Chapitre 7

Genetic and non genetic effects on growth traits of West African Dwarf sheep in Benin (West Africa)

Gbangboche A. B[a,b,*]., Abiola F. A[d] ., Alimi S[c]., Tondji P[c]., Monsia C[c]., Detilleux J[b]., Leroy P. L[b], Michaux C[b].

[a] Université d'Abomey Calavi - Faculté des Sciences Agronomiques - Département des Productions Animales- 01 BP 526 Cotonou, République du Bénin.

[b] Université de Liège - Faculté de Médecine Vétérinaire - Département des Productions Animales. Bât B 43, 20 Boulevard de Colonster, 4000 Liège Belgique.

[c] Direction de l'Elevage, Projet pour le développement de l'Elevage, Ferme d'Elevage de Bétécoucou - République du Bénin.

[d] Ecole Inter Etat des Sciences et Médecine Vétérinaires. BP : 5077 Dakar. Senegal.

Article soumis dans la revue Livestock Production Science

7. 1. Abstract

Genetic parameters of monthly weights from birth to 180d and of preweaning daily gain (0 - 90d) and postweaning (90 – 180d) of 891 West African Dwarf lambs (469 males and 422 females) born during the rainy and dry seasons from years 2000 to 2003 were studied. The pedigree file included 900 records of which 9 and 891 records were from sires and progeny respectively.

The average weights at birth (BW), 30d-weight (W1), 60d-weight (W2), 90d-weight (W3), 120d-weight (W4), 150d-weight (W5) and 180d-weight (W6) were 1.93±0.02kg, 4.25±0.06kg, 7.60±0.12kg, 10.97±0.12 kg, 13.58±0.15kg, 14.85±0.20kg and 17.30±0.21kg respectively. The pre- and post-weaning average daily gains were 100.41±1.30g/d (ADG1) and 71.08±1.70g/d (ADG2) respectively. Non genetic factors examined (sex of lamb, birth type, parity of ewe, season and year of birth) showed significant effects on all weights and daily gains.

The variance components were estimated for growth traits from multiple trait animal model and sire model analyses. Estimates of heritability obtained from animal model and sire model were 0.43 and 0.44 for BW; 0.10 and 0.07 for W3; 0.13 and 0.09 for W6; 0.05 and 0.05 for ADG1; 0.10 and 0.05 for ADG2, respectively. Heritability estimates of 0.10, 0.02, 0.08 and 0.10 for W1, W2, W4 and W5 were obtained from sire model, respectively. In the animal model, genetic and phenotypic correlations ranged from -0.02 to 0.87 and -0.16 to 0.95. In the sire model they ranged from –0.21 to 0.99 and–0.20 to 0.99.

Keywords: Sheep; genetic parameters; growth; West Africa.

7. 2. Introduction

The challenge to meet meat demands and alleviate poverty in rural area should lead to the genetic improvement of local breeds growth traits in developping countries. Then, body weight and rate of gain require particular attention, because they are the most economically important and easily measured traits (Snowder and Van Vleck, 2003).

The West African Dwarf (WAD) sheep, commonly named Djallonke sheep, are found all over West and Central Africa and are widely distributed throughout the savannah and humid zones (Epstein, 1971; FAO, 1992). They remain productive in tsetse-infested areas where other breeds cannot survive without treatment (Mawuena, 1986, 1987; Osaer *et al*., 1994; Backer 1995; Goosens *et al*., 1999). Due to its adaptation to local conditions, the West African Dwarf (WAD) breed is suitable and more economic for sustainable genetic improvement of growth traits.

The majority of studies have shown the effect of various factors such as the year and season of birth, type of birth, sex and parity of ewe, on the growth of WAD lambs (Fall *et al*., 1982; Poivey *et al*., 1982; Ambuster *et al*., 1991; London and Weniger, 1995; Yapi-Gnaoré *et al.*, 1997a, 1997b). Yapi-Gnaoré *et al.* (1997b) reported increased breeding value by 11 and 14g/year at 180-d and 365-d of age in WAD sheep, respectively. Poivey *et al*. (1982) reported estimates of heritability, genetic and phenotypic correlations for weights from 1 to 5 months (table 4).

In Republic of Benin, there is a lack of information regarding genetic parameters for body weight and rate of growth of the WAD sheep. The purpose of this study was to assess the non genetic factor influencing growth traits and to estimate genetic parameters of growth traits from birth to 180 days of age.

7. 3. Materials and methods

7. 3. 1 Environment and animal management

The data used in this study consisted of growth records of West African Dwarf (WAD) sheep kept on the Betecoucou breeding farm of the Ministry of Agriculture, Livestock and Fisheries in Republic of Benin. The objective of this farm is to promote good management practices and to provide elite animals to sheep farmers.

