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IMPACTS OF TRAMPLING BY CATTLE AND SHEEP ON FLUVIC NEOSOL IN THE IFPB-CAMPUS SOUSA, PB SEMI-ARID IN BRAZIL

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ABSTRACT

Brazil stands out in animal husbandry with great influence on the export market of meat. However, this activity is causing high soil degradation in pastureland. The aim of this work was to assess the effects of animal trampling in the physical and chemical soil attributes in grazing areas and environmental reserves. For this, an experiment was conducted in the IFPB Campus Sousa, carried out in a block design with 5 treatments and 3 replicates each. The treatments used were: Sabiá Forest (T1), Mountain with bovine grazing (T2), Bovine rotational grazing system (T3), Ovine grazing area (Coconut) (T4), Ovine rotational grazing system (T5). Samples were collected at a depth of 0-20 cm and taken to the laboratory of the Institute LASAP for physical [particle size, soil density (Ds), total porosity (En), clay dispersed in water (CDW) and degree of flocculation (DF)] and chemical analysis [pH, potassium (K +), sodium (Na +), phosphorus (P), calcium (Ca), magnesium (Mg^+), organic matter (OM)], sum of bases (SB), CEC and bases saturation (V%). Grazing pressure with cattle and sheep induced an increase in soil density and total porosity reduction. Sheep trampling favored the reduction in levels of organic matter in the soil due to greater use of pastures by the animals. Treatments T2, T3 and T5, maintained adequate fertility levels compared to preservation area (T1), while the T4 had decrease of nutrients.

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INTRODUCTION

Pasture-based animal production is one of the main competitive and profitable alternatives of Brazilian livestock. However, pasture degradation has becoming a threat to the sustainability of Brazilian farming system (Santos *et al.*, 2010). Most studies relate pasture degradation process to interaction among zootechnical factors (animal stocking rate), plant (loss of vigor, morphologic alteration) and soil (chemical features), while physical degradation of soil has received little attention (Leão *et al.*, 2004). Goats and sheep are recognized as great sources of damage to vegetation in arid environments around the world. Specifically, sheep herbivory relates to a decrease in several herbaceous plants. However, an improper management of sheep livestock together with incompatibility among supply and demand of forage by the animal have caused high degradation. Thus, goats are known as promoters of desertification in semiarid areas (FAO, 1993). A common practice by cattle farmers is to use the same stocking density throughout the year, which causes the grazing pressure to exceed the carrying capacity of the system during the dry season, contributing to accelerate the process of degradation by trampling (Silva *et al.*, 2004). Degraded or desertified land are increasing and the animal overstocking and consequently overgrazing is listed as one of the main factors of land and pasture degradation (EMBRAPA, 2005) together with the lack of planning and good agricultural practices which reinforce the problem in semiarid regions. Soil compaction is the main

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consequence of an excessive animal trampling and consists of an increase in soil density due to the applied pressure (leão *et al*. 2014). In this way, assess the impacts of animal trampling allows the development of appropriate practices of soil, animal and vegetation management. According to Flores *et al*. (2007), management of systems that involve animal grazing may lead to changes in physical, chemical and biological attributes of soil, which may affect the growth, root development and production of implanted crops. Therefore, this work aims to evaluate the impacts of animal trampling on chemical and physical attributes of soil and compare it with preserved areas.

MATERIALS AND METHODS

This study was carried out at Instituto Federal de Educação, Ciência e Tecnologia da Paraíba - Campus Sousa, Unidade São Gonçalo, at the geographical coordinates 06° 50' 22” S and 38° 17' 42” W at 220 meters of altitude. The region comprise a hot semiarid area, type Bsh of Koppen Classification. The average annual precipitation is 654 mm, with rainfall period concentrated between January and June. Average annual temperature is 27 °C, maximum 38 °C, while average relative humidity is 64%. Hyper-xerophytic Caatinga is the predominant vegetation on a Fluvic Neosol.

