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## European perspectives in donkey husbandry and breeding with insights from Bulgaria

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**Abstract:** Donkeys have served as valuable working animals since their domestication approximately 6,000 to 7,000 years ago in Northeast Africa. The global population is currently estimated at 50.5 million donkeys and 7.9 million mules, primarily concentrated in developing countries. According to official data, these numbers are increasing, particularly in African and Asian regions. In contrast, the trend in many European countries is one of decline, with some local breeds already extinct or facing the threat of extinction. The situation is especially critical in the Balkan region, where, despite a growing interest in donkey milk and related products, local breeds remain poorly described and the populations exhibit significant phenotypic and genetic variation. The objective of this study is to identify current trends in donkey husbandry, with a particular focus on the situation in Europe and, more specifically, in Bulgaria—a country with a long-standing tradition in donkey breeding that faces the challenge of recognizing or rediscovering the value of this species. Donkeys have the potential to make a meaningful contribution to modern, sustainable agriculture, promoting livestock diversity and enhancing food security.

**Keywords:** donkeys; donkey breeds; Bulgarian local donkey; donkey milk; donkey mea; donkey husbandry

## INTRODUCTION

Donkeys belong to the order of odd-toed Ungulates (*Perissodactyla*), suborder Horse-like (*Hippomorpha*), Family Horses (*Equidae*), which includes the genus Horse (*Equus*) with five subgenera, where domestic horses (*Equus caballus*) and donkeys (*Equus asinus*) belong (Maswana et al., 2023; Kugler et al., 2008). Wild donkeys inhabit arid and rocky regions, consuming browse, forbs, grass, and other available forages, such as bark, twigs, or even roots. They usually occur in groups and rarely live solitary (Yilmaz et al., 2012). The species was domesticated in Northeast Africa around 6,000 – 7,000 years ago, from the African wild ass (*Equus africanus*) (European Platform on Animal Welfare, 2019), and contributed to the expansion of human populations across the Old World (Camillo et al., 2018). Donkeys likely reached Europe with Phoenician traders via the Southern countries. The expansion of

the species continued during the Roman Empire's conquests (Raw et al., 2021). They have always been kept as valuable working animals - nowadays about 95% continue to be used for transportation, pulling carts, farm tillage, threshing, raising water, milling, or other operations (Ivanković et al., 2023; Starkey and Starkey, 2000), especially across semi-arid and upland environments (Todd et al., 2022). Other, less common, but potentially niche areas include milking, meat production, recreation, and companionship (Starkey and Starkey, 2000). A variety of breeds have been developed, though not as prominent and well-known as horse breeds. According to FAO, 178 donkey breeds have been recorded worldwide, 90% of which are of local character (Ivanković et al., 2023).

Donkeys, after the Industrial Revolution and especially after WWII, faced the rise of machines and gradually became less popular, resulting in population decreases and neglect in breed-

ing. This tendency spread across Europe, threatening the traditional place of the species in the continent's history and driving many breeds to the brink of extinction.

## **MATERIALS AND METHODS**

Data was obtained from international and national resources namely FAO Report on Working Equid Population (Allan, 2021), FAOSTAT website for the years 2000 to 2018 (as no data is available for Bulgaria after 2018), in March 2025 (FAOSTAT), DAD-IS website, BFSA (Bulgarian Food Safety Agency) website, Bulgarian Ministry of Agriculture and Food database, as well as review of literature. The FAO official data originates from government resources for each country listed. However, data, especially for donkeys, may be incomplete due to animals not being officially registered or reported. Furthermore, the donkey is not universally accepted as a productive species, and often, statistics on productivity values are lacking. Nevertheless, FAO data remains the most reliable one as the organization attempts to correct figures by using estimates and sometimes even unofficial sources. As far as Bulgarian government resources are concerned, information about donkeys is incomplete and needs to be updated. A comprehensive research study was also conducted based on scientific resources, primarily using the PubMed and Google Scholar databases, to outline the significance and development of donkey husbandry worldwide and in the European context. Internet sites were analyzed to extract information about prices and progress in various business fields related to donkey productivity. This study aims to present the overall picture and trends in the donkey industry, with insights into future perspectives that will allow the restoration of a stable population with new and hopefully more attractive functions.

### **Distribution of donkeys worldwide**

The global equid population size is estimated at 116 million working animals, with 36 million in the 38 lowest-income countries (Allan, 2021).

This supports the lives of approximately 600 million people; however, this figure is likely a gross underestimate (Norris et al., 2021). The latest FAO report states that there are 50.5 million donkeys and 7.9 million mules worldwide (Allan, 2021). Data concerning the number and distribution of donkeys is often complex to analyze due to inaccuracy or insufficiency. However, specific trends have emerged that have proven stable over the last few decades (Starkey and Starkey, 2000). According to the FAO, the period from 1961 to 1997 is characterized by a global trend of increasing donkey populations at a rate of ~1% per annum, while mule populations are in decline at a rate of ~2% per annum. The same trend is observed during the next report period, 1997-2018 (Norris et al., 2021). Reliable data are essential for disease surveillance, epidemiological research, and the management of endangered status in some donkey breeds (Allen, 2021).

The tendency can be explained by the increase in donkey numbers in specific regions, such as sub-Saharan Africa, the north of the Indian subcontinent, and the tropical highlands of Latin America (Starkey and Starkey, 2000). Between 1997 and 2018, the donkey populations in Sudan, Chad, and Zimbabwe increased by 80% (Norris et al., 2021). Currently, Ethiopia is the country with the highest number of over 8 million (Wang et al., 2022).

A distinctly opposite tendency can be observed in several industrialized regions of the globe. Statistics from the United States demonstrate a significantly low number of donkey population compared to the large territory, between 48,000 in 1931 and 55,000 in 1989 (Starkey and Starkey, 2000). In the Americas (North, South, and Central America), the 2008 donkey population was estimated at 7.1 million, but had decreased to 6.6 million by 2018, representing a 7% decline over 10 years. In South America alone, the 2008 donkey population stood at 3.3 million, but had fallen to 2.8 million by 2018, indicating a 15% population decrease (Raw et al., 2021). Data from the Soviet Union showed a decrease from 700,000 in 1935 to 410,000 in 1979 (Starkey and Starkey, 2000). In 2000, China had the highest

population (approximately 11 million) (Starkey and Starkey, 2000), which declined drastically to 2,677,800 by 2018 (Norris et al., 2021). According to Zhang et al. (2023), the main reasons for this process are the rapid agricultural modernization and the depopulation of rural districts. The article states that there has been a decrease from 4.85 to 1.97 million in the past 10 years, reaching a relatively stable plateau.

As a result of mechanization in agriculture and transportation, the number of donkeys reared in Europe has decreased by more than 80% since the middle of the last century (Camillo et al., 2018). It was estimated to be 967,057 in 1994 (Camillo et al., 2018), approximately 400,000 around 2000 (Starkey and Starkey, 2000), and then increased steadily to 514,591 in 2014 (Camillo et al., 2018). Countries that traditionally maintained donkey populations suffered a significant decrease in donkey numbers during the period 1939 – 1996, for example, France with 185 000 donkeys in 1939 to 25 000 in 1996, Ireland (148 000 to 14 000), Italy (790 000 to 27 000), Spain (805 000 to 90 000) and Greece (404 000 to 110 000) (Starkey and Starkey, 2000).

