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RESEARCH

Improving working donkey (*Equus asinus*) welfare and management in Mali, West Africa

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Abstract Working conditions for cart donkeys in West Africa are often harsh. In collaboration with the Society for the Protection of Animals Abroad, we conducted 3 studies and a welfare assessment. In the first study, we compared behavioral and physiological measures of donkeys (n = 10) driven in 2 standard Malian ways (1 = halter and reins, 2 = no halter and with a stick). In a second study, we assessed pressure associated with harness and cart quality. Pressure was measured according to several different parameters, including type of harness (satisfactory or unsatisfactory), type of cart (satisfactory or unsatisfactory), and weight (no weight or 200 kg of weight). Because education likely plays an important role in enhancing working equid welfare, we conducted a third study aimed at educating paraprofessionals about donkey husbandry (n = 82). We also conducted a welfare assessment on a donkey population in Segou, Mali (n = 54). Among training methods, no significant difference was found in either heart rate variability or behavior. A significant difference in back/wither pressure ($P < 0.05$) was found for the following parameters: harness type ($P = 0.02$) and cart with weight ($P = 0.009$). The welfare assessment examined how body condition scores, age, number of lesions, scarring, lameness, behavior parameters, and dehydration were related. The results indicated a significant effect between body condition score and hydration, that is, donkeys with lower body conditions were often less hydrated ($P = 0.01$). The relationship of body condition was significant when comparing the behavioral response with the ear test ($P = 0.03$). Finally, educational workshops were conducted at 2 schools, one in Segou (n = 54 students) and one in Bamako (n = 28 students), to measure donkey management knowledge before and after a husbandry education seminar and practical demonstration were conducted. The average test scores for pre- and post-tests numerically increased at both schools. However, the increase in test scores was not significant (Segou $P = 0.15$ and Bamako $P = 0.06$). This study provides additional methods to professionals and paraprofessionals on alternative methods for training, harnessing, and working donkeys in developing parts of the world.

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Introduction

The Malian economy depends heavily on agriculture and animal husbandry (Diarra et al., 2007). Mali is considered 1 of the 10 most resource-poor countries, with the per capita gross domestic product averaging $420. Agriculture comprises 32.9% of the country's annual gross domestic product ($7.3 billion) and occupies more than 70% of the workforce. Small shareholder farmers dominate the agricultural sector, with subsistence farming of cereals, sorghum, millet, and maize covering more than 1.4 million hectares (3.4 million acres) (http://www.state.gov/r/pa/ei/bgn/2828.htm). The agricultural economy depends heavily on the donkey. Donkeys are used especially for traction (96%) and occasionally plowing (Diarra et al., 2007). They perform many duties, including transporting commodities and people to the market, hauling garbage, or simply carrying water and firewood (Diarra et al., 2007). In some cases, the poorest of farmers cannot afford a donkey and must rent 1 or work for someone who does own donkeys. Despite their importance, donkeys have received little attention in terms of welfare and management research (Starkey, 1994).

Worldwide, there are an estimated 52 million donkeys, mules, and hinnies (a hybrid offspring between a male horse [stallion] and female donkey [jenny], which is the reciprocal cross to that used to produce a mule); this is similar to the number of horses, which is estimated at 55 million (FAO, 2006). A majority of these animals are found in developing areas of the world (Herbert, 2006; Starkey and Starkey, 2000). Approximately 27 million working equids are found in Africa and nearly 2 million of these are Malian donkeys (Herbert, 2006; A. Doumbia, personal communication, 2008).

The donkey has increased in popularity in West Africa because of extended periods of drought that have made it harder to feed and care for oxen. However, many of the same implements once used for oxen are now being used with donkeys, and this has created problems such as oversized carts and improper harness (Starkey, 1994). Unfortunately, due to a myriad of problems, donkeys are often unable to work or unable to work at their potential. Diarra et al. (2007) reported that most donkeys receive little medical care and problems go largely untreated. The loss of a donkey or the time that a donkey cannot work creates many hardships for the people it serves.

Diarra et al. (2007) carried out a survey with more than 2,500 donkeys to identify reason(s) why donkeys cannot work. The survey indicated that most donkeys were equipped with poor harnesses (n = 2,033; 76%), traveled long distances (>20 km/d) (n = 2,086; 79%), worked many hours (>6 h/d, n = 1,782; 82%), carried/pulled loads weighing >500 kg (n = 1,344; 51%), and were provided with inadequate nutrition, as evidenced by low body condition scores (BCSs) (Diarra et al., 2007). Pearson et al. (1999) has also indicated a need for further understanding on donkey management and working practices (e.g., harnessing and training); furthermore, she indicates that problem areas can often be overcome through better training and education. For example, harsh training methods can be avoided when training donkeys to perform novel tasks ranging from crossing a tarp to pulling a cart (Heleski et al., 2008; McLean et al., in preparation). The decrease in harsh and abusive type training methods plus improved nutrient management has great potential to improve the welfare and longevity of working donkeys. The correct application of learning theory, such as appropriately using training techniques like negative reinforcement (e.g., applying pressure on the right driving rein and releasing the pressure when the donkey responds and turns right), that has been used by Heleski et al. (2008) could be taught to donkey owners/drivers. Correctly using a halter or bridle for driving may decrease the use of sticks and subsequent beating of donkeys, commonly observed in developing countries.