Five areas with different use and management systems (experimental units) were selected:

- T1 = Sabiá Forest (control): a preserved area of 50 x 20 m, whose main vegetation consist of Sabiá (*Mimosa caesalpinifolia* Benth). Geographical coordinates: 6º 50’ 38” S and 38º 18’ 01” W, 243m of altitude.
- T2 = Mountain with bovine grazing: forest area of caatinga at the base of a mountain (60 x 30 m). Cattle graze at this area during the drought period. The following plant species are found: Embiratanha *(Pseudobombax marginatum* (A. St. - Hil.), Juazeiro (*Ziziphus joazeiro* (Mart. ex Tul.), Angico (*Anadenanthera colubrina* (Vell.), Imburana (*Commiphora leptophloeos* (Mart.) and Aroeira (*Myracrodruon urundeuva* Allemão). Geographical coordinates: 6º 50’ 45” S, 38º 17’ 80” W, 253m of altitude.
- T3 = Bovine rotational grazing system: grazing area of 100 x 50 m, with a stocking density of 15 dairy cows per pickets in a rotated form. The forage grass consists of Tifton (*Cynodon ssp*.). Geographical coordinates: 6º 50’ 28” S, 38º 17’ 25” W, 237 m of altitude.
- T4 = Ovine grazing area (Coconut): coconut plantation (*Cocus nucifera* L.) of 100 x 50m with 7.5 x 7.5 spacing between plants. A sprinkler-irrigated area used for sheep grazing during dry season. Non-cultivated species present at the area are: Vassourinha (*Scoparia procumbens Jacq*), Capim-de-burro (*Cynodon dactylon Perl*), Capim-pé-de-galinha (*Eleusine indica Gaertner)*, Tiririca (*Cyperus rotundus L. ssp) and* braquiaria (*Brachiaria decumbens (Stapf) Webster*). Geographical coordinates: 6º 50’ 18’’ S, 38º 17’ 41’’ W, 236 m of altitude.
- T5 = Ovine rotational grazing system: an area of 600 x 30 m consisting of the foragegrass Tifton (*Cynodon ssp.*) and used as grazing area for sheep in a rotated way. Geographical coordinates: 6º 50’ 17” S, 38º 17’ 47” W, 234 m of altitude.

A randomized block design was used consisting of 5 treatments and 3 replicates. Three samples of soil were collected at each treatment at a depth of 0-20cm. We used the Dutch soil auger for samples, than we packed and identified them in plastic bags. At the laboratory, samples were dried in shade and then subjected to physical and chemical analyses. We measured the granulometry (g kg^{-1}) through content of clay (Bouyoucos hydrometer method), content of sand (weighing), and content of silt as the difference (silt = sand+clay-1000). Soil density was measured using the volumetric ring method (Kopecky), and dried in a heating chamber at 105º for 24 hours. The apparent soil density (g/cm³) was calculated using the weight of the dried sample (g) divided by the ring or cylinder volume (cm³). Total porosity (m^{-3} m^{-3}) was set by the relation between apparent density (AD) and particle density (PD): Total porosity = 1-(AD-PD) x 100. Clay dispersed in water (g kg^{-1}) was measured by the suspension method conferred by a certain density of the liquid using a stirrer and hydrometer. Clay content was calculate using the formulae: clay = (a+b) x 20, in which a = sample reading at the hydrometer and b = blank proof reading. Flocculation was measured as the relation among naturally dispersed clay and total clay: Flocculation level = 100 - (a-b), where a = total clay, b = clay dispersed in water. We measure pH, H_2O, potassium (K^+), and sodium (Na^+) by flame photometry and phosphorous (P) by spectrophotometry, using extractive solution of Mehlich (1M). Calcium (Ca^{+2}), magnesium (Mg^{+2}) and aluminum (Al+) were measured by titration after extraction with KCL 1M. Hydrogen plus aluminum (H^+ Al^+) was measured by titration after extraction with calcium acetate. Sum of Bases (SB), exchangeable sodium percentage (SP) and saturation per base (V%) was measured by calculation and organic matter (OM) by titrations after Walkley-Black wet digestion. All chemical and physical analyzes followed EMBRAPA (1997). Data collected were submitted to analysis of variance and when significant by F test, Tukey test was applied at the 1% probability level. All analyses were performed at ASSISTAT software (Silva *et al*., 2002).

