Journal of Cell and Animal Biology Vol. 6 (6), pp. 99-103, 15 March, 2012
Available online at http://www.academicjournals.org/JCAB
DOI: 10.5897/JCAB12.018
ISSN 1996-0867 ©2012 Academic Journals

Full Length Research Paper

Growth curve estimation in pure goat breeds and crosses of first and second generation in Tunisian oases

Amor Gaddour*, Mabrouk Ouni and Sghaier Najari

Arid Land Institute, Medenine, Tunisia.

Accepted 30 January, 2012

Five non-linear statistical models were tested to fit the growth curve parameters of the kids of indigenous, Alpine and Damascus goats and their crosses. Data from 16 years' periodical weight study was used to adjust the growth curve of 1,687 suckling kids before they attained the age of five months. Among the tested models, the iterative procedure made it possible for the Gompertz model to be identified as the best for use to adjust kids' growth evolution. Brody, Richards, Logistic and Polynomial models showed some convergence problems of accuracy. Curve parameters were fitted by Gompertz model after about 16 iterations with a coefficient of determination (CD) value of 71%. Growth parameters were established by genetic groups and the shape of the curve changed with kids' genotypes. Crossbreeding allowed for a better growth kinetic in indigenous kids. After birth, kids' weights increased rapidly to an asymptotic weight at an early age. The best growth performances were obtained in the first generation of crossbreeding due to heterosis. The growth curve adjustment helped in better flock management and in the fattening of kids according to the potentialities of each genotype.

Key words: Goat, kids' growth, curve model, Gompertz, crossbreeding, Tunisian oases.

INTRODUCTION

In many marginal regions, goats often constitute the only source of protein through their meat production. In Tunisia, goat flocks contain about 1,500,000 females and more than 60% of goats are raised in the semi-arid and arid zones (Najari et al., 2007). The indigenous goat is genetically considered as a population that has a wide phenotypic variability; it is essentially raised via pastoral and agro-pastoral modes. The lactated kid's meat is the main product that results from indigenous goat breeding in Oasian conditions and it contributes about 75% to the regional meat production in very low input systems (Najari et al., 2007d). Under Oasian conditions, goat husbandry plays a key role through its various significant contributions to the farmers' incomes. Goats thrive in an intensified breeding mode with low climatic risks which characterize the arid area (Trangerud et al., 2007).

To increase the production of Oasian goat flocks, some high yielding exotic breeds were introduced in 1980 in the arid regions (Gaddour et al., 2008c). The objective of this program was either to produce meat where goats were not milked or to increase dairy yields where milk contributes to the income of farmers (Gaddour et al., 2008a). This goal was achieved by upgrading local breeds to different levels through crossbreeding so as to produce new goat genotypes that have high performances and are adapted to local environments (Serradia, 2001).

The model assessment of the growth of kids is particularly important in animal production because of its practical implications in genetic evaluation and flock management (Gipson and Wildeus, 1994; Schinckel and de Lange, 1996). Like other animal phenotypes, growth curve parameters change with all factors affecting the weight, especially the genetic potentials of the breed (Alexandre et al., 1997a; De Lange et al., 1998; Oltenacu,

*Corresponding author. E-mail : gaddour.omar@yahoo.fr or amor.gaddour@ira.agrinet.tn. Tel: +216 75 63 30 05. Fax: +216 75 63 30 06.

1999).

During an animal's lifetime, essential weight gain is reached before maturity stage, and it is well known that animals achieve the target mature size in a well-defined sigmoid or S-shaped curve (Najari et al., 2007, 2007b). Thus, typical curves are used to describe animal growth due to the general predictable pattern followed by the growth process (De Lange et al., 1998). A typical growth curve can be divided into two phases, an early phase where the weight gain rate increases and a later phase where the weight gain rate decreases (Trangerud et al., 2007). The point of inflexion is the point where the curve turns from concave to convex. Several non-linear functions have been proposed for various domestic livestock species and breeds to model the growth curve per genetic group (Barbato and Vasilatos-Younken, 1991; Bathaei and Leroy, 1996).

The present study aims at adjusting the growth curve of kids from local population, introduced breeds and crosses so as to evaluate the meat production kinetics and potentials for each genotype. Establishing curve parameters leads to an optimised use of the genetic resources of local and introduced animal breeds, and subsequently, to increased incomes for farmers in the southern Tunisian oases.

