



RESEARCH ARTICLE

DETERMINATION OF ANIMAL LOAD AND GRAZING SYSTEM IN THE WEIGHT GAIN OF BOVINES WITH SECONDARY VEGETATION FEEDING

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Abstract

The present study was to evaluate the weight gain of bovines in three animal loads with two grazing systems and three levels of grazing, furthermore to evaluate the botanic composition of secondary vegetation areas. The study was carried out during two years, in the first year, the animal loads used were 0.25, 0.50 and 0.75 animal unit per hectare (AU/ha). The vegetation which animals were evaluated was secondary vegetation of 8 years old. Botanic composition was determined by transects at the beginning of experiment. The two systems used were rotational and alternate grazing with three animals per each load and system. The initial average weights were 175 kg and evaluation were carried out each 56 days. The experimental design used was random totally with factorial arrangement of 3X2, the first factor was the animal load and the second was the grazing system. Results indicated changes in botanic composition caused by grazing effect ($P \leq 0.05$), furthermore, grazing system and animal loads showed significant statistical differences between treatments and interaction. The best weight gain was 520 g of weight gain average per day detected in 0.50 AU/ha with rotational grazing system ($P \leq 0.05$).

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Introduction:-

Animal production in extensive management is affected by climate, soil, plant, animal and human factors (Peclet *et al.*, 2017; Cavicchioli *et al.*, 2019). In Mexican tropic the low production and productivity of livestock is influenced by land management (Mancera *et al.*, 2018), moreover floristic composition in land management is usually not considered (Mejía, 2002) which can be a disadvantage for communities because they produce low technology application, generate health problems in cattle and obtain low economic benefits (Améndola *et al.*, 2016). In Quintana Roo state, the grazing livestock is usually based on some introduced grass (Ramírez-Avilés *et al.*, 2019). According to Sosa *et al.* (2000), it exists a surface of 1.5 million of hectares of low forest and secondary vegetation unused. Those hectares constitute an important forage source which are not used for animal feeding in dry season. Furthermore, many trees, herbaceous and shrubs contain important nutritive characteristics for animals (Sosa *et al.*, 2004). Studies carried out in Quintana Roo have showed that shrubs can be used by cattle feeding in dry season (Ziblimet *et al.*, 2019; Avornyo *et al.*, 2018), additionally, it represents 60% of diet when grass are not available (Sosa *et al.*, 2004; Ortega *et al.*, 1999). Mohammed *et al.* (2015) mentioned that animals which graze in native pastures are superior than those which graze in forage species monocrops. Studies carried out in Yucatán peninsula by Ortega *et al.* (1999), showed that quality diet for cattle in deciduous tropical forest was heterogeneous through the year. Vegetation growing in

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raining season produced that animals were capable to select crude protein up to 16%, moreover, cattle that grazed in soil level, selected litter, seeds and fruits in dry season. Those results are the background to study an integral system with nutritional value species of the region for improving the animal diet and determining the adequate load to avoid food resource scarcity (Mijares-López *et al.*, 2012). It is well known that forage productivity is not stable per year, but with a grazing system can be controlled (Nicaretta *et al.*, 2020). Grazing system has as principal objective for improving the grassland and animal condition (Williams *et al.*, 2019), like so their distribution and composition (Feria *et al.*, 2002), therefore, animal load influences the production and persistence of the species (Marchi *et al.*, 2019). A range of animal load permits to estimate the potential in secondary vegetation areas, furthermore it helps to evaluate the reaction of the vegetation to the overgrazing and undergrazing. Accord to above mentioned the objective of this study was to determine the adequate animal load and the best grazing system in a secondary vegetation area.

Materials and Methods:-

Study localization, climate and soil conditions

The present study was carried out in el Consuelo ranch belongings to Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), campo experimental Chetumal, located in Othon P. Blanco, Quintana Roo at 3.5 km of Xul-Ha community with 21°30' N and 89°29' W coordinates. Climate conditions are 27.6° C and 62.3% of relative humidity on average, annual medium precipitation is 1300 mm and the period with the most precipitation was from June to November. Soils of this area are chromic luvisols which are characterized to contain high organic matter.