The overall decline primarily affected Eastern European countries, with numbers falling from 384,657 in 1994 to 103,491 in 2014 (Camillo et al., 2018) or, according to another report, from 370,474 in 1997 to 87,542 in 2018 (Norris et al., 2021). The countries with the most significant reduction in donkey population size were Bulgaria, Greece, and Ecuador (Allan, 2021). It was emphasized that the stock numbers from Greece continue to decline, despite the recent import of donkeys for milking (SAVE Foundation, 2013). Estimates of donkey numbers in Greece are also not reliable, as there is considerable variation between different sources. A decrease by 96% was reported between 1955 and 2005 (508,000 to about 21,000). The official data from 2007 shows 15,483 donkeys and 13,370 mules (Kugler et al., 2008). The donkey population in Romania has remained relatively stable at about 33,000 for several decades. (Starkey and Starkey, 2000). A nearby country with important economic connections to the European market, like Turkey, had seen a rap-

id decline in donkey population from 1.7 million in 1949 to 800,000 by 1996 (Starkey and Starkey, 2000) and 170,000 by 2014 (Camillo et al., 2018).

A 2008 report states that Bulgaria is among the European countries with the highest number of donkeys – 185,744; however, it was noted that the number of animals was not accurate due to unreliable governmental estimates (Kugler et al., 2008). According to Vlaeva and Barzev (2019), the number of donkeys in Bulgaria has been steadily decreasing. It used to be around 348,769 in 1985 and had fallen to 35,000 by 2013. The same tendency can be observed in mules – from 27 196 to 3 000 during the same period. However, different statistics can be found during a search in the FAOSTAT database. Starting from 2000, the number of donkeys was 207,689, 90,000 in 2005, 40,189 in 2010, and 18,500 in 2017. The number of mules ranged from 15,539 in 2000, 9500 in 2005, 3069 in 2010, to 1500 in 2017. Unfortunately, no data is available after 2018. It is essential to note that some of the values are estimated, rather than official, which serves as a reminder about the current state of donkey husbandry in the country.

### Donkey breeds in Europe

Donkeys were affected more than any other livestock animals by the Industrial Revolution and suffered a drastic decrease not only in number but also in diversity (Kugler et al., 2008). Donkey breeds in Europe are often difficult to identify (Camillo et al., 2018), and some, such as the Miller's donkey, known to us from central European fairy tales (Kugler et al., 2008), are already extinct. Furthermore, there can be significant regional differences within the population originating from a specific country regarding external as well as body measurements (Maswana et al., 2023). Where the breeds are known, the number of breeding animals is dramatically low, and often reproduction is managed with very little or no attention to breed preservation (Camillo et al., 2018). Other breeds are so rare that there is no longer reliable data about them (Kugler et al., 2008).

Current knowledge of the evolutionary history of donkeys remains incomplete (Wang et al.,

2020). It is believed that the majority of European donkey breeds originate from two African wild breeds: the Nubian wild donkey (*Equus asinus africanus*) and the Somalian wild donkey (*Equus asinus somaliensis*) (Beja-Pereira et al., 2004). Geographically determined isolation, climate conditions, and differing husbandry and fodder availability led to the development of considerable diversity, and eventually, the development of distinct breeds (Kugler et al., 2008). Genomic studies reveal selection for large size and the practice of inbreeding (Todd et al., 2022). The diluted gray pigmentation (Dun phenotype), found in wild asses, changed to non-diluted black or chestnut coat colors (non-Dun) in domestic donkeys, which is probably the result of domestication (Wang et al., 2020). Breed differences depend on colour variation, as well as some primitive markings, such as an eel stripe on the spine, a cross on the shoulder, or “zebra stripes” on the legs. (Kugler et al., 2008).

Only several donkey breeds have been described by the recommendation of the Food and Agriculture Organization (Stanišić et al., 2015). Many are not systematically developed, and the population is characterized by small numbers (Kugler et al., 2008). The registration of donkey breeds was facilitated by ongoing FAO programs, which led to increased interest and the development of new breed standards after 2000 (Vlaeva and Barzev, 2019). Nevertheless, donkeys comprise around 3% of the globally documented livestock breeds. The current edition of the DAD-IS database (Domestic Animal Diversity Information System) from the FAO states that 185 donkey breeds are recorded in the 7 FAO world regions, with 51 of these originating from the Europe and Caucasus region (Kugler et al., 2008).

According to FAO's DAD-IS, there are 60 donkey breeds in Europe. However, the list includes two already extinct breeds, five synonymous breeds, and many that lack a clear description. Therefore, the actual donkey breeds in Europe are 28 and include (Camillo et al., 2018):

- Croatia: Istrian donkey, Littoral Dinaric donkey, North Adriatic donkey;

- France: Ane Bourbonnais, Ane de Provence, Ane des Pyrénées, Ane du Cotentin, Ane Grand Noir du Berry, Ane Normand, Baudet du Poitou;

- Hungary: Hungarian Plain donkey;

- Italy: Asino dell' Amiata, Asino dell' Asinara, Asino di Pantelleria, Asino Sardo, Grigio Viterbese, Martina Franca, Ragusano, Romagnolo;

- Portugal: Burro de Graciosa, Burro de Miranda;

- Spain: Andaluza, Asno de las Encartaciones, Balear, Catalana, Majorena, Zamorano-Leonés;

- Serbia: Balkan donkey.

Donkey breeds, according to Kugler et al. (2008), are listed below:

- Albania: Common Albanian (Syn.: Commune; Albanian; Gomari);

- Austria: Baroque donkey (Syn.: Barockesel, Österreichisch-Ungarischer Albinoesel, Austro-Hungarian Albino);

- Belgium: Waalse Ezel; Wallon Donkey;

- Bosnia & Herzegovina: Domestic Balkan Donkey, Herzegovinian Donkey;

- Bulgaria: no knowledge about autochthonous breeds; no herdbook for donkeys;

- Croatia: Primorsko Dinarski Magarac (Littoral Dinaric Donkey), Istarski Magarac (Istrian Donkey), Sjeverno-Jadranski Magarac (North Adriatic Donkey);

- Cyprus: Cyprus Donkey (Gaidouri);

- Denmark: no particular pure-bred donkeys;

- France: L'Âne de provence (Syn: Ane d'Arles; Ane de berger; Ane de la Crau; Ane de Savoie; Ane de transhumance; Ane gris de Provence; Provence; Savoie; Savoy Esel); Grand noir du Berry (Syn.: Grand noir; Ane du Berry; Berry Black); Ane Normand (Syn.: Normand); Ane des Pyrénées (Syn: Pyrénéen; Pyrenean); Ane Gascogne; Ane Bourbonnais; Ane du Cotentin; Baudet de Poitou (syn.: Ane de Poitevin; Ane du Poitou; Poitou-Esel); L'Âne de L'Île de Ré; Ane corse;

- Germany: no autochthonous donkey breeds left; Thuringian Forest Donkeys (Thüringer Waldesel);

- Greece: Arcadian donkey, Ellinikon (syn.: local Greek Ass), Cyprus Ass;

- Hungary: “common donkey” (Scrub donkey);

