Scientific Paper

Productive indicators in *Cavia porcellus*, fed five forage species in the Austro region of Ecuador▲

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Abstract

Objective: To evaluate the performance of productive indicators in *Cavia porcellus* (Guinea pig), fed five forage species, during the growth-fattening stage.

Materials and Methods: A study was conducted in the Gupancay farm, located in the Gualaceo canton, Azuay province, Ecuador. A complete randomized experimental design was applied with five treatments, which corresponded to the evaluated species: T1- *Medicago sativa* L., T2- *Alnus acuminata* Kunth**,** T3- *Cenchrus purpureus* (Schumach.) cv. Morado, T4- *Tithonia diversifolia* (Hemsl.) A. Gray and T5= *Saccharum officinarum* L. + balanced feed. The duration of the experimental period was four months. The diets were formulated with the forage species and the concentrate feed, in 70-30 % ratio for all the treatments. Fifteen male crossbred newly-weaned Guinea pigs, similar in age and weight, were used. The evaluated indicators were: live weight, weight gain, feed conversion and carcass yield.

Results: The best bromatological composition was for *M. sativa* and *T. diversifolia*, with crude protein values of 20 and 21 %, respectively. *A. acuminata* showed the lowest protein values (5 %), but the highest crude fiber (35,2 %) and organic matter ones (94,8 %). However, the *in vitro* organic matter digestibility was low with regards to the other forage plants (59,3 %). The best productive results were for the treatments that used *M. sativa* and *T. diversifolia*. The lowest values were recorded in S. *officinarum* and *A. acuminata*, with significant differences (p<0,001).

Conclusions: The best performance for the variables weight gain, feed conversion ad carcass yield were obtained in the treatments that included *M. sativa* and *T. diversifolia* in the diet of Guinea pigs. These forage species had a crude protein percentage higher than 20 %.

Keywords: *Tithonia diversifolia*, Guinea pigs, *Medicago sativa*

Introduction

The production of Guinea pigs in Ecuador is, generally, a rural activity, in which the traditional-family rearing system prevails. The Guinea pig constitutes one of the most traditional dishes of the Ecuadorian Andes and its elaboration represents an employment source for hundreds of farmers. Hence it is considered by the UN and FAO as a source of food security for the world population with scarce economic resources (Rosales Jaramill *et al.,* 2018).

Guinea pigs are monogastric, herbivore animals. Their digestive physiology is characterized by post-gastric cecal fermentation (Canto and Bernal-Wilmer*,* 2018). Diverse research works have been conducted about Guinea pig feeding (Choez and Ravillet, 2018), in order to evaluate its effect on the productive parameters (pregnancy and parturition rate, litter size, sow and pup morbidity, post-parturition weight of the sows, growth rate for fattening, weight at slaughter and carcass quality, among others).

Fresh alfalfa (*Medicago sativa* L.), barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.) and wheat (*Triticum vulgare* L.) constitute the principal basis of this mammal feeding, because they contribute important energy and protein quantities to the diet (Alvarado-Zuta, 2017). Different research works have aimed at obtaining adequate feedstuffs for the nutritional requirements of these animals in order to achieve optimum production levels. The use of grasses and tropical shrub forage plants (Meza-Bone *et al.,* 2014), dry velvet bean forage [*Stizolobium deeringianum* L. Medik.] (Valenzuela-Rocha, 2015), roots and foliage of cassava [*Manihot esculenta* Crantz] (Paillacho-Sánchez, 2017), as well as the inclusion of cowpea (*Vigna unguiculata* L. Walp) as ingredient in rations for growth-fattening (Choez and Ravillet, 2018), are among the feeding

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sources that can cover the nutritional needs of this species. The use of different proportions of cattle blood meal (Bazán-García *et al*., 2016) and the stubble of such plants or crops as pepperweed [*Lepidium peruvianum* Chacón] (Castro-Bedriñana *et al.,* 2018), among other feedstuffs, is also included.

The feeding and nutrition needs of Guinea pigs vary according to the stages of their life cycle (lactation, growth and reproduction). However, in all of them protein, energy, fiber, vitamins, minerals and water are required. Hence the production and profitability of Guinea pig rearing will depend on the feeding sources (Castro-Bedriñana *et al.,* 2018).