Characteristics of study area

The study area was 18 hectares which was constituted with vegetation classified as secondary forest (acahual). The average age of forest was eight years and was constituted by medium sub-evergreen forest. Those areas were dominated by diversity of grasses, herbaceous, shrubs, trees and is used by wildlife and domestic animals.

Evaluation of floristic composition

Previously to establishment of animal load treatments and grazing system, the floristic composition in experimental area was estimated. The methodology to evaluate the floristic composition was the Canfield lines or transects (Bonhan, 1989), furthermore, the methodology of America United State Forestal Services (USDA, 1974) was applied. In this case, three samples were collected by species. Each sample included stems, leaves and fruits, then samples were dried in a laboratory oven and posteriorly identified in Instituto Tecnológico de Chetumal and INIFAP herbarium. Other factors considered in the methodology were cover percentage, density, frequency and vigor of species. Each three months were collected and separated the species obtained inside of 0.5 m² in the rectangular quadrant. These cuts were carried out to determine the effect of treatments influenced by change direction in vegetation tendency. Each species was dried in a laboratory oven at 60°C for 72 hours. The variables registered were total dry matter, new buds and floristic composition.

Creation of reference laminas to determine the diet botanic composition

Botanic composition was determined by histological technique. Samples per season (spring, summer, fall and winter) were collected in two years. Then, a sample of each part of plants identified were ground in a Willey mill with mesh of 1 mm. Samples were put on slides to prepare the histological reference tissues. These references consisted in drawings and microphotographs by observation in a contrast microscopy of phases with camera. The drawings were vegetal tissue characteristics as stomata, trichomes, crystals etc. per species.

Evaluation of animal diet

Samples were collected in three consecutive days per month. The process consisted in collect animal feces samples at 8:00 to 9:00 in the morning directly in the rectum of animals. Then, samples were dried in a laboratory oven at 55°C for 48 hours, posteriorly were ground in a Willey mill with mesh of 1 mm. Afterward, 0.1 g of sample was put on a slide. Per each sample was carried out four replicates. Then, samples were observed in 25 fields per slide obtaining 100 fields per sample. Species number that appears in diet were obtained from slides lecture. Data frequency was obtained per sampling range. Those data were transformed in density using Curtis and Macintosh formula (Watson and Whiteman, 1981).

Evaluation of grazing system

The two grazing systems evaluated were alternated grazing system (AGS) and rotational grazing system (RGS). The AGS had rest periods with occupation of 21 days and the RGS had 21 days of rest with occupation of 7 days. The

animal loads used in both systems were 0.25, 0.50 and 0.75 AU/ha. Three animals of 200 kg per treatment were used in experiment. The surface was modified to obtain the adjustment of animal in respect with load. Animals had access to enough mineral salts and water. Furthermore, they were weighted each 56 days and replaced when they had 350 kg. Animals were subjected to an adaptation period of two weeks with electric fence.

Experimental design and variables evaluated

A complete randomized experimental design was used with factorial arrangement of 3x2. The first factor was the animal load (0.25, 0.50 and 0.75 AU/ha) and the second factor was the grazing system (rotational and alternate). The experimental unit was one animal per treatment. The variance analysis, correlation, regression and Duncan test ($P \leq 0.05$) were carried out with Statistical Analysis System (SAS) Software. The variables evaluated were floristic composition of study area, botanic composition of animal diet and weight gain /animal.

Results and Discussion:-

Floristic composition

The total of species detected were 65 which were distributed in 55 genera and 30 families. Woody species were dominants with percentages from 45 to 47% of presence, followed by herbaceous and grass. Changes in floristic composition ($P \leq 0.05$) were observed during the four-sampling season (Figure 1). These results could be due that many herbaceous species as *Ipomea batatas*, *Passiflora* sp. and *Sabal yapa* were disappearing when grazing increased. Contrary, woody species as *Cydistapotosina*, *Dalbergia glabra*, *hameliapatens* and *Bahuiadivaricates* showed dominance. On the other hand, herbaceous grew again in raining season and this effect showed no significant differences statistically both grazing systems and animal load. Many studies carried out in shrubs areas, showed the importance in animal diet both wild and domestics (Murgueito 2003; Senra et al., 2005).