- Italy: Asino Amiatina (syn. Asino Amiatino; Asino dell'Amiata; Amiata), Asino Argentato di Sologno, Asino Asinara (syn.: Asino bianco di Asinara; Asino Albino dell'Asinara Asino dell'Asinara; Albinotischer Zwergesel), Asino di Martina Franca (syn.: Pugliese; Martinese; Martina Franca; Puli; Martina Franca Esel; Ane de Martina-Franca; Apulian), Asino di Pantelleria (syn.: Asino Pantesco; Pantelleria; Pantescia; Pantesco), Asino Ragusana (syn.: Ragusano; Sicilian; Ragusan; Ragusana), Asino Romagnolo (syn.: Romagnola), Asino Sardo (syn.: Sarda; Ainu; Burriku; Molente; Molingianu; Pegus de mola; Poleddu; Sardo; Sardinian Dwarf), Asino Grigio Siciliano;

- Kosovo: Domestic Balkan Donkey;  
 - Malta: Maltese Donkey (Hmar Malti);  
 - Macedonia: Macedonian Donkey, Domestic Balkan Donkey;  
 - Montenegro: Domestic Balkan Donkey;  
 - Netherlands: no autochthonous breeds of donkeys known;

- Portugal: Burro de Miranda (syn.: Burro do Planalto Mirandes, Raça asinina de Miranda; Mirandes; Transmontano), Burro de Graciosa (syn.: Burro anão da Graciosa; Dwarf Donkey of Graciosa);

- Romania: Domestic Balkan Donkey;  
 - Serbia: Domaci Balkanski Magarac; Domestic Balkan Ass;  
 - Slovenia: no autochthonous breeds of donkeys are known.

- Spain: Asno Andalucia (syn.: Cordobesa; Andaluz; Gran raza Asnal Andaluza o Cordobesa; Cordobés; Córdoba; Campizies; Campinesa; Asnal Andaluza; Andaluza-Córdoba; Andaluza o Cordobesa; Andaluza; Andalusischer Riesen-Esel; Cordobese; Andalucian; Andalusian), Burro Castellana (syn.: Castellana; Common Spanish; Castilian), Asinina Catalana (syn.: Vich; Catalana; Catalán; Ausetan; Catalana; Katalanischer Riesen-Esel; Catalan; Ane catalan; Catalanian Donkey; Catalanian), Asno de las Encartaciones (syn.: Las Encartaciones), Burro Majorero (syn.: Canary Island; Common Spanish), Ase Mallorquí (syn.: Asno Mallorquin; Burro Mallorquin; Malorqunia; Balear), Zamorano-Leonés;

- Switzerland: Baudet de Poitou;  
 - Turkey: Anatolian Donkey.

Yilmaz et al. (2012) have also conducted a comprehensive study of world donkey breeds, as described in the scientific literature, and presented the findings in a table.

There are a few European breeds that deserve scientific attention with detailed reports. One such breed is the Amiata donkey from Italy, which has been published with morphological characterization (Salari et al., 2023; Sargentini et al., 2018) and well-defined milk characteristics (Ragona et al., 2016; Martini et al., 2014). Another is the Martina Franka, again from Italy, an endangered breed (De Berardinis et al., 2024; Trimboli et al., 2020; Rizzi et al., 2011), known for its high-quality milk and meat (De Palo et al., 2017).

All Balkan Countries mention their local form of the so-called “Domestic Balkan Donkey”; however, experts have failed to conduct investigations and estimate probable occurring breeds (Kugler et al., 2008). The domestic Balkan donkey inhabits the mountainous regions of the Balkan Peninsula. It is believed to have originated from two ancestors: the Namibian donkey (*Equus asinus africanus*) and the Somali donkey (*Equus asinus somaliensis*) (Bunevski et al., 2018).

The name Balkan donkey is sometimes used to describe the Bulgarian population; however, in scientific literature, the terms “Bulgarian donkey” or “local donkey” are preferred. Kugler et al. (2008) mention that the term “Bulgarian Donkey” is found in literature, but it is rarely used within the country. According to Vlaeva (2021), the population in Bulgaria is referred to as “local” and does not belong to any specific breed. There are no breeding associations or any financial support from the state (Ciganovic, 2019). The lack of a breeding goal can explain the wide phenotypic variation among animals (Vlaeva, 2021). However, a “Breeding program for conservation of the genetic resources and breeding of the population of Local donkeys in Bulgaria” was initiated in 2017 (Ciganovic, 2019).

The situation is similar in neighboring North Macedonia (Ciganovic, 2019), Greece (Arsenos et al., 2010), and Romania. Arsenos et al. (2010)

mention the difficulty in distinguishing an indigenous donkey breed from Greece, where less than 5% of the estimated animals possessed the distinctive morphological characteristics of the Arcadian donkey. Little is known about the Cyprus donkey breed, although it can be found through a Google search. More information is available about the Serbian Balkan donkey as an endangered autochthonous breed with a sexually mature population size of 250-300 individuals (Stanišić et al., 2015). The Banat donkey is also described as a larger breed with a lighter coat color compared to the middle-sized Balkan donkey (Stanišić et al., 2020).

Donkeys were often maintained for the production of mules and hinnies, as their offspring demonstrate heterosis with improved viability and stamina (Kugler et al., 2008). They were preferred working animals, and continue to be used in some parts of the world (Kubasiewicz et al., 2024; Cousquer et al., 2023), including European countries such as Spain, France, and Greece, where mules participate in agro-forestry activities (Raw et al., 2021).

According to FAO criteria for the degree of endangerment, most European breeds are classified as endangered and are even at risk of extinction (Camillo et al., 2018). The study “Risorse genetiche agrarie in Italia” from the Monitoring Institute from 2000/2001, concluded that 6 Italian donkey breeds are extinct: Cariovilli from Abruzzo (Aquila), Castelmorone (Castel Morrone) from Campania (Caserta), Emiliano, Grigio viterbese from Lazio (Viterbo), Irpinia from Campania (Benevento, Avellino), and Sant’ Alberto from Emilia Romagna (Ravenna, Forlì) (Kugler et al., 2008). According to Ivanković et al. (2023), only 5.62% of donkey breeds are not at risk of extinction.

## Breeding

The reproductive cycle and gestation length in jennies are longer than those in mares (Miragaya et al., 2018). Female donkeys reach sexual maturity at the age of one to two years; however, foaling before four years old is associated with a higher mortality rate for the jenny and/or foal.

Therefore, breeding is not recommended before 2.5 to 3 years (European Platform on Animal Welfare, 2019). The species is territorial, non-seasonal, polyestrous, and single-bearing (Zhang et al., 2022). During oestrus, jennies develop characteristic behavior, including a clapping mouth, ears back against the neck, rhythmic eversion of the clitoris, urination in small drops, braying vocalizations, a mounting stance, and mounting between females (European Platform on Animal Welfare, 2019). The gestation length ranges between 333 and 395 days, with an average of 371 days (Miragaya et al., 2018). Twin pregnancy represents the most important cause of abortion and should be managed appropriately to allow a normal single fetus development (Veronesi et al., 2024).

One jack can realistically serve 10-15 jennies. Breeding strategies include: pasture breeding, where one jack is kept free in the same paddock with one or more jennies, or in-hand breeding, where the jack and the jenny are managed by handlers (European Platform on Animal Welfare, 2019). Insemination with raw semen is often used, and some efficient protocols with cooled semen have been applied; however, use of frozen-thawed semen remains a challenge (Miragaya et al., 2018).

