



Donkey *Equus asinus* morphometry, health and uses in Veracruz, Mexico



Bernardo Alberto López-Yáñez ^a

Juan Manuel Pinos-Rodríguez ^a

Patricia Devezé-Murillo ^{a*}

Fabián Francisco Vanoye-Lara ^a

^a Universidad Veracruzana. Facultad de Medicina Veterinaria y Zootecnia. Miguel Ángel de Quevedo S/N esquina Yáñez, Veracruz, Ver., México.

*Corresponding author: pdeveze@uv.mx

Abstract:

Donkeys *Equus asinus* are very important in rural Mexican communities for their utility as transport and pack animals. Morphometric and health data were collected for donkeys in a rural municipality in central Veracruz state, Mexico. A participatory workshop on donkey care and use was held with owner families to establish how they cared for their animals, and social perceptions of them. A total of 200 adult donkeys from 200 families were sampled. Morphometric measurements were taken, blood samples taken for hematology analyses, and feces for parasitology. Donkey morphometric data placed them in the small to medium standard size. Average age was six years, and body condition and weight were acceptable. Two thirds of the sampled donkeys had a medium-low parasite load, and all had hematological data within reference indices for healthy animals. Average daily use of the donkeys was six hours, and they were most commonly used for hauling.

Key words: Well-being, Equids, Body condition, Participatory workshop.

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Introduction

In Mexico and other countries around the world, the donkey *Equus asinus* is an example of animal power compatible with sustainable technology in rural work and transport^(1,2). Donkey care and use differ regionally in response to environment and social perceptions. For instance, donkeys in Mexico have been subject to an empirical selection process by the largely indigenous user population which created donkeys shorter than their European ancestors but similar in height to African donkeys⁽³⁾. In Asia and Latin America, they are mainly used as pack animals in family and commercial uses⁽⁴⁾. Their ability to work on small farms at low costs has led to their worldwide use in dryland agriculture, even in areas where they are used for other ends^(1,5,6). They are generally the cheapest option when replacing other equines in agricultural and livestock activities⁽⁵⁾. In Africa, they are frequently used by women in firewood collection and water transport⁽⁷⁾. Their docility, ease of handling, learning capacity, drought and disease tolerance, and relatively low cost compared to other working species make them important assets in lower socioeconomic groups^(1,7). Widely used because of their versatility as pack or hauling animals, to plow land, and as a food source, donkeys are now even used in therapies for handicapped children^(8,9). In many cultures, the lower socioeconomic groups that prefer donkeys may not properly care for them, undermining a portion of their productive potential^(3,10). This energy loss can be equivalent to approximately 1/3 horsepower per donkey⁽¹¹⁾.

Donkeys were introduced to the Americas by Fray Juan de Zumárraga with the intention of providing indigenous peoples a means of cargo transport and locomotion in farm work⁽⁴⁾. In Mexico, they have been present since shortly after European contact. They were imported for producing the mules needed in mining activities, particularly in silver mines in central Mexico⁽¹²⁾. The specific needs of the time may be one reason why donkeys in Mexico differ from the larger Spanish breeds⁽¹³⁾. This difference may also stem from the fact that Mexican donkeys originated in both European and African breeds⁽¹⁴⁾.

Most common in rural Mexican communities, donkeys are used for their strength, to transport supplies to farming parcels, or to assist in extraction, storage or sale of farm production. They are also used in livestock production to support milking, and for water and milk transport. Their domestic functions include transporting water, firewood, clothes

for washing, children to school, food to farming parcels, etc.⁽⁹⁾. In the State of Veracruz, Mexico, donkeys are most frequent in the center and north of the state⁽¹⁴⁾. Here they are used as work animals, but not in the same activities as oxen, horses and mules⁽⁷⁾. They complement activities more common in rural areas far from developed areas, although they can still be found in poor suburban areas⁽¹⁵⁾. Little data has been published on the morphology, health, use and social perceptions of donkeys in general, and even less so in Mexico. The present study objective was to generate much needed data on these aspects to contribute to a more complete understanding of *E. asinus*' condition and role in Mexico.

Material and methods

The study area was the municipality of Paso de Ovejas, Veracruz, Mexico, located between the coastal plain and the Sierra Madre Oriental mountain range (19°17' N, 96°26' W; 40 - 300 m asl). The region is semiarid with cambisol and vertisol soils, a warm-regular climate with 25 °C average annual temperature and 900 to 1,500 mm annual rainfall. Most (65 %) of the municipality's surface area is used for agriculture and livestock production.

