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Pulling capacity of Halari donkeys during carting in pneumatic wheel cart on pucca road

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Abstract
Two local donkeys of Halari breed, weighing 221.33±3.17 kg were used in carting to pull load equal to i) twice (x2) and ii) thrice (x3) their live weight including the weight of operator for three consecutive days. The carting was carried out for a total distance of 10 km in two stretches of 5 km each with a rest of 20 min between the two stretches. During work under carting, donkeys were under trot. All physiological indices (pulse rate (PR), respiration rate (RR) and rectal temperature (RT°C) increased significantly (p<0.05) after work and returned to normal by next morning. Donkeys carrying two times of their body weight were able to carry load without stress whereas under the three times of body weight load, donkeys were fatigued as indicated by biochemical indices and fatigue symptoms.

Keywords: Halari donkeys, physiological responses, hematological parameters, pay load

Introduction
The overall population of equids has drastically decreased during the last three decades in India, Livestock Census, (2019) [1]. As per Livestock Census 2019, the total number of horses and ponies in the country is 3.4 Lakhs, (45.6% lower than the previous Census, (2012) [2]. The total population of mules in the country is 84000, decreased by 57.1% over previous Census in 2012. The total population of donkeys in the country is 1.2 Lakhs, decreased by 61.23% over previous Census, 2012. In spite of mechanization of agriculture and allied fields, equids are being used for carrying pack load and carting. Donkey, being an excellent work animal, is mainly engaged in transport of goods over short distances. In India, donkeys are mainly used by brick kiln owners, potter men, shepherds, nomadic herders or dhobis (washer men) since they are more economical for short distances than other light transport vehicles. Donkeys are also used for draught purposes especially in carting works in planes of Rajasthan, Haryana, Gujarat and Uttar Pradesh states of India. They transport construction materials, food items, agricultural produce as well as agricultural inputs, and household items of nomads in addition to various other utilities. It is available at low price and can be maintained at low cost, thus making it an animal of choice for work amongst the poor people. Poorest of the poor, often use them extensively to earn a livelihood without caring for their health, providing meager quantity of feed and fodder, Pal *et al*., (2012) [3]. There is a lack of knowhow of wellbeing of the working animals amongst their owners, and many times, these animals are overloaded which attracts the welfare issues of animals, Pal *et al*. (2002) [4]; Pritchard *et al*. (2005) [5]; Pal *et al*. (2012) [3]; Legha *et al*. (2018) [6]. Keeping the above welfare aspects in view, this experiment was planned to find the optimum load pulling capacity of Halari male donkeys during carting in a pneumatic wheel cart on a *pucca* road, which does not adversely affect the health of the animal by causing undue stress.

Materials and Methods
Animals and carting protocol
Two Halari male donkeys weighing 221.33±3.17 Kg were used in carting to pull load equal to two (x2 BW load) and three times (x3 BW load) of their live weight including the weight of operator. Weight of cart was 165.0 Kg. Prior to experiment, the donkeys were trained for a period of one month with a load equivalent to two times and three times of their body weight to complete 10 km distance in two-wheeled pneumatic tire cart. During this training period, various physiological responses were recorded occasionally to acclimatize them and to rule out any fluctuation in these parameters due to anxiety during the experimental period.

Mean maximum and minimum environmental temperature during the experiment were 37.1±0.25 and 24.9±0.22 ºC, respectively. Relative humidity at 8.30 and 14.30 hr IST was 71.5±2.0 and 46.3±1.0%, respectively.

Donkeys carried each load (x2 BW and x3 BW) for three consecutive days. The donkeys walked 5 km in the first stretch and then a rest of 20 min was given. After rest, donkeys again walked for 5 Km and thus completed total 10 Km. during the work, the donkeys were trotting during the most part of the work. The speed of donkeys during the work was 0.97–1.11 m/s during the experiment on a tar road. The speed of travel was observed by noting down the time taken to cover each round of fixed distance during the entire working period.

Feeding and management

The donkeys were maintained under similar and standard feeding and management conditions. All the donkeys had free access to drinking water except during working hours. One kg of concentrate feed was offered to each donkey in the morning after recording their physiological indices and after collecting the blood samples. After an hour of consumption of feed, these donkeys were used for carting experiment. After completion of work, fodder (groundnut straw) was made available *ad libitum* along with water.