From the above-explained facts, the objective of this research was to evaluate the performance of productive indicators in *Cavia porcellus* (Guinea pig), fed five forage species, during the growth-fattening stage.

Materials and Methods

Characteristics of the research area. The study was conducted in the Gupancay farm, owned by the Macancela-Urdiales family, located on the old road to San Juan del Cid, km $6^{1/2}$, in the San Juan parish, Gualaceo canton, Azuay province, Ecuador. The farm has a total area of 9 ha and is located in a zone of mountainous topography, at an altitude of 2 400 m.a.s.l., on a Vertisol soil. The mean annual rainfall is 1 100 mm, distributed throughout the year. The mean temperature is 17 ºC (table 1).

Experimental design and treatments. A complete randomized design was used with five treatments and 15 animals per treatment, each one was considered a repetition. The duration of the experimental period was four months (16 weeks) and was in correspondence with the growth-fattening stage.

T1- *Medicago sativa* L. + balanced feed

T2- *Alnus acuminata* Kunth + balanced feed

T3-*Cenchrus purpureus* (Schumach.) cv. Morado + balanced feed

T4- *Tithonia diversifolia* (Hemsl.) A. Gray + balanced feed

T5- *Saccharum officinarum* L. + balanced feed

Characteristics and management of the forage species. Each species was managed according to the crop characteristics:

- *M. sativa* (alfalfa). Legume, cutting frequency of the forage between 50 and 60 days.
- *A. acuminata*. Betulaceae, tree, three years as average after being planted.
- *C. purpureus* cv. Morado (king grass morado). Grass, cutting frequency of the forage between 50 and 60 days.
- *T. diversifolia* (Mexican sunflower). Asteraceae, cutting frequency of the forage between 50 and 60 days.
- *S. officinarum* (sugarcane). Gramineae, plantation with two years after the establishment, without homogenization cut.

The forages were cut in the morning and were chopped with a chopping machine F-150 (4 mm cutting size) to homogenize the feedstuffs.

Animal management and feeding. Male, crossbred, weaned Guinea pigs were used, similar in age (15 ± 3 days) and weight (381 g). They were identified with aluminum ear rings and randomly distributed to form homogeneous groups. They received a diet constituted by forages (according to the treatment) and concentrate feed. The balanced feed was offered in the morning; while the forage species were chopped and distributed at three moments of the day (morning, afternoon, night). The animals were subject to an adaptation period of 15 days, before the experimental period.

Measurements. Of each forage species, three 500-g samples were taken during the experimental period. They were transferred to the laboratory of chemical sciences of the University of Cuenca in order to determine their bromatological composition, according to the technique proposed by the AOAC (2016): dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ash (ASH), calcium (Ca), magnesium (Mg) and phosphorus (P). For determining the organic matter *in vitro* digestibility (OMD), the KOH technique was used.

Table 1. Climate data of the experimental stage.

Variable	September	October	November	December	January	February
Mean temperature, ºC	16,6	17,3	17,6	17,6	17,5	17,6
Mean temperature of the last ten years, ºC	16,6	17,3	17,6	17,6	17,5	17,6
Mean rainfall, mm	60	75	75	70	65	80
Mean rainfall of the last ten years, mm	60	77	77	74	63	81

Source: Provincial Government of Azuay (2015)

Feed intake. It was determined through an offer-consumption-refuse test (determined by the difference of the supplied feed during the day and the waste recorded the next day) with a weekly frequency.

Live weight and weight gain. The animals were weighed with a monthly frequency. A Century® digital scale was used, with maximum capacity of 10 kg and accuracy of ± 0,5 kg. The accumulated weight gain for the period was quantified. The mean daily gain (MDG) was expressed in grams/animal/day, from the differences of initial and final live weight.

