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Application of random regression model to estimate genetic parameters for average daily gains of Tunisian local kids population

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Abstract. A random regression model was applied to estimate co-variance components and genetic parameters for average daily gains (ADG1 from birth to 30 days, ADG2 from 30 to 60 days, ADG3 from 60 to 120 days, ADG4 from 120 to 150 days and ADG5 from 150 to 180 days). The data comprised13.095 records belonging to 945 local kids (progenies of 22 sires and 285dams) born between 1998 and 2014.The data were first assessed by SPSS Program in order to identify the fixed effects to be included in the model. Year*month, sex*type of birth, dam's class weight were classified as fixed effects and dam's age at kidding as covariate. Random effects included in model were direct additive genetic effect, maternal additive genetic effect, direct permanent environmental effect, maternal permanent environmental effect and residual effect. Direct and maternal heritability estimates of ADG ranged from 0.1 to 0.39 and 0.09 to 0.24, respectively, in which ADG1 had the lowest direct and highest maternal heritability estimates among the other age groups. Estimated co-variance components increased with age for direct effects. A significant maternal effect was found in the pre-weaning stage that decreased in the post-weaning stage. Unlike in breeds raised in favorable conditions, the estimated maternal component of variance was larger than the direct variance in the pre-weaning period, indicating the importance of maternal ability in this breed. A negative correlation was found between direct and maternal additive genetic traits. Estimates of genetic correlations among the traits studied were high and positive with values ranging from 0.06 to 0.98, whereas the magnitude of the phenotypic correlation ranged from 0.05 to 0.83. Heritability estimates indicate that selection for maternal and direct components of ADG is possible in this bred. However, direct components need to be evaluated after weaning for a more efficient selection.

Keywords. Local kids – ADG – Correlations – Heritability – Selection.

Application du modèle de régression aléatoire pour estimer les paramètres génétiques des gains moyens quotidiens des chevreaux de la population tunisienne locale

Résumé. *Un modèle de régression aléatoire a été appliqué pour estimer les composantes de covariance et les paramètres génétiques des gains moyens quotidiens (ADG1 de la naissance à 30 jours, ADG2 de 30 à 60 jours, ADG3 de 60 à 120 jours, ADG4 de 120 à 150 jours et ADG5 de 150 à 180 jours). Les données comprennent 13,095 enregistrements appartenant à 945 chevreaux locaux (progénitures de 22 boucs et 285 chèvres) nés entre 1998 et 2014. Les données ont été évaluées par le programme SPSS afin d'identifier les effets fixes à inclure dans le modèle. Année * mois de naissance, sexe * mode de naissance, classe du poids de la mère à la mise bas ont été classés comme des effets fixes et l'âge de la mère comme co-variable. Les effets aléatoires inclus dans le modèle ont été l'effet génétique additif direct, l'effet génétique additif maternel, l'effet environnemental direct permanent, l'effet environnemental maternel permanent et l'effet résiduel. Les estimations de l'héritabilité directe et maternelle de l'ADG varient de 0,1 à 0,39 et de 0,09 à 0,24 respectivement, dans lesquelles ADG1 avait les estimations d'héritabilité maternelle les plus élevées. Les composantes de covariance estimées ont été augmentées avec l'âge pour les effets directs. Un effet maternel significatif a été trouvé dans le stade de pré-sevrage qui a diminué au stade du post-sevrage. Contrairement aux populations élevées dans des conditions favorables, la composante de la variance maternelle estimée était plus grande que la variance directe au cours de la période de pré-sevrage, indiquant l'importance de la capacité maternelle dans cette population. Une corrélation négative a été trouvée entre les caractères génétiques additifs directs et maternels. Les estimations des corrélations génétiques parmi les phénotypes étudiés étaient élevées et po-*

sitives avec des valeurs allant de 0,06 à 0,98 alors que la corrélation phénotypique varient de 0,05 à 0,83. Les estimations de l'héritabilité indiquent que la sélection pour les composants maternels et directs de l'ADG est possible chez cette population. Cependant, les composants directs doivent être évalués après le sevrage pour une sélection plus efficace.

