Growth Trait Heredity in Two Cavy Sublines Native to the Ecuadoran Mountain Range

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ABSTRACT

Background: No studies have been published on South American cavy preservation and breeding programs; therefore, the aim of this article was to analyze the genotypic and environmental factors that act upon the growth traits of a South American native cavy line found in the Ecuadoran Mountain Range.

Methods: The study took place on Irquis experimental farm, from the Faculty of Agricultural Sciences, University of Cuenca, using two native cavy sublines from rural breeders in provinces Azuay and Cañar. Weight per age and daily weight gain (g) were analyzed by a mixed variance analysis of litter size (5), season (semester), sex, and parturition number of the mother as fixed effects, using software R 3.4.4. The random effects were made by sub-lines Azuay (1) and Cañar (2), and their male parents. The basic statistical values were determined.

Results: Birth weight, weaning weight, and weight at 90 days in grams, were 110.2 ± 1.81, 117.0 ± 1.44; 212.2 ± 4.30 and 221.13 ± 3.38; 540.7 ± 12.01, and 659.1 ± 9.44, respectively. The heredity values for these traits were 0.09 ± 0.101, 0.34 ± 0.201, and 0.11 ± 0.111. Besides, weight was analyzed at 30, 45, 60, 75, and 90 days after birth, which included gains at every age. The BLUP predictors for the parents of the two sub-lines were determined. Variation and heritability allowed for selection of weight at weaning and at 90 days.

Conclusions: This line showed low growth levels, though the variations observed were adequate. Their heredity might lead to the expected favorable results, provided a selection program is implemented in the mid-term.

Key words: *cavies, heredity, weight, gain*

INTRODUCTION

According to FAO and other organizations for the protection of nature, there is a continuous loss of species, subspecies, and animal and plant lines. This scenario calls for changes, studies, and thorough and sustainable development plans to minimize the current trend (FAO, 1997).

Although the South American covies are not in danger, no particular studies have been carried out on preservation and genetic breeding programs, despite the several ecotypes of this species, mainly in remote Andean cities and rural areas. Recently, the implementation of genetic breeding programs in Peru (Chauca 1997; Rodríguez, Gutiérrez, Palomino, and Hidalgo, 2015) has increasingly allowed the so-called improved Peru covy line, to replace the native ecotypes. This practice has proven effective and fast, since the improved animals almost double the native individuals, and continue to be studied, regardless of their success (Sánchez, Barrera, Orozco, Torres, and Monsivaís, 2013).

The aim of this paper was to analyze genotypic and environmental factors that influence on growth traits of a native covy line, south of the Ecuadoran mountain range.

MATERIALS AND METHODS

This study was conducted on an experimental farm in Irquis, property of the Faculty of Agricultural Sciences, University of Cuenca, in Vctoria Portete, Cuenca Canton, Azuay province, km 23 via Giron, 2 664 m above sea level, with temperature values between 7 and 12 °C.

The database comprised the records of two generations of animals born between 2017 and 2018, from native breeding animals, and their progeny, which had been previously screened among farmers from Azuay and Cañar, according to the Ecuadoran native animals' phenotypic traits described in the literature (Avilés, 2016). Mating did not include siblings. Five females were used per father in each cage, and after weaning, the animals from all the sublines were placed in cages following conditions of equality. Meas-

urements and recording of several traits, like weight (grams) per age, at birth (BW), weaning at 14 days (WW), at 30 days (P30), at 45 days (P45), at 60 days (P60), at 75 days (P75), and at 90 days (P90), as well as daily weight gain, weight gain between birth and weaning (G014), between weaning and 30 days (G1430), between 30-45 days (G3045), between 45-60 days (G4560), 60-75 days (G6075), 75-90 days (G7590), between birth and 90 days (G090), and between weaning and 90 days (G1490).

These variables were analyzed by a mixed variance analysis with fixed effects, such as litter size, season (semester), sex, and number of parturitions of the mother (1,2). Two random effects were used: sublines Azuay (1) and Cañar (2), and the fathers within the sublines (10). Their basic statistical values were determined.

Heredity was estimated from half-sibling litters, along with their standard errors, according to Swiger, Harvey, Everson, and Gregory (1964). Analysis of variance was REML-nested, along with the random effects of sublines and their male parents, which determined the variance components and BLUP predictors. An R routine, version 3.4.4 (2018) was used.

Feeding was mixed, and food supply was based on live weight using weekly calculations of a forage mix of *Lolium perene* and *Trifolium renfes*, plus a supplement including commercial feed.