Herbaceous species showed great dominance at the beginning, however, these tend to disappear because of grazing. On the other hand, woody species had a slow growth but tended constantly to increase. These results are similar to the observed in other studies of secondary vegetation areas (Sosa et al., 2000) when floristic diversity showed dominance in herbaceous and woody species which were preferred by animals.

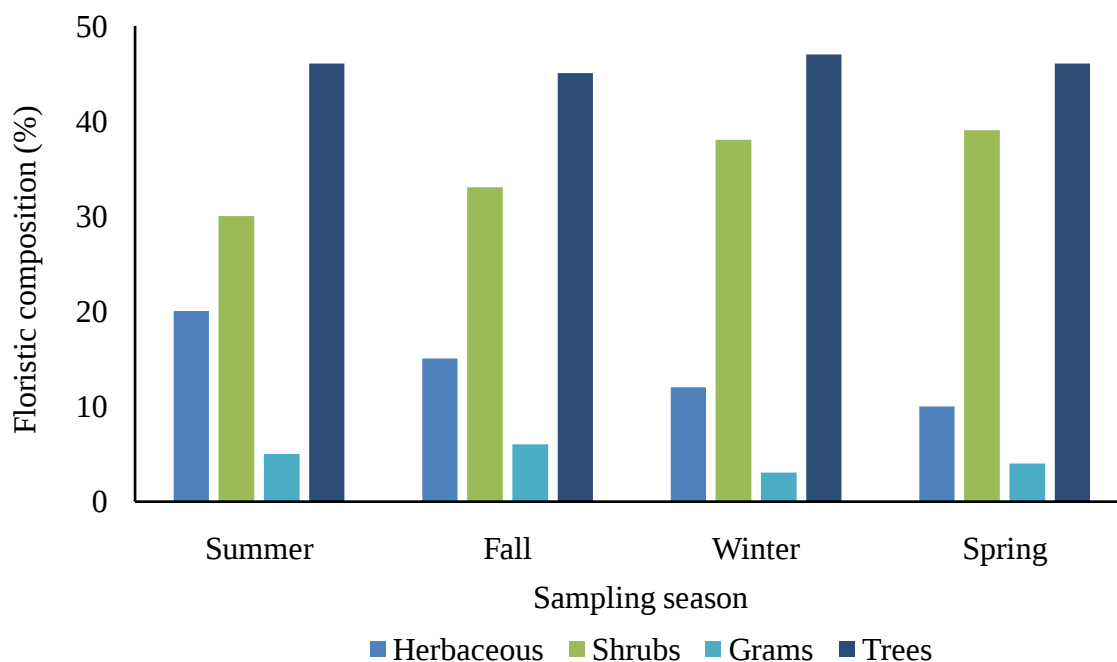


Figure 1:- Percentage of floristic composition in four sampling seasons carried out in grazing areas with three animal loads.

The coverage average value in RGS was 70% and for AGS was 40% ($P \leq 0.05$), in general, coverage values showed stability in all study. The persistence frequency of species was detected in RGS with 60 species at the end of study contrary to 45 species in AGS. This fluctuation was determined by selectivity of animals. Sosa et al. (2004)

mentioned that attributes that determine the forage quality as well as capacity of dry matter production, are not important if the species have not the capacity of persist in grazing system.

Botanical composition of animal diet

The most important species in diet were shrubs with 68% of average consumption (Table 1). In the first sampling-period, the shrubs contain detected in diet was 72.5% without significative statistical differences ($P \geq 0.05$), but in second and third sampling-period, the shrubs contain were 66 and 65.5% respectively. In both periods with R x 0.50 AU/ha were the only different ($P \leq 0.05$). The grazing system A x 0.25 AU/ha showed the highest consumption of average shrubs for three periods with 68.27%, followed by A x 0.25 AU/ha with 66.3% and R x 0.50 AU/ha with 68% of average consumption. The lowest consumptions were detected in A x 0.75 AU/ha with 67.9%.

Table 1:- Average consumption percentage of observed species in three periods of evaluation with six grazing systems.