RESULTS AND DISCUSSION

There was no significant difference between sand and silt for studied areas, however clay fraction was predominant in relation to the others ($p<0.01$) (Table 1). According to Klepker and Anghinoni (1995), changes in granulometric fractions are difficult to occur and are only detected after long period of varied use.

Table 1. Average values of sand, silt and clay fractions (textural analyses) of soil at distinct bovine and ovine grazing areas at 0-20cm of depth, IFPB Campus Souza – PB, 2016

Treatments	---------g Kg-¹---------			
	Sand	Silt	Clay	Textural Class
T1	637 a	245 a	117 ab	Sand loam
T2	607 a	237 a	155 a	Sand loam
T3	651 a	228 a	121 ab	Sand loam
T4	695 a	200 a	104 b	Sand loam
T5	615 a	280 a	104 b	Sand loam
CV (%)	10.02	25.04	14.01	-
F	ns	ns	**	-
MSD	18.42	168.38	47.63	-

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

Pereira Junior *et al*. (2014) found significant difference in agroecosystems only for sand fraction under Fluvic Neosol. But Prado and Natele (2003) did not find difference at sand, silt and clay fractions under dystrophic Red Latosol. The degree of soil compaction is defined by the arrangement of particles and characteristics of the porous system. A significant difference of soil density among treatments ($p<0.01$) was found (Table 2). Treatment 1 (Sabiá Forest – our control treatment) showed a significantly lower density than the other treatments (Table 2). The lower density is probably a result of leaf litter presence, but the effect of cattle trampling on pasture may account for the higher soil density in the other treatments. Carneiro *et al*. (2009) and Figueiredo *et al*. (2009) reported the effects of bovine trampling on the increase in soil density in comparison with a native area of Cerrado. In areas of high grazing pressure and grazing by lambs in a crop-livestock integration system, high density of soil was found at the deepest layers (5-10cm) (Carassi *et al*., 2011). Total porosity (Table 2) was significantly different among treatments ($p<0.01$). Treatment T4 showed the highest density and the lowest porosity, which might be related to the long years of ovine grazing at this area. Compaction caused by sheep trampling may induce increased soil density, decreased total porosity and change the pore size distribution in Fluvic Neosol at the shallow soil layer 0-5cm (Pereira Junior *et al*. 2014). A higher porosity and low dense soil showed higher organic matter (Table 2) promoting the development of roots and plants. Preservation area (T1) and areas in which the grazing was seasonal and at a low pressure (T2 and T3) showed the highest levels of organic matter (Table 2). A high level of organic matter indicates a better soil condition, favoring the maintenance of physical conditions and can influence the reversal of the compaction soil state (Santos; Salcedo, 2010). Treatments with ovine present a lower organic matter due the greater utilization of pastures by these animals.

Table 2. Average values of soil density, total porosity and organic matter (OM) at depth of 0-20cm at different areas of bovine and ovine grazing, Souza – PB, 2016

Treatments	Density Kg dm-¹	Total porosity m³ m⁻³	OM g kg-¹
T1	1.39 b	0.49 a	44.81 a
T2	1.60 a	0.40 b	44.62 a
T3	1.55 a	0.41 b	33.12 ab
T4	1.66 a	0.39 b	22.37 b
T5	1.60 a	0.40 b	24.02 b
F	**	**	**
CV (%)	2.42	3.80	14.71
MSD	0.10	0.04	14.02