The Betecoucou breeding farm is situated in Central region of Benin (West Africa). A rainy season extends from March to October and dry season from November to February. About 1000 heads of purebred WAD sheeps are raised in semi-extensive condition. They graze for 7h a day (9. 00h to 13. 00h and 14. 30 h to 17. 30h) on cultivated and natural pastures containing leguminous (*pterocarpus erinaceu, tephrosia pedicellata, Alysicarpus ovalifolius, tephrosia bracteolate, cajanus cajan*) and grass (*Panicum maximium C1, Setaria barbata, Brachiaria falcifera, Pennicetum sp, Andropogon tectorium, Hyparrhenia subplumosa*..). Quantity and quality of forage available for grazing vary according to the season and the distribution of rainfall: during the dry season the grass is reduced to standing straw with poor nutritive value or burned by bush fires. Supplemental feeding (Mineral, cottoncakes, wheat bran, rice and maize straw, and vitamins....) is usually provided. Health management involved routine dipping against external parasites, deworming and vaccination for the control of ruminant's rinderpest. Annual brucellosis analyses are done by the national veterinary laboratory, any positive animals are culled.

Sexually mature ewes are exposed to rams for the fist time at 12-18 months of age and lamb in 8-months breeding cycles. Sires are randomly mated to about 25 to 30 breeding ewes. Peek of lambings occur in rainy season. Ewes with newborn lambs are housed during the first seven days in individual box to ensure that lambs received adequate colostrum, before being moved to larger outside pens with other ewes and their lambs. Lambs are nursed by their dams up to weaning at 90d of age. The average litter size is generally 1.2-1.4, triplets are rarely observed. The average mortality rate in the pre-weaning stage never exceeds 7-10% nor differs between single and multiple lambs. Weaned male and female lambs graze separately under similar conditions.

Sires were brought from Kolokopé sheep selection Center of Togo (West Africa). They were all born in 1999 and selected for general health (trypanosomonis resistant), body weight, vigor, body conformation, lack of observable defects (small testes, hocked joint, over and under shot jaw), according to Abassa *et al.* (1992), Traore and Bonfoh (1993).

7. 3. 2. Data description and traits recorded

Data were collected on 469 males and 422 females lambs, born and reared as twins (330) and as single (561). These 891 lambs were progeny of 726 ewes and 9 rams. Performance recording of progeny (Table 1) included identification number, date of birth, sire, sex, type of birth, parity of ewes. Birth weight (BW), 30d-weight (W1) and 60d-weight (W2) were recorded using a platform-type dial balance (10 kg of capacity, accuracy of 0.05 g). The 90d-weight or weaning weight (W3), 120d-weight (W4), 150d-weight (W5) and 180 d-weight (W6) were taken using a suspended spring balancer (25 kg of capacity, 100 g of accuracy). To attain a more reliable estimate of empty liveweight body, animals were deprived of feed and water overnight, prior to each weighing. Besides those weights, preweaning average daily gain (ADG1) and postweaning average daily gain (ADG2) were computed. The sires were only recorded for BW, W3, W6, ADG1 and ADG2 (Table 1).

7. 3. 3. Statistical analysis

Data were first analysed using *Proc GLM of SAS*®(1989). All interactions among fixed effects were found to be non-significant and were ignored in the final model, which was:

$Y_{ijklmno} = \boldsymbol{\mu} + \boldsymbol{S}_i + \boldsymbol{A}_j + \boldsymbol{B}_k + \boldsymbol{C}_l + \boldsymbol{D}_m + \boldsymbol{F}_n + \boldsymbol{e}_{ijklmno}$, where $Y_{ijklmno}$ is the record on the oth animal; $\boldsymbol{\mu}$ the population mean; $\boldsymbol{S}i$ is the effect of the ith sire (i=1, ...9); $\boldsymbol{A}_j$ is the jth year of birth (j=1, 2, 3, and 4 for 2000, 2001,2002 and 2003); $\boldsymbol{B}k$ is the effect of kth season of birth (k=1 for rainy season, k=2 for dry season); $\boldsymbol{C}l$ is the effect of lth sex of lambs (l=1 for male, l=2 for female); $\boldsymbol{D}m$ is the effect of mth type of birth (m=1 for single, m=2 for twins); $\boldsymbol{F}n$ is the effect of nth parity of ewe (n=1, 2, 3, 4) and $\boldsymbol{e}_{ijklmno}$ is the residual error. The comparison of the means was made by the student's *t–test*. Significance level was chosen at 5%.

The variance and covariance components for growth traits were estimated from multiple trait animal model and multiple trait sire model, using REML Procedure form VCE program (Neumaier and Groeneveld, 1998). The multiple trait animal model provide an even greater accuracy by using the genetic relationships and in our case additional information for W1, W3, W6, ADG1 and ADG2 from sires records. However, multiple trait sire model was implemented because it allowed estimating genetic parameter for W2, W4 and W5, which were not available in sires. Sire model was fitted to records on 891 lambs born from 9 sires. Animal model was fitted to records on 891 born lambs and to records on 9 sires. The pedigree file included 891 offsprings and 9 sires. Ancestor information was not available for sires. Furthermore, some non genetic factors were unknown for sires, so animal model included year and sex as fixed effect when sire model included year x season of birth, parity of ewe, birth type and sex of lambs. Phenotypic correlations (r_p) were calculated from heritability (h^2) and from environment (r_e) and genetic (r_g) correlations.