Grazing system X animal load (AU/ha)	Average consumption (%)								
	Grass			Shrubs			Herbaceous		
	1 st P	2 nd P	3 th P	1 st P	2 nd P	3 th P	1 st P	2 nd P	3 th P
Rx 0.25	9.1 ^{ax}	10.1 ^{ay}	10.7 ^{ay}	72.1 ^{ay}	66.0 ^{ax}	65.7 ^{ay}	18.1 ^{by}	14.1 ^{ax}	14.8 ^{ax}
Rx 0.50	9.8 ^{ax}	10.5 ^{ay}	10.9 ^{ay}	73.2 ^{ay}	65.5 ^{bx}	65.3 ^{by}	18.4 ^{ay}	14.8 ^{ax}	14.9 ^{ax}
R x 0.75	9.2 ^{ax}	9.3 ^{bx}	10.8 ^{ay}	72.7 ^{ay}	66.0 ^{ax}	65.4 ^{ay}	17.2 ^{by}	13.7 ^{ax}	14.1 ^{bx}
A x 0.25	9.6 ^{ax}	10.4 ^{ay}	10.3 ^{ay}	72.8 ^{ay}	66.7 ^{ax}	65.3 ^{ay}	17.3 ^{by}	13.9 ^{ax}	14.7 ^{bx}
Ax 0.50	9.4 ^{ax}	10.1 ^{ay}	10.9 ^{ay}	71.9 ^{ay}	66.3 ^{ax}	65.4 ^{ay}	17.4 ^{by}	14.1 ^{ax}	14.6 ^{bx}
A x 0.75	9.2 ^{ax}	10.3 ^{ay}	10.4 ^{ay}	72.1 ^{ay}	66.0 ^{ax}	65.7 ^{ay}	17.6 ^{by}	14.0 ^{ax}	14.9 ^{ax}
Average per period	9.3	10.1	10.6	72.5	66.0	65.5	17.6	14.1	14.7
Average per species		10.0			68.0			15.5	

Different letters correspond to different statistical treatments accord Duncan test ($P \leq 0.05$). R: rotational, A: alternate, P: period of evaluation. a and b show differences between treatments, x and y show differences between periods.

The second species detected with 15.5% of consumption was the herbaceous (Table 1). The highest consumption detected was 17.6% in the first period of evaluation, furthermore, the highest dietary content of herbaceous observed was in R x 0.50 AU/ha with 18.4% while in A x 0.50, R x 0.75 and A x 0.75 AU/ha were 17.4, 17.2 and 17.6% of consumption respectively. In second period of evaluation, significative statistical differences were not detected, however in third period of evaluation were detected different values ($P \leq 0.05$) in R x 0.25, R x 0.50 and A x 0.75 AU/ha with 14.8, 14.9 and 14.9% of consumptions respectively. On the other hand, grass showed in third period percentages of 10.6% followed by second period with 10.1% and finally the first period with 9.3% of consumption. In second period the highest grass consumptions were detected in A x 0.75 AU/ha (10.3%), A x 0.50 AU/ha (10.1%), A x 0.25 AU/ha (10.4), R x 0.50 AU/ha (10.5%) and R x 0.25 AU/ha (10.1%), contrary the lowest consumption was detected in R x 0.75 AU/ha (9.3%). This showed that animal develop preferences in diet accord of the vegetation presence in grazing area (Bovalet *et al.*, 2007).

Weight gain in alternate grazing system

In the first evaluation of dry season was observed an increasing in weight gain for the first two months, however from third month, significative statistical differences were detected ($P \leq 0.05$). The load of 0.75 AU/ha showed gains of 310 g/month while 0.50 AU/ha was 440 g/month and 0.25 AU/ha was 451 g/month. For animal load of 0.50 AU/ha, diminution of weight gain was not abrupt compared with 0.75 AU/ha. Similar gains was observed in 0.25 AU/ha. This result could be because animal maintain their weight through dry season.

In the first period of evaluation of rain season, weight gains for the first month were 425, 475 and 480 g/month for 0.75, 0.50 and 0.25 AU/ha respectively. However, from the second month, animal showed weight loss for 0.75 AU/ha, but for 0.50 and 0.25 AU/ha the gains were maintained until the third month and then showed weight loss.