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

There was no difference among treatments for clay dispersed in water (CDW) (Table 3), but treatments T1, T2 and T5 showed the highest levels of CDW, which may indicate a better particle accumulation influenced by organic matter content, which aggregate the particles. Pereira Junior *et al*. (2006) found similar result at different agroecosystems in Neosl, Souza/PB. Flocculation level (FL) was significantly different among treatments ($p<0.01$) and showed an opposite pattern from clay dispersed in water (Table 3). This variable indicates the proportion of flocculated clay, showing the degree of aggregates stability. According to Santos *et al*. (2010), higher levels of flocculation in the inner layers of native forest and degraded pasture leads to a lower fraction of clay dispersed in water. Still, lower levels of flocculation in semi-degraded pastures indicates vulnerability to water erosion in the absence of vegetal cover. The relationship silt/clay (S/C) was not different between treatments (Table 3), consisting in an indicative of the degree of soil weathering, and allows to evaluate the clay movement at the soil profile.

Table 3. Average values of clay dispersed in water (CDW), flocculation level (FL) and silt/clay relation (S/C) at distinct bovine and ovine grazing areas at 0-20cm of depth, IFPB Campus Souza – PB, 2016

Treatments	----------------- g Kg-¹---------------------		
	CDW	FL	S/C
T1	79.66 a	316.00 b	2.19 a
T2	63.33 ab	576.66 ab	1.54 a
T3	42.00 ab	658.33 ab	1.87 a
T4	29.66 b	718.00 a	1.92 a
T5	46.33 ab	561.00 ab	2.67 a
CV (%)	33.85	22.75	27.07
F	ns	**	ns
MSD	49.88	33.61	1.55

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

There was significant difference for pH ($p<0.01$) (Table 4). Higher pH was found for treatment 5, which may be a result of high sodium content due improper management of irrigation over the years. Silva *et al*. (2000) also found pH changes with animal trampling in areas of grazed and non-grazed planting. The authors observed a pH about 4.5 to 5.2 in red-yellow Ultisol with Loam superficial texture. Siqueira Junior (2005) found a similar result for pH under crop-livestock integration, with pH ranging from 5.1 to 5.3 in a Bruno Latosol. Phosphorous content (P) was significantly different among treatments ($p<0.01$). Phosphorous content was low for T4 treatment and very high for T1, T2, T3 and T5. Treatments 1 and 2 showed higher phosphorous content probably coming from Sabiá Forest and native vegetation. Pereira Júnior (2006) found a decrease in phosphorous content as the number of animals per area increased indicating a phosphorous exporting by animal consumption. Potassium values (K^+) differed statistically among treatments ($p<0.01$), with higher levels at T5 and T1 treatments. At Sabiá Forest the leaf litter, fertilization with potassium chloride and the urine of animals might have contributed to the potassium high levels. According to Williams and Haynes (1995), ovine urine and feces are rich in potassium. Jakelaitis *et al* (2008) found higher potassium levels at native forests followed by cultivated area under no-tillage and pasture of *Brachiaria brizantha* at Rio Casca (MG). Sodium (Na^+) was significantly different among treatments ($p<0.01$) (Table 4) with higher levels at treatment 5. This area was previously used to crops, such as rice, with inappropriate management practices, such as flood irrigation, favoring the increase of sodium levels, with the emergence of spots, which may be a limiting factor for the growth of most crops.

Values of Calcium (Ca^{+2}) were significantly different among treatments ($p<0.01$). A lower concentration was found for treatments with animal grazing. Magnesium (Mg^{+2}) content did not differ between treatments, but showed a similar pattern from Calcium. Decrease in Calcium and Magnesium concentration may be attributed to a reduction in organic matter by animal stocking density, long-term grazing, low vegetable cycling and animal dejects. Calcium is excreted by feces and is poorly soluble in water leading to a slow release to the soil (Pereira Junior 2006). Siqueira Junior (2005) found the same pattern of reduction in calcium content in grazing areas in relation to non-grazing areas. Bertol *et al*. (1998) found that a decrease in pasture supply causes decreases the levels of magnesium. Sum of the bases (SB) have a similar behaviour to those of the cation exchange capacity (CEC) (Table 5 and 6). Both SB and CEC were significantly different among treatments ($p < 0.01$). High intense management practices seems linked to increase in SB and CEC either by fertilization or soluble salt in soil solution and decomposition of soil deposited material.