Physical and physiological observations

Physical changes in animal's behaviour *viz*. unwillingness to continue operation, legs uncoordinated, frothing, excitement, sweating and tongue protrusion were recorded as seen visibly. Physiological parameters, such as rectal temperature (RT ºC), pulse rate (PR, beats/min) and respiration rate (RR, breaths/min) were recorded daily, early in the morning before feeding and watering (before work values); immediately after completion of work at 5 km and 10 km, 20 min of rest after completion of the work at 5 and 10 km, during the carting experiment. RT was recorded using a clinical thermometer, PR was taken by palpation of the maxillary artery and RR was measured by counting the abdominal movements per minute.

Collection of blood sample and analysis

Blood samples were collected directly from the jugular vein in heparinised vacutainer tube for hematological parameters and in centrifuge tubes without any anticoagulant for separation of serum for biochemical estimations. This protocol was followed throughout the experiment for blood collection from all the donkeys after taking physiological observations in the morning (pre work) and after completion of work at 10 km (post work). Average values of all physical and physiological indices taken in the morning at the start of experiment were taken as normal or zero hour values for further comparison with those taken after work or rest.

Statistical analysis: Data collected during the experiment from all the donkeys were pooled for each parameter under each work scheme and results were analyzed statistically using the't' test ,Snedecor and Cochran(1967) [7].

Results

Body weight changes

Two local donkeys weighing 221.33±3.17 Kg were used in carting to pull load equal to two and three times of their live weight including the weight of operator. Weight of cart was 165.0 Kg and the laden weight excluding the cartload but including the weight of the driver are presented in Table 1. The animals exhibited loss of weight after the trial, the mean post work load are also presented in the table 1.

Physiological indices

The results on changes in the body weight and physiological indices of the donkeys under the two trials with loads twice (x 2 BW) and thrice (x 3 BW) live body weight of the donkeys is shown in table 2. All physiological indices increased significantly (P<0.05) from the initial resting (pre-work) values after the carting work was completed at 5 and 10 km distance. After 20 min of rest given to the animals at completion of 5 km and 10 km (total distance), the values for these indices remained significantly higher (p<0.05) than the pre-work values, but declined significantly (p<0.05) from the post work values which were observed immediately after work. The increase observed after covering the total distance of 10 km was significantly higher (p<0.05) than that observed at 5 km in both the loads, but the values after rest were similar (p>0.05, change being non-significant). These indices returned to normal by next morning.

Physical fatigue symptoms

Physically observed fatigue symptoms such as excessive frothing, sweating, tiredness, in-coordination of leg movements, prolonged protrusion of tongue, and walking in between trotting, and unwillingness to continue operation during the later part of 10 km distance were observed in x3 load. These symptoms were either absent or less intense in x2 load.

Hematological and Biochemical indices

Hematological and biochemical indices estimated in the blood samples taken during rest at pre work and after rest of 20 min post work at 10 km are presented in the Table 3. Post work, leukocyte counts increased remarkably in both the loads, although the increase was non-significant. Hemoglobin increased significantly (p<0.05) post work in both the loads, while RBC and packed cell volume increased significantly post work only in the x3 load Glucose decreased significantly in both the loads post work when compared to pre work values. None of the biochemical parameters except glucose exhibited any significant change post work under x2 BW load. However, blood urea, albumin, potassium, creatinine kinase and lactate dehydrogenase exhibited significant change post work under x3 BW load (Table 3).

Discussion

As evident from the results, the physiological, biochemical indices and fatigue symptoms indicated that donkeys carrying a load of two times of their body weight were able to carry load without stress whereas under the load of three times of body weight, the donkeys were fatigued. It may also be noticed here that the increase of physiological responses (except for pulse rates), was also higher in the x3 BW load at every 5 km distance covered than those observed in the x2 BW load. During visual examination of fatigue symptoms, a greater fatigue was observed in the donkeys under x3 BW Load. There was higher reduction in the speed, higher lethargy and inco-ordination of leg movements, excessive frothing, sweating, prolonged protrusion of tongue, walking in between trotting, and unwillingness to continue operation during the later part of 10km distance in x3 load. The lower intensity of these symptoms under x2 BW load is indicates

that donkeys carrying x2 BW load under carting were fit enough to carry load to 10 km distance at the speed of 0.97-1.11m/s without stress. However, under trial with load equal to three times of body weight, the donkeys were fatigued. Such indices have been previously reported in fatigues donkeys, Bhatt *et al* (2005) [8]; AICRP on UAE, Annual Report (2015) [9], (2016) [10], Pal *et al*. (2012) [11].