In second evaluation of dry season, it was observed that 0.75 AU/ha and 0.50 AU/ha loads are not effective to maintain weight gains in animals. This result was observed when animals were removed from grazing area at 90 days. Furthermore at 60 days of evaluation, 0.75 and 0.50 AU/ha loads showed weight loss ($P \leq 0.05$) of 300 and 390 g/month respectively, contrarily in 0.25 AU/ha which showed weight gains of 445 g/month.

Table 2:- Weight gains in three animal loads with alternate grazing system in dry season.

Grazing days	Weight gains (g)		
	0.25 AU/ha	0.50 AU/ha	0.75 AU/ha
30	420 ^a	466 ^a	470 ^a
60	400 ^a	450 ^a	455 ^a
90	310 ^b	440 ^a	451 ^a
120	290 ^b	410 ^a	420 ^a

Different letters correspond to significant statistical differences according to Duncan test ($P \leq 0.05$). AU/ha: Animal Unit per hectare.

Weight gain under a rotational system

Similar weight gains were observed at 30 days of evaluation, nevertheless at the 60 days, significant statistical differences ($P \leq 0.05$) were observed between treatments. At the 120 days of evaluation, 0.75 and 0.50 AU/ha showed gains of 390 and 400 g/month respectively. In raining season at the 30 days of evaluation, it was observed weight gains of 525, 535 and 540 g/month for 0.75, 0.50 and 0.25 AU/ha respectively, however, at the 60 days the weight loss only was observed in 0.75 AU/ha.

Interaction of load animal with grazing system

The best treatment observed was RGS with 0.5 AU/ha, which showed weight gains of 520 g/month. The interaction with animal load and grazing system obtained in this study are similar to the reported by Brown (1977), who mentioned that weight gain per animal is better when the animal load is low (Souza *et al.*, 2020), furthermore, the gain is maintained when the animal load increases gradually. Other studies (Senra *et al.*, 2005; Reyes, 2003) indicated that reduction of animal load, increases the weight gain per animal, moreover this weight gain is related with consumption of forage maturity and animal metabolism capacity (Hackney *et al.*, 2021). Weight gains obtained in this study were low, however in dry season of tropic conditions, many animals die because of forage shortage.

In dry season, many studies have indicated the stationary grass and legumes consumption of animals (Craine, 2021; Jean *et al.*, 2020; Watter *et al.*, 2020). They usually have the opportunity to select their diet, which impacts in weight gain (Pfister and Malecheck, 1986). Other reason of low weight gains, could be due to animals maintaining low selection of grasses which have growing excessively and lose their quality. Moreover, in raining season, dried grasses increase more than 50% which represent negative weight gains (Senra *et al.*, 2005). These results are according with Cowlishaw (1969) and Wheeler *et al.* (1973), who mentioned that weight gains in RGS was similar that AGS evaluated. Moreover, RGS neither improved the grassland nor increased the weight gains, however, they are important systems because of their botanic composition and conditions of natural lands (Peyraud *et al.*, 2019; Hennessy, 2019; Senra, 2005).

Utilization of 0.75 AU/ha in RGS has resulted better than AGS, nevertheless AGS has showed better weight gains than RGS. This result could be because of animal selection and consumption of species. Studies reported by Baumont *et al.* (2000) and Baumont *et al.* (2004) showed that independently of system used, the animal load permitted better weight gains in dry season. However it is important considered that those studies have been carried out in monocrop lands or in association with two species, differently that our studies which contained more than 120 species.

Conclusions:-

Native vegetation was modified by animals grazing, this modification induced changes in botanic composition. The first species to decrease their population were herbaceous because of animal consumption preference, however, shrubs and forest species are not considered less important in the system because of high nutritional value and availability during the year.

Animal load is the most important factor to determine the persistence and prevalence of secondary vegetation species, furthermore, the adequate grazing system it is necessary to improve the efficiency in the use of forage and animal production.

The AGS with 0.75 AU/ha showed negative effect in weight gain, however, in 0.5 and 0.25 AU/ha the weight gains were constant. The best weight gain was obtained in RGS with 0.25 and 0.50 UA/ha.

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