MATERIALS AND METHODS

Data base

For the last 16 years, crossing scheme has been in use and an individual periodical weighing control has continuously been realized from birth until the weaning of the kids at the beginning of summer. A total of 1,687 data files of kids were registered and used as the data base for this study. The data of each kid included genotype and control dates with respective observed weights (Gaddour et al., 2007a, b, c, d).

Growth curve assessment and curve parameters estimation

Due to the fact that the basic aspects of the physiological growth process are identical, some developed functions are largely used to describe the general growth curves (Wahi and Lal, 2004). The models used in our study are Gompertz, Richards, Logistic, Brody and Polynomial. These mathematical functions are considered as non-linear regression models and are solved by iterative procedures that minimize the residual variance (Yang et al., 2006). The residual values are assumed to be independent with a constant variance (Trangerud et al., 2007).

The evaluation criteria used to compare the accuracy of studied models were computing difficulty and goodness of fit. Computing difficulty is defined as the number of iterations needed to converge (Najari et al., 2007a). Except for the Richards' model, the starting values of parameters are null to allow the same convergence conditions (Wahi and Lal, 2004; Yang et al., 2006). Goodness of fit is defined as the magnitude of the residual mean squares (RMS) at convergence, which provides a measure of the estimation precision. The accuracy is evaluated by the non-linear coefficient of determination (CD). Statistical analysis was done by using SPSS 12.0.

RESULTS AND DISCUSSION

Growth model choice

The tested models' convergence performances and criteria are Gompertz: $A*Exp^{(-Exp\ (-bt-c))}$, Richards: $A*(1+(b-1)*Exp\ (-c*((âge)-d)))^{(1/\ (1-b))}$, Logistic: $A/\ (1+b*Exp\ \{-c*(âge)\})$, Brody: $A*(1-b*Exp^{\ (-c*âge)})$ and Polynomial: $A+b*âge+c*âge^2+d*âge^3$. For each tested model, the iteration number, CD as well as RMS were considered. Note that the convergence criterion value was fixed to 10^{-8}. Among the tested models, only the Brody showed a convergence problem up to 300 iterations; the other three models met the convergence criterion after an iteration number varying between 12 and 26. The starting values were set to "zero" except for the Richards' model; this can be considered as a constraint on the use of this model. The choice of the starting values can inhibit the convergence when the estimation is not adequate (Najari et al., 2007a).

The most rapid convergence was obtained with the Logistic and Polynomial functions which needed only 12 iterations to generate the best possible estimation of the growth curve parameters. However, the Gompertz function seemed to be the most accurate; the CD value, estimating the goodness of fit, was 71%. The RMS values ranged from 5.92 to 6.34; the Logistic model generated the best as well as the worst values. The Polynomial regression model provided a good curve fit, but its parameters had no meaningful biological interpretations (Trangerud et al., 2007).

In view of the foregoing results, the Gompertz equation seems to be the most appropriate to adjust the growth curve of the kids. According to de Lange et al. (1998), this model is suitable for describing growth curve because domestic animal meat generally comes from animals that do not achieve mature or asymptotic weight (Najari et al., 2007a; Trangerud et al., 2007). The model takes into account the exponential decay of the specific growth rate of the animal based on initial body weight and inflexion point parameters. The Gompertz model confirms, in our case, that it can be considered a typical representation of the S-shaped growth curve as proposed by de Lange et al. (De Lange et al., 1998). Indeed, this model has been shown to be valid for a wide range of mammalian species and Aves (Barbato, 1991).

Shape and parameters of the growth curve of kids

The growth parameters of kids, which are derived from the assessment of the curve from the Gompertz functions are asymptotic weight (A), Gompertz curve parameters (b and c), age of inflexion (days) and weight at inflexion (kg). The growth curve of the kids, which is adjusted by the Gompertz function is presented in Figure 1 and includes lower and upper limits of weights' estimation.