Physiological indices

The carting was stressful as has been evident from significantly increased physiological responses, i.e., RR; RT and PR at 5kms, 10kms and 20min post work in comparison to pre work values. The return to near normal values by next day morning also indicates that stress was not severe enough to cause a drastic metabolic change/ disorder due to the carting. These observations are similar to those reported earlier in working donkeys by Hallikeri *et al*.(1995) [12]; Hallikeri *et al* (2000) [13]; Ram, (2007) [14]; Ram *et al*., (2012) [15]; Pal *et al*., (2012) [3]; Dagar *et al*., (2015) [16]; Kumar *et al*., (2016a) [17], Kumar *et al* (2016b) [18]; Chotiya, (2017) [20]. The pulling load, distance and duration of work proportionately causes a change in these responses during carting by Ram *et al*. (2012) [15]; Dagar *et al*., (2015) [16]; Sharma *et al*, (2014)[21]. These responses due to increased stimulation of sympathetic nervous system, catecholamine (adrenaline) release, for the required increase in metabolic rate (Geor and McCutcheon, (1980) [22]; Allaam *et al*., (2014) [23]. Intermittent rest in between work (as given at 5 km in our experiment) provides essential the vitality that improves the performance output (Pal *et al*., (2002) [4]. Similarly recovery during the rest has been reported in donkeys earlier (Pal *et al*., (2002) [4]; Pal *et al*., (2012) [3]; Dagar *et al*., (2015) [16]; Chotiya, (2017) [20]

Hematological Indices

Increased white blood cell counts, red blood cell counts, hemoglobin and haemaocrit are attributed to the cumulative effect of hemoconcentration in the vascular system caused by excessive sweating during work. Such a sweating causes excessive loss of body fluids. An influx of erythrocytes in the bloodstream from spleen also results during the draught work under the influence of catecholamines in equines (Hodgson and Rose, (1994) [24]; Thompson *et al*., (20010 [25]; Piccione *et al*., (2008) [26]; Chotiya, (2017) [19]. The results obtained in our study are in line with the results obtained in exercising horses. Haemoglobin concentration is considered to be the most reliable measure of plasma volume change during exercise (Harrison *et al*., (1975) [27]; Coenen, (2005) [28]. Hemoglobin concentration increase is also required for increased delivery of oxygen to the exercising muscles and other tissues involved in work during carting. Several studies in trotters have found that post-exercise haematocrit and total circulating haemoglobin increase progressively (Persson (1983) [29]; Wood and Fedde, (1997) [30]; Allaam *et al*., (2014) [23]. Significant leukocytosis has been observed in exercising horses (Rose and Hodgson, (1982) [31]; Snow *et al*., (1983) [32]; Allaam *et al*., (2014) [23] and Zobba *et al*., (2011) [33], and donkeys (Sharma *et al*, 2014) [21]. This is synergized primarily by the corticosteroid release during exercise (Allaam *et al*., (2014) [23].

Biochemical indices

In general there is a significant increase in plasma proteins (Total protein, albumin and globulin) in response to exercise (Chotiya, (2017) [19]; however in the present study we did not observe any significant change in total proteins. Albumin however, increased significantly as reported by previous workers in exercising and working equines (Zobba *et al*., (2011) [33]; Allaam *et al*., (2014) [23]; Chotiya, (2017) [19]. Donkeys have excellent tolerance to dehydration and can quickly rehydrate (Yousef *et al*., (1990) [34]. For this reason we observed very slight change in plasma proteins post work and an almost complete recovery of body weight the next day morning. In the present study only albumins have increased and not the globulins. Primary cause could be that the donkeys were able to adjust the changes in protein fractions brought into circulatory system when erythrocytes are forced into the vascular system from spleen in addition to redistribution of fluids and electrolytes. Nevertheless, the change in plasma albumin level is not a correct indication for dehydration also (Lucke and Hall, (1989) [35]. Higher total protein and albumin may also be due to high ACTH and TSH production in horses (Alrhman, (2015) [36] which generally occurs during the exercise.