An earlier pilot study conducted with 10 donkeys in the United States showed that donkeys could be trained to pull a cart with only a halter and reins or a halter, reins, and a donkey motivator (a lunge whip or driving stick with plastic sheeting or a plastic bag attached to the end used to encourage the donkey to move). This earlier study was conducted in an attempt to identify alternative methods of driving donkeys compared with the traditional stick method observed in Mali. The motivator was shown to work effectively in previous studies to motivate the donkey to move forward without adverse affects (Heleski et al., 2008; McLean et al., in preparation). In the current study, we conducted 3 experiments and a welfare assessment. When examining how to train donkeys to pull carts, the hypothesis was that donkeys trained to drive with a halter and lines would exhibit less signs of behavioral and physiological stress (such as heart rate variability [HRV], decreased respiration rate, signs of fear and signs of bolting, or refusing to move when pulling the cart). Our second experiment focused on assessing another major problem affecting many working donkeys, inadequate harnesses and carts. We hypothesized that donkeys with a good-quality harness hitched to a well-balanced cart would have less pressure applied to their withers/back and therefore be subjected to fewer subsequent lesions of the withers/back. The third experiment focused on testing the donkey management knowledge of students enrolled in an agricultural preparatory high school and an agricultural college. We hypothesized that increasing education and awareness among paraprofessionals and professionals (e.g., "train the trainers" workshops) who work closely with donkeys and their owners would be important to improving working donkey welfare. In addition, a welfare assessment was conducted to measure current management practices and to assess the welfare of working donkeys in conjunction with a Society for the Protection of Animals Abroad (SPANA) monthly mobile clinic in Segou, Mali.

Materials and method

Assessing the driving method, halter versus stick, related to behavioral assessment, HRV, and pressure associated with harness and cart quality

Animals

Ten Malian donkeys owned by 2 owners and driven by 10 hired drivers were tested. Donkeys were driven with a halter and line(s) (HM) or only with a stick/donkey motivator (SM). Four donkeys (age, 8.6 years; all jacks) were driven in the HM manner and 6 (age, 9.25 years; all jacks) were driven in the SM manner. Any signs of scars and lesions were noted (Figures 1-3).

Methods

Before beginning the driving test, each donkey was given a behavioral assessment test. The following parameters were measured based on the donkey's overall physical appearance and its behavior toward the observer and surrounding environment. The position and expression of the ears, eyes, nostrils, nose, head, and tail were observed while conducting the behavioral examination when measuring these parameters: (1) general attitude (alert or apathetic, measured according to the general appearance of the donkey with regard to showing expression in the ears, eyes, nostrils, head, or tail before the observer approached the donkey), (2) response to observer approaching the donkey's neck (no response, friendly approach, avoidance, aggression, measured according to the reaction of the donkey to the observer approaching the left side of the donkey's neck, by evaluating the position of the head, neck, eyes, nostrils, nose, body, and tail), (3) walk around the donkey (no response, moves away, tucks tail, aggression, measured according to the reaction of the donkey to the observer walking first around the left side and then right side of the donkey but not touching the donkey), and (4) ear test (allows ear to be touched, tolerates, avoids ear touch, measured according to the response of the donkey's head, eyes, and position of the ears when the observer first touched the left ear of the donkey; if the donkey allowed touch and did not move away, it was scored as "allows ear to be touched"; if the donkey allowed the ear to be touched yet displayed signs of resistance such as positioning its head to the right, enlarged eyes, or displayed other signs of tension, then the reaction was graded as tolerates; a donkey that moved or shied away from the tactile experience was graded as avoids ear to be touched), (5) response to unfamiliar person (approaches, no

Figure 1 Halter method. Donkey is being driven with the halter method. The halter is the rope device placed around the donkey's head and nose. This is being used as a method to control and guide the donkey when pulling the cart.

Figure 2 Stick method. Donkey is being guided and driven with the stick method. The donkey moves away from the contact made by the stick.

Figure 3 Donkey motivator method. Donkey is being driven with no halter and the donkey motivator. The donkey motivator is a stick with a plastic bag tied to the end. It is a low-cost implement that can replace the stick. The donkey responds to the sound of the motivator and moves away versus moving away from the contact made by the traditional stick method.

approach, spooks, measured based on the donkey's reaction to the observer placing his/her hand in front of the donkey's lips). These assessments were adapted from previous work by Burns et al., 2009; and Pritchard et al., 2005.