RESULTS AND DISCUSSION

Table 1 shows the significant influence of genotypic effects on almost all the weight ranges. Factors litter size and season had no influence on weight from 45 days on. Moreover, factors sex and parturition number did not influence on weights in general.

Table 1. Results of weight variance analysis

Variation source	LG	BW	WW	P30	P45	P60	P75	P90
Sublines	1	**	**	**	**	**	**	**
Male parents within the subline	8	**	**	**	**	NS	**	**
Litter size	5	**	**	**	NS	NS	NS	NS
Season	1	*	**	*	NS	NS	*	*
Sex	1	NS	NS	NS	NS	*	NS	NS
Number of parturitions	1	**	NS	NS	NS	NS	NS	NS
Error gl		335	278	258	258	258	258	258
R^2		0.31	0.28	0.24	0.28	0.29	0.31	0.32
VC		17.7	19.5	19.2	19.0	18.8	19.1	18.8

The influence of litter size was only observed at early ages, until 30 days, coinciding with Rodríguez, Palomino, Hidalgo, and Gutiérrez (2013), and Rodríguez, Gutiérrez, Palomino, and Hidalgo (2015) in relation to the improved Peru line, the number of litters per parturition was observed to have an effect on birth weight and weaning weight. Following the deaths related to these stages, the growth capacity of the covy line was not affected by the kind of litter the animals belonged to.

The other factors had a significant influence on few traits. Season, considered in two categories (winter and summer), had an influence on several traits, such as birth weight and weaning weight at 14 days, coinciding with Rodríguez, Gutiérrez, Palomino, and Hidalgo (2015), but important traits like P90 and daily gain were influenced throughout the growth period. Sex and number of parturitions barely affected any

trait. The high variability observed was also influential; hence, the determination coefficients found for the model were low.

Daily weight gains were mainly influenced by genotypic effects, though the effect of fathers within the sublines was observed in gains, from 60 days on, and the ones observed at birth and weaning lasted until 90 days. The other factors did not have a significant influence on most gains (Table 2). The variation coefficients for daily weight gain were higher than the reports of weight per age. This can be attributed to very irregular individual variations, individuals with lower weight than others at certain ages, which underwent a marked weight gain during the next stage to reach their mean weights, but with reduced weight gain on the next stage. Feeding competition in the cages during the pre and post weaning stages is complex, and it has not been thoroughly studied.

Table 2. Results from variance analysis of weight gain

VF	LG	G014	G1430	G3045	G4560	G6075	G7590	G090	G1490
Sublines	1	NS	**	**	**	**	NS	**	**
Fathers within the sublines	8	**	NS	NS	NS	**	*	**	*
Litter size	5	*	*	NS	NS	NS	NS	NS	NS
Season	1	*	NS	NS	NS	*	NS	*	NS
Sex	1	NS	NS	NS	NS	NS	NS	NS	NS
Number of parturitions	1	NS	*	NS	NS	NS	NS	NS	NS
Error gl		261	258	257	249	232	223	253	250
R^2		0.19	0.18	0.34	0.29	0.16	0.12	0.30	0.32
VC		32.5	41.0	33.4	35.4	37.0	29.8	20.8	22.0

Table 3 shows the weights and gains of each trait for the two sublines. The most important traits were better in Cañar than Azuay; weight at 90 days and weaning gain at 90 days, the superiority was above 20%. P90, possibly the most important trait internationally established for Peru, of approximately 1 000 g (Tuquinga, 2011; Malagón, and Meza 2013; Hernández 2015), was way over in this study based on non-selected animals. Even Remache (2016), reported values above 200 g, higher than in this paper. However, Kouakoa, Grongnet, Assidjo, Thys, Marnet, Catheline, and Kouba (2013), reported similar results to this study.

There are few reports on other ecotypes of Andean covies for age weights and the gains among these ages, between 4 and 7 g approximately, which did not increase alongside age, according to Mínguez and Calvo (2018), who found gains between 8.5 and 11.7 g per day, thus higher than the reports for the line. There are reports for birth weight and weaning weight of Peru (Sánchez, Barrera, Orozco, Torres, and Monsivais, 2013), with a weaning weight of 167.9 g at 10 days, similar to the values found in the current research.