Feed conversion (FC). It was calculated establishing the relation between the feed intake and weight gain, according to the formula:

$$FC = \frac{\text{consumed feed (kg/animal/period)}}{\text{live weight gain, kg}}$$

Carcass yield (CY). It was determined by considering the weight of the warm carcass weight with regards to the live weight of the animal at the moment of slaughter. Head, legs and viscera (heart, liver and kidney) were included. The following formula was used:

$$CY = \frac{\text{carcass weight x 100}}{\text{live weight gain, kg}}$$

Statistical analysis. The results were recorded in an Excel database. Simple variance analysis was used, after testing the variance homogeneity (Levene's test) and normal distribution (Shapiro-Wilk test) assumptions. For the mean comparison, Tukey's test was used for a significance level of $p < 0,05$ through the statistical package SSPS®, version 10.0.1 for Windows.

Results and Discussion

Table 2 shows the bromatological composition of the evaluated forage species. The DM, CP and CF values are in correspondence with the bromatological indicators described for *M. Sativa* (Aguilar-Quintana 2017), *Saccharum spp.* (Salazar-Ortiz *et al.,* 2017), *T. diversifolia* (Rivera *et al.,* 2019) and *C. purpureum* (Vivas-Quila *et al.,* 2019).

The best bromatological composition was for *M. sativa* and *T. diversifolia*, with CP values of 20 and 21 %, respectively. Both species represent a potential for Guinea pig feeding, when considering that this indicator is one of the most important, because their nutritional requirements can vary between 14 and 22 % depending on the phase of their productive cycle (pregnancy, lactation, growth), as stated by señala (Alvarado-Zuta, 2017)

A. acuminata showed the lowest protein values and the highest CF ad OM; while the *in vitro* OM digestibility was low with regards to the other forage plants (59,3 %).

The highest ASH, Ca, P and Mg values were for *T. diversifolia* and *M. sativa*. According to Gualoto-Lata (2018), minerals fulfill multiple functions in the organism, among them the structural, physiological and catalyst ones, the most important ones being the formation of bones and nerves.

Table 3 shows the initial and final live weight, total weight gain and feed conversion.The best productive results were for the treatments that used *M. sativa* and *T. diversifolia*. The lowest values were recorded in *S. officinarum* and *A. acuminata,* with significant differences ($p < 0,001$).

The values of final live weight in the forage species oscillated between 1 100 and 1 500 g/animal. These are similar to the ones reported by Camino and Hidalgo (2014), who evaluated a mixed diet based on balanced feed, vitamin C (70 mg/100 g of feedstuff) and broccoli (*Brassica oleracea* L.) stubble. Nevertheless, they were higher than the ones reported by Andrade-Yucailla *et al.,* (2015), when evaluating three substitution levels (25, 40 and 55 %) of green forage of *lpomoea batatas* L. (sweet potato) in diets for Guinea pigs during the growth-fattening stages in the Ecuadorian Amazonia region. These authors reported values between 910 and 1 050 g/Guinea pig.

The results of final live weight for the treatment with *S. officinarum* were among the lowest ones, but were higher than those referred by Toro-Molina *et al.* (2017), who used 15 % of bagasse of this plant

Table 2. Bromatological composition of the forage species, %.

Treatment	DM	CP	CF	OM	ASH	Ca	Mg	P	OMD
M. sativa	23	20	24,4	88,0	12,00	5,2	2,7	0,6	72,4
A. acuminata	37	5	35,2	94,8	5,16	2,3	1,9	0,4	59,3
C. purpureus	16	10	28,8	82,6	17,40	2,2	1,7	0,4	65,2
T. diversifolia	20	21	25,1	84,4	15,59	5,3	2,6	0,7	68,6
S. officinarum	36	6	24,8	97,2	2,76	2,4	1,7	0,3	67,8

Table 3. Performance of the productive indicators of Guinea pigs fed five forage species.

Treatment	Initial weight, g	Final weight, g	Total weight gain, g	Feed conversion
M. sativa	386,9 ± 21,65	1427,0 ± 45,92[a]	1040,1 ± 59,83[a]	8,8 ± 0,49[a]
A. acuminata	393,4 ± 26,24	1130,5 ± 37,39[b]	737,1 ± 40,22[b]	15,8 ± 0,95[b]
C. purpureus	367,0 ± 19,62	1239,8 ± 48,54[ab]	872,8 ± 47,46[ab]	9,8 ± 0,51[a]
T. diversifolia	375,3 ± 18,23	1262,5 ± 33,73[ab]	887,3 ± 41,84[a]	8,5 ± 0,40[a]
S. officinarum	381,5 ± 15,16	1146,5 ± 34,38[b]	765,0 ± 39,78[b]	13,9 ± 0,69[b]
P–value	0,891	0,000	0,000	0,000

a, b: Different letters in the same column indicate significant differences ($p \leq 0,05$)

(935,2 g). They were also better than those obtained by Avalos-Sánchez (2010), when evaluating four inclusion levels of chopped fresh sugarcane (20, 40, 60 and 80 %), in both cases in mixed diets with *M. sativa* during growth-fattening.