The sample consisted of 200 families and 200 donkeys in Paso de Ovejas. Participatory research techniques were used. These initiated with informal interviews addressing employment, donkey care and use, socioeconomic factors, priority ranges, and a calendar of activities. Direct observation helped to corroborate part of the data generated with the tests^(16,17,18). Donkey morphological, physiological, management, and agricultural and domestic activity data were collected.

Zoometric measurements

Following established protocols^(19,20,21), zoometric measurements were taken of 200 healthy donkeys older than 2 yr of age using a 150 cm measuring tape and a 170 cm graduated height measuring rod. Height was measured with the animal standing on a flat surface, from the ground surface to the highest point of the withers and the head, in a normal position. Body length was measured using the olecranon at the elbow and the ischial tuberosity of the pelvis as reference points. Thoracic perimeter was measured at a point about 10 cm behind the elbow. Live weight was recorded with a portable electronic large animal scale.

Body condition was scored on a 1-9 scale⁽²⁰⁾: 1 emaciated, 2 very thin, 3 thin, 4 less than moderate, 5 moderate, 6 more than moderate, 7 less fat, 8 fat, and 9 is obese.

Age was estimated applying the technique used to measure dental emergence, wear and deformation in horses, as modified for donkeys⁽²²⁾. Coat color was described using two scales: dark and light tones; and specific colors. Sex was recorded, and general health condition described with physiological constants used to clinically establish an apparently healthy status⁽²³⁾.

Blood and coproparasitological analyses

Blood samples were taken by jugular puncture using vacuum tubes with anticoagulant (EDTA). These were processed with an automatic analyzer (Cell-Dyn Emerald, Abbott, Illinois, USA). Stool samples were collected directly from the rectum of each animal and processed by the flotation technique to identify parasite eggs with a microscope⁽²⁴⁾.

Participatory workshop and questionnaire

Participatory workshops based on the methodology of McCracken and Anderson⁽¹⁶⁾ were held with the families owning the donkeys. These analyzed their perception of their donkey's value in their daily activities. Value range tests were done for agricultural and livestock activities. The animals were ranked based on their economic and social value. A record was made of use times and values for the main activities, both agricultural and rural activities, for both the producers and the donkey. Daily and annual activities schedules were also generated. The data was entered into Excel (ver. 7.0) and analyzed with the Statistica 5.1 M '98 Edition program.

Results

Donkeys were classified as apparently healthy based on normal mucous membrane color and physiological constants within normal ranges considering that they had been engaged in hauling or other work of varying intensity. Rejected animals had physiological constants outside of normal post-work ranges; they classified as healthy, but not at levels suitable for

study inclusion⁽²⁵⁾.

Although most were unshod, all accepted animals had normally-shaped hooves that were apparently healthy. The animals' outer coat was normal, with most having short, shiny hair.

Of the total number of sampled donkeys (n= 200), most were males (79 % vs 21% females). Recorded morphometric traits included height, body length, weight, body condition, age and coat color. Average height was 112.62 ± 5.63 cm, with a 93 cm minimum and 127 cm maximum. Within the international donkey size classification, the sampled animals were of standard size, within the small standard and medium standard subgroups (Table 1).

Table 1: Donkey morphometry (n= 200)

Variables	Average	SD
Height, cm	112.6	5.63
Thoracic perimeter, cm	121.2	7.83
Length, cm	99.8	6.95
Weight (males), kg	152.0	31.64
Weight (females), kg	147.0	33.96
Overall weight, kg	151.4	29.93
Age, years	6.0	2.51
Body condition (1-9)	5.2	1.30

Mean age as estimated by dentition was 6 yr, and ranged from 2 to 19 yr. Donkeys in the studied region are normally retired from work at 10 to 12 yr of age, much younger than the average retirement for European donkeys, which can reach ages greater than 24 yr. Donkey working age is 5 to 15 yr, beginning at maturity (based on osteo-muscular development) and ending when chewing becomes difficult due to dental wear; the latter can be accelerated by foraging conditions.

Coat color (skin and hair) varied. Initial classification into dark and light colors identified most (60 %, n= 120) to be light in color and the remaining 80 (40 %) animals to be dark. Six color categories were observed: 7 (3.5 %) were black; 99 (49.5 %) brown; 65 (32.5 %) grey; 24 (12 %) cream; 3 (1.5 %) pinto, and 2 (1 %) of undefined color.

Health condition

The surveyed owners stated that only some of their animals had been dewormed in the previous year, and none remembered the product used (suggesting that the animals had not

been dewormed previously). However, the clinical and coproparasite examination identified no cases of severe parasitosis.