Table 3. Weights and gains of covy sublines

Traits	Sublines				
	Azuay (1)		Cañar (2)		Sig.
	Mean	SE±	Mean	SE±	
BW	110.2	1.81	117.0	1.44	*
WW	212.2	4.30	221.13	3.38	NS
P30	286.2	6.00	315.4	4.72	*
P45	348.6	7.55	408.7	5.94	**
P60	392.6	8.96	492.3	7.05	**
P75	471.1	10.53	570.8	8.28	**

P90	540.7	12.01	659.1	9.44	**
G014	7.1	0.23	7.2	0.23	NS
G1430	4.6	0.23	5.9	0.18	**
G3045	4.0	0.19	6.2	0.15	**
G4560	3.8	0.19	5.7	0.15	**
G6075	4.5	0.21	5.2	0.15	**
G7590	5.8	0.15	5.4	0.21	NS
G090	4.8	0.12	6.0	0.10	**
G1490	4.5	0.13	5.8	0.10	**

NS: not significant differences * P<0.05; ** P<0.01

The estimated heredities are shown in table 4. In this research, birth weight heredity was always comparatively lower than the reported estimates in reviewed articles. Solarte, Imuez, and Pérez (2002), and Rodríguez, Palomino, Hidalgo, and Gutiérrez (2013) reported heredities of 0.12 and 0.13, and 0.17 and 0.26, respectively, for birth weights and weaning weights, both in Peru breed. However, they found lower estimates for weaning weight. Vargas (2015), in addition to sex, included the number of parturitions, season and animal, and litter size, with heredity estimates of 0.16 and 0.24, respectively. Using the Bayesian method, Vargas, Gutiérrez, and Mamani (2015) practically found the same values. Heredity for these traits is considered to range within those values, based on the large database consulted by researchers. Although the results for weaning weight was somewhat high, it was acceptable, and allows for the selection of this particular trait.

Table 4. Heredities and standard error for every trait studied

Trait	Heredity (half siblings)	SE ($_h^2$)
BW	0.09	0.061
WW	0.34	0.201
P30	0.21	0.152
P45	0.12	0.105
P60	0.07	0.053
P75	0.08	0.096
P90	0.11	0.077
G014	0.47	0.251
G1430	0.19	0.147
G3045	0.04	0.036
G4560	0.16	0.131
G6075	0.21	0.147
G7590	0.22	0.151
G090	0.24	0.163
G1490	0.18	0.139

No updated heredity reports have been established for the remaining weights per age, which may be originated by difficulties to deal with individual controls during postweaning. There is only one report for P90, by Meza, Raymondi, and Cisneros (2017), with heredity values higher than this research, which was found low (0.32), using BLUP with 91 descendants (41 mothers and 30 fathers). In this research, fewer fathers were included, which may have caused a lower added variance for this particular trait. Gains from birth to 90 days (G090) and from weaning to 90 days (G1490), showed lower estimates, though they can be used for effective selection in a period no longer than 10 years. In other species, traits with heredities below 0.15 were successfully used during selection. Even with the low estimates for the three last eco-

nomically important traits, it is possible to conduct selection programs, since traits like litter size have been improved with 0.15 heredity.

A glimpse at BLUP predictors in table 5 will help separate the male parents from subline Azuay, 732 and 734 were the best; the former showed a similar level to the best two, in terms of weight gain at 90 days. Regarding the two most important gains, they were slightly above the mean of all the fathers studied in the respective subline. The best fathers of subline Cañar were 224 and 225, both showed weight improvements, especially P90, and slightly above gain average.

Table 5. BLUP predictors for the main weights and gains of the two sublines

MALE PARENTS WITHIN THE SUBLINES	BW	WW	P90	G090	G1490
1:203	-1.96	-2.86	-8.50	-0.07	-0.08
1:216	1.81	9.44	-10.48	-0.21	-0.28
1:224	-1.24	3.32	9.26	0.17	0.13
1:225	-0.50	-8.91	11.30	0.17	0.23
1:226	1.48	-0.98	-1.58	-0.05	-0.01
2:702	2.30	-0.26	0.72	0.09	0.07
2:721	-1.38	-13.64	-20.39	-0.38	-0.22
2:732	1.41	0.38	11.22	0.17	0.21
2:733	-2.88	-6.52	-4.51	-0.05	-0.06
2:734	0.55	20.05	12.96	0.17	0.00

This paper provides the results from creating and developing an Ecuadoran native line from the southern mountain range, which can set a basis for genetic breeding and preservation.

CONCLUSIONS

The covy sublines considered as a whole underwent low growth rates and their heredities (not so high) might create favorable expectations, provided a mid-term selection program depending on the high reproductive rate of the species, is implemented.

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REFERENCES

Avilés, D. E. (2016). *Caracterización genética del cuy doméstico de América del Sur mediante marcadores moleculares*. Córdoba, España: Departamento de Genética, Universidad de Córdoba.