Having the curve parameter values A, b and c, the growth

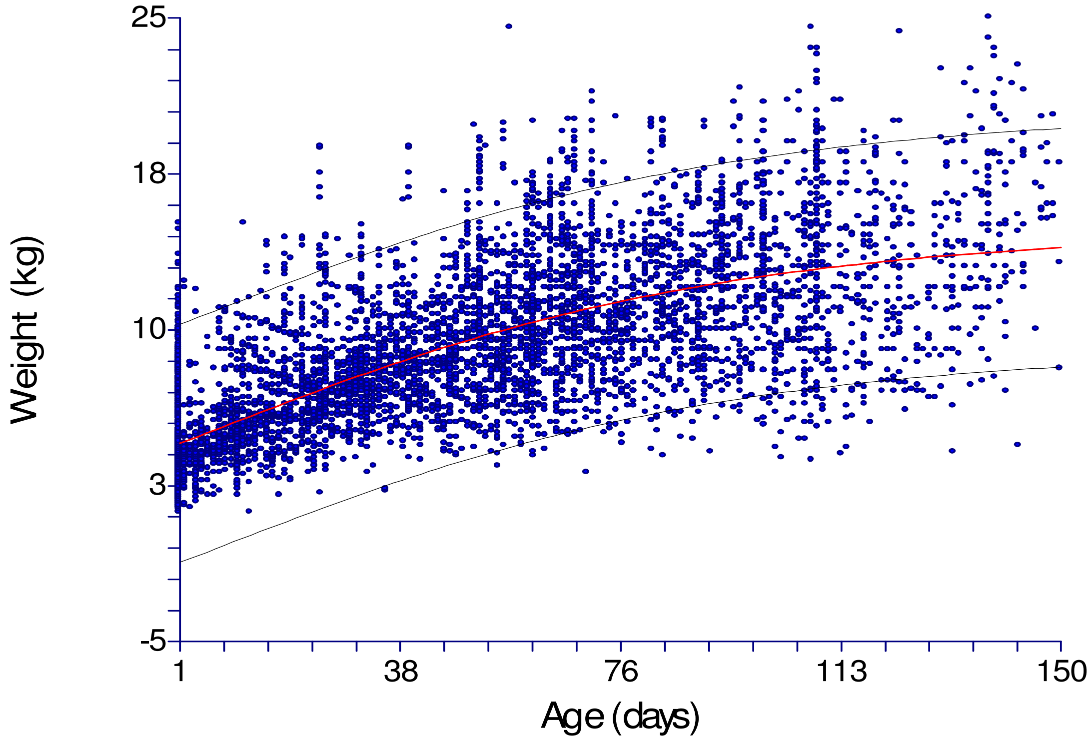

Figure 1. Growth curve of kids adjusted by the Gompertz model, with lower and upper limits.

curve equation is as shown in equation 1:

$$P = 15.74\ e^{(-e\ (-0.03*t+0.31))} \quad (1)$$

Where, P is the kids' weights (kg), and 't' the kids' ages (days).

The model's function allows for the estimation of some crucial growth curve parameters: the asymptote A value represents the adult weights, while the age 't' tends to infinity; the inflexion point corresponds to the point at which the second derivative becomes "zero" and the growth rate is maximum (Wang and Zhang, 2005; Najari et al., 2007a). The weight and the age at inflexion are, consequently, calculated as shown in equations 2 and 3:

$$\text{Age at inflexion (days)} = c/b \quad (2)$$

$$\text{Weight at inflexion (kg)} = A\ e^{(-e(-b*age-c))} \quad (3)$$

The inflexion point is located at 10 days, at a weight of 5.79 kg; the asymptotic weight is estimated to be 15.74 kg.

The curve asymptote is usually used to estimate the adult weight, while the Gompertz model is used to adjust the growth (Najari et al., 2007a; 2007b). As shown in equation (1), the A value is 15.74 and seems to be less than the adult goat's real weight estimated through other studies (Wang and Zhang, 2005; Gaddour et al., 2007c). It is well known that the Gompertz model can underestimate the A constant, especially when a relatively belated age is used to estimate the curve parameters (Trangerud et al., 2007).

Kids' growth curve of caprine genotypes

The asymptotic value (A) seems to be the highest for Alpine kids and the crossed Alpine*local. These kids reach more than 16.5 kg of body weight before the age of 5 months whereas the indigenous kids' asymptotic weight is estimated to be 12.47 kg.

Among the pure breeds, the Alpine kids showed the heaviest weight inflexion with 6.08 kg, reaching an average at the age of 15 days (Figure 2). The Damascus and indigenous kids showed the lowest weight inflexion starting from one week of age. Barbato (1996) related the age at which the curve inflexion occurred with the value of the corresponding weight which can affect the maturity age of the animals.