After the behavioral assessment, each donkey was then fitted with a Polar Equine RS 800 G3 heart rate monitor (Polar Electro Europe BV, Fleurier, Switzerland). Ultrasound transmission gel (Aquasonic 100; Parker Laboratories, Inc., Fairfield, NJ) was applied to the girth and wither areas of the donkey, where the electrode strips of the heart rate monitors were placed. The heart rate was taken by the electrode strips (Polar Weblink; Polar Electro Europe BV) and then transmitted to the watch receiver (Polar Watch Receiver; Polar Electro Europe BV) attached on the left side of the donkey's halter, close to the throat latch. Heart rate data were then downloaded from the watch receiver by an infrared USB drive (IrDA USB; Polar Electro Europe BV). HRV parameters (square root of interval to interval, standard deviation from beat to beat interval, high frequency [parasympathetic tone], and low frequency [sympathetic tone]) were recorded to the software program (Polar Protrainer, 5; Polar Electro Europe BV).

Pressure film (extreme low pressure 4 LW Fujifilm, Tokyo, Japan), approximately 21 $\times$ 31 cm (0.5-2 kg/cm^2), was placed over the withers of the donkey, underneath where the harness back pad would be placed. The donkeys were then harnessed and hitched to their respective carts. Each donkey was then driven at a walk for 5 minutes by their respective driver and pulling their own cart with no additional weight added. The harness and cart were graded as satisfactory or unsatisfactory based upon criteria developed by the authors, along with information from Chadborn, 2008; Davis, 2008; Davis, 2006; and Jones, 2008 (Table 1). Some donkeys were equipped with double padding under the saddle/backband and this was noted. Pressure associated with donkeys pulling added weight (400 kg, eight 50-kg bags of corn were placed in the cart) versus pulling no weight in their cart was also measured. When the donkeys were finished driving, the harness was removed and the film was photographed; labeled right, left, and front; and then removed. After returning to the United States, the film was scanned (Imager Scanner II; Amersham Bioscience, Piscataway, NJ) and analyzed for intensity of the dots by using ImageQuant TL Software (Amersham Bioscience, Piscataway, NJ). Film was photographed as a precautionary step because it was not known how the high temperatures and humidity would affect image stability.

Welfare assessment of donkeys in Segou, a representative village in Mali with a large working donkey population

Survey protocol

A welfare assessment was held in Segou in conjunction with a monthly scheduled SPANA mobile veterinary clinic at the Ecole Secondaire Agropastorale (ESAP), a technical school for teenaged students studying agriculture. The clinics are held traditionally on market day, so donkey owners are already coming to town and SPANA can serve the most owners at once. The assessment was taken during the clinic to record the number of donkeys that were being driven with halters versus driven with sticks, donkeys' BCSs (1-5; Donkey Body Condition Score Chart UK, www.thedonkeysanctuary.org.uk), color, sex, age, branded or not, with or without lesions/lacerations, severity of lesions/lacerations (superficial, subcutaneous, severe/bone or multiple layers of tissue showing), location of lesions/lacerations, location of scarring and lameness (0 = sound, 1 = irregular gait, 2 = not bearing weight on limb), and hydration status (scored based on a skin tent test on the left side of the neck, 1 = hydrated, 2 = dehydrated). A behavioral assessment test was conducted as in the first experiment discussed previously. The Michigan State University Animal Care and Use Committee, East Lansing, MI, approved all experiments and testing procedures (number 04-09-067-00).

Testing paraprofessionals' knowledge and skills on donkey husbandry

Materials and methods

Two "train the trainer" sessions were conducted in Mali. The first session took place in Segou at the ESAP. Fifty-four students (males = 45, females = 9) were included in

Table 1 Description of the parameters measured when testing pressure on the withers of the donkeys

Parameters	Satisfactory	Unsatisfactory
Harness quality	Soft nonabrasive material for the back padding and collar	Abrasive material for back padding and/or collar
Cart quality	Balanced shafts, shafts that came to the point of the donkey's shoulder, inflated tires, and balanced over the axle	One or more of the following problems: uneven/unbalanced shafts, shafts that were shorter than the point of the donkey's shoulder, flat tire(s), unbalanced over axle (placing a majority of the weight on the shafts)
	No weight	Weight
Cartload	No weight	400 kg of weight (bagged maize, each bag weighed 50 kg, 8 were loaded in the center of the carts)

the study and varied in their level of study from first-year to fourth-year students. Each student was given a preassessment examination about donkey management and welfare. The test questions were written and also read aloud in French. The questions were accompanied by photographs of donkeys in different management situations, such as different BCSs or different types of forage that a donkey should consume. A 45-minute seminar was then presented to the students and translated into French by a local translator. Our translator, B.D., is an animal science professor at the Rural Polytechnic Institute for Training and Applied Research of Katibougou, University of Mali. A 30-minute hands-on demonstration was conducted after the seminar. The students were shown how to tell the donkey's age, how to correctly use methods of restraint, how to identify parts of the hooves, how to clean the hoof, importance of grooming and cleaning the area where the harness is placed, and how to properly harness and hitch a donkey. The students were then retested with the same examination. After completing the session, each student was presented with a certificate of completion.