Owners kept no vaccination records, although some engaged in livestock activities stated they had applied leftover vaccines (paralytic rabies and triple) to their donkeys.

Mucous membrane color was normal and physiological constants were within normal ranges, even in animals rejected from the sample due to overexertion the day of sample collection.

Hematology

The variables selected to quantify health status were red blood cell count (erythrocytes, hemoglobin and hematocrit) and white blood cell count (leukocytes). Red blood cell counts below the mean indicate general anemic conditions, while counts above the mean indicate dehydration. Based on reference values (normal= 5 to 9.5 million/ml), some healthy donkeys had values qualifying as anemia (3.97 M/ml), though no cases of hemoconcentration or dehydration were observed (Table 2). Normal reference values for hemoglobin levels are 10 to 14 g/dL⁽²⁶⁾. Mean hemoglobin level in the present results was 12.64, perhaps because some samples had been collected when the donkey had just returned from work. Only 17 % of the sampled donkeys exhibited hemoglobin levels above 10 to 14 g/dL⁽²⁶⁾, indicative of dehydration or intense exercise. Values below the minimum value in the literature can be considered a sign of slight anemia⁽²⁶⁾. Normal hematocrit values range from 37.7 to 53.7 %⁽²⁶⁾. Most (75 %) of the sampled donkeys had levels below this range, probably due to poor diets and because the study area is below 300 m asl.

Table 2: Blood analysis values in donkeys (n=200)

Blood Fractions	Value			
	Minimum	Maximum	Mean	Reference values ¹
Erythrocytes, x10 ¹² /L	3.9	9.3	5.9	5.5 (4.4-7.1)
Hemoglobin, g/L	8.9	20.2	11.8	11 (8.9-14.7)
Hematocrit, %	23.2	56.4	32.8	33 (27-42)
Leukocytes, 10 ⁹ /L	2.6	21.4	9.9	10 (6.2-15)

¹ Modified from: The Donkey Sanctuary⁽²⁷⁾.

Parasitology

Equines are susceptible to parasitism. The resulting reductions in productivity can lead to economic losses, and gastrointestinal parasites can cause considerable damage and even animal death⁽²⁸⁾. Of the 200 donkeys sampled, no parasite eggs (*Trichostrongilus*, *Strongylus*, *Parascarius* and *Oxiurus* genera) per gram of feces were detected in 35.5 %, 14.5 % had 1 to 4 eggs, 27 % had 5 to 9 eggs, 4.5 % had 10 to 14 eggs and 18.5 % had 15+ eggs. This suggests that only 23 % of the donkeys had high levels of these gastrointestinal parasite genera. The generally low parasitosis in most (77 %) of the animals may be a product of their ingesting papaya leaf, which contains papain, a proteolytic enzyme known to effect parasites' attachment hooks⁽²⁹⁾.

Donkey work activities

Data on donkey work activities was collected through direct observation: weighing of loads (water tanks, sand, and firewood), papaya production cultivation activities, equipment, etc. Key informants also provided information on load capacities and the reasons for donkey activities. The studied donkeys were used only for carrying loads and transporting people (Table 3). They were not directly used in agricultural or livestock work, in contrast to other solipeds (mules and horses) which were used to pull plows, herd cattle, etc. The most important accessories when using the donkeys were the pack saddle, a wood, chair-like structure to which loads and gear are attached by ropes; metal tanks for transporting water and sand; jute sacks for loose loads; baskets; milk pots; agricultural gear (plough, sprayer, hoe, machete, etc.).

Table 3: Loads, duration and distances involved in work by donkeys

Activity	Weight (kg)	Period	Time (h/d)	Distance (km)
Agricultural:				
Irrigation water (<i>burreo</i>)	110	Dry	6	1
Plowing	32	Preplanting	2	5
Fruit and grains	140	Harvest	8	5
Stubble	60	Postharvest	2	5
Domestic:				
Water	110	Daily	2	2
Fuel wood	100	Fortnightly	8	5
Clothes for washing	20	Weekly	1	2
Diverse materials	140	Occasional	6	3

Includes weight of pack saddle and ropes. Distances and time are cumulative. Although no work load was carried for half the work day, owners rode donkeys when there was no load.

Water tanks were used in both domestic and agricultural activities. Transport of domestic water supplies represents between 300 and 900 h annually to provide approximately 200 L water daily. The round-trip journey is approximately 2 km, and two trips are usually made a day, resulting in 4 km per day for domestic water transport. Annually, that represents more than 1,100 km traveled for domestic water transport.