Another significant problem is the discrepancy between the total number of donkeys and the purebred ones. A consistent database by country is still missing, and breeding practices lack a selection strategy or attention to genetic preservation (Camillo et al., 2018). A substantial decrease in the population size of autochthonous breeds may lead to high levels of inbreeding and the occurrence of inbreeding depression (Stanišić et al., 2015). At present, many European breeds face the threat of extinction (Camillo et al., 2018), and due to the small numbers in some populations, there is a danger of inbreeding (Kugler et al., 2008).

In the now “en vogue” business with donkey milk, animals are imported without a knowledge base and mated for higher production profits; however, little emphasis is placed on selection (SAVE Foundation, 2013). In Greece, for ex-

ample, the common practice in donkey breeding programs was the importation of jacks from foreign countries' breeds, such as those from Cyprus, Sicily, and France (Camillo et al., 2018). Numerous donkey crosses were produced, resulting in significant variation in morphological characteristics and phenotypes (Kugler et al., 2008). Unfortunately, the same strategy is maintained in Bulgaria, where owners confess to importing jacks from Romania, as well as from Italy and France, due to the low number of local animals in the country.

The donkeys in the Balkans are presented as a metapopulation and transboundary breed in almost all countries; therefore, a regional breeding program with flexible standards and breeding goals may be a viable option (Bunevski et al., 2018).

Recently, the European Union recognized the importance of native breeds as an invaluable genetic resource and established several strategies, including the Rural Development Programme, overseen by local breeding associations, and the national genetic resources monitoring program (Raw et al., 2021). A breeding program for autochthonous donkey breeds should focus on aspects such as rearing area, breeding structure, population size, breeding goals, breeding standards, breeding methods, and selection programs (Bunevski et al., 2018).

### Economic importance

The global donkey population can be categorized into the following groups: working donkeys, companion donkeys, feral donkeys in the Western Hemisphere, East Africa, and Australia, and intensively farmed donkeys (in China and elsewhere) (Allen, 2021). Historically, donkeys were used predominantly as harness and pack animals (Camillo et al., 2018), a practice that remains common in rural regions of Asia and Africa (Starkey and Starkey, 2000). Despite the extensive mechanization of farming worldwide, approximately 50% of the world's agricultural power is still generated by working animals, with working equids representing the majority (Raw et al., 2021).

Landscape maintenance is gaining importance as some endangered plant and insect species appear to be encouraged by the selective feeding behavior of donkeys (Camillo et al., 2018). They have also been valued for keeping open scrubby meadows and pastures that are no longer used for agriculture (SAVE Project, 2013). Donkeys and mules are still preferred in difficult-to-access mountainous regions and areas where machines are not permitted (e.g., national conservation parks) (Camillo et al., 2018). Animal-powered systems are gradually reappearing as a modern, ecologically and economically sound farming practice that provides a clean and sustainable source of energy (Raw et al., 2021).

Across Europe, the purpose of keeping donkeys is constantly changing. They are still used as reliable working animals in some parts of the continent. In contrast, elsewhere, they serve as pets, participate in leisure activities and therapy programs, or provide milk and meat (Dai et al., 2016). In forest management, equids offer several benefits compared to conventional motorized methods (Raw et al., 2021). Modern purposes include flock guarding, especially of sheep (Starkey & Starkey, 2000), as donkeys manage well against attacks by wild dogs and wolves (Camillo et al., 2018; SAVE Project, 2013). Other non-working roles include meat and milk production, nutraceuticals, cosmetics, silviculture, tourism, and *onotherapy* (Norris et al., 2021).

In the late 20<sup>th</sup> century, donkey milk began to attract the attention of farmers and researchers as a product with varied benefits (Raw et al., 2021). The sale and marketing of raw donkey milk and donkey milk products have increased, creating a gourmet niche on the market (Kugler et al., 2008). As a result, donkey farms reappeared in Europe, especially in the Mediterranean region (Raw et al., 2021). Donkey milk has a remarkable similarity to human milk in protein homogeneity and antigenic composition, which makes it suitable as a substitute for infants, especially in the case of cow's milk allergies (Baloš et al., 2023; Bhardwaj et al., 2020; Souroullas et al., 2018). Clinical studies report a tolerability of 82.6-98.5% (Martini et al., 2021). Donkey milk is also considered a

suitable nutraceutical for geriatrics due to its high calcium content (Hassan et al., 2022).

Donkey milk is characterized by low contents of fat and cholesterol, total protein and casein, and high contents of lactose, whey proteins, calcium, selenium, and vitamin D<sub>3</sub>. It is rich in various protective proteins ( $\alpha$ -lactalbumin, lysozyme, lactoferrin, lactoperoxidase, and immunoglobulins), and shows potent antioxidant, antibacterial, antiviral, antifungal, antiparasitic, hypoglycemic, and antitumor activity (Khan et al., 2024; Baloš et al., 2023; Wang et al., 2022; Martini et al., 2021). Antibacterial properties against *Escherichia coli*, *Salmonella enteritidis*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus*, *Enterococcus faecalis*, and *Shigella dysenteriae* have been reported (Hassan et al., 2022). Aspri et al. (2017) demonstrated that *Enterococci* in raw donkey milk do not pose a risk to human health and can be utilized as potential starter/adjunct cultures for food fermentations.

The use of donkey milk to heal wounds and treat various diseases, such as bronchitis, asthma, joint pain, and gastritis, is being explored. Anticancer, antidiabetic, atherosclerotic, and anti-inflammatory properties have also been reported (Khan et al., 2024; Derdak et al., 2020).

The commercialization of donkey milk and dairy products remains limited due to low production levels (Baloš et al., 2023). Lactation status, processing, and manufacturing techniques are known to influence the levels of macronutrients (Garhwal et al., 2022). Lactation curves of individual milk yields vary in respect to breed (Ivanković et al., 2023), and range between 1.54 and 1.73 kg/day on specialized farms with higher milk yields, obtained through three milkings per day and during the autumn-winter period (Khan et al., 2024). A wide variety of dairy products is gaining popularity on the market, including cheese, ice cream, milk powder, novel functional fermented beverages, and milk powder for infant formulas (Garhwal et al., 2022).

The price of raw donkey milk starts from 2.99 Euros for 100 ml, which corresponds to 30 Euros per liter. A lyophilized product can also be ordered for 66 Euros per 200 g (Camillo et al.,

2018; online research). The price of raw donkey milk in Bulgaria ranges from 60 to 80 BGN per liter, which aligns with the trends in the European market.

A variety of donkey milk delicacies can be found on the market, including cheese, fermented desserts, candies, and even deluxe Swiss chocolate (Camillo et al., 2018; online research). The raw material is often mixed with milk from other species (usually goat milk) to enhance coagulation, and technological parameters need to be adjusted (D'Alessandro et al., 2019; Faccia et al., 2018). For example, Pule cheese, also known as Magareći sir, is a Serbian product made from 60% Balkan donkey milk and 40% goat's milk. Similar attempts have been made in Bulgarian donkey farms, but production is small-scale and high-priced. Cocoa candies and immune stimulatory pastilles with donkey milk have also been advertised by a Bulgarian company (personal data).