The most important period of growth seems to be the first two months after birth for all genotypes; the kids' weights tended rapidly to the asymptotic value. Consequently, keeping kids that are over four or five months of age in the flock does not provide any additional meat production, but rather induces more production costs per kg of kids' meat.

The weight inflexion was heaviest for the crosses of the first generation (F_1). The asymptotic and inflected weights of the F_1 kids were both higher than those of the paternal and F_2 genotypes (Figures 3 and 4). This illustrates a

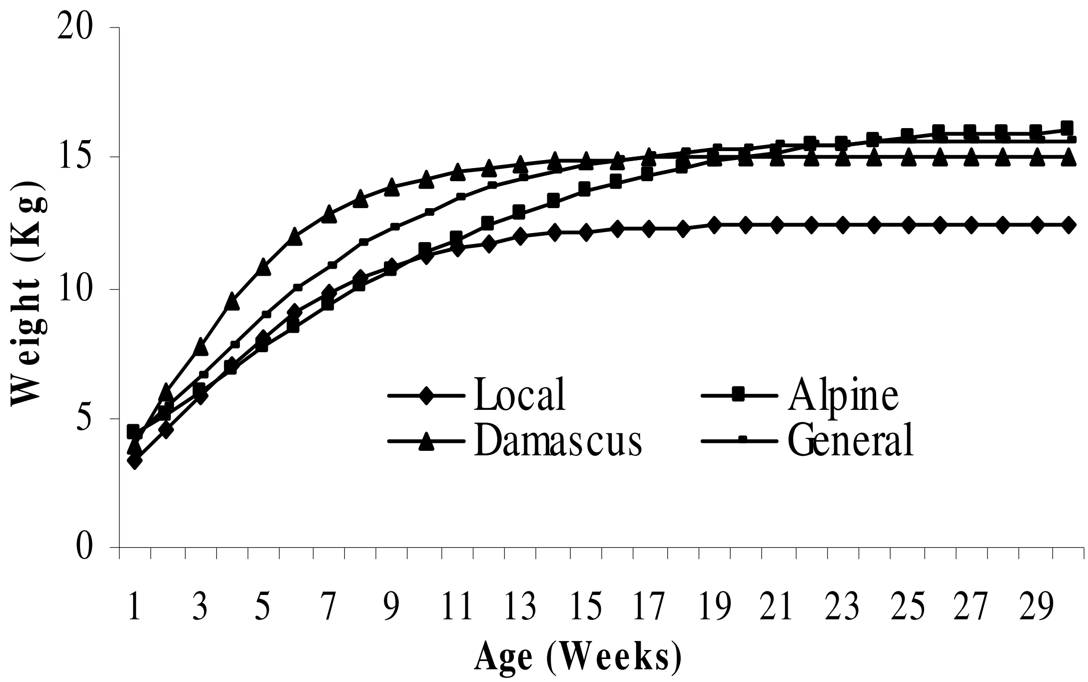

Figure 2. Growth curve of the kids of indigenous goat and pure breeds adjusted by the Gompertz model.