The most intense carrying activity occurs during what is known locally as *burreo*, when donkeys are used to carry water to irrigate papaya crops. Done during the months following transplanting (April to June), it is no longer required once the rainy season begins. Papaya plants need 1 L water per plant every third day, and planting density is approximately 1,200 plants/ha. This equates to six trips in a day delivering approximately 110 L of water each trip, meaning a donkey walks 6 to 10 km/d and carries 600 L (i.e., 600 kg) of water. After the approximately sixty days of *burreo*, a donkey will have walked about 300 km and carried 24 t of water.

Donkeys are also important during the six to eight weeks of papaya harvest. Harvests are done weekly, and there are six to eight harvests per season. In a harvest day, a donkey can carry up to 80 kilos of papayas per basket, and there are two baskets per animal, meaning each load can be as much as 160 kilos. It then transports these for no more than 500 m, which requires approximately 30 min. During the six to seven hours (six effective hours) of a harvest day, a donkey will have made 12 trips loaded (approx. 2 t papaya) and travelled 12 km (six loaded and six unloaded). At the end of the harvest season, an animal will have carried 16 t of fruit and traveled about 100 km within the plot.

In fuel wood collection, loads are determined more by the distance travelled than weight or volume. Loads of 100 kg are common, although they can exceed 120 kg. Key informants commented that they must travel increasingly longer distances to gather wood, not to mention the added challenge of collecting in ravines and distant hills.

Other activities are complementary, but a donkey's total energy expenditure is high. It uses 300 h annually to travel 1,100 km, carrying average loads of 100+ kilograms. Cumulatively, the donkey thus contributes about 2,600 work hours annually, with an average of nearly 7 h work per day, and a total annual distance travelled of 2,600+ km with an average of 9 km per day. At medium speed (4 km h^{-1}), light donkeys (around 120 kg), exert a force equivalent to $0.15 \text{ kw h}^{-1(30)}$, in the donkeys studied here this would be equivalent to each donkey exerting 1.05 kw d^{-1} per day.

Donkeys are trained to work by the owner depending on individual requirements. Generally, training begins when they reach adult size, about 18 mo of age, with the intent of them beginning work at about 2 yr of age.

Care of donkeys

The most common practice in the region's communities is tie the donkey to a tree or post in the yard at night. They are fed grass and papaya leaves as fodder, the amount depending on the work they are doing. During the irrigation season (when the *burreo* technique is used), the normal feed is supplemented with a liter of corn, equivalent to approximately 600 g per day.

Supplementation with corn was documented in informant interviews and by direct observation. This was corroborated to establish the daily administration of a corn ration as a dietary standard. Most (83 %) of the owners provided corn (Table 4), and the amounts and resulting body condition did not differ between owners. Mean corn ration was $0.810 \pm 0.673 \text{ L d}^{-1}$ (range= 0 to 3 L). Considering that 1 L of corn weighs approximately 600 g, the weight equivalents are a mean ration of 0.5 kg d^{-1} , and a maximum of 1.5 kg d^{-1} .

Table 4. Care of donkeys (proportion of surveyed owners)

Housing	%
Unstabled (tied to post or tree)	97
Earth floor and palm roof	3
No feed or water trough	98
Feed trough	2
Feed	
Corn	83
Corn stover or cut grass	17
Daytime grazing	100
Nighttime grazing in plot (complementary)	12
Papaya leaves	80

Among the informants, donkey care is primarily the responsibility of the head of household. This remains the case as long as any children are young, but once they are old enough, they are expected to saddle and unsaddle it, as well as feed and water it.

Informants described a series of challenges when caring for their donkeys. The primary problem they perceived is a lack of veterinary services or their very high cost. Males are deemed to be very aggressive, but “castration is not an option since they lose the ability to work”. In contrast, poor general care means females have low productivity. Because of the low value assigned them, donkeys receive no specific care (e.g., limited feeding and seasonal scarcity), meaning only the strongest animals survive, especially in the dry season or during prolonged droughts. Finally, their hooves are not shod nor are their hooves cared for; when they cannot walk, they are set free to heal.

Reproduction

Based on informant interviews, donkey reproduction is fairly simple. When a female donkey enters into heat, a male is chosen to service her. Questions on the criteria used to decide between males were met with vague answers such as “because it was the one at hand” or “it was my friend’s”. However, direct observations suggest that the choice is made based on the height of the male or female donkey’s owner; in other words, owners prefer donkeys that complement their own height.

