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Weed control with small ruminants: Exploratory evaluation on *Senecio inaequidens*

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ABSTRACT

Objective: Carry out an exploratory evaluation of sheep and goats grazing in a temperate pasture invaded by *Senecio inaequidens*, as a means of biological control of weeds in small-scale dairy systems (SSDS).

Methodology: Crude protein (CP), neutral detergent fibre (NDF), and acid detergent fibre (ADF) were determined on pasture and *Senecio* samples. The effect of grazing by sheep and goats on the pasture was assessed by means of the height, density and soil cover of *Senecio*, and also sward height; and the live weight of the animals, daily weight gain and body condition score were recorded. Statistical analysis was by a 2×2 factorial design, with species (sheep or goat) and two grazing intensities at 28.3 or 50.3 m^2/animal per day.

Results: height, coverage and density of *Senecio* did not show significant differences ($P>0.05$), neither did sward height. The chemical composition of the pasture did not show statistically significant differences for the assessed periods either. Animal weight, body condition and daily weight gain did not show significant differences among the evaluated treatments ($P>0.05$).

Implications: This is the first report evaluating sheep and goat grazing to control of *Senecio* invasion in temperate pasture in central Mexico. In addition, knowing the chemical quality of *Senecio* will allow decisions to be made for supplementation in grazing systems with sheep or goats.

Conclusions: The grazing of sheep and goats reduced the number of *Senecio* plants in the assessed pasture, which indicates the possibility of controlling this weed by grazing sheep or goats over longer-term grazing.

Keywords: *Senecio inaequidens*; weed control; grazing; sheep; goats.

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INTRODUCTION

Cow feed in small-scale dairy systems (SSDS) is based on pastures cultivated for grazing, avoiding cut and carry (Pincay-Figueroa *et al.*, 2016); however, such pastures face the invasion of species that are considered weeds, which directly compete for space and nutrients, making the pasture less persistent, thereby the animals have less forage available to feed on (Gardner *et al.*, 2006).

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One such invasive species is *Senecio inaequidens* DC, which comes from North Africa. It contains pyrrolizidine alkaloids that are toxic for livestock and human beings (Scherber *et al.*, 2003). The way it was introduced into Mexico is not known, though it has become a great problem for cultivated pastures. In the municipality of Amealco, state of Queretaro, Mexico, it is an extremely abundant plant; although it was collected for the first time in 1990, the local population has known it for more than 50 years (Rzedowski *et al.*, 2003). To control or eliminate invasive species, different physical measures are undertaken such as controlled slash and burn, chemical or rudimentary biologic controls with herbicides and insects, as well as grazing management (Firn *et al.*, 2013). Measures to combat *Senecio* include herbicide application and goat and sheep grazing (Rzedowski *et al.*, 2003).

Different animal species have different grazing behaviours. Sheep and cows prefer grazing on herbaceous, whereas goats prefer more mature growths such as ears and also graze woody species such as heathers and gorses, among others (Osoro *et al.*, 2000); goats as compared to other ruminants are more tolerant to tannins and alkaloids, and prefer shrub by plants when herbaceous species are in dry vegetative rest (Azócar, 1987).

In dairy production systems, attempts have been made to control *Senecio* invasions, so far however, this plant has neither been eradicated nor controlled. Although in South America (Brazil, Argentina and Uruguay) there are works on the control of this weed, in Mexico few are the works reported on this species. In this way, the goal of the present work was to carry out an exploratory evaluation by means of setting up sheep and goat grazing, in a temperate pasture invaded by *Senecio inaequidens*, as a means of biological control of weeds in SSDS, and determine the chemical composition of *Senecio* and pasture.

MATERIALS AND METHODS

Experimental site

The study was carried out in January and February 2020, in a small-scale dairy farm in the municipality of Aculco (20° 06' N and 99° 50' W), at an altitude of 2440 m. Climate is temperate subhumid, with minimal temperatures below zero in winter, and mean maximum temperatures of 24 °C, and around 800 mm rainfall (Plata-Reyes *et al.*, 2021).

