managed for behavioral traits, hold significant socio-economic value and present intriguing genetic characteristics on a global scale (L). Despite their importance, the economic, social, and genetic influences of these breeds have not been adequately represented in zootechnical research(M). This is primarily due to the challenges associated with handling and interacting with these animals, which render the task of measuring live specimens nearly unfeasible (N). The morphological characterization holds significant importance for the preservation and biodiversity of bovine breeds.

Through the examination of phenotypes within a breed, there lies the potential to enhance diversity and select for environmental adaptation and functionality (O) According to (Herrera, [27]), conventional zoometric measurements are carried out using conventional measuring rods, inelastic measuring tapes, compasses, goniometers, and calipers. All these tools require physical manipulation and animal restraint. Considering the behavioral characteristics of these animals, particularly their bravery. These measurements have numerous limitations for their execution, which may potentially cause injuries to both the animals and the technicians performing them (O). In 2019, a comprehensive morphological characterization of the Lidia breed was carried out by Lomillos and collaborators (Lomillos-Pérez, et al. [28]), employing photogrammetry. This advanced technology facilitates remote measurement of animals by utilizing three-dimensional photographic data. The application of this technique for measuring the Brava population in the Azores could provide reliable data regarding morphological characterization, particularly zoometric measurements, of these animals (P). Given the behavioral and management similarities between the two breeds, we believe that this could be the technique to use in the phenotypic measurements of Brava dos Açores population. In addition to the progeny data, already compiled by the competent authority in animal improvement since 2010, the photographic data will certainly highlight the historically described origin of the breed and its phenotypic structural definitions (P).

Prior methodologies for zoometric measurements incorporated conventional measuring rods, inelastic measuring tapes, compasses, goniometers, and calipers, all of which necessitated physical manipulation and restraint of the subject (N). Such manipulation and restraint can potentially induce stress. Animals with a highly reactive temperament may necessitate immobilization via cattle crushes or containment apparatuses, and in some instances, tranquilization may be required. These procedures inherently elevate the risk of injury to both the animal and the human handlers involved (O)

Registered Animals

In 2003, an assessment began on the distribution of livestock and animals used in traditional shows on Terceira Island, which exhibited phenotypic characteristics and behaviors distinct from the animals of Lidia Cattle. Although the Brava dos Açores Population is still in the recognition phase, in 2010 the competent authority in agriculture established the criteria and published legislation that regulates the entry of animals into the Zootechnical Register of the Brava dos Açores Population. The legal criteria established are as follows: For animals to be admitted to the Birth Book, their ancestors must be registered in the Adult Book of the Zootechnical Register of the Brava dos Açores Population. For animals to be admitted to the Adult Book, they must meet the following criteria: have been born in the Azores; have a minimum age of 24 months; be identified with the prototype of the Brava Bovine Population of the Azores; be proven descendants of animals registered in the Zootechnical Register; do not present inhibitory defects of their function as reproducers, namely taras or somatic defects whose transmissibility is recognized, or to fear; and belong to stocks under official sanitary surveillance and comply with their respective plans. For the purpose of controls or complementary examinations, the results obtained through DNA tests may be admitted to prove the animal's ancestry (Table 1&2).

Table 1: Number of animals registered in the Birth Book (LGN) of the Brava dos Açores cattle population, per year.

Year of Registration	No. of Animals	Females	Males	No. of Breeders
2010	201	76	61	24
2011	327	125	143	35
2012	367	120	149	48
2013	362	118	139	60
2014	319	101	137	59
2015	352	133	124	53
2016	380	127	128	60
2017	366	115	142	59
2018	394	133	120	52
2019	351	85	129	47
2020	437	136	139	52
2021	302	70	79	41
2022	342	68	62	43
2023	269	16	26	36
2024*	145	2	2	28

Note: *Data extracted from ruralbit.pt "Brava dos Açores" on May 31st, 2024.

Table 2: Number of animals registered in the Adult Livestock Book of the Brava dos Açores cattle, per year.

Year of Registration	No. of Animals	Females LG A	Males LG A	No. of Breeders
2010	147	47	80	18
2011	245	112	119	20
2012	285	131	143	30
2013	177	75	100	29
2014	289	140	149	38
2015	183	79	104	20
2016	273	129	144	33
2017	238	114	123	27
2018	272	134	136	31
2019	224	114	110	28
2020	201	85	109	23
2021	291	134	150	30
2022	233	111	116	29
2023	181	85	94	23
2024*	49	46	31	15

Note: *Data extracted from ruralbit.pt "Brava dos Açores" on May 31st, 2024.