Donkey milk is a valuable ingredient for the cosmetic industry. Its beneficial skincare properties were well known by the ancient Egyptians, Greeks, and Romans (Derdak et al., 2020). Nowadays, it is advertised as a product that provides hydration and antioxidant action to prevent aging (Khan et al., 2024). The favorable effect of creams with skimmed donkey milk encapsulated in nanoliposomes on skin physiology has also been reported (Kocic et al., 2020). An online search yielded several cosmetic products, primarily hand and face creams, containing donkey milk, which can be purchased in Europe. Such items, whether imported or local, are also available on the Bulgarian market.

Although interest in donkey milk is increasing and the number of donkey farms is growing, there is still limited information available from official sources. Neither FAOSTAT nor Bulgarian local authorities provide data about this type of production, which makes it difficult to analyze how this kind of business is developing.

The situation is similar in the production of donkey meat. FAOSTAT search under the keywords "meat of mules fresh or chilled", "meat of asses fresh or chilled", "edible offals of horses and

other equines, fresh, chilled or frozen” produces no results (FAOSTAT). Annual reports from the Bulgarian Ministry of Agriculture and Food also lack such information – horses and donkeys are listed together with bullocks under the section for small ruminants. The number of animals for 2024 is 150.84 thousand with 3523.5 tons live weight and 1590.3 tons carcass weight (Ministry of Agriculture and Food, 2024). According to Camillo et al. (2018), the slaughtering of 8626 donkeys was reported in Bulgaria for the year 1976. This number progressively decreased until 1986 and the following years, when no more production of donkey meat was reported for the country.

Donkey meat has an excellent nutritional profile, characterized by high levels of polyunsaturated fatty acids (Aroua et al., 2024; Marino et al., 2022). It is characterized by a high protein content, low levels of lipids and cholesterol (Polidori et al., 2008), and a high iron content (Polidori & Vincenzetti, 2017).

Consumer preferences play a role in the availability of products (Hassan et al., 2022). The consumption of donkey meat in Europe is limited to countries such as Italy and Spain, which also produce some notable meat delicacies (Camillo et al., 2018). However, there is a growing market for rare and extraordinary tastes, and donkey meat, with its health benefits, seems a possible alternative.

In fast-growing developing countries, donkeys are often used as a source of protein (Wang et al., 2022). The top three countries in terms of donkey meat production are China, Niger, and Burkina Faso (Ivanković et al., 2023). For example, in 2014, China reported 2,411,256 heads or 193,000 tons of donkey meat (Camillo et al., 2018). A gelatin called ‘ejiao’ is produced from donkey skins and is used in traditional Chinese medicine. Due to the export to China, the donkey populations in some African and Asian countries have been constantly declining in recent years (Allen, 2021).

Nowadays, social activities related to animal interaction have been developed, and centers offering such services are open to the public. Assisted therapy with donkeys (*onotherapy*) is gaining attention. Compared to horses, donkeys are

more miniature and slower; they have longer and softer hair that enhances tactile sensations, making simple contact with this animal easier and more pleasant (Camillo et al., 2018). Some donkey breeds, especially mules, have a so-called “Tölt-gait”; the rider sits nearly without any vibration on a loosely swinging back (SAVE Project, 2013). A study by Borioni et al. (2012) on the physical and psycho-social performances of subjects affected by intellectual disability suggested that onotherapy is a suitable and effective alternative to equestrian therapy, which can result in improved autonomy and social integration. Another study also described a significant improvement in the psycho-social functioning of adults with intellectual disabilities, especially for participants who received longer sessions (Colombo et al., 2020).

Another aspect of the social role of donkeys is hobby keeping, which has seen an increased interest in Northern and Central Europe (SAVE Foundation, 2013). The use of donkeys for tourism and leisure activities is also widespread in many countries on the continent (Kugler et al., 2008), and several articles have been published to describe the historical role of the species as a symbol for maintaining tourism traditions (Tully and Carr, 2020a), and a possible alternative to horses in health tourism (Pecsek and Beke, 2023). Several small-scale farms in Bulgaria offer communication and riding experiences for children, as well as the degustation of donkey milk and meat.

### Pitfalls and challenges

Data analysis, as demonstrated in the opening part of this article, has already highlighted the difficulty in gathering accurate population statistics for donkeys. Breed identification and the assessment of their economic value to a country have also turned out to be problematic. Another aspect of the matter is the limited or fragmented objective information available in the literature about welfare conditions and recommendations for donkeys in the EU (Dai et al., 2016). Donkeys and mules are often misunderstood due to their distinct behavioral characteristics compared to

horses (McLean et al., 2019). Donkeys are more likely than mules or horses to demonstrate avoidance or aggressive behavior towards an observer (Pritchard et al., 2005). Therefore, training from an early age is key to modifying behavior and acceptance of unfamiliar people (McLean et al., 2019).

Welfare assessment is crucial to developing a strong animal-to-human bond and preventing harmful practices. Main welfare problems affecting donkeys include inadequate body condition, dental disease, hoof neglect and limb deformities, lameness, integument lesions, and sub-optimal behaviour (Cruz et al., 2021; Pritchard et al., 2005). Haddy et al. (2020) also reported associations with obesity and the use of harmful practices. The tourism sector may facilitate oppressive treatment towards donkeys and support exploitation (Tully and Carr, 2020b). Raw et al. (2021) state an important example from Ireland, where donkeys are used as a source for gaining government subsidies. When these subsidies are no longer in effect, the animal loses its value and, consequently, may suffer poor welfare and abandonment.

The AWIN (Animal Welfare Indicators) project, funded by the European Commission in the Seventh Framework Programme, aimed to improve the welfare of several species, including donkeys, by developing on-farm welfare assessment protocols (Dai et al., 2016). The need for a more holistic approach should be emphasized, and additional points, such as management practices, social transmission of expertise, environmental stressors, and analysis of local traditions, should be included (Haddy et al., 2020).

Several non-governmental organizations operate internationally to enhance the health and welfare conditions of working and non-working equids (Norris et al., 2021). One of the biggest and most popular is the Donkey Sanctuary, which maintains a network of farms, sanctuaries, holding bases, and donkey hospitals not only in Europe but also abroad.

Legislation concerning donkeys remains incomplete and requires updating. According to 98/58/EC Directive, donkeys kept for milk/meat

production should be considered as farm animals. Unfortunately, the document is not species-specific; however, it establishes minimum standards for the protection of animals used for farming purposes (Dai et al., 2017). Legislation in Bulgaria also lacks specific recommendations regarding donkeys, which are grouped under the term “equids” regardless of their unique husbandry needs. Inarguably, this can be a potential factor for welfare violation.

Donkeys’ requirements as a whole are largely unfamiliar; veterinary knowledge is insufficient, and there are few professional books published (SAVE Foundation, 2013). Working with these animals requires more patience and the ability to notice changes in behavior, as well as the ability to diagnose disease (McLean et al., 2019). Clinical evaluation and preventive care protocols should be developed considering the species-specific characteristics, given the desert-adapted physiology of the donkey (Barrio et al., 2019). A study from Switzerland demonstrated suboptimal implementation of preventive healthcare, resulting in poor or moderate health status among the donkey population (Schäfer et al., 2024). Diseases often present late or may go unrecognized, leading to poor welfare and quality of life (Barrio et al., 2019). Donkey owners, veterinarians, and official veterinary offices express their interest in more education opportunities in donkey husbandry and medicine (Schäfer et al., 2024).