7. 4. Results and discussion

7. 4. 1. Overall growth performances

Number of records in the final data set and the descriptive statistics are shown in Table 1. From birth to 180d of age, the number of lambs decreased, due to the lack of weighing and mortality.

The overall mean of the weights in this study is within the range reported in WAD sheep for BW of 1.59 and 2.2 kg (Fall *et al*., 1982; Ambuster *et al*., 1991; London and Weniger, 1995; Yapi Gnaoré *et al*., 1997) and for W3 of 7.0 and 12.7 kg (Poivey *et al*., 1982; Ambuster *et al*., 1991b; London and Weniger, 1995). On the other hand, the value in WAD sheep of 6.02 kg for W2 (London and Weniger, 1995), 8.7kg-9.1 kg for W4 (Fall *et al*., 1982; Yapi Gnaoré *et al*., 1997a) and 15.1 kg for W6 (Poivey *et al.*, 1982) were lower than those of this study. The average daily gain of 100.41g (ADG1) and 71.1g (ADG2) found in this study were higher than 69.6 g for ADG from 0 to 80 days (Yapi Gnaoré *et al*., 1987). The differences between the growth of WAD lambs observed in the literature could be attributed to the management, the level of genetic make up, the nutritional factors, the incidence of diseases, the herdsman skills and other factors.

7. 4. 2. Non genetic effects

Least - squares means (±standard errors) and test of significance (F) are given in Table 2. Significant effects were observed for all fixed factors, with the exception of birth type for ADG1 and ADG2, of sex of lambs and ewe parity for ADG2 and for season of birth for ADG1, W5 and W6 (Table 2). The superiority of male over female, single over twins, second or third parity over first parity lambs, lambs born in rainy season over those in dry season, and the slight and erratic difference between years are shown in Table 2.

The effect of sex agrees with those reported previously in WAD and in West African Long legged sheep (Adeleye and Oguntola, 1975; Fall *et al*., 1982; Taïwo *et al*., 1982; Adeleye, 1984; Poivey *et al*., 1982; Armbruster *et al*., 1991; Abassa *et al*., 1992; London and Weniger, 1995; Ebangui *et al*., 1996; Yapi Gnaore *et al*., 1997a; El Fadili *et al*., 2000). The sex effect might be attributed to physiological difference mainly of hormonal mediation that tend to become more pronounced as animal approach sexual maturity (Ebangui *et al*., 1996). However, the sex effect tended to disappear, from birth to 30 days (Poivey *et al*., 1982) and to 120 days of age (Tuah and Baah, 1985). The superiority of male over female lambs in this study was +0.04 kg for BW and +1.04 kg for W6.

The advantages of single lambs over twins have been observed in West African Dwarf and other tropical sheep breed (Fall *et al*., 1982; Armbruster *et al*., 1991; Abassa *et al*., 1992; Rajab *et al*., 1992; Bonfoh *et al*., 1996; Ebangui *et al*., 1996; Yapi-Gnaoré *et al*., 1997a). This could result from the limited capacity of ewes to provide enough nourishment for the development of multiple fetuses and more milk for lambs as reported by Rajab *et al*. (1992) in tropical hair sheep breeds. However, increasing multiple births may be a efficient method to increase meat production in adequate nutritional conditions. In this study single lambs produced 2.2 and 17.9 kg and twins 3.2 and 33.4 kg per ewe at birth and at 180d of age respectively.

All growth traits increased with advanced ewe parity. The effect of ewe parity have been reported in several studies (Fall *et al*., 1982; Filius *et al*., 1986; Abassa *et al*., 1992; Bologun *et al*., 1993; London and Weninger, 1995; Ebangui *et al*. 1996; Yapi-Gnaoré *et al*., 1997a). Young ewe continued to grow and would competed with fetus for available nutrients (London and Weninger, 1995). Cloete *et al.*, (2003) in Merino sheep, reported that lamb weaning weight increased curvi-linearly with dam age, reaching a maximum in 3 to 5 year-old dams.

Seasonal influences on lamb growth have also been reported (London and Weniger, 1995 in WAD sheep; Ebangui *et al*., 1996 in Fulbe sheep). Season represents not only changes of the physical and nutritional environment of the lambs, but also of the pregnant ewe, which could affect indirectly the birth weight (Yapi-Gnaoré *et al*., 1997b). In this study, lambs born in the rainy season were heavier than those born in the dry season +0.43 kg, +0.58 kg and +1.12 kg for BW, W3 and W4 respectively. For W5 and W6, the difference was slight. Consequently, mating at the end of dry season (February) and at the beginning of rainy season (March, April and May) would increased the growth performance of the flock.

The effect of year is in agreement with the literature (Fall *et al*., 1982; Rajab *et al*., 1992; Ebangui *et al*., 2001) and could be explained by the variations in management, health, feeding and climatic conditions and herdsman skills. Wilson (1987) reported a non-significant effect of year on birth weight and pre-weaning weight.