In December 2018, a pasture of 7844 m^2 was established with ryegrass, associated with red clover and white clover, at a seeding rate of 30 kg ryegrass, 8 kg/hared clover, and 3 kg/ha white clover. Fertilization at seeding was 160 kg/ha diammonium phosphate, 120 kg/ha potassium chloride; plus, 50 kg urea/ha were applied every four weeks. About a year after establishing the pasture, it was invaded by *Senecio inaequidens*, nowadays it has almost disappeared due to the presence of this invasive plant.

The animals used were 4 sheep and 4 crossbreed goats, 2 years of age, weighing between 20 and 30 kg, with a body condition (BC) score of 2.6 for sheep and 2.5 for goats.

Sheep and goats were tethered and had access to a grazing surface of pasture and *S. inaequidens* (28.27 m^2 and 50.26 m^2, respectively). The following treatments were evaluated: T1=goat+50.26 m^2; T2=sheep+50.26 m^2; T3=goat+28.27 m^2; T4=sheep+28.27 m^2; animals were not supplemented and had *ad libitum* access to water on buckets for each one.

Pasture variables

Senecio inaequidens density in pasture was measure using a 0.5×0.5 m quadrant (0.25 m^2), estimating the number of plants/m^2 according to Ibarra-Flores *et al.* (1999), 4 measurements were taken for each sub-pasture. Sward height was according to Hodgson (1994), measurements were taken following a "W" pattern every 20 steps, covering the total area of each sub-pasture. To measure the height of *S. inaequidens*, the Santa Cruz method for the height of the key species was resorted to (Borrelli and Oliva, 2001), over a transect in each sub-pasture, every 10 steps, the first *Senecio* plant closest to the foot in front was located and three plants were counted; these were evaluated with a 1-metre rule, measuring from the ground up to the leaf modal level, when it was noticed that the plant had been eaten unevenly, the height of long and short leaves was averaged.

S. inaequidens coverage was with the point method (Levy and Madden, 1933), drawing a transect with a 50-metre rope at random in each sub-pasture. The rope was divided in 5 groups of 10 points each, all separated 1.0 m from one another, plants in touch with the points above were counted, considering that if a point did not touch a plant, it was not counted, but was assessed. Coverage was evaluated with the percentage of the points of touch of *Senecio* plant in relation with the total points.

Simulated grazing samples, weighing about 50.0 g DM, were taken every day the pasture was measured; as well, samples of *S. inaequidens* were obtained, taking notice of what parts of the plants were eaten by sheep or goats.

Animal variables

Live weight (kg) and body condition (5-point scale) were registered every 8 days, at the end of each evaluation period; moreover, to evaluate daily weight gain, a linear regression was applied.

Chemical analyses of forages

The samples were dried in a forced draft oven at 60 °C, up to constant weight to ascertain dry matter (DM). Nitrogen in samples was by the Kjeldahl method (AOAC, 1990); the results were multiplied by a factor of 6.25 (AFRC, 1993) to calculate crude protein (CP) content. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were by ANKOM following Van Soest *et al.* (1991). *In vitro* dry matter digestibility (IVDMD) for the pasture and *S. inaequidens* was according to the equation by Jerenyama and García, (2004): $IVDMD = 88.9 - (0.779 * ADF\%)$.

Statistical analysis

A 2×2 factorial design was utilised (Lawal, 2014) with the following mathematic model:

$$Y_{ijk} = \mu + B_i + T_j + BT_{ij} + e_{ijk}$$

Where: Y_{ijk}=response variable; μ=overall mean; B_i=effect of animal species, T_j=effect of forage availability; BT_{ij}=effect of the interaction between animal species and forage availability; e_{ijk}=experimental error. With these data, a variance analysis was run with

Minitab V 14 (2003); in case of significant differences between treatments, a Tukey test was applied at a significance level (P<0.05). Descriptive statistics was used to report crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), and *in vitro* dry matter digestibility (IVDMD).

RESULTS AND DISCUSSION

Table 1 shows results for live weight and body condition. No significant differences were noticed (P>0.05) among treatments for daily weight gain. Although no significant differences are observed in the variable of daily weight gain, a 20% more weight gain is observed in goats compared to sheep, which is also reflected in the weight of the animals, as well same in body condition.