A second instructional session was conducted at the Higher Institute of Training and Applied Research (ISFRA), University of Mali, Bamako, Mali, with 28 college students (27 = males, 1 = female) enrolled in the animal science program. These students were given a longer preassessment examination before the presentation. The presentation was prepared in French and verbally translated by Professor B.D. A 30-minute hands-on harness training and practical demonstration was conducted after the seminar. The students at the college were shown how to age donkeys (by viewing their teeth), restraint methods, how to pick up and clean a hoof, importance of cleaning the back and belly of the donkey before harnessing, and how to use the donkey motivator, as well as given instructions on hitching and cart design. Heart rate of the donkey (Polar Equine RS800 G3; Polar Electro Europe BV) was recorded during the harness and driving demonstration. The students were then shown the HRV results after the driving demonstration. Finally, the students were retested with the earlier examination. These students also received certificates of completion at the end of the day's sessions. At both schools, students were allowed a question and answer period. Also, each student received a copy of the *Basic Husbandry Manual for Donkeys*, written by the authors, which had been translated into French.

Statistical analysis

The logistic regression model (PROC GLIMMIX SAS 9.2, SAS Institute, Cary, NC) was used for statistical analysis to model the relationship between various behaviors and driving treatment (HM or SM). The analysis of variance model was used when testing the relationship between treatment and HRV data. Normality of the residual and equal residual variance assumption was checked. The logistic regression model was used when testing the pressure data in relation to the type of harness, cart, and weight. The average intensity was the predicted variable. The Pearson correlation coefficient was used to test BCS and age. The logistic regression model was used to test the relationship between BCS and age, sex, lameness, scarring, hydration, color, and lesions. BCS, behavior responses, and hydration correlation were tested using logistic regression model (PROC GLIMMIX v9.2, SAS). The mean and standard deviation were obtained for each sex and variable: age, brand, BCS, number of lesions, and number of scars. A generalized linear model approach (PROC GLIMMIX v9.2, SAS) was used to determine the significant effects of BCS, age, and hydration in relation to general attitude, response to unfamiliar people, and ear test. Normal probability plot and Shapiro–Wilk test were used to test normality for the examinations administered at both schools. Because the scores were not normally distributed, Wilcoxon signed rank test was used to test the difference in scores in the 2 schools. The P value for significance was 0.05.

Results

Effect of behavioral responses among driving treatment groups

When measuring behavioral responses for group HM ($n = 6$) and group SM ($n = 4$), the results indicated that there was no significant difference in treatment effect for all behaviors (Table 2).

Effect on HRV among driving treatment groups (HM vs. SM)

Heart rates were recorded on the day of testing at the SPANA clinic in Bamako, Mali. The donkeys had been either trained to drive with the halter method (HM group) or with the stick method (SM group). There was no significant difference in HRV parameters for either group (Table 3). However, baseline heart rates could not be taken

Table 2 Behavioral response mean for group HM (n = 6) and group SM (n = 4) in Malian donkeys at the SPANA clinic in Bamako, Mali

Behavioral response	Mean for group A	Mean for group B	*P* value
To unfamiliar person	0.83	1.5	0.94
General attitude	1	1.5	0.97
To observer approaching neck	0	0.5	0.97
Ear test	1	1.25	0.97

HM, donkeys driven with a halter and line(s); SM, donkeys driven only with a stick/donkey motivator; SPANA, Society for the Protection of Animals Abroad.

Table 3 HRV responses for donkeys (n = 10) in HM group or SM group on test day at the SPANA clinic in Bamako, Mali, West Africa (significant at $P < 0.05$)

Group	MHR (bpm)[a]	SDRR (ms)[b]	rMSSD (ms)[c]	LF (n.u.)[d]	HF (n.u.)[e]
HM group (n = 6)	73 ± 4.04	176.41 ± 42.50	60.43 ± 32.82	2,078.14 ± 1,476.88	1,377.14 ± 1,568.50
SM group (n = 4)	71.75 ±9.87	198.4 ± 86.03	63.52 ± 7.74	1,420.92 ± 958.18	1,019.04 ± 515.91
P value	0.81	0.64	0.49	0.45	0.84

HRV, heart rate variability.

[a]Mean heart rate in beats per minute (MHR, bpm). The average beat to beat per minute over a period reflecting both sympathetic and parasympathetic nerve activity/responses (von Borrell et al., 2007; Rietmann et al., 2004; Visser et al., 2002).

[b]Standard deviation from beat interval to interval (SDRR) is used to quantify the overall heart rate variability (von Borrell et al., 2007; Rietmann et al., 2004; Visser et al., 2002).

[c]Square root of mean beat interval to interval (rMSSD). rMSSD reflects short-term variations in heart rate related to parasympathetic nervous responses, for example, breathing, physical activity (von Borrell et al., 2007; Rietmann et al., 2004; Visser et al., 2002).