7. 4. 3. Genetic parameters

Heritability, genetic and phenotypic correlations estimates from animal model and sire model, are presented in Table 3. Recent estimates of genetic parameters from different breed sheep are summarised in Table 4. The differences between Table 3 and Table 4 could partly be explained by the breed, the model fitted, the pedigree structure and the size of the data set.

The heritability of BW under animal model (0.43) and sire model (0.44) was higher than most estimates found in the literature (Table 4) and than monthly post-natal weights found in this study (Table3). The fact that maternal genetic effect could not be taken into account in the current study could lead to the over-estimation of BW direct heritability, as found by Abegaz *et al*. (2000) who compared different models with and without genetic maternal effect. A sizeable maternal genetic effect on growth traits have been reported before weaning (Snyman *et al.*, 1995 in Afrino sheep; Lewis and Beatson, 1999 in New Zealand Coopworth sheep).

Previous heritability estimates reported by Poivey *et al*. (1982) for W1 (0.30), W2 (0.34), W3 (0.46) and W4 (0.32) in WAD sheep (Table 4), were larger than our estimates (Table 3). Higher heritability estimates for W1, W2, W3, W4, W5 and W6 were generally found in other breeds (Table 4). Similar heritability estimates for W3 within the range from 0.07 to 0.16, were reported by Notter (1998) for Polypay sheep (0.07), Maria *et al*. (1993) for Romanov sheep (0.09) and El Fadili *et al*. (2000) for D'man x Timahdite sheep (0.16).

The low heritabilities for ADG1 (0.05 for both models) and ADG2 (0.05 for sire model and 0.10 for animal model) in this study, contrast with the moderate to high estimates from earlier studies (Table 4) ranging from 0.18 to 0.56 (Mavrogenis *et al*., 1980; Shrestha *et al*., 1985; El Fadili *et al*., 2000; Mandal *et al*., 2003).

Among both fitted models, animal model seems the most appropriate to estimate heritability for body weights on account of the slightly higher values and of the lower standard error for BW. A possible source explanation for lower heritabilities for post-natal weights, achieved in this study (Table 3) could be the small size of the data set, the unfavourable conditions during post-natal growth and other, no identified factors.

The BW was positively genetically correlated with most of the post natal weights (Table 3). Genetic correlations among other weights were in general moderate to high (Table 3), in agreement with values from the literature (Table 4). Poivey *et al*. (1982) in WAD sheep, Mandal *et al*. (2003) in Muzaffarnagari sheep, and El Fadili *et al*. (2000) in D'man x Timahdite and Timahdite sheep also reported high genetic correlations between BW and W1, W2, W3 and W4, ranging from 0,88 to 1,00 (Table 4). The positive and high genetic correlations between BW and other weights traits, indicated that selection for BW would not affect adversely the other weights.

Phenotypic correlations between adjacent weights (Table 3), were within the ranges from -0.09 to 0.98 reported in literature for phenotypic correlations (Table 4). Mandal *et al*. (2003) reported negative phenotypic correlations of -0.08 and -0.09 between ADG, BW and W3.

In general, genetic and phenotypic correlations among monthly body weights and ADG, obtained from animal model and sire model in this study, were all comparable.

7. 5. Conclusion

Some environmental factors as sex of lamb, parity of ewe, year and season of birth, and litter type, showed significant effects on growth traits of the WAD sheep, and should therefore be taken into account in the estimation of genetic parameters.

In our population, BW was the more heritable trait and was genetically correlated with most post natal weights. Therefore, post-natal weights could be indirectly improved by selection on BW. However, care must be taken to avoid possible problems related to dystocia.

Deeper pedigrees for both paternal and maternal sides are needed to improve reliability of genetic parameters estimation.

7. 6. Acknowledgements

This study was made possible through support provided by the Directorate General for International Cooperation (DGIC) of Belgium and the Belgian Technical Cooperation (BTC). Special thanks to Mrs. Tchobo A, Onibon P and Adda F.

7. 7. References

Abassa, K. P., Pessinaba, J., Adeshola-Ishola A., 1992. Croissance pré-sevrage des agneaux Djallonké au Centre de Kolokopé (Togo). Revue. Elev. Méd. vét. Pays trop. 45, 49–54.

Abegaz, S., Negussie, E., Duguma, G., Rege J. O. E., 2002. Genetic parameter estimates for growth traits in Horro sheep. J. Anim. Breed. Genet. 119, 35-45

Adeleye, L. O., Oguntona, E., 1975. Effects of age and sex on liveweight and body composition of the West African warf Sheep. Nigerian J. Anim. Prod. 2, 264-269.

AI-Shorepy, S. A., Notter, D. R., 1998. Genetic parameters for lamb birth weight in spring and autumn lambing. Anim. Sci. 67, 327-332.