Chauca, L. Z. (1997). *Producción de cuyes* (*Cavia porcellus*). Perú: Estudio FAO.

FAO. (1997). *Lista mundial de vigilancia para la diversidad de los animales domésticos* (2da ed.). Organización de las Naciones Unidas para la Alimentación y la Agricultura, FAO UNEP. Retrieved on April 14, 2019, from https://www.fao.org/docrep/V8300S/V8300S00.htm.

Hernández, C. (2015). *Efecto del sexo y edad de sacrificio sobre los quintos cuartos y la calidad de la canal de cuy*. Riobamba, Ecuador: Facultad de Ingeniería, Universidad Nacional de Chimborazo.

Kouakou N. D., Grongnet, J. F., Assidjo, N. E., Thys, E., Marnet, P. G., Catheline, D., Legrand, P., & Kouba, M. (2013). Effect of a supplementation of *Euphorbia heterophylla* on nutritional meat quality of Guinea pig (*Cavia porcellus* L.). *Meat science*, *93*(4), 821-826.

Malagón M. A. P. y Meza A. M. (2013). *Pasto Guatemala (Tripsacum laxum) con maní forrajero (Arachis pintoi) en la alimentación de cuyes (Cavia porcellus linnaeus) en la etapa de engorde en la Maná-Cotopaxi, Ecuador.* Re-

trieved on April 14, 2019, from http://biblioteca.uteq.edu.ec/cgi-bin/koha/opac-detail.pl?biblionumber=3403&query_desc=su%3A%22MANI %20FORRAJERO%22

Meza, E. R.; Raymondi, J. C. y Cisneros, S. A. (2017). Evaluación Genética de un Plantel de Cuyes Reproductores de Genotipo Perú. *Rev Inv Vet Perú*, *28*(2), 293-298.

Mínguez, C. y Calvo, A. (2018). Effect of supplementation with fresh orange pulp (*Citrus sinensis*) on mortality, growth performance, slaughter traits and sensory characteristics in meat guinea pigs. *Meat Science*, *145* (1), 51-54.

R versión 3.4.4. (2018). *The R Foundation for Statistical Computing.* Vienna, Austria

Remache, R. (2016). *Progresión de la calidad de la canal, vísceras, pH y color de la carne de cuy a los 3, 4 y 6 meses de edad*. Riobamba, Ecuador: Facultad de Ingeniería, Universidad Nacional de Chimborazo

Rodríguez, H. L.; Palomino, M. T.; Hidalgo, V. L. y Gutiérrez, G. R. (2013). Efectos de factores fijos y al azar sobre el peso al nacimiento y al destete en cuyes de la costa central del Perú. *Rev. Inv. Vet. Perú*, *24* (1), 16-24.

Rodríguez, H. L.; Gutiérrez, G. R.; Palomino, M. T. y Hidalgo, V. L. (2015). Características Maternales al Nacimiento y Destete en Cuyes de la Costa Central del Perú. *Rev. Inv. Vet. Perú*, *26*(1), 77-85.

Sánchez, X.G.P.; Barrera, S.Z.; Orozco, T.O.; Torres, S. F. M. S. y Monsivais, R.I. (2013). Modelo animal multicarácter para la estimación de parámetros genéticos del *Cavia porcellus* en Colombia. *Revista Cubana de Ciencia Agrícola*, *36*(1), 19-24.

Swiger l. A., W. R. Harvey, D. O. Everson and K. E. Gregory. (1964).The Variance of Intraclass Correlation Involving Groups with One Observation. *Biometrics*, *20* (4), 818-826.

Tuquinga F. (2011). *Evaluación de diferentes niveles de desecho de quinua en la etapa de crecimiento y engorde de cuyes*. Riobamba, Ecuador: Escuela Superior Politécnica de Chimborazo.

Vargas, A. P. (2015). Estimación de parámetros genéticos en cuyes utilizando ASReml-R. *Anales Científicos*, *76* (2), 393-395.

Vargas, A. P.; Gutiérrez, G. R. y Mamani, G. M. (2015). Una Aplicación del Muestreo de Gibbs en la Estimación de Parámetros Genéticos en Cuyes Utilizando MCMCglmm. *Rev Inv Vet Perú*, *26*(2), 182-188.

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Conception and design of research: CRJ and GGV; data analysis and interpretation: CJRJ, PNE, AECR y GEGV; manuscript redaction: CJRJ, AECR, and GEGV

CONFLICTS OF INTEREST:

The authors declare the existence of no conflicts of interests