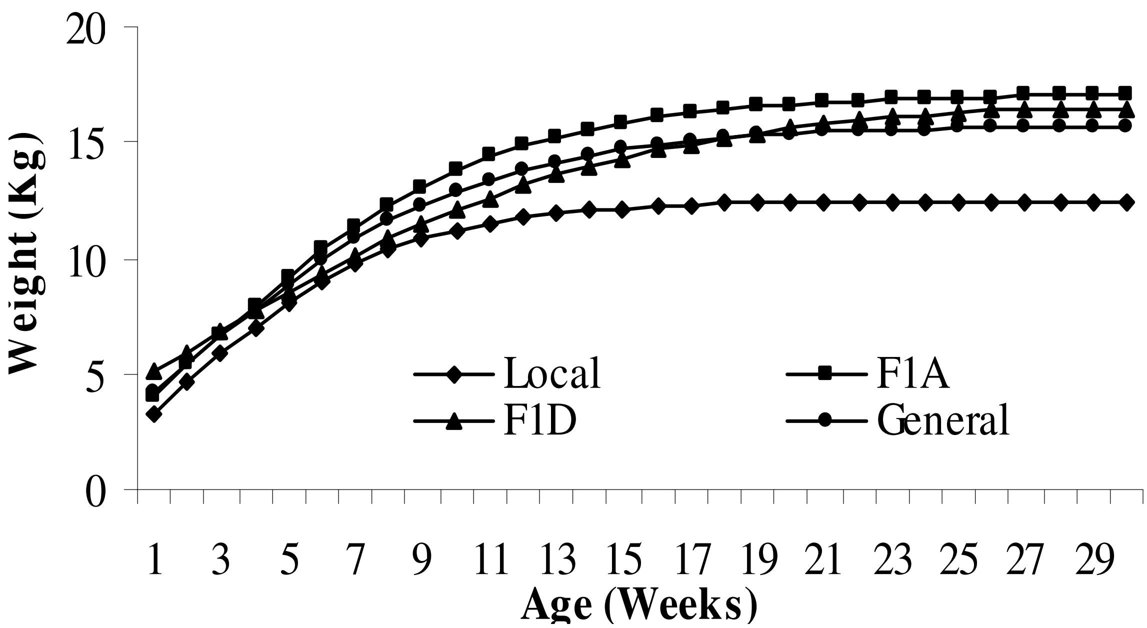

Figure 3. Growth curve of the kids of indigenous goat and first generation crossbreed adjusted by the Gompertz model.

clear effect of heterosis. This result agrees with that of Najari et al. (2007a), underlining the superiority of the performances of the F_1 to the parental breeds. Again, all the crossbred kids performed better than the indigenous genotypes; therefore, crossbreeding can improve caprine meat production (Serradia, 2001; Trangerud et al., 2007).

The parameters and shape of the growth curve illustrate a specific growth behavior for the studied genotypes. Apparently, some groups were able to produce an additional weight with age, while others stopped weight gain at an early age. This aspect has to be considered to optimize the genotypes' management to

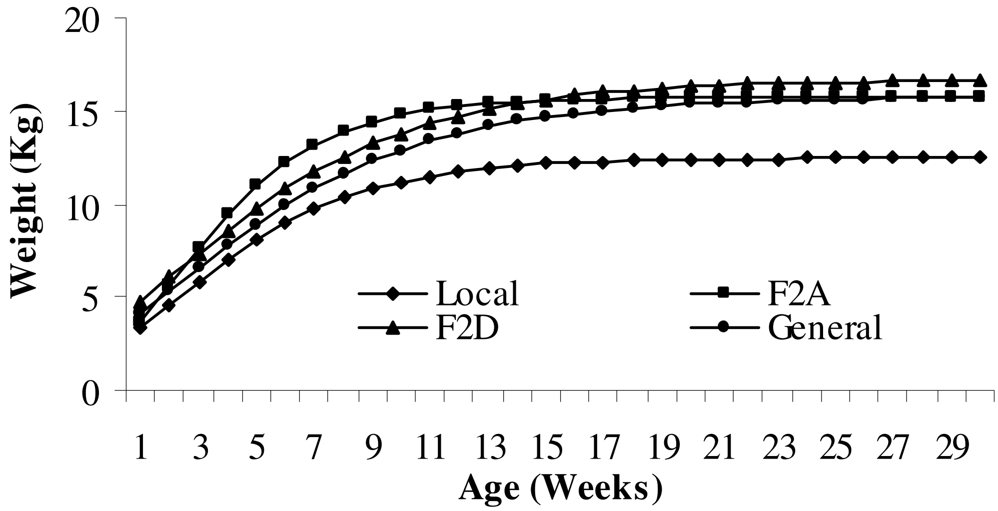

Figure 4. Growth curve of the kids of indigenous goat and second generation crossbreed adjusted by the Gompertz model.

ensure better meat production and more income for farmers.

REFERENCES

Alexandre G, Aumont G, Despois P, Mainaud JC, Coppry O, Xandé A (1997a). Productive performances of Guadeloupe in Creole goats during the suckling period. Small Rum. Res., 34: 157-162.

Barbato GF (1991). Genetic architecture of growth curve parameters in chickens. Theor. Appl. Genet., 83: 24-32.

Barbato GF (1996). Genetics of the growth curve in poultry: Physiological implications. Proc. 2nd European Poultry Breeders Roundtable. Landbrugs, 73: 153-165.