[d]Low frequency in normalized units (LF, n.u.) measures the sympathetic nerve response/tone (von Borrell et al., 2007; Rietmann et al., 2004; Visser et al., 2002).

[e]High frequency in normalized units (HF, n.u.) measures vagal activity (parasympathetic activity) such as breathing or stress. A positive emotion can increase HF or negative emotion can decrease HF (von Borrell et al., 2007; Rietmann et al., 2004; Visser et al., 2002).

before the donkeys were unhitched and rehitched to the cart.

Testing back and wither pressure associated with harness and cart quality in working donkeys

A significant difference was found when measuring the average intensity of pressure placed on the donkeys' withers when equipped with unsatisfactory quality harness and carts with 400+ kg of weight (harness type: average intensity for satisfactory harness = 97.3 kg/cm^2 compared with unsatisfactory = 113.2 kg/cm^2; $P = 0.02$, no weight had an average intensity of 93.4 kg/cm^2 compared with 400 kg of added weight = 111.2 kg/cm^2; $P = 0.009$). Unsatisfactory quality harness and heavier loads resulted in increased pressure, as verified by the Fuji pressure film. There was no significant difference in average pressure intensity when testing extra back pad padding or type of cart (satisfactory vs. unsatisfactory) (extra padding: $P = 0.23$, cart type: $P = 0.27$) (Table 4, Figures 4 and 5).

Assessment results of general condition of working donkeys in Segou

During the welfare assessment, we recorded many conditions related to donkey welfare, such as the donkey's age, BCS, coat color, hydration status, number of lesions, scars, and lameness. For each donkey, a behavior assessment test examining its general attitude, response to an unfamiliar person, response to the observer walking around the donkey, and an ear test was conducted (Table 5). In general, most donkeys appeared alert (44/46), 25 approached the unfamiliar person (9/54 did not and 20/54 were spooked), and 34 allowed their ears to be touched during the ear test (12/53 tolerated touch and 7/53 avoided their ears being touched). When examining age in relation to behavioral responses, there was no correlation among general attitude ($P = 0.49$), response to an unfamiliar person ($P = 0.56$), and the ear test ($P = 0.60$). There was no correlation to BCS and behavioral responses, with the exception of the ear test ($P = 0.03$, Table 5). The higher the BCS; the more resistance was seen when touching the ear.

Table 4 Comparing average intensity of Fuji pressure film (kg/cm^2) when testing harness and cart type, cart with/without added weight (400 kg), and extra saddle padding over the withers with Malian donkeys at the SPANA clinic in Bamako, Mali

Variable	Mean satisfactory	Mean unsatisfactory	*P* value
Harness type	97.3	113.2	
n	4	1	0.02[a]
Cart type	103.3	110.9	
n	9	6	0.27
	n = no weight	n = weight	
Cart with weight	93.4	111.2	
n	3	2	0.009[a]
	n = no extra padding	n = extra padding	
Extra saddle padding	105.7	114.6	
n	6	4	0.23

[a]Significant at $P < 0.05$.

Figure 4 Extreme low pressure 4 LW Fujifilm showing low-intensity results. This film was used with a good cart and harness. The film shows very little pink coloration. The pink color is a response to pressure placed on the film. The less pink indicates less pressure placed on the withers and back of the donkey. This film sample is from a donkey equipped with good harness and a good cart.

The mean and standard deviation were calculated for BCS, age (years), and hydration status. In general, most donkeys were considered thin (BCS: 2.3 ± 0.70, n = 41), averaged 6.9 ± 3.9 years of age (n = 53), and were considered to be hydrated (1.29 ± 0.46, n = 44; 1 = hydrated, 2 = dehydrated). When comparing the relationship of hydration to age and BCS, there was no significant effect when comparing hydration status with age ($P = 0.07$), but there was a significant effect when comparing hydration status and BCS ($P = 0.01$). The results indicated that donkeys that were in better body condition tended to be less dehydrated than those that were thinner. When testing the relationship between the BCS and hydration, the results suggested it was more likely for a donkey with BCS 1 to be dehydrated than hydrated (95% confidence interval for

Figure 5 Extreme low pressure 4 LW Fujifilm showing higher-intensity results. This film was used with a cart with 400 kg of maize (corn) loaded on it. The film shows pink concentrated in the front, near the withers.

the odds ratio: 0.013, 0.623, $P = 0.01$). When comparing the relationship between BCSs and age, sex, lameness, scarring, color, and lesions, there were no significant effects.

The results suggest that there may be a relationship between age and hydration, but it is not a significant effect ($P = 0.07$).

Measuring current donkey management knowledge among paraprofessionals

The pre- and postexamination results from both schools, the ISFRA (in Bamako) and at the ESAP (in Segou), did not show a significant increase in test scores, even though there was a numerical increase in each case. The average examination scores did numerically improve (ESAP: pre-examination average = 80.72, postexamination average = 84.18; ISFRA: pre-examination average = 88.11, post-examination average = 92.70). In Segou, the test scores were not normally distributed, and when using the Wilcoxon signed rank test, there was no significant improvement in test scores ($P = 0.15$). The distribution of test scores was normally distributed at the ISFRA annex in Bamako. When using the *t* test, the increase in average test scores at the annex did not significantly increase when using the significance level at 0.05 ($P = 0.06$).