Armbruster, T, Peters, K.J., Metz, T., 1991. Sheep production in the humide zone of West Africa: II – Growth performance and live weighs of sheep in improved and traditional production systems in Côte - d'Ivoire. J. Anim. Breed. Genet. 108, 210-219

Backer, R. L., 1995. Genetic resistance against helminth infections in cattle, sheep and goats in the tropics. In: Proc. 6th Symp. Trop. Anim. Hlth. Prod., Faculty of Veterinary Medicine, Ultecht. The Netherlands, 6 October 1995 pp 40-47.

Bologun, R. O., Olayemi, M. E., Osinowo, O. A., 1993. Environmental factors affecting birth weight and litter size in Yankassa sheep. Nigerian J. Anim. Prod. 20, 14.

Bonfoh, B., Traore, A., Ayewa, T., 1996. Contrôle de performances, sélection des mâles au sein de la race ovine Djallonké et création d’un flock-book. Proceeding of the third Biennial Conference of the African Small Ruminant Research Network Workshop.5 – 9 December 1994. International Livestock Research Institute (ILRI) P.O. Box 30709 Nairobi, Kenya. p 71 – 78

Cloete, S. W. P., Olivier, J. J., Van Wyk J., B., Erasmus, G. J., Schoeman, S. J., 2003. Genetic parameters and trends for birth weight, birth coat score and weaning weight in Merino lines divergently selected for ewe multiple ability. S. Afr. J. Anim. Sci. 33, 248-256.

Ebangi, A. L., Nwakalor L. N., Mbah D. A., Abba D., 1996. Factors affecting the birth weight and neonatal mortality of Massa and Fulbe sheep breeds in a hot and dry environmental, Cameroon. Revue. Elev. Méd. vét. Pays trop., 49, 349-353.

Ebangui, A. L., Njoya, A., Ngo-Tama A., C., Awa, D. N., Mbah, D. A., 2001. Genetic and Phenotypic Parameters of Birth Weight Traits in Fulbe Sheep in Cameroon. Revue Elev. Méd. vét. Pays trop. 54, 147-151.

El Fadili, M., Michaux, C., Boulanouar, B., Leroy, P. L., 2000. Environmental and genetic effects on growth in Timahdite and crossbred lambs in Morocco. Revue Elev. Méd. Vét. Pays trop. 53, 75-83.

Epstein, H., 1971. The origin of domestic animals of Africa, vol 2. Africana Publishing Corporation, New York.

Fall, A., Gueye, E., Diop, M., Sandford, J., Wissocq, J. Y., Durquin, J., Trail, J. C. M., 1982. Evaluation des productivités des ovins taurins et des taurins Ndama au Centre de Recherches zootechniques de Kolda, Sénégal. Institut sénégalais de Recherches agricoles (ISRA)-Centre International pour l'Elevage en Afrique, Addis-Abeba (Cipea) 74p.

Filius, P., Weniger, J. H, Teuscher T., 1986. Investigations on the performance of Djallonké sheep. Animal Research and Development 24, 85-97.

Food and Agricultural Organization of the United Nation (FAO)., 1992. Petits ruminants ; production et ressources génétiques en Afrique tropicale 88, 193 p.

Goossens, B., Osaer, S., Ndao, M., Van Winghem, J., Geerts, S., 1999. The susceptibility of Djallonké and Djallonké-Sahelian crossbred sheep to Typanosoma congolense and helminth infection under different diet level. Vet. Parasitology. 85, 25-41.

Hanford, K. J., Van Vleck, L. D., Snowder, G. D., 2002. Estimates of genetic parameters and genetic change for reproduction, weight, and wool characteristics of Columbia sheep. J. Anim. Sci. 80, 3086-3098.

Hanford, K. J., Van Vleck, L. D., Snowder, G. D., 2003. Estimates of genetic parameters and genetic change for reproduction, weight, and wool characteristics of Targhee sheep. J. Anim. Sci. 61, 630-640.

Lewis, R. M., Beatson, P. R., 1999. Choosing maternal effect models to estimated (co)variances for live and fleece weight in New Zealand Coopworth sheep. Livest. Prod. Sci. 58, 137 - 150.

London, J. C., Weniger, J. H., 1995. Investigation into traditionally managed Djallonke-sheep production in humid and sub humid zones of Asante, Ghana. III. Relationship between birth weight, preweaning growth, and postweanning growth of lambs. J. Anim. Breed. Genet. 112, 431-453.

Mandal, A., Pant, K. P., Nandy, D. K., Rout, P. K., Roy, R., 2003. Genetic analysis of growth traits in Muzaffarnagari sheep. Trop. Anim. Hlth. Prod. 35, 271-284.

Marria, G. A., Boldman, K. G., Van Vleck, L. D., 1993. Estmates of variances due to direct and maternal effects for growth traits of Romanov sheep. J. Anim. Sci. 71, 845-849.

Matika, O., Van Wyk, J. B, Erasmus, G. J., Baker R. L., 2003. A description of growth, carcass and reproductive traits of Sabi sheep in Zimbabwe. Small Ruminant Res. 48, 119-126.