Barbato GF, Vasilatos-Younken R (1991). Sex-linked and maternal effects on growth in chickens. Poult. Sci., 70: 709-718.

Bathaei SS, Leroy PL (1996). Growth and mature weight of Mehraban Iranian fat-tailed sheep. Small Rumin. Res., 22: 155-162.

De Lange CFM, Szkotnicki B, Morphy J, Dewey C (1998). Establishing feed intake and growth curves for individual growing-finishing pig units. Community center (eds). Proceedings of 17th Annual Centralia Swine Research Update, Kirkton-Woodham, p. 341.

Gaddour A, Najari S, Ouni M (2007a). Dairy performances of the goat genetic groups in the southern Tunisian. Agric. J., 2: 248-253.

Gaddour A, Najari S, Ouni M (2007b). Kid's growth of pure breeds and crossed caprine genotypes in the coastal oases of southern Tunisia. Res. J. Agro., 2: 51-58.

Gaddour A, Najari S, Ouni M (2007c). Reproductive performances and kid's mortality of pure breeds and crossed caprine genotypes in the coastal oases of southern Tunisia. Paki. J. Biol. Sci., 14: 2314-2319.

Gaddour A, Najari S, Ouni M (2007d). Kid's growth and dairy performances of pure breeds and crossed caprine genotypes in the coastal oases of southern Tunisia. Pakistan J. Biol. Sci., 17: 2874-2879.

Gaddour A, Najari S, Ouni M (2008a). The genotype-environment interaction effects on dairy performances of goat genetic groups in the Tunisian oases. Res. J. Dairy Sci., 1: 22-26.

Gaddour A, Najari S, Ouni M (2008c). Genotype effect upon crossed goats' performances in the oases of southern Tunisia. "Sustainable Mediterranean grasslands and their multi-functions. Options Mediterrannennes, Series, A: 234-238.

Gipson TA, Wildeus S (1994). Growth curve analysis of body weight and scrotal circumference in dairy and meat-type goats. J. Anim. Sci., 72: 258.

Najari S, Gaddour A, Abdennebi M, Abdennebi M, Ouni M (2007). Specificities of the local kid's genotypes expression towards arid conditions in southern Tunisia. J. App. Sci., 3: 301-306.

Najari S, Gaddour A, Ben Hamouda M, Djemali M, Khaldi G (2007a). Growth model adjustment of local goat population under pastoral conditions in Tunisian arid zone. J. Agron., 1: 61-67.

Najari S, Gaddour A, Ouni M, Abdennebi M, Ben Hammouda M (2007b). Indigenous kid's weight variation with respect to non-genetic factors under pastoral mode in Tunisian arid region. J. Anim. Vet. Adv., 6: 441-450.

Najari S, Gaddour A, Ouni M, Abdennebi M, Ben Hammouda M (2007d). Non-genetic factors affecting local kids' growth curve under pastoral mode in Tunisian arid region. J. Biol. Sci., 6: 1005-1016.

Oltenacu EAB (1999). Using math to see how well your goat is growing. New York state 4H Meat Goat Project Fact Sheet 16. Cornell University, Ithaca, NY,

Schinckel AP, de Lange CFM (1996). Characterization of growth parameters needed as inputs for pig growth models. J. Anim. Sci., 74: 2021-2036.

Serradia JM (2001). Use of high yielding goat breeds for milk production. Livestock Prod. Sci., 71: 59-73.

Trangerud C, Grondalen J, Indrebo A, Tverdal A, Ropstad E, Moe L (2007). A longitudinal study on growth and growth variables in dogs of four large breeds raised in domestic environments. J. Anim. Sci., 1: 76-83.

Wahi SD, Lal Chand Bhatia VK (2004). A growth pattern study in crosses and pure Indian breeds of goats. Indian J. Anim. Sci., 74: 955-958.

Wang CF, Zhang JY (2005). Analysis of body conformation and fitting growth model in Tibetan chicken raised in plain. Sci Agric. Sin., 38: 1065-1068.

Yang Y, Mekki DM, Wang LY, Wang JY (2006). Analysis of fitting growth models in Jinghai Mixed-Sex Yellow Chicken. Int. J. Poult. Sci., 6: 517-521.