Mots-clés. *Chevreaux locaux – ADG – Corrélations – Héritabilité – Sélection.*

I – Introduction

Actually, more than 60% of the national caprine herd estimated to 1 500 000 goats were raised in the Tunisian arid area (FAO, 2014). Since centuries, the pastoral breeding mode allows to valorize the rangelands resources by ambulant small ruminant herds under harsh conditions. In southern Tunisia, kids' meat represents about 75% of the local meat production (Najari, 2010). Further, the demand for meat from kids is increasing because of its nutritional quality.

Therefore, body weight and average daily gains are also economically important in breeding objectives that need particular attention in order to improve meat production of the local goat population. One way to improve growth performance is to select the best animals to be used as parents of the next generation. Estimation of heritability for various traits and their correlations with each other are therefore essential for successful selection in a genetic improvement programme.

The study aims to estimate the genetic parameters of kids 'average daily gains at different range of ages, using random regression models.

II – Material and methods

1. Animals and management

All experimental goats were raised in the Arid Areas Institute of Médenine (IRA), in the South-East of Tunisia with an arid continental Mediterranean climate, with irregular and sporadic rains. The season of kidding begins in October and continues until February, with a concentration during November and December. Throughout the study, replacement animals were selected based on weaning weight and physical conformation. Animals grazed in natural pastures during the day. In general, grazing pasture grasses covered about 70% of breeding animals feed requirements. The remaining 30% was covered by a supplementation provided during the mating (600 g/day), the last month of pregnancy and the beginning of lactation (750 g/day). Goats received about 1 kg per day of concentrate mixture. All animals were provided with water allowed twice a day; before and after grazing.

2. Data recording and studied traits

The data used in present study were collected between 1998 and 2014 from a total of 945 kids (531 males and 414 females), the progeny of 19 sires and 284 dams. Out of the 284 dams, 88 had weight records as kids. Since the start of the kidding period and till 180 days of age, kids were weighed once every two or three weeks. Based on the weight records of individual kids, average daily gains were calculated assuming linear growth rate between the appropriate weights. The investigated traits were: ADG1 (from birth to 30 days), ADG2 (from 30 to 60 days), ADG3 (from60 to 90 days), ADG4 (from 90 to 120 days), ADG5 (from 120 to 150days) and ADG6 (from 150 to 180 days).

3. Random regression analysis

Firstly, an ANOVA analyses was carried out for determining the environmental effects and two way interactions that had a significant influence on average daily gains. The analysis of variance showed that dam's age at kidding, dam's weight at kidding, the interaction between sex and birth type and between year and month of kidding were significant. Consequently, those effects were included in the model for those traits. The general model can be represented as follows:

$$y_{ij} = Fij + \sum_{m=0}^{2} \beta_m \phi_m(a_{ij}) + \sum_{m=0}^{2} \alpha_{im} \phi_m(a_{ij})$$

$$+ \sum_{m=0}^{2} \gamma_{im}(a_{ij}) + \sum_{m=0}^{2} \delta_{im} \phi_m(a_{ij}) + \sum_{m=0}^{2} \rho_{im} \phi_m(a_{ij}) + \varepsilon_{ij}$$

Where:

y_{ij} is the j^{th} record from the i^{th} animal ; a_{ij}= standardized age at recording in the [-1,1] interval; =is the m^{th} Legendre polynomial covariates for age at weighing; F_{ij}=is a set of fixed effects including, dam's weight at kidding, the interaction between sex and birth type and between year, month of kidding and dam's age at kidding (as covariate up to quadratic order), β_m=are the fixed regression coefficient to model the population mean; α_{im}, γ_{im}, δ_{im}, ρ_{im} are the random regression coefficients for direct and maternal additive genetic effects, animal and maternal permanent environmental effects, respectively, and ε_{ij}= residual environmental effect related to y_{ij}.