Live weight for sheep and goats (Table 1), which is higher for goats, indicates that the hardiness of goats helps them to consume not very palatable foods such as *Senecio*. Santra and Karim, (2001) found that goats are more efficient to digest cellular walls in comparison with sheep. These results are in line with Wilson and Mulham (1980), who reported higher weight gain by goats versus sheep in mixed grazing in arid forest, dominated by belah (*Casuarina cristata*) coverage and other trees, shrubs, and herbage.

Animals had the same body condition during the experiment, which suggest that pasture and *Senecio* covered the requirements of these animals. These results diverge from García *et al.* (2005), for sheep and goat mixed grazing in heathlands-shrublands, burnt beforehand, and previously grazed by sheep, in Asturias, Spain, 2004, the authors observed BC losses of 0.54 for sheep, while 0.66 for goats.

Considering the condition of the pasture infested by *S. inaequidens*, the fact that sheep and goats had gained a little weight may be because the pasture they grazed had good

Table 1. Live weight and body condition of sheep and goats over all the experimental periods.

Surface (m^2)	Animal	Weight (kg)	Mean	SEM	P-value
28.27	Sheep	28.80	29.72	1.85	0.25
50.26	Sheep	28.75			
28.27	Goat	30.85			
50.26	Goat	30.05			
		Body condition (1-5)			
28.27	Sheep	2.60	2.63	0.19	0.78
50.26	Sheep	2.55			
28.27	Goat	2.75			
50.26	Goat	2.65			
		DWG (kg)			
28.27	Sheep	0.028	0.030	0.004	0.62
50.26	Sheep	0.026			
28.27	Goat	0.033			
50.26	Goat	0.035			

SEM: Standard error of the mean; BC: Body condition; DWG: Daily weight gain; * Interaction between animals and surface was not representative.

Table 2. Variables of the pasture invaded by *Senecio inaequidens*.

Surface (m^2)	Animal	Height of Senecio	Mean	SEM_{as}	P value
28.27	Sheep	28.27	28.72	1.85	0.25
50.26	Sheep	29.17			
28.27	Goat	31.63	31.01		
50.26	Goat	30.40			
SEM_S		2.78			
Density					
28.27	Sheep	16.56	16.99	2.42	0.64
50.26	Sheep	17.43			
28.27	Goat	16.25	15.90		
50.26	Goat	15.56			
SEM_S		3.96			
Coverage					
28.27	Sheep	48.75	47.99	2.21	0.88
50.26	Sheep	47.23			
28.27	Goat	44.26	44.39		
50.26	Goat	44.52			
SEM_S		1.41			
Sward height					
28.27	Sheep	1.88	1.81	0.52	0.33
50.26	Sheep	1.75			
28.27	Goat	2.04	2.06		
50.26	Goat	2.08			
SEM_S		0.77			

SEMas=Standard error of the mean for animal species; SEMS=Standard error of the mean for grazing surface; *Interaction between animals and surface was not representative.

quality, adding to good dry matter digestibility, as noticed in Table 3; furthermore, *Senecio* contains tannins, which in moderate amounts help to better use the proteins in feed. In this regard, Bonilla-Valverde *et al*. (2017) found an increase in the daily weight gain of sheep by adding tannin extract to the feed.

Table 2 shows results for variables of the pasture invaded by *S. inaequidens*. The height, density and coverage of *Senecio* did not show significant differences among treatments, interaction was not significant either (P>0.05). The height of the *Senecio* was higher on the surface of the goats, without presenting significant differences (P>0.05) with respect to the surface of the sheep. However, there was less Senecio coverage on the surface where goats grazed, compared to sheep, although without significant differences (P>0.05). The height of the pasture was greater in the area grazed by goats compared to the area grazed by sheep (P>0.05).