According to data from the Regional Directorate for Agriculture, Veterinarian and Food Department of the Regional Secretariat for Agriculture and Food of the Regional Government of the Azores, 2103 bovine animals are recorded in the zootechnical register of the bovine populations Brava dos Açores, for a total of 49 breeders. Of the current herd, it was observed that it is composed of a total of 1208 females distributed in the following age groups:

- Females less than 6 months old: 50 animals
- Females older than 6 months and less than 24: 225 animals
- Females older than 24 months: 933 animals

According to the study conducted by Carolino and collaborators (Carolino, et al. [37]) within the scope of the "Strategic Plan for the Common Agricultural Policy 2023-2027", the Brava dos Açores cattle population is considered endangered since it has a female population of fewer than 7500 individuals in purebred lines.

Females are maintained, with productive and genetic objectives, forming herds that can have a range of ages that can vary from 37 months to 216 months. Our team's study carried out in 2019 determined that the average age of females in the reproductive herd, in this population, was 100.08 ± 23 months. The first birth occurred at 36 ± 8.5 months, varying from 30 to 48 months with an average interval between births of around two years (680 ± 75 days) (Lima, et al. [38]).

The age at first calving is clearly influenced by the functional selection process called "tenta" which conditions the age at first birth differently from other breeds. The selection test for females is carried out between 18 and 26 months, and only then are they placed in the breeding batch (Carolino, et al. [37]). Another important fact is that the age at first calving of heifers in the Iberian Peninsula is influenced by the geographical area and climatological characteristics of the cows, being related to what is expected in a breed essentially produced extensively (Direito, [39]). In fact, the use of animals with high genetic potential and with excellent results in their progeny can lead to the maintenance of these animals in the breeding herd for a long time. As far as males are concerned, a total of 895 animals are registered. Animal's selection (males and females) are based on behavioral criteria. According to each breeder, it is also common to observe phenotypic criteria, such as coat and horn conformation, which is quite variable (Pares-Casanova, et al. [40]). In the vast majority of animals from this population, a profile with a straight or sub-concave chamfer, lyre-shaped cornea, tail above the hock, anterior third higher than the posterior third is observed. Thin and strong limbs, hard nails due to the floor on which they usually find themselves, namely a soil composed of basalt rocks characteristic of the Azores (Carolino, et al. [41]). The bovine coats can be classified as simple, compound, mixed and particular coats.

In simple coats, only one color appears, and in this case, the most common coat color is black. Coats with two or three colors in interpolation (bicolor or tricolor) are called compound coats. In this case, one of the most common in this population is the so-called Salgada, in which white and black hairs mix, giving a grayish appearance. The brownish coat with white or black areas is also visible in some animals from this Azorean bovine population.

Reproductive Management

The reproductive management of Bravos dos Acores cattle is based on natural mating, where, generally, the number of cows per breeding bull ranges between 25-40. With a gestation period of nine months, mattings take normally place in September and October, when the pasture still has enough forage to trigger estrus behavior and fertile's ovulation in females. The mating and consequently calvings from the Brava dos Açores population also has a strong influence from the environment, (Lomillos-Pérez, et al. [28]) when the mother can feed better and provide milk in quantity and quality to the young newborn (Lima, et al. [42]). In general, the calving season occurs when food is available (Lomillos-Pérez, et al. [28]), which normally occurs in the interior of the island from late May to early July. After the calves are born, they remain with their mothers until they are 5/9 months old. Calves at the 4th/5th week of age begin to consume pasture and water by imitating their mother's behavior and then begin to develop their digestive tract as ruminants and become more independent (Lima, [43]). A calm and adequate environment, with abundant food availability are significant factors to which the Lidia cow has reproductive behaviors. Moreover, a more nervous and restless female than normal, without eating in a relaxed way, may be the few possible signs of identifying an angry cow in heat, being difficult to observe her behavior in the bush (Chaveiro, et al. [44]). In the case of males, they are separated from females when secondary sexual characteristics appear, normally between the first and second year of age (Faria, et al. [45]).