Mavrogenis, A. P., Louca, A., Robison, O. W., 1980. Estimates of genetic parameters for pre-weaning and post-weaning growth traits of Chios lambs. Anim. Prod. 30, 271- 276.

Mawuena, K, 1986. Trypanosomose des moutons et des chèvres de race naine Djallonké des régions sud guinéennes du Togo. Revue Elev Méd Vét Pays trop. 39, 307 – 315.

Mawuena, K, 1987. Haut degré de tolérance à la trypanosomose des moutons et des chèvres de race Naine Djallonké des régions sud – guinéennes du Togo. Comparaison avec les bovins trypanotolérants. Revue Elev Méd Vét Pays trop. 40, 55 – 58.

Näsholm, A., Danell, O., 1996. Genetic relationships of lamb weight, maternal ability, and mature ewe weight in Swedish finewool sheep. J. Anim. Sc. 74, 329-339.

Neumaier, A., Groeneveld, E., 1998. Restricted Maximum Likehood Estimation of covarariances in sparse linear models. Génét. Sél. Evol. 30, 3-26.

Notter, D. R., 1998. Genetic parameters for growth traits in Suffolk and Polypay sheep. Livest. Prod. Sci. 55, 205-213.

Osaer, S., Goosens, B., Clifford, D. J., Kora, S., Cassama, M. A., 1994. comparison of the susceptibility of Djallonke sheep and West African Dwarf goats to experimental infection with two differents strains of *Trypanosoma congolense*. Vet. Parasitol. 51**,** 191-204.

Osinowo, O. A., Abubakar, B. Y., Trimnell, A. R., 1993. Genetic and phenotypic relationships between gestation length, litter size and litter birth weight in Yankasa sheep. Anim. Rep. Sci. 34, 111-118.

Pessinaba, L. Y., Programme de développement de l'élevage des petits ruminants au Togo : essai de mise au point des possibilités d'association de la production vivrière et de l'élevage ovin. In Rey B., Lebbie S. H.B., Reynolds L. (eds.) Proc of the 1st Biennial Conference of the African Small Ruminant Research Network, 10-14 December 1990, Nairobi, Kenya. International Livestock Centre For Africa, Nairobi, Kenya (1992) p. 545 -554.

Poivey, J. P., Landais, E., Berger, Y., 1982. Etude et amélioration génétique de la croissance des Djallonké. Résultats obtenus au Centre de Recherches Zootechniques de Bouaké (Côte – d'Ivoire). Revue Élev. Méd. vét. Pays trop. 35, 421 – 433.

Rajab, M. H., Cartwright, T. C., Dahm, P. F., Figueireda, E. A. P., 1992. Performance of three tropical hair sheep breeds. J. Anim. Sci. 70, 3351-3359.

Shaat, I., Galal, S., Mansour, H., 2004. Genetic trends for lambs weights in flocks of Egyptian Rahmani and Ossimi sheep. Small Ruminant Res. 51, 23-28.

Shrestha, J. N. B., Heaney, D. P., 2003. Review of Canadian, Ouataouais and Rideau Arcott breeds of sheep. 1. Developement and characterization. Small Ruminant Res. 49, 79-96.

Shrestha, J. N. B., Vesely, J. A., Chesnais, J. P., 1985. Genetic and phenotypic parameters for daily gain and body weights in Suffolk lambs. Can. J. Anim. Sci. 65, 575-582.

Snowder, G. D., Van Vleck, L. D., 2003. Estimates of genetic parameters and selection strategies to improve the economic efficiency of postweaning growth in lambs. J. Anim. Sci. 81, 2704-2713.

Snyman, M. A., Erasmus, G. J., Wyk Van, J. B., Olivier, J. J., 1995. Direct and maternal (co) variance components and heritability estmates for body weight at different ages and fleece traits in Afrino sheep. Livest. Prod. Sci. 44, 229-235.

Statistical Analysis Systems Institute Inc. 1989. SAS/STAT User's guide, Version 6, 4th Edition, Volume 2, Cary, NC: SAS Institute. Inc., 846pp.

Tosh, J. J., Kemps, R. A., 1994. Estimation of variance components for lamb weights in three sheep populations. J. Anim. Sci. 72, 1184-1190.

Troare, A., Bonfoh, B., 1993. Optimisation du programme de selection chez les ovins au Centre d'appui technique de Kolokopé. Document technique N°2/93, 21p, Atakpamè, Togo.

Tuah, A. K., Baah, J., 1985. Reproduction performance, pre-weaning growth rate and pre-weaning lamb mortality of Djallonke sheep in Ghana. Trop. Anim Hlth Prod. 17, 107-113.

Wilson, R. T., 1987. Production of tradionnally managed small ruminants in an agro-pastoral system in Northem Burkina-Faso. Trop. Agric. (Trinidad) 64, 163 – 169.

Yapi-Gnaoré, C. V., Oya, A., Rege, J. E. O., Dagnogo, B., 1997a. Analysis of an open nucleus breeding programme for Djallonke sheep in the Ivoiry Coast. 1. Examination of non-genetics factors. Anim. Sci. 64, 291-300.