Social perceptions

In the study area, donkeys were commonly used by people engaged in agriculture and other rural activities. Before the municipal water system was built in Paso de Ovejas, they were essential to transport domestic water, regardless of a family's socioeconomic level or primary economic activity. Currently, only farmers and livestock producers own donkeys since the communities increasingly depend on external income from sources such as jobs and remittances from family members in the United States. When asked what they use their donkey for, a common response was "My husband needs it for work in the fields, my children take it to school and I need it to take clothes to the stream and for my children to bring water when the pump doesn't work." Apparently, the general perception is that the person who uses a donkey is the one who needs it most, based on established priorities.

Female donkeys are assigned less value than males. They were perceived as less efficient than males because they are not as strong, can only be used for six to eight months during pregnancy, and are not useable while nursing, slowing daily work. In contrast, their greater docility and relative strength are appreciated; they are considered on a par with castrated male donkeys.

Discussion

Donkey health as observed during data collection was the result of both environmental adaptation and owner care to keep their animals healthy and productive. In terms of the environment, the study area is located below 300 m asl, while owner care involved nutritionally deficient diets and minimal health care, especially compared to developed countries. Coat and body condition were used to provide some quantification of animal health. Overall, coat color and shine (skin and fur) indicated an adequate nutritional state, which was confirmed during different visits to the communities. Body condition scores were generally acceptable given that the studied donkeys were used for hard work. The average score was 5 (moderate), indicating that, despite the hard work and exertion, they received at least a minimum of attention and care; this score coincides with previous reports⁽²¹⁾. One animal scored at 2 had been overworked, while others scored 8 had had lower workloads prior to measurement.

On a global scale, donkeys are classified by size, although both morphometric and hematological variability are also considered. In the present study, all selected donkeys had a dentition-estimated age greater than two years, a criterion used to ensure that they were mature and had reached full height. Height varied from 93 to 127 cm, placing them in the small standard and medium standard worldwide donkey size groups. Body length ranged from 73 to 115 cm, but most fell between 103 and 115 cm. Thoracic perimeter also tended to concentrate within a certain range, with outlier values of 92 and 137 cm; these values coincide with previous reports⁽³⁰⁾. When these morphometric data were compared to the weight data, they were comparable to studies from other parts of the world^(20,31,32). The morphometric data and size classification of the studied donkeys open the possibility that they may be more African than European in origin.

Estimated age based on dentition indicated that approximately 80 % of the studied animals were of suitable work age, that is, 3 to 11 yr of age; very few animals were 12 yr of age or older. This suggests inadequate health care of donkeys in the study region, since it is common for them to reach 20 yr and reported maximum lifespan is 30+ yr⁽¹³⁾. Informant responses regarding this discrepancy consistently mentioned three reasons for not keeping older animals: “they no longer work as well and so we sell them”; “I sell it before it is old and I cannot sell it”; and “I do not have space to have one aging and another for replacement, so I sell the oldest and keep the young one”. The latter explains why so many females are sent to slaughter at early ages and why there were so few in the study area.

Laboratory tests confirmed the health status estimated by clinical examination. Samples were collected from apparently healthy animals with no clinical signs of dehydration. In terms of values reported in the literature, the average values here were near the minimum reported values, suggesting a tendency towards anemia. However, values in the literature are for healthy animals in developed countries with better nutritional conditions. Indeed, they are largely from altitudes higher than the range in the study area (300 m asl and lower), raising the possibility that the studied animals may exhibit a physiological adaptation to low altitudes.

Most (75 %) of the studied donkeys exhibited some degree of parasitism. This can be attributed to the poor care they receive, including feeding of corn and other forages directly on the ground and infrequent deworming. However, the use of papaya plant elements (seedlings, leaves, etc.) as a dietary input likely has a deworming effect since papain is known to soften endoparasite attachment appendages; indeed, green papayas are used as a sheep dewormer in Africa⁽²⁹⁾.

Conclusions and implications

Donkey use, handling and care are influenced by regional agriculture practices and cultural patterns. The morphometric and hematological data, as well as the degree of parasitism, correspond to animals raised in critical environmental situations. However, they are well adapted to regional needs, exhibiting complementary relationships between donkey characteristics and agricultural and/or family activities. The general health status observed here highlights the species' resistance and the presence of at least minimal care by owners. The low proportion of females in the studied donkey population could lead to a genetic bottleneck, negatively affecting species robusticity. This could easily be corrected if excess males were castrated and females were used rationally. The morphometric data placed the studied donkeys in the small standard and medium standard subgroups. Body condition results were generally above five, meaning they were well-nourished but subjected to constant work.

Conflict of interests

The authors declare no conflict of interest.

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