Table 4. Average values of PH, phosphorous (P), potassium (K^+) and sodium (Na^+) at distinct bovine and ovine grazing areas at 0-20cm of depth, IFPB Campus Souza – PB, 2016

Treatments	pH	P	K^+	Na^+
	H_2O	mg dm^{-3}	--- cmol$_c$ dm^{-3} ---	
T1	6.6 ab	922 a	0.42 ab	0.03 b
T2	6.3 b	473 b	0.35 ab	0.02 b
T3	6.3 b	406 b	0.35 ab	0.03 b
T4	6.7 ab	21 d	0.21 b	0.04 b
T5	7.2 a	145 c	0.49	0.30 a
CV(%)	3.3	6.6	20.4	43
F	**	**	**	**
MSD	0.63	73.82	0.21	0.10

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

Table 5. Average values of Calcium (Ca^{+2}), magnesium (Mg^{+2}) and sum of bases (SB) of soil at distinct bovine and ovine grazing areas at 0-20cm of depth, IFPB Campus Souza – PB, 2016

Treatments	Ca^{+2}	Mg^{+2}	SB
	-------------- cmol$_c$ 38M^{-3} --------------		
T1	8.4 a	2.5 a	11.4 a
T2	7.6 a	2.2 a	10.1 ab
T3	5.2 b	2.5 a	8.2 b
T4	3.9 c	1.7 a	5.5 c
T5	6.0 b	2.0 a	8.6 b
CV (%)	7.1	23	8.4
F	**	ns	**
MSD	1.25	1.46	2.08

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

Table 6. Average values of cation exchange capacity (CEC), saturation by base (V%) and sodium saturation (SS) of soil at distinct bovine and ovine grazing areas at 0-20cm of depth, IFPB Campus Souza – PB, 2016

Treatments	CEC	V	SS
	cmol$_c$ dm^{-1}	---------- % ----------	
T1	15,6 a	73 b	1,0 a
T2	14,8 a	68 b	1,0 a
T3	11,5 ab	71 b	1,0 a
T4	7,4 b	74 b	1,0 a
T5	8,6 b	100 a	3,0 a
CV(%)	13,5	5,5	63,89
F	**	**	ns
MSD	4,44	12,21	2,52

T1= Sabiá Forest; T2= Mountain with bovine grazing; T3= Bovine rotational grazing system; T4= Ovine grazing area (Coconut); T5= Ovine rotational grazing system; CV= Coefficient of Variation. Distinct letters mean significant difference by the Tukey Test. ** $p<0.01$, * $p<0.05$, ns = non-significant.

Values of saturation by base (V%) significantly differed among treatments ($p<0.01$), but all were characterized as eutrophic (V% > 50%) (Table 6). Eutrophic soils show high nutritional value bellow the arable layer (in B horizon, or in C horizon if there is no B horizon, or in A horizon of Litholic Neosol), high productivity as long as they are not saline as may occur in northeastern Brazil. Liming and fertilization to increase productivity of studied areas might be responsible by the eutrophic state of soil. Corrêia *et al*. (2009) also found eutrophic soil at Petrolândia a semiarid area in Pernambuco. Sodium saturation (SS) did not differ statistically among treatments (Table 6). Animal trampling did not induce alteration being within the limit range of less than 7 (Richards, 1954).

According to Lima *et al*. (2001) the improper management of land and irrigation is responsible for the reduction in crop yield and for the soil degradation by salinization. Lima *et al*. (2001) found 39.48% of studied areas showed altered soil by salt. However, our studied areas do not fall within the above-mentioned conditions.

Conclusion

1- Bovine and ovine grazing pressure increases soil density and decreases total porosity of soil.
2- There was a decrease in organic matter at the areas of ovine grazing.
3- Ovine grazing at coconut plantation reduced the content of phosphorous, potassium, calcium, magnesium and sum of base in relation to the other treatments.
4- Treatments 2, 3 and 5 maintained adequate fertility levels compared to the conservation area T1.

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