The values recorded in this research for total weight gain in the period were higher than the ones reported by Sánchez-Laiño *et al.* (2009), who evaluated three tropical grasses (*Panicum maximum*[1] Jack, *Zea mays, S. officinarum*) plus concentrate feed during the fattening of improved Guinea pigs in the Ecuadorian coastal region. These authors obtained values of 478,5; 521,9 and 398,3 g/period, respectively.

The MDG of the animals was similar to the one reported by Meza-Bone *et al.,* (2014), when evaluating forage tropical grasses (*P. maximum*; *Pennisetum* sp.) and shrubs (*Morus alba* L., *Erythrina poeppigiana* (Walp.) O.F.Cook*, Hibiscus rosa-sinensis* L.) *ad libitum* in Guinea pig feeding in Quevedo, Ecuador. However, they were higher than the 10,5 g/animal/day referred byYamada *et al.* (2019) in the evaluation of two meat lines of Guinea pigs (improved genotypes) in the central coast of Peru, with feeding regime based on forage corn, wheat bran and fresh water.

Significant differences were found ($p > 0,001$) in the average feed conversion among the treatments *M. sativa, T. diversifolia* and *C. purpureus* with regards to *S. officinarum* and *A. acuminata* (table 3). These results are similar to the ones reported by Guevara and Carcelén (2014) when evaluating the effect of probiotics on improved Guinea pigs for the growth and fattening stage. They also coincide with those referred in the study conducted by Andrade-Yucailla *et al*. (2015) about the evaluation of grasses adapted to the Amazonian region.

When evaluating the carcass yield (table 4), the values were between 71 and 76 %. The best results were found in *M. sativa* and *T. diversifolia.* They were followed by *C. purpureus* and *S. officinarum*. In studies conducted by Camino and Hidalgo (2014), these authors obtained carcass yields similar to the ones recorded in this work , with values of 72 and 73 %, when evaluating different feeding alternatives (concentrate feed as pellet and meal and concentrate feeds with restriction of the forage offer, respectively). However, the result of this study slightly surpassed those obtained by Canto *et al*., (2018), who evaluated the effect of supplementation with probiotic (*Lactobacillus*) in diets of *M. sativa* and concentrate feed, and obtained values between 70 and 72 %.

Table 4. Carcass yield of the animals for the evaluated forage species.

Treatment	Carcass yield,%
M. sativa	75
A. acuminata	72
C. purpureus	74
T. diversifolia	75
S. officinarum	74

The animals that consumed the *T. diversifolia* forage showed higher efficiency in their conversion from feed to meat, without significant differences regarding the carcass yield, for which it could be inferred that this species has the same nutritional effect as *M. sativa*, because significant differences were not found either between both treatments for the live weight and animal gain.

The productive indicators were very affected in *A. acuminata*, if compared with the other forage plants. This performance could have been influenced by the lower percentages in forage utilization, as well as the low protein contents and high fiber levels, characteristics which qualify *A. acuminata* as a local resource with limitations for Guinea pig feeding.

[1]Current scientific name: *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs

Conclusions

The best performance for the variables weight gain, feed conversion and carcass yield were obtained in the treatments that included *M. sativa* and *T. diversifolia* in the diet of Guinea pigs. These forage species had a crude protein percentage over 20 %.

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Authors' contribution

- Wilson Geovanny Macancela-Urdiales. Conducted the experiments and data collection. In addition, he prepared the work for its publication.
- Mildrey Soca-Pérez. Conceptualized the research idea and supervised the research activity.
- Tania Sánchez-Santana. Carried out the statistical analysis and reviewed the manuscript.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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