## CONCLUSION

Working equids provide sustainability value by supporting local economies and contributing to the stabilization of human populations in marginal areas. Despite decades of neglect, donkeys still play a role in agriculture, landscape, and forest management. They have been rediscovered as producers of milk and meat, as contributors to tourism and leisure activities, and as valuable participants in therapy programs. The purpose of this study was to draw attention to the problems in donkey husbandry, particularly the declining numbers in the southern part of Europe, and the need for a scientific approach when classifying

and estimating donkey breeds. Furthermore, it aims to highlight the potential and benefits of developing donkey farms as part of a broader approach to maintaining biodiversity. Bulgaria, together with other Balkan countries, is a part of the FAO's Convention on Biological Diversity, and needs to initiate specific actions in order to preserve the local Bulgarian donkey population and hopefully create conditions for the implementation of a selective program.

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### REFERENCES

- Allan, F. K. (2021). A Landscaping Analysis of Working Equid Population Numbers in LMICs, with Policy Recommendations. Brooke: Action for Working Horses & Donkeys and Supporting Evidence-Based Interventions, Royal (Dick) School of Veterinary Studies, University of Edinburgh. [https://www.thebrooke.org/sites/default/files/Images/Equid\\_Population\\_Landscaping\\_Analysis.pdf](https://www.thebrooke.org/sites/default/files/Images/Equid_Population_Landscaping_Analysis.pdf). Accessed: 21.02.2025.
- Aroua, M., Fehri, N. E., Ben Said, S., Quattrone, A., Agradi, S., Brecchia, G., Balzaretto, C. M., Mahouachi, M. & Castrica, M. (2024). The Use of Horse and Donkey Meat to Enhance the Quality of the Traditional Meat Product (Kaddid): Analysis of Physico-Chemical Traits. *Foods*, 13(18), 2974. doi: 10.3390/foods13182974.
- Arsenos, G., Gelasakis, A. & Papadopoulos, E. (2010). The status of Donkeys (*Equus asinus*) in Greece. *Journal of the Hellenic Veterinary Medical Society*, 61(3), 212 - 219. doi: 10.12681/jhvms.14888.
- Aspri, M., Bozoudi, D., Tsaltas D., Hill, C. & Papademas, P. (2017). Raw donkey milk as a source of Enterococcus diversity: Assessment of their technological properties and safety characteristics. *Food Control*, 73, 81 - 90. doi: 10.1016/j.foodcont.2016.05.022.
- Baloš, M. Z., Pelić, D. L., Jakšić, S. & Lazić, S. (2023). Donkey Milk: An Overview of its Chemical Composition and Main Nutritional Properties or Human Health Benefit Properties. *Journal of Equine Veterinary Science*, 121, 104225. doi: 10.1016/j.jevs.2023.104225.
- Barrio, E., Rickards, K. J. & Thiemann, A. K. (2019). Clinical Evaluation and Preventative Care in Donkeys. *Vet. Clin. North Am. Equine. Pract.*, 35(3), 545 - 560. doi: 10.1016/j.cveq.2019.08.013.
- Beja-Pereira, A., England, P. R., Ferrand, N., Jordan, S., Bakhiet, A. O., Abdalla, M. A., Mashkour, M., Jordana, J., Taberlet, P. & Luikart, G. (2004). African origins of the domestic donkey. *Science*, 304, 1781 - 1781. doi: 10.1126/science.1096008.
- BFSA (Bulgarian Food Safety Agency). <https://iisr.egov.bg/BABHRegsExt/pagesPublic/registers/registerAnimalDefault.xhtml?reg=61&locale=bg>. Accessed: 28.02.2025.
- Bhardwaj, A., Pal, Y., Legha, R. A., Sharma, P., Nayan, V., Kumar, S., Tripathi, H. & Tripathi, B. N. (2020). Donkey milk composition and its therapeutic applications. *Indian Journal of Animal Sciences*, 90(6), 837 - 841. doi: 10.56093/ijans.v90i6.104972.
- Borioni, N., Marinaro, P., Celestini, S., Del Sole, F., Magro, R., Zoppi, D., Mattei, F., Dall' Armi, V., Mazzarella, F., Cesario, A. & Bonassi, S. (2012). Effect of equestrian therapy and onotherapy in physical and psycho-social performances of adults with intellectual disability: a preliminary study of evaluation tools based on the ICF classification. *Disabil Rehabil*, 34(4), 279 - 287. doi: 10.3109/09638288.2011.605919.
- Bunevski, G., Nikitovic, J., Janzekovic, M., Merge-dugh, A., Prishenk, J., Trjkovski, B. & Antic, M. (2018). Defining breed standards and breeding goals for domestic donkey. *Acta Agric. Seerbica*, 46, 213 - 221. doi: 10.5937/AASerl846213B.
- Camillo, F., Rota, A., Biagini, L., Tesi, M., Fanelli, D. & Panzani D. (2018). The Current Situation and Trend of Donkey Industry in Europe. *Journal of Equine Veterinary Science*, 65, 44 - 49. doi: 10.1016/j.jevs.2017.11.008.
- Ciganovic, N. (2019). Donkeys in north macedonia, bulgaria and croatia – actual situation, new opportunities and business models for new future. <https://donkey.mk/wp-content/uploads/2020/10/IO4-Donkey-farm-breeding-EN.pdf>. Accessed: 25.03.2025.
- Colombo, E., Manti, F., Milani, L. & Bernardini, D. (2020). Assessing the Effects of Donkey-Assisted Therapy on Adults with Intellectual Disabilities Using the ICF Framework. *Society and Animals*, 30(2), 1 - 22. doi: 10.1163/15685306-00001542.
- Cousquer, G., Alyakine, H. & Lindsay-McGee, V. (2023). The history and welfare of working mules in the valleys of the Toubkal massif, in the High Atlas of Morocco. *Front. Vet. Sci.*, 10, 1256501. doi: 10.3389/fvets.2023.1256501.
- Cruz, Z., Nóvoa, M., Leiva, B., Andrade, D. & Quaresma, M. (2021). Donkey welfare assessment in north-east Portugal. *Animal Welfare*, 30(1), 61 - 70. doi:10.7120/09627286.30.1.061.
- DAD-IS (Domestic Animal Diversity Information System) <https://www.fao.org/dad-is/browse-by-country-and-species/en/> Accessed: 02.03.2025.
- Dai, F., Dalla Costa, E., Murray, L. M., Canali, E. & Minero, M. (2016). Welfare Conditions of Donkeys in