The above statistical model matrix form was as follows:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_1\mathbf{a}_d + \mathbf{Z}_2\mathbf{a}_m + \mathbf{W}_1 p_d + \mathbf{W}_2\mathbf{p}_m + \boldsymbol{\varepsilon}$$

$$V\begin{bmatrix} \mathbf{a}_d \\ \mathbf{a}_m \\ \mathbf{p}_d \\ \mathbf{p}_m \\ \boldsymbol{\varepsilon} \end{bmatrix} = \begin{bmatrix} \mathbf{K}_{ad} \otimes \mathbf{A}_{gxg} & \mathbf{K}_{ad,am} \otimes \mathbf{A}_{gxg} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{K}_{ad,am} \otimes \mathbf{A}_{gxg} & \mathbf{K}_{am} \otimes \mathbf{A}_{gxg} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{K}_{pd} \otimes \mathbf{I}_{dxd} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{K}_{pm} \otimes \mathbf{I}_{mxm} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \sigma_e^2 \times \mathbf{I}_{NxN} \end{bmatrix}$$

y = observations vector; **b** = vector of fixed effects ;$\mathbf{a}_d$ = vector of additive genetic direct random coefficients for all animals in the pedigree (g = 1152);$\mathbf{a}_m$ = vector of maternal additive genetic random coefficients for all animals in the pedigree(m = 1152); $\mathbf{p}_d$ = vector of animal permanent environmental coefficients for animals with records (d = 939); $\mathbf{p}_m$ = vector of maternal permanent environmental coefficients for all dams with records (m = 282); $\mathbf{X}$,$\mathbf{Z}_1$, $\mathbf{Z}_2$, $\mathbf{W}_1$, and $\mathbf{W}_2$ incidence matrices including Legendre polynomial co-variables; and = vector of residuals; $\mathbf{K}_{ad}$, $\mathbf{K}_{am}$, $\mathbf{K}_{pd}$, $\mathbf{K}_{pm}$ are the (co)variance matrices associated to additive direct and maternal effects and animal and permanent environmental regression coefficients, respectively, and is the matrix of covariance between additive genetic direct and maternal regression coefficients; σ_e^2 is the residual variance; a is the additive numerator relationship matrix and **I** is the identity matrix of differing order depending on the effect associated with it; N =13,095 is the total number of records.

III – Results and discussion

1. Growth

The descriptive statistics for average daily gains are presented in table 1. The overall average daily gains were 85.62, 75.25, 72.67, 50.04, 39.21, and 29.28 respectively for ADG1, ADG2, ADG3, ADG4, ADG5 and ADG6. Kids had a faster growth rate from 60 to 90 days with daily gain 72.67 (g/d) that the average daily gain in kids decreased with the age increase from 150-180 days of age. A similar result was found by Al-Shorepy et *al.,* (2002).

2. Heritability estimation

Direct and maternal heritability estimates for average daily gains at different range of ages are shown in Table2. Direct heritability estimates ranged from 0.1 to 0.39. The highest heritability estimate was found for ADG6 while the lowest heritability was revealed to be for ADG1followed by ADG2. The heritability estimates for ADG4 and ADG5 were approximately the same.

These estimates for average daily gains were in the range of those found by Sharma et *al.,* (2010) in Sirohi kids. However, they were lower than those obtained by Gerstmayr (1988) in Beetal goats. In Teddy goats, a low estimate of heritability 0.10 for post weaning daily gains was reported by Shafiq & Sharif (1996) which was lower than the ones found in the present study. Gowane et *al.,* (2011) reported low heritability estimates of 0.04for daily weight gain at six months in Sirohi goat breed, while Mohammadi et *al.,* (2012) reported that heritability estimates for daily weight gains from three to six months of age was 0.08 in Raeini Cashmere goat.

The low direct heritability estimates may be attributed to the low quality of pastures on which the flock was maintained, resulting in a high environmental variance. Furthermore, since in this case, the average daily gains of local kids could be classified as lowly or moderately heritable traits, performance of animals would be less useful in identifying the individuals with the high genetic merit, and therefore, low genetic progress would be expected through phenotypic selection programmes. Thus, to detect the best animals and to realize a genetic progress, selection should be based on estimates of breeding values, which are based both on phenotype and pedigree information and not on raw performance of kids alone.