Significantly ($P<0.05$) increased ALP enzyme activity was observed at 10km in case of x3 BW load. Similar results have been reported earlier by Sharma *et al* (2014) [21] in draught donkeys. The significant increase in ALP can be attributed to its leakage into the circulation from the skeletal muscles and bones during stressful conditions (Rudberg *et al*., (2000) [37]; Fazio *et al*., (2014) [38]; Sharma *et al*., (2014) [21]; Chotiya, (2017) [19, 20]. Its release from liver, bone and kidney might have also contributed to its high levels in blood as they are major source of ALP (Chotiya, (2017) [19, 20], Keer and Snow, (1983) [39]; Balogh *et al*., (2001) [40]; Fazio *et al*., (2014) [38]. Arslan *et al*. (2002) [41] reported non-significantly increased ALP level during exercise.

Our results on increased LDH post exercise under x3 BW load are in line with the observations of Assenza *et al* (2016) [42] and Chotiya (2017) [19, 20] who reported increase in the post-exercise activity of LDH compared to pre work values. These increases are believed to have been caused by leakage of LDH from working muscles either to due to damage by stress or to a transient increase in permeability of muscle fiber membranes (Zobba *et al*., (2011) [33]; Assenza *et al*., (2016) [42]; Chotiya, (2017) [19]. Kratz *et al* (2002) [43] and Tateo *et al* (2008) [44] also attributed to release of LDH from horse tissues after exercise, primarily from muscles. LDH is involved in the production of lactate in exercising muscles especially during heavy exercise to supply energy during anaerobic respiration. But the mild increase in LDH in our studies in x3 load is only suggestive of a normal enzyme response to the exercise (Zobba *et al*., (2011) [56].

Plasma creatine kinase activity increased significantly post work only in X3 BW load. Similar to our results, increased creatinine kinase activity has been reported in exercising horses due to increased permeability of enzyme from muscle cells due to muscular stress (Hodgson and Rose, (1994) [20]; Zobba *et al*., (2011) [33]; Fazio *et al*., (2014) [38]; Assenza *et al*., (2016) [42]; Chotiya, (2017) [19]. Fazio *et al*. (2014) [38] suggested that increased mitochondrial membrane permeability, rather than muscle damage, during strenuous exercise is the primary cause of creatine kinase activity.

Plasma urea concentrations increased significantly post work only in the x3 BW load. Our results confirm the previous reports in draught mules (Lamba *et al*., (2015) [45] and donkeys (Moolchandani and Sareen, (2015) [46]; Chotiya, (2017) [19, 20]. These authors associated the increase in urea

metabolites with the higher rate of protein break down to muscular activity on draught performance. Hemoconcentration due to sweating, reduction in blood flow combined with glomerular filtration rate leads to increased urea concentrations (Hodgson and Rose, (1994) [24]; Ozcan *et al*., (2002) [47]; Piccione *et al*., (2008) [48] & (2010) [26]; Allam *et al*., (2014) [23]. Plasma urea is also supposed to increase due to its increased reabsorption along with sodium and water under the influence of vasopressin and aldosterone during stress and exercise (Garcia *et al*., (2015) [49].

In the present study, cholesterol levels declined non-significantly in the x3 BW Load. The mean±S.E. concentration of cholesterol in the present study are within the normal range as illustrated by Laus *et al* (2015) [50]; Gupta *et al* (2016) [51] in donkeys. The slight decline in cholesterol levels is similar to the observation in previous studies in draught donkeys during work (Molchandaani and Sareen, (2015) [46], Chotiya, (2017) [19, 20] and mules (Lamba *et al*., (2015) [45]. This decline could be attributed to exercise induced oxidation of cholesterol (Malinow *et al*., (1969) [52]. All other biochemical parameters as presented in Table 3 did not exhibit any significant change, signifying their little association with the exercise induced stress or it might be that these parameters require still a larger magnitude of stress to deviate significantly. These parameters remained within the normal range of equines.