There is a strong sense of hierarchy and territoriality, which develops as the horns show a marked development, being, however peaceful, especially from the age of 2.5 years, spending many hours in rumination. Animals are generally used from 3 years old, when the group of males already has a well-established hierarchy. With the most isolated animals, it is between the ages of 4 and 5 that great muscular development occurs, with deposition of body fat (Farto, [46]). Based on the performance of the males, those with more longevity and more positive performances are used as breeders, with the intention of transmitting the characteristics presented to their progeny. Males in the soil and climate conditions of the Azores reach their ability to be placed with females for reproduction at around 10-12 months of age. Unlike the female, the male has a permanent libido throughout the year, increasing considerably when spring arrives, maintaining it during the summer months with the longest daylight hours and decreasing in the winter months (Lima, et al. [47,48]). Each mating requires on average 5 to 6 copulations with associated physical wear. The volume of semen produced per ejaculation varies from 2 to 5 ml in young bulls and from 5 to 15 ml in older bulls (Lima, et al. [42]). In general, animals in this population present a very marked sexual dimorphism, females weigh around 260 kg on average while males weigh around 480 kg at 4 years of age (Mendes, et al. [13]).

Developed musculature based on a thin skeleton, balanced proportions giving rise to a harmonious conformation. There is a greater balance between body and muscular size compared to the Azores Bravas females, this is due to the greater genetic selection pressure on males, animals around which the entire economic return of the livestock farms where these animals are raised revolves (Borges, [29]).

Rope Bullfights Rules

Males are the main product of this livestock activity, being exploited for their athletic, behavioral and physical abilities, and during their lifespan they can have dozens of presentations, enhancing their economic value (Figure 1). These cattle therefore have a productive life that, starting at 3 years old, can reach 15 years. Each time the animal is used, it can generate an individual income ranging from the most basic value of 200 euros to 1500, in the case of the most valued males (Pacheco-Lima, et al. [49]). During his performance, the male undergoes a veterinary inspection to certify his physical capabilities, since legally the bull has to move several times along a maximum path of 500 meters. Between each performance the bull has a mandatory rest period for at least eight days. These legal imperatives aim to ensure the wellbeing and verify its integrity and physical capacity (rope bullfighting law) (Mendonça, [50]). Despite having varied characteristics, animals chosen for these shows, must have be ellipsometric and brevilinear animals, of small to medium size, with a reduced dewlap, particularly less bulky and more agile when compared to other specimens of the bovine Lidia breed from Iberian Peninsula (Mendes, et al. [13]), and the main choice is normally based on behavior and not on phenotype rather than morphological characteristics.

Figure 1: Typical photos of the "rope bullfight" in Terceira Island. (Photo: Nuna Faria).

Genetic Characteristics

At the beginning of 2022, official entities collected blood from about 200 animals from this population, selecting between males and females with the aim of understanding genetic proximity through scientific validation, proceeding with the extraction of DNA with other breeds of cattle. These collections had the collaboration of our team, which had previously carried out the study to evaluate the genetic diversity of "Brava dos Açores Bovine Population" using autosomal, maternal and paternal DNA molecular marker, where Brava dos Açores bovine population showed the highest observed and expected heterozygosity (Lima, et al. [46]). The data related to the genotyping of these animals are currently being analysed, and there are no conclusions yet regarding this study. In the study of 2017 (Lima, et al. [46]), samples were collected from unrelated individuals by qualified veterinarians during their routine practice. DNA was extracted by standard methods to study the genetic relationships among different populations as they were indigenous Portuguese bovine breeds and Spanish Lidia breed (Correia, et al. [51]). Results showed a remarkably high frequency of the maternal haplogroups such as L4 in Brava dos Açores population, characteristics of the Spanish Lidia cattle breed. This fact suggests crossbreeding among Lidia lineages and Brava dos Açores populations during their development (Cortés, et al. [52]).

Brava dos Açores bovine population showed, in fact, similar patterns of paternal and maternal haplogroups distribution to those previously described in Spanish Lidia lineages (Correia, [8]). Through this analysis, the historical indication that appears to be the origin of the animals of the Brava dos Açores (Mendes, et al. [13]) population was documented, a fact that can be confirmed by phenotypic observation of currently existing animals.

Conclusion

This population of animals is raised in a grazing system adapted to the environment and the main source of income from this livestock production depends on taking advantage of the behaviour of these cattle. Livestock farms have a strong social implantation, a result of the importance of this type of cattle in ethnographic culture of the Azores, especially Terceira Island. They are distinct animals with a very diverse ethnic origin, making it important to conserve this

population as indigenous cattle. This population of Azorean cattle is very similar to the fighting breed of the Iberian Peninsula. Not only in terms of its conformation, but also in terms of behaviour, reproductive efficiency, adaptation to the environment and economic efficiency. They are animals kept for their athletic and behavioural abilities that generate relevant cultural interest for society. The genetic studies that have been carried out will be fundamental for the constitution of this population as an indigenous Portuguese breed.

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