- Europe: Initial Outcomes from On-Farm Assessment. *Animals (Basel)*, 6(1), 5. doi: 10.3390/ani6010005.
- Dai, F., Segati, M., Dalla Costa, E., Burden, F., Judge, A., Canali, E. & Minero, M.** (2017). Ensuring welfare on farm of donkeys kept for milk production: An analysis of the legislation. *Large Animal Review*, 23(2), 59 - 64.
- D'Alessandro, A. G., Martemucci, G., Loizzo, P. & Facciarom, M.** (2019). Production of cheese from donkey milk as influenced by addition of transglutaminase. *Journal of Dairy Science*, 102(12), 10867 - 10876. doi: 10.3168/jds.2019-16615.
- De Berardinis, A., Bucci, R., De Amicis, I., Del Signore, F., Parrillo, S., Massirio, I., Vignoli, M. & Carluccio, A.** (2024) Phenotypic Characterization of the Martina Franca Donkey: An Endangered Italian Donkey Breed. *Animals (Basel)*, 14(13), 1950. doi: 10.3390/ani14131950.
- De Palo, P., Tateo, A., Maggolino, A., Marino, R., Ceci, E., Nisi, A. & Lorenzo, J. M.** (2017). Martina Franca donkey meat quality: Influence of slaughter age and suckling technique. *Meat Sci.*, 134, 128 - 134. doi: 10.1016/j.meatsci.2017.07.025.
- Derdak, R., Sakoui, S., Pop, O. L., Muresan, C. I., Vodnar, D. C., Addoum, B., Vulturar, R., Chis, A., Suharoschi, R., Soukri, A. & El Khalfi, B.** (2020). Insights on Health and Food Applications of Equus asinus (Donkey) Milk Bioactive Proteins and Peptides-An Overview. *Foods*, 9(9), 1302. doi: 10.3390/foods9091302.
- European Platform on Animal Welfare** (2019). Guide to good animal welfare practice for the keeping, care, training and use of donkeys and donkey hybrids. [https://food.ec.europa.eu/system/files/2021-03/aw\\_platform\\_platform\\_guide\\_donkeys\\_en.pdf](https://food.ec.europa.eu/system/files/2021-03/aw_platform_platform_guide_donkeys_en.pdf) Accessed: 20.10.2024.
- Faccia, M., Gambacorta, G., Martemucci, G., Natrella, G. & D'Alessandro, A. G.** (2018). Technological attempts at producing cheese from donkey milk. *Journal of Dairy Research*, 85(3), 1 - 4. doi: 10.1017/S0022029918000420.
- FAOSTAT** <https://www.fao.org/faostat/en/#data/QCL> Accessed: 02.03.2025.
- Garhwal, R., Sangwan, K., Mehra, R., Kumar, N., Bhardwaj, A., Pal, Y., Buttar, H. S. & Kumar, H.** (2022). A Systematic Review of the Bioactive Components, Nutritional Qualities and Potential Therapeutic Applications of Donkey Milk. *J. Equine. Vet. Sci.*, 115, 104006. doi: 10.1016/j.jevs.2022.104006.
- Haddy, E., Rodrigues, J. B., Raw, Z., Burden, F. & Proops, L.** (2020) Documenting the Welfare and Role of Working Equids in Rural Communities of Portugal and Spain. *Animals (Basel)*, 10(5), 790. doi: 10.3390/ani10050790.
- Hassan, Z. M., Manyelo, T. G., Nemukondeni, N., Sebola, A. N., Selaledi, L. & Mabelebele, M.** (2022). The Possibility of Including Donkey Meat and Milk in the Food Chain: A Southern African Scenario. *Animals (Basel)*, 12(9), 1073. doi: 10.3390/ani12091073.
- Ivanković, A., Šubara, G., Bittante, G., Šuran, E., Amalfitano, N., Aladrović, J., Kelava Ugarković, N., Paden, L., Pećina, M. & Konjačić, M.** (2023). Potential of Endangered Local Donkey Breeds in Meat and Milk Production. *Animals*, 13(13), 2146. doi: 10.3390/ani13132146.
- Khan, M. Z., Chen, W., Li, M., Ren, W., Huang, B., Kou, X., Ullah, Q., Wei, L., Wang, T., Khan, A., Zhang, Z., Li, L. & Wang, C.** (2024). Is there sufficient evidence to support the health benefits of including donkey milk in the diet? *Front Nutr.*, 11. doi: 10.3389/fnut.2024.1404998.
- Kocic, H., Stankovic, M., Tirant, M., Lotti, T. & Arsic, I.** (2020). Favorable effect of creams with skimmed donkey milk encapsulated in nanoliposomes on skin physiology. *Dermatol. Ther.*, 33(4), e13511. doi: 10.1111/dth.13511.
- Kubasiewicz, L. M., Watson, T., Thapa, S., Nye, C. & Chamberlain, N.** (2024). Mule trains to mountain roads: the role of working mules in supporting resilient communities in the Himalayas. *Front Vet. Sci.*, 11, 1390644. doi: 10.3389/fvets.2024.1390644.
- Kugler, W., Grunenfelder, H. & Broxham, E.** (2008). Donkey Breeds in Europe. Inventory, Description, Need for Action, Conservation. Report 2007/2008. [https://www.doc-developpement-durable.org/file/El-evages/Anes/donkey%20\(1\).pdf](https://www.doc-developpement-durable.org/file/El-evages/Anes/donkey%20(1).pdf). Accessed: 20.10.2024.
- Marino, R., Della Malva, A., Maggolino, A., De Palo, P., d'Angelo, F., Lorenzo, J. M., Sevi, A. & Albenzio, M.** (2022). Nutritional Profile of Donkey and Horse Meat: Effect of Muscle and Aging Time. *Animals (Basel)*, 12(6), 746. doi: 10.3390/ani12060746.
- Martini, M., Altomonte, I., Tricò, D., Lapenta, R. & Salari, F.** (2021). Current Knowledge on Functionality and Potential Therapeutic Uses of Donkey Milk. *Animals (Basel)*, 11(5), 1382. doi: 10.3390/ani11051382.
- Martini, M., Altomonte, I., Salari, F. & Caroli, A. M.** (2014). Short communication: Monitoring nutritional quality of Amiata donkey milk: Effects of lactation and productive season. *J. Dairy Sci.*, 97, 6819 - 6822. doi: 10.3168/jds.2014-8544.
- Maswana, M., Mugwabana, T. J. & Tyasi, T. L.** (2023). Morphological Differentiation Among Donkey Breeds: A Review. *Pakistan J. Zool.*, 55(1), 413 - 418. doi: 10.17582/journal.pjz/20210607200603.
- McLean, A. K., Navas González, F. J. & Canisso, I. F.** (2019). Donkey and Mule Behavior. *Vet. Clin. North Am. Equine. Pract.*, 35(3), 575 - 588. doi: 10.1016/j.cveq.2019.08.010.
- Ministry of Agriculture and Food** (2024). Preliminary data from the monthly activity of the slaughterhouses processing red meat in 2024. <https://www.mzh.govern->