Discussion

Effect of behavioral responses among treatment groups

We had expected to see greater differences in behavioral responses between donkeys driven with the halter method (HM) versus donkeys driven with the stick method (SM). However, it should be noted that only 2 individuals owned the donkeys used in this training study (n = 10) and these owners hired drivers for each donkey. These donkeys were in good physical condition, as compared with the general Bamako population, and no lesion or scarring was observed. It is possible that this population was above average in care and physical condition and subsequently indicated less signs of behavioral stress associated with either treatment.

Effect on HRV among driving treatment groups (HM vs. SM)

Some researchers have claimed that monitoring and identifying stress in equines can be difficult to assess (Herd, 1991; Miller, 2001). The difficulties arise in measuring the response in several physiological systems, for example, neuroendocrine and cardiovascular systems, along with behavioral responses. Stress can be defined as a threat, real or

Table 5 Relationship between mean BCS compared with mean behavioral responses, age, and hydration of donkeys in Segou survey held at the Ecole Secondaire Agropastorale School and SPANA mobile clinic

Values	BCS[a]	General attitude[b]	Ear test[c]	Response to unfamiliar person[d]	Age[e]	Hydration[f]
Mean	2.3 ± 0.7	1.1 ± 0.3	1.5 ± 0.7	2.3 ± 0.7	6.9 ± 3.9	1.3 ± 0.4
n	41	46	53	54	53	44
P value		0.78	0.03[g]	0.81	0.13	0.01[g]

[a]BCS, body condition score (1 [thin] to 5 [fat]; Donkey Sanctuary, 2007).
[b]General attitude: alert (1) or apathetic (2).
[c]Ear test: allows touch (1), tolerates (2), avoids (3).
[d]Response to unfamiliar person: no approach (0), approaches (1), spooks (2), aggression (3).
[e]Age (years).
[f]Hydration status: hydrated (1) or dehydrated (2).
[g]Significant at $P < 0.05$.

implied, to the psychological or physiological integrity of an animal (McEwen, 1999). Animals dealing with stressors exert behaviors known as "coping" behaviors, but when an animal can no longer cope with the stressor, then stress-related behaviors and problems are often exhibited (Stauffacher, 1992). If an animal is stressed for a long period, then the sympathetic nervous system along with chronically elevated or depressed adrenocortical functions can become harmful to the animal (Keeling and Jensen, 2002). HRV can provide more information of both individual stress and the magnitude of an actual stress response (Porges, 1995). Our study suggested that no significant differences were found in HRV when looking at standard deviation from beat to beat interval, the square root of interval to interval, high frequency (parasympathetic tone), or low frequency (sympathetic tone) when comparing 2 different training methods, HM versus SM. Several studies have shown a decrease in HRV in horses during exercise on a treadmill (Thayer et al., 1997; Physick-Sheard et al., 2000; Voss et al., 2002). Because our study was measuring heart rate during exercise, this could have reduced the HRV. Also, it is possible that a difference may have been noticed in these parameters if taken over multiple sampling periods and, ideally, had we taken fully resting heart rates. Researchers have shown that heart rate can vary according to diurnal variations (morning vs. afternoon), environmental conditions (e.g., ambient temperature, relative humidity, and wind speed), physical conditions of the donkey (e.g., age, breed, nutrition status), and fatigue (Ayo et al., 2008; Matthews et al., 1998; Minka and Ayo, 2007; Yousef and Dill, 1969). Ayo et al. (2008) indicated that donkeys in Nigeria during the rainy season had a mean resting heart rate of 36-72 bpm over a 10-hour period. The peak in heart rate was noted at around 3 PM (Ayo et al., 2008). Ayo et al. (2008) reported the temperature varied from 34.7 °C to 38.7 °C and the relative humidity was 76.0% at 3 PM. The conditions in the Ayo et al. (2008) study were similar to the conditions in this study, at 2 PM, 32.7 °C temperature and 89% humidity, with the exception of measuring the heart rate while donkeys were exercising. Minka and Ayo (2007) reported the mean heart rates for donkeys (n = 10) after packing 93.9 ± 1.5 kg for 19.1 ± 0.6 km to be 71.0 ± 3.4 bpm. Our study recorded similar mean heart rates for donkeys exercising at 2 PM, 73 ± 4.04 (HM group) and 71.75 ± 9.87 (SM group) bpm.