Table 1. The characteristics of the data structure for average daily gains of Tunisian local kids population

	Statistical characteristics				
Age groups (days)	**Min.**	**Max.**	**Mean**	**SD**	**CV%**
ADG1 (0-30)	31.02	179.18	85.62	37.71	44.04
ADG2 (30-60)	42	165	75.25	23.46	31.17
ADG3 (60-90)	36.7	156.04	72.67	23.24	31.98
ADG4 (90-120)	40	144.6	50.04	24.52	49.00
ADG5 (120-150)	35.66	111	39.21	14.26	36.36
ADG6 (150-180)	12	85.44	29.28	11.36	38.79

Table 2. Heritability estimates for average daily gains in local kids population

	Age groups (days)					
	ADG1	**ADG2**	**ADG3**	**ADG4**	**ADG5**	**ADG6**
Direct heritability	0.10	0.11	0.15	0.21	0.24	0.39
Maternal heritability	0.24	0.15	0.12	0.11	0.10	0.09

The higher estimate of maternal heritability for ADG1 compared with the estimate for ADG 5 and ADG 6 supports the conclusion of Robinson (1981) that maternal genetic effects generally are important at early age and diminishes with an increasing age. The resultsare in agreement with other literature (Singh,1997; Bata,1989). The deacaying impact of maternaleffects on ADG with increasing agesmay be due to thefact that suckling kids rely mainly on their mother's milk from birth to 30 days, whereas after this age, the importance of milk yieldof dams decreases more rapidly and kids depend more on themselves.

3. Genetic and phenotypic correlations

Estimates of direct genetic correlations between growthtraits at different ages were positive and medium to high, varying from 0.12 between ADG 2 and ADG 6 to 0.98 between ADG 5 and ADG 6. The positivedirect genetic correlations among the studied traits suggest that genetic factors which influence these traits were in similar direction and that selection for any of these traits will bring out a positive response to selection for others. Similar to our estimates, high and positive genetic correlations have been reported by several authorsin various goats breeds (Common African x Alpine (Mourad and Anous, 1991) and Black Bengal goats (Singh, 1997). Consequently, it is logical to suggest that the traits to be included in the goat recording system couldmainly be those measured early in life of the kids, e.g. beforeweaning.

Table 3. Estimates of genetic correlations (below diagonal) and phenotypic correlations (above diagonal) for average daily gains in local kids

	ADG1	ADG2	ADG3	ADG4	ADG5	ADG6
ADG1		0.76	0.51	0.50	0.20	0.17
ADG2	0.94		0.80	0.52	0.10	0.05
ADG3	0.62	0.85		0.70	0.68	0.40
ADG4	0.20	0.52	0.89		0.80	0.61
ADG5	0.06	0.27	0.74	0.96		0.83
ADG6	0.22	0.12	0.62	0.90	0.98	

Phenotypic correlations varied from 0.17 and 0.83.The highest phenotypic correlation (0.83) was recorded between ADG5 and ADG6 and the lowest (0.17) was found between ADG 1and ADG6. The present findings are in agreement with those obtained by Rashidi et *al.,* (2008) in Markhoz goats and Schoemanet *al.,* (1997) in Boer goats.

IV – Conclusions

The low to moderate heritability estimates obtained in this research suggest that selection based on these traits may result in slow to moderate genetic progress for average daily gains. Due to the existence of genetic variation for those traits and generally positive and medium to high genetic correlations among the investigated traits, it can be concluded that improvement of growth traits of local kids seems feasible in selection programmes. Nevertheless, it is recommended to improve the management of flock in order to reduce the environmental variance and to increase heritability estimates, and also to select replacement animals based on their genetic merit but not on their raw performances because without a selection on the genetic merit, smaller genetic improvement will be expected.

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