- ment.bg/bg/statistika-i-analizi/izsledvane-zhivotnovdstvo/danni/. Accessed: 28.02.2025.
- Miragaya, M. H., Neild, D. M. & Alonso, A. E.** (2018). A Review of Reproductive Biology and Biotechnologies in Donkeys. *Journal of Equine Veterinary Science*, 65, 55 - 61. doi: 10.1016/j.jevs.2017.12.005.
- Norris, S. L., Little, H. A., Ryding, J. & Raw, Z.** (2021). Global donkey and mule populations: Figures and trends. *PLoS One*, 16(2), e0247830. doi: 10.1371/journal.pone.0247830.
- Pecsek, B. & Beke, S.** (2023). The potential role of donkeys in health tourism. *Recreation*, 13(2), 16 - 20.
- Polidori, P., Vincenzetti, S., Cavallucci, C. & Beghelli, D.** (2008). Quality of donkey meat and carcass characteristics. *Meat Sci.*, 80(4), 1222 - 1224. doi: 10.1016/j.meatsci.2008.05.027.
- Polidori, P. & Vincenzetti, S.** (2017). Quality and Nutritional Characteristics of Donkey Meat. In *Meat and Meat Processing*. McCarthy, D.B., Ed. Nova Science Publishers, Inc. New York, NY, USA. ISBN 978-1-53612-210-7.
- Pritchard, J. C., Lindberg, A. C., Main, D. C. & Whay, H. R.** (2005). Assessment of the welfare of working horses, mules and donkeys, using health and behaviour parameters. *Prev. Vet. Med.*, 69(3-4), 265 - 283. doi: 10.1016/j.prevetmed.2005.02.002.
- Ragona, G., Corrias, F., Benedetti, M., Paladini, I., Salari, F., Altomonte, I. & Martini, M.** (2016). Amiata Donkey Milk Chain: Animal Health Evaluation and Milk Quality. *Italian Journal of Food Safety*, 5(3). doi: 10.4081/ijfs.2016.5951.
- Raw, Z., Rodrigues, J. B., Santurtun, E., Cooke, F. & Clancy, C.** (2021). Donkeys in transition: changing use in a changing world. *Braz. J. Vet. Res. Anim. Sci.*, 58(special issue), e174325. doi: 10.11606/issn.1678-4456.bjvras.2021.174325.
- Rizzi, R., Tullo, E., Cito, A. M., Caroli, A. & Pieragostini, E.** (2011). Monitoring of genetic diversity in the endangered Martina Franca donkey population. *J. Anim. Sci.*, 89(5), 1304 - 1311. doi: 10.2527/jas.2010-3379.
- Salari, F., Altomonte, I., Boselli, C. & Martini, M.** (2023). Amiata donkey body conformation, udder characteristics, and their relationship with milk yield and quality. *Canadian Journal of Animal Science*, 103(2), 128 - 133. doi: 10.1139/cjas-2022-0130.
- Sargentini, C., Tocci, R., Martini, A. & Bozzi, R.** (2018). Morphological characterization of Amiata donkey through multivariate analyses. *Bras Zootec*, 47, e20170310. doi: 10.1590/rbz4720170310.
- SAVE Foundation** (2013). Added Value of Donkey Breeds in Europe. Project Report. [http://www.agrobiodiversity.net/topic\\_network/donkey/Donkey/Donkey-ReportEN.pdf](http://www.agrobiodiversity.net/topic_network/donkey/Donkey/Donkey-ReportEN.pdf).
- Schäfer, J., Gerber, V., Hungerbühler, V., Schaefer, S. & Unger, L.** (2024). Management, health, and veterinary care of donkeys in Switzerland: A cross-sectional study. *ASMV* 12. Original contributions. doi: 10.17236/sat00439.
- Souroullas, K., Aspri, M. & Papademas, P.** (2018). Donkey milk as a supplement in infant formula: Benefits and technological challenges. *Food Res. Int.*, 109, 416 - 425. doi: 10.1016/j.foodres.2018.04.051.
- Stanišić, L., Aleksić J. M., Dimitrijević V., Kovačević B., Stevanović J. & Stanimirović Z.** (2020). Banat donkey, a neglected donkey breed from the central Balkans (Serbia). *Peer J.*, 3(8), e8598. doi: 10.7717/peerj.8598.
- Stanišić, L., Dimitrijević, V., Simeunović, P., Lakić, N., Radović, I., Ivanković, A., Stevanović, J. & Stanimirović, Z.** (2015). Morphological, biochemical and hematological characterization of endangered balkan donkey breed. *Acta Veterinaria-Beograd*, 65(1), 125 - 136. doi: 10.1515/acve-2015-0010.
- Starkey, P. & Starkey, M.** (2000). Regional and world trends in donkey populations. In: *Donkeys, people and development. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA)*. ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands, 244. ISBN 92-9081-219-2.
- Todd, E. T., Tonasso-Calvière, L., Chauvey, L., Schiavinato, S. & Fages, A.** (2022). The genomic history and global expansion of domestic donkeys. *Science*, 377, 1172 - 1180. doi:10.1126/science.abo3503.
- Trimboli, F., De Amicis, I., Di Loria, A., Ceniti, C. & Carluccio, A.** (2020). Reference Ranges for Hematological and Biochemical Profile of Martina Franca Donkeys. *Front Vet. Sci.*, 7, 602984. doi: 10.3389/fvets.2020.602984.
- Tully, P. A. G. & Carr, N.** (2020a). Presenting the donkey at the seaside: a move towards tackling speciesism in the tourism industry. *Annals of Leisure Research*, 25(2), 161 - 178. doi: 10.1080/11745398.2020.1737549.
- Tully, P. A. G. & Carr, N.** (2020b). The Oppression of Donkeys in Seaside Tourism. *Int. J. Sociol. Leis.*, 3, 53 - 70. doi: 10.1007/s41978-019-00047-x.
- Veronesi, M. C., De Amicis, I., Giangaspero, B. A., Fusi, J., Robbe, D., Castelli, F. & Carluccio, A.** (2024). Twin Pregnancy in the Martina Franca Donkey Breed Managed by Natural Reduction and Post-Fixation Manual Crushing. *Animals (Basel)*, 14(17), 2512. doi: 10.3390/ani14172512.
- Vlaeva, R.** (2021). Characteristics of the main body measurements of male and female donkeys in Bulgaria. *Journal of Central European Agriculture*, 22(2), 280 - 284. doi: /10.5513/JCEA01/22.2.3153.
- Vlaeva, R. & Barzev, G.** (2019). About donkeys around the world and in our country (Bg). <https://ezdapress.com/wp-content/uploads/2019/01/Za-magaretata.pdf>. Accessed: 12.03.2025.

- Wang, Y., Hua, X., Shi, X. & Wang, C.** (2022). Origin, Evolution, and Research Development of Donkeys. *Genes (Basel)*, 13(11), 1945. doi: 10.3390/genes13111945.
- Wang, C., Li, H., Guo, Y., Huang, J. & Sun, Y.** (2020). Donkey genomes provide new insights into domestication and selection for coat color. *Nat Commun*, 11(1), 6014. doi: 10.1038/s41467-020-19813-7.
- Yilmaz, O., Boztepe, S. & Ertugrul, M.** (2012). The domesticated donkey: 2 types of breeds. *Can. J. appl. Sci.*, 2, 260 - 266. doi: 10.21065/19257430.81.2.
- Zhang, Z., Huang, B., Wang, Y., Zhu, M. & Wang, C.** (2022). Dynamic alterations in the donkey fecal bacteria community and metabolome characteristics during gestation. *Front. Microbiol.*, 13, 927561. doi: 10.3389/fmicb.2022.927561.
- Zhang, Z., Huang, B., Wang, Y., Zhu, M., Liu, G. & Wang, C.** (2023). A survey report on the donkey original breeding farms in China: Current aspects and future prospective. *Front. Vet. Sci.*, 10, 1126138. doi: 10.3389/fvets.2023.1126138.

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