Another factor when comparing the different driving treatments (HM vs. SM) with HRV was that the donkeys used for this test were in good physical condition as compared with many of the other working donkeys we observed in Mali. More variations in HRV may have been seen in the SM group if application of the stick was used differently. Traditionally, it is not uncommon to see drivers hitting the donkeys with the stick repeatedly, which often leads to lesions. However, what we observed with our SM group was the drivers often waved the stick over the hindquarter of the donkey to encourage him to move forward and contact was avoided. Although several possibilities exist, it is likely that the drivers did not want to actually hit the donkeys while we, the researchers, were watching. It is possible that testing more donkeys from a broader background over several sampling periods may have shown more differences in HRV. Further studies looking at HRV as an indicator of stress should consider the donkey's conditioning history as well as monitoring fatigue. Matthews et al. (1998) examined the physiological response of donkeys driving in a hot (29 °C-34 °C) and humid climate and the effect of conditioning. They found that the heart rate while working after a month of conditioning was lower.

Pressure response of harness and cart quality on the withers of working donkeys

Harness development and design have long been a problem for working equids in developing parts of the world (Connan, 2008; Davis, 2006; Herbert, 2006). It is widely accepted that most debilitating injuries are due to poor harnesses (Davis, 2006). Many researchers have reported a high proportion of poor harnesses, which cause lesions and scarring, found among donkeys working in Africa (Chadborn, 2008; Diarra et al., 2007; Herbert, 2006;

Figure 6 Wither lesion caused by unsatisfactory harness and padding.

Pearson et al., 1999; Starkey, 1994). Veterinarians may treat as many as 60% of their total caseload that has been caused by ill-fitting or poorly constructed harnesses (Davis, 2008). Veterinarians are then left to make harness recommendations, and many claim that they lack the knowledge and/or time to properly do so (Davis, 2006). Davis (2008) claims that work production can be increased by 20%-25% with a properly fitting harness. Other work-related problems include the design of the cart, maintenance level of the tires, and weight of the load being carried by the donkey.

This study suggested that pressure is associated with the type of harness and weight carried by the donkey. Part of the mission of many organizations and researchers is to educate owners and drivers on how to properly harness working equid. During this study, the owners and drivers were shown the pressure film after each driving test as evidence of the pressure response to harness and cart type (Figures 4-6). In addition, this information was shared with students at both schools. Improving harnessing methods, such as padding used under the saddle of the harness, has the potential to decrease pressure applied on the withers and back, reduce the number of harness lesions, and increase the longevity of a working donkey. In addition, not overloading donkeys and maintaining the carts, such as by keeping the tires inflated, can also decrease pressure placed on the withers. Many researchers have engaged in harness-making workshops throughout Africa to show owners how to make affordable harnesses (Davis, 2008; Connan, 2008; Chadborn, 2008; Jones, 2008). Teaching veterinarians and paraprofessionals how to build low-cost harnesses as well as well-balanced and well-maintained carts has tremendous potential for enhancing the welfare of working equids. Part of this study examined the current knowledge of paraprofessionals and professionals in Mali on donkey management, including how to properly harness, train, and work donkeys. Future workshops and research should focus on these key individuals who can share the knowledge with many owners for years to come.

Table 6 Comparing survey data examining age, lesions, and lameness of working donkeys in Mali from 2007 (Diarra et al.) to 2010

Parameters	2007	2010	Difference
Age	2	6.9	+4.9 years
Lesions	9.9%	39.5%	+29.6%
Lameness	43%	16.9%	−26.1%

Welfare assessment of working donkeys in Segou

The assessment provided some insight into current management conditions of donkeys in the Segou area of Mali. When SPANA first began working in Mali, the average work life for a donkey was 2 years (A. Doumbia, personal communication, 2008). The mean age for donkeys in the Segou area during this study was 6.9 ± 3.9 years (Table 6, Figure 8). Therefore, it appears that through the efforts of SPANA's treatment and education programs, the longevity of the donkey may have increased. Diarra et al. (2007) found only 9.9% (n = 73 of 736) of the Malian donkeys to show signs of lesions, but this survey indicated 39.5% (n= 19 of 48) of the donkeys had lesions (Table 6). In terms of lameness, this survey indicated that 15% (n = 8 of 52) of the donkeys exhibited an irregularity in gait and 1.9% (n = 1 of 52) showed signs of not being able to bear any weight on a limb. Diarra et al. (2007) had found 43% (n = 320 of 736) of the donkeys to be lame (Table 6). It is possible that different measurements or definitions were applied when the 2 researchers (Diarra et al., 2007; current researcher McLean et al.) measured lameness (e.g., using a lameness score of 1-4 vs. lame or not lame scoring) as well as scored lesions differently (Table 6). The welfare assessment survey suggests that lameness has possibly decreased and the number of lesions has increased. This study also provided some insight into current donkey welfare, indicating that lower BCSs were often associated with donkeys that were dehydrated (Figure 7). BCS also had a significant effect on the behavioral test, ear touch. The donkeys with a BCS of 2 and mostly 3 avoided having their ears touched, whereas donkeys that scored a 1 allowed touch, possibly because of being in poorer shape and/or fatigued.