Yapi-Gnaoré, C.V., Rege, J. E., Oya, A., Alemayenu, N., 1997b. Analysis of an open nucleus breeding programme for Djallonke sheep in the Ivoiry Coast. 2. Response to selection on body weights. Anim. Sci. 64, 301-307.

Yazdi, M. H., Ensgström, G., Näsholm, A., Johansson, K., Jorjani, H., Liljedahl, L. E., 1997. Genetic parameters for lamb weight at different ages and wool production in Baluchi sheep. Anim. Sci. 65, 247-255.

Table 1

Number of records, means and standard deviations for birth weight, pre-and post-weaning weights and pre-and post-weaning average daily gain in West African Dwarf (WAD) sheep.

	Monthly weights (kg) from birth to 180d of age							Average daily gain (g/d)	
	BW	W1	W2	W3	W4	W5	W6	ADG1	ADG2
Progeny performances									
No. of records	891	864	831	778	728	594	590	778	590
Mean	1.98	4.29	7.62	11.02	13.69	14.94	17.29	100.30	71.23
Standard deviation	0.60	1.55	2.41	2.03	2.52	2.65	2.93	20.61	23.41
Minimum	0.30	0.70	3.00	4.60	6.60	8.00	10.80	33.33	11.11
Maximum	4.70	10.20	16.30	18.00	23.30	25.00	30.00	172.22	154.44
Sire performances									
No. of records	9			9			9	9	9
Mean	2.42			13.51			20.41	123.26	76.90
Standard deviation	0.44			1.40			1.40	16.90	1.06
Minimum	2.10			11.20			18.10	151.00	79.50
Maximum	3.12			15.20			22.10	97.70	75.50
No. of dams (without records)	726	699	677	634	599	484	482	634	482

Birth weight (BW); 30-d weight (W1); 60-d weight (W2); 90-d weight (W3); 120-d weight (W4); 150-d weight (W5) and 180-d weight (W6); ADG1: Average daily gain from birh to 3 months (weaning) ; ADG2: average daily gain from weaning to 6 months.

Table 2
Least-squares means ± standard errors (LSM ±s.e.), number of observations and significance level for birth weight, pre-and post-weaning weights (kg) and pre-and-post weaning average daily gain (g) in WAD sheep

Fixed effects	BW		W1		W2		W3		ADG1	W4		W5		W6		ADG2
	LSM±s.e.	N	LSM±s.e.	N	LSM±s.e.	N	LSM±s.e.	N	LSM±s.e	LSM±s.e.	N	LSM±s.e.	N	LSM±s.e.	N	LSM±s.e.
Overall	1.93±0.02	891	4.25±0.06	864	7.60±0.12	831	10.97±0.12	778	100.41±1.29	13.58±0.15	728	14.85±0.18	594	17.30±0.21	590	71.08±1.67
Season	**		**		*		**		ns	**		ns		ns		**
DS	1.71±0.01^{a}	391	3.83±0.05^{a}	380	7.45±0.10^{a}	372	10.68±0.10^{a}	352	99.61±1.15^{a}	12.99±0.13^{a}	339	14.65±0.15^{a}	295	17.27±0.18^{a}	292	73.62±1.48^{a}
RS	2.14±0.01^{b}	500	4.68±0.05^{b}	484	7.76±0.09^{b}	459	11.26±0.10^{b}	426	101.20±1.06^{a}	14.16±0.12^{b}	389	15.04±0.14^{a}	299	17.34±0.17^{a}	298	68.54±1.35^{b}
Year	**		**		**		**		*	**		**		**		**
2000	1.99±0.02^{a}	177	4.62±0.08^{a}	176	7.72±0.16^{a}	166	11.30±0.16^{a}	162	103.46±1.80^{a}	13.62±0.20^{a}	151	15.07±0.24^{a}	108	17.77±0.28^{a}	107	71.79±2.30^{a}
2001	1.79±0.02^{b}	221	3.37±0.06^{b}	221	5.74±0.12^{b}	221	10.56±0.12^{b}	221	97.38±1.37^{b}	14.19±0.15^{b}	221	14.64±0.16^{b}	221	17.54±0.19^{b}	221	77.84±1.54^{b}
2002	1.94±0.02^{c}	249	4.36±0.06^{c}	229	7.84±0.12^{c}	229	11.05±0.13^{c}	192	101.18±1.43^{c}	14.22±0.16^{b}	185	15.68±0.17^{c}	185	16.44±0.20^{c}	182	59.29±1.65^{c}
2003	1.99±0.02^{a}	244	4.67±0.08^{a}	238	9.11±0.14^{d}	215	10.96±0.15^{c}	203	99.61±1.68^{c}	12.28±0.19^{c}	171	14.00±0.28^{d}	80	17.46±0.33^{d}	80	75.41±2.70^{d}
Birth ype	**		**		**		**		ns	**		**		**		ns
Single	2.22±0.01^{a}	561	4.60±0.04^{a}	552	7.85±0.08^{a}	527	11.33±0.08^{a}	500	101.22±0.90^{a}	14.00±0.10^{a}	470	15.43±0.13^{a}	374	17.89±0.15^{a}	373	72.75±1.22^{a}
Twins	1.63±0.01^{b}	330	3.90±0.06^{b}	312	7.36±0.10^{b}	304	10.61±0.11^{b}	278	99.59±1.22^{a}	13.16±0.14^{b}	258	14.26±0.16^{b}	220	16.72±0.20^{b}	217	69.41±1.59^{a}
Sex	**		*		**		**		**	**		**		**		ns
Male	1.95±0.01^{a}	469	4.33±0.05^{a}	456	8.18±0.09^{a}	441	11.42±0.09^{a}	406	105.19±1.0^{a}	14.01±0.11^{a}	368	15.33±0.14^{a}	288	17.83±0.17^{a}	287	71.03±1.37^{a}
Female	1.91±0.01^{b}	422	4.18±0.05^{b}	408	7.03±0.09^{b}	390	10.52±0.10^{b}	372	95.62±1.0^{b}	13.14±0.12^{b}	360	14.36±0.14^{b}	306	16.78±0.17^{b}	303	71.13±1.40^{a}
Parity	**		**		**		**		**	**		**		**		ns
1	1.56±0.01^{a}	341	3.25±0.06^{a}	326	7.07±0.11^{a}	316	10.19±0.12^{a}	289	95.87±1.29^{a}	12.29±0.14^{a}	274	13.54±0.17^{a}	230	16.56±0.20^{a}	230	71.78±1.63^{a}
2	1.91±0.01^{b}	321	4.37±0.06^{b}	314	7.41±0.11^{b}	296	11.02±0.11^{b}	277	101.18±1.2^{b}	13.88±0.14^{b}	257	15.00±0.16^{b}	209	17.40±0.19^{b}	207	71.78±1.63^{a}
3	2.31±0.02^{c}	229	5.14±0.07^{c}	224	8.34±0.13^{c}	219	11.69±0.14^{c}	212	104.17±1.5^{c}	14.56±0.17^{c}	197	16.00±0.20^{c}	155	17.96±0.24^{c}	153	70.00±1.94^{a}