Table 1: Body weight changes in donkeys with different loads during carting

Parameters	x2 BW load (kg)		x3 BW load (kg)	
	Before work	After work	Before work	After work
Animal Body weight (Kg)	221.33±3.17	212±2.88	221.67±3.45	212.5±3.35
Weight loaded including weight of driver (excluding empty weight of cart=165kg)	443.33±7.6		664±10.41	

Table 2: Physiological responses of donkeys under carting carrying load of twice and thrice their lie body weight

Donkey carrying load two times of their live body weight (x2 BW)					
Physiological indices	**Before work**	**After 5 Km**	**After 20 min rest**	**After 10 Km**	**After 20 min rest**
PR per min	39.17±0.83^{a}	76.5±0.62^{b}	38.0±0.73^{a}	83.5±0.96^{c}	38.33±1.31^{a}
RR per min	29.83±0.98^{a}	55.83±2.83^{c}	33.33±0.88^{b}	60.50±2.75^{c}	34.17±1.83^{b}
RT (^{0}C)	36.51±0.24^{a}	38.40±0.12^{b}	37.44±0.12^{b}	38.59±0.06^{b}	37.47±0.17^{b}
Donkey carrying load three times of their live body weight (x3 BW)					
PR per min	34.67±0.49^{a}	72.83±5.88^{c}	36.83±0.48^{b}	82.50±1.26^{d}	37.17±0.60^{b}
RR per min	27.17±0.60^{a}	59.83±1.17^{d}	30.83±0.48^{b}	66.00±0.86^{c}	31.50±0.76^{b}
RT (^{0}C)	36.59±0.12^{a}	38.41±0.05^{b}	37.85±0.12^{b}	38.34±0.22^{b}	37.52±0.1^{b}
a,b,c,d: values within a row with different superscripts vary significantly from each other ($p<0.05$)					

Table 3: Hematological and biochemical indices of donkey carrying load three times of the body weight during carting

Parameters	x2 BW load		x3 BW load	
	Before work	After work	Before work	After work
WBC (x10^{3}/µl)	11.21±1.36	15.28±1.45	9.37±0.96	12.28±1.15
RBC (x10^{6}/µl)	6.02±0.95	7.08±0.18	6.98±0.22^{a}	7.79±0.23^{b}
Packed cell volume (%)	37.72±1.11	40.22±0.46	37.98±1.12^{a}	42.7±1.13^{b}
Hemoglobin (g/dl)	15.83±0.24^{a}	16.83±0.34^{b}	15.75±0.25^{a}	17.71±0.33^{b}
Glucose (mg/dl)	87.16±0.65^{a}	79.5±0.76^{b}	82.5±0.61^{a}	76.33±0.99^{b}
Blood urea (mg/dl)	21.41±1.78	21.68±0.64	21.36±0.81^{a}	26.70±1.2^{b}
Total protein (g/dl)	6.50±0.11	6.29±0.05	6.59±0.18	6.64±0.14
Albumin (g/dl)	4.48±0.31	5.27±0.27	4.74±0.12^{a}	5.37±0.05^{b}
Cholesterol (mg/dl)	94.69±1.71	94.36±2.71	99.22±2.36	97.34±0.54
Sodium (mEq/l)	145.05±0.96	144.3±0.31	144.33±0.49	148.55±2.88
Potassium (mEq/l)	3.89±0.23	3.78±0.02	3.91±0.03^{a}	3.58±0.06^{b}
Alkaline phosphatase (IU/l)	93.63±6.36	96.86±6.87	100.30±2.49	105.26±0.95
Creatine kinase (IU/l)	85.43±2.57	95.95±4.72	84.84±1.98^{a}	127.76±7.4^{b}
Lactate Dehydrogenase (IU/l)	123.2±2.59	124.63±6.89	87.58±1.74^{a}	107.66±2.26^{b}
A, b: values within a row, within a treatment with different superscripts differ significantly from each other ($p<0.05$)				

Conclusion

It is concluded that Halari donkeys weighing around 220.0 kg can easily carry two times load of their body weight without any physiological complication and fatigue, but not three times load of their body weight. A load of x3 BW is not suitable for utilizing these donkeys in pulling cart for 10 km distance. Although x2 BW load seems optimum for donkeys used in carting, there could be breed and individual differences. The optimum conditions of load (such as distance, speed and number of intermittent rests) can be further optimized while determining the optimum pulling capacities of donkeys as reference values.

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