Measuring current donkey management knowledge among paraprofessionals

Starkey (1994) has reported an increase in the use of donkeys in sub-Saharan Africa in the last 10 years, but that there is a shortage of information relating to donkeys in this area. Diarra et al. (2007) also reported that many

Figure 7 Conducting behavioral assessment during the survey measuring the donkey's response to an unfamiliar person.

Figure 9 Teaching undergraduate students about donkey husbandry and methods of restraint without using inhumane techniques.

owners were unaware that donkeys could be treated for injuries or disease, or at least were unaware of the free treatment options at local SPANA clinics. To our knowledge, there is just 1 donkey science course taught at ISFRA in Bamako, Mali, by Dr. Amadou Doumbia, Director of SPANA, and this may be the only course taught throughout Mali, despite the prevalence of donkeys throughout the region (Figure 10). Dr. Doumbia and his SPANA team work on a monthly basis with ESAP, a secondary school in Segou, Mali. Thus, both populations of students we worked with and tested were more likely to be exposed to donkey husbandry knowledge than the average student enrolled in an institution in most developing countries (or elsewhere in Mali). Many groups advocate training owners on how to properly harness their donkeys as well as care for them. However, we believe reaching out to those who will continue to work as professionals and paraprofessionals has tremendous potential to reach out to even more owners versus concentrating efforts on only training owners. Based on the starting test scores of the 2 groups of students tested in this study, their baseline donkey knowledge appeared to be fairly high, and therefore, significant increases in test score averages were not seen. Nonetheless, students were enthusiastic about attending the seminars and the hands-on workshops and followed up with many excellent questions on the material. It is important to point out that very few women were enrolled in either school, and yet, women often work the donkeys. There was only 1 female student (out of 28) in the ISFRA training session and 9 (out of 54) at ESAP in Segou. The females at both schools had less practical knowledge than the male students, for example, the females could not tie a common knot referred to as a slip or safety knot, yet all of the male students knew how to do this (Figure 9). Therefore, reaching out to more women and children who are often responsible for working donkeys would likely be tremendously beneficial.

Figure 8 Examining the age of the donkeys during the survey. When the Society for the Protection of Animals Abroad first began work in Mali, the average donkey only lived for 2 years. The age has increased since to 7 years.

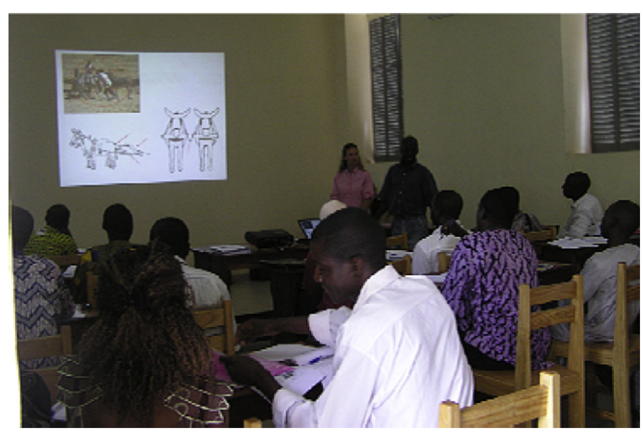

Figure 10 Teaching undergraduate students about donkey husbandry, including an in-class seminar and hands-on practical demonstration.

Conclusion

This multipart study examined several key areas that have the potential to improve overall working donkey welfare in developing parts of the world: (1) testing donkey driving methods and their relationship to donkey stress; (2) measuring pressure associated with harness, carts, and cartload; (3) surveying current conditions and assessing welfare of working donkeys in a representative village of Mali; and (4) implementing donkey management and welfare education in colleges and secondary schools in an effort to test the efficacy of "train-the-trainer" workshops. Improved training methods were explored as a post hoc treatment and as an example of an alternative to the use of the traditional stick. The adoption of the donkey motivator was well received by the SPANA veterinarians, drivers, and students at the 2 schools. Follow-up work to assess whether the motivator is still being used will be important.

This study, as with previous studies with working equids, showed that improved harnesses are greatly needed. The welfare assessment provided more insight about general donkey management and conditions in the Segou area. With regard to the final experiment, which assessed the knowledge of donkey management among agricultural and veterinary technical students, even though a significant difference in test scores was not shown at each school, the enthusiasm displayed by all involved indicated a keen interest in donkey management and welfare. Continuing to train those who will live and work in developing countries about working equids is vital to the well-being of working equids. These individuals have the potential to reach out to many donkey owners for many years.

Future implications

It is likely that donkeys will continue to be very important resources in developing parts of the world. Enhancing their welfare subsequently improves the well-being of the families that the donkeys provide for and should be emphasized. There is a severe lack of information on how best to implement proactive strategies for enhancing working equid welfare. New strategies and sharing of information can all be implemented with minimal or no cost increases to resource-poor donkey owners and drivers. Future nongovernmental organizations and research institutions should focus on training individuals who will continue to live and work in these developing countries. Adding curricula to secondary schools, agricultural colleges, and veterinary institutions on donkey husbandry and management could have a major impact on donkey welfare.

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