The height of *Senecio* is a marker for the consumption of the animals; a considerable height is noticed, which may point out that the animals preferred pasture over *Senecio*. The mean of the four treatments at the end of the experiment is within the range from 15 to 70 cm in height mentioned by Rzedowski *et al.* (2003). *Senecio inaequidens* has a great spread capacity (CONABIO, 2016), which makes this plant have good density in the pasture under assessment (16.86 plants/m^2), concurring with Sindel and Coleman (2012), who report that one plant of *Senecio madagascariensis* might produce from a few to hundreds of new plants when cows graze the pastures, since they scatter the *Senecio* seeds; this situation was also noticed in this experiment. Besides, it was observed that wind is a factor that contributes to the spread of the plant. This relates with the density of the plants present in the pasture on average. Added to the grazing pressure of the animals, it causes the *Senecio* to disperse quickly and there are risks of intoxication in the animals (Rissi *et al.* 2007).

As for the coverage of *Senecio* at the end of the experiment (Table 2), it covers about 50% of 1.0 m^2, which indicates that the amount of *Senecio* plants in the pasture was higher than what animals were able to consume, adding to this, the duration of the experiment was relatively short. The coverage results of this investigation were lower than Jáuregui *et al.* (2009), who evaluated the coverage of heather, a weed similar to *S. inaequidens*, after the 3-year experiment heather coverage was 36.2% in pastures grazed by sheep, and 31.8% in pastures grazed by goats, which suggests that time and liberty to graze influence on the species coverage. In an experiment with sheep to control *Senecio*, Bandarra *et al.* (2012) found a drop from 1622 Senecio plants on a 2700-square-metre surface to 0 plants/m^2; this is because these authors' experiment lasted about three years.

In this experiment, sward height is below Hodgson's (1994) recommendation, *i.e.*, sward height must be between 5.0 and 8.0 cm so that animals graze well and their voluntary consumption is not restricted. Short sward height may be due to the competence between the gramineous plant with *Senecio*; this competence depends on the dynamics of the plants under study and on the grazing of goats, which help to control shrubby and woody species (Jáuregui *et al.*, 2009).

The chemical characteristics of pasture and *Senecio inaequidens* are displayed in Table 3. The pasture CP content over the assessment period was 160.2 g/kg DM; NDF was 446.4 g/kg DM, ADF 216.8 g/kg DM and IVDMD 720.05 g/kg DM.

There is an inverse relationship between CP and the number of structural carbohydrates (Table 3); this may be because the contents of CP and structural carbohydrates change

Table 3. Chemical composition pasture and Senecio inaequidens (g kg^{-1} DM) grazed by sheep and goats.

Period	Pasture			IVDMD	Senecio inaequidens			IVDMD
	CP	NDF	ADF		CP	NDF	ADF	
1	162.3	422.6	210.2	725.2	78.4	762.4	432.5	552.1
2	156.5	446.2	218.4	718.8	78.6	766.2	423.7	558.5
3	163.4	454.6	216.2	720.5	77.4	778.4	428.4	555.2
4	158.6	462.4	222.4	715.7	76.4	782.6	438.2	547.6
Mean	160.2	446.4	216.8	720.05	77.7	772.4	430.7	553.3
SD	3.21	17.22	5.09	34.3	1.01	9.63	6.16	41.5

CP: Crude protein; NDF: Neutral detergent fibre; ADF: Acid detergent fibre; IVDMD: *In vitro* dry matter digestibility; SD: Standard deviation.

over time and such changes are attributed to the ripeness of the plant and the increase in stem ratio (Ammar *et al*., 2004). CP in pasture is different from Martínez-Hernández *et al*. (2019), who report 102.9 g/kg DM, and from Plata-Pérez *et al*. (2020), for pastures cultivated with annual ryegrass, winter vetch and common vetch (99.3 g kg^{-1} DM).

The chemical quality of *S. inaequidens* (Table 3) is lower than that of tropical grasses. CP content over the assessment period was 77.7 ± 1.01 g kg^{-1} DM; NDF was 772.4 g kg^{-1} DM, ADF 430.7 g kg^{-1} DM and IVDMD 553.3 g kg^{-1} DM. The above suggests that as a forage *Senecio* has poor quality (López-González *et al*., 2020), in addition to the toxicant agents it has (pyrrolizidine alkaloids), which may severely harm liver, mainly in cows; *Senecio* is a grave problem for pastures in dairy production systems.

CONCLUSIONS

Sheep and goat grazing reduced the number of individuals of *Senecio inaequidens* in the evaluated pasture without noticing significant differences. Assessing the effects over longer periods of time is necessary.

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