Birth weight (BW); 30-d weight (W1); 60-d weight (W2); 90-d weight (W3); 120-d weight (W4); 150-d weight (W5) and 180-d weight (W6); ADG1, average daily gain from birh to 3 months (weaning) ; ADG2, average daily gain from weaning to 6 months; DS, dry season; RS, rainy season; means with same superscripts do not differ significantly ($p>0.05$) from each other.

Table 3

Estimates (±s.d.) of genetic parameters from multiple traits analysis, using animal model and sire model on growth traits of WAD sheep.

Traits	BW	W1	W2	W3	W4	W5	W6	ADG1	ADG2
BW	**0.43±0.06†**	-	-	0.17±0.04†	-	-	0.10±0.05†	0.81±0.27†	0.04±0.07†
	0.44±0.15‡	0.16±0.30‡	-0.21±0.44‡	0.82±0.19‡	0.99±0.14‡	0.63±0.22‡	0.53±0.25‡	0.62±0.35‡	0.12±0.32‡
W1	-	-	-	-	-	-	-	-	-
	0.14±0.2‡	**0.10±0.05‡**	0.38±0.07‡	0.68±0.21‡	0.44±0.27‡	0.97±0.05‡	0.81±0.12‡	0.76±0.19‡	0.03±0.05‡
W2	-	-	-	-	-	-	-	-	-
	0.21±0.43‡	0.20±0.3‡	**0.025±0.02‡**	-0.14±0.52‡	-0.11±0.48‡	0.94±0.06‡	0.78±0.12‡	-0.12±0.58‡	-0.13±0.53‡
W3	0.95±0.07†	-		**0.10±0.03†**	-	-	0.68±0.02†	0.96±0.00†	0.03±0.29†
	0.80±0.14‡	0.45±0.03‡	0.74±0.03‡	**0.07±0.04‡**	0.54±0.25‡	0.65±0.20‡	0.70±0.17‡	0.97±0.03‡	0.81±0.38‡
W4	-	-	-	-	-	-	-	-	-
	0.99±0.13‡	0.40±0.05‡	0.59±0.04‡	0.44±0.22‡	**0.08±0.04‡**	0.91±0.10‡	0.22±0.43‡	0.32±0.36‡	0.83±0.20‡
W5	-	-	-	-	-	-	-	-	-
	0.63±0.22‡	0.73±0.02‡	0.74±0.02‡	0.68±0.18‡	0.70±0.18‡	**0.10±0.05‡**	0.71±0.17‡	0.62±0.23‡	0.33±0.35‡
W6	0.59±0.16†	-	-	0.79±0.13†		-	**0.13±0.06†**	0.97±0.05†	0.97±0.05†
	0.62±0.20‡	0.82±0.02‡	0.83±0.02‡	0.65±0.21‡	0.91±0.10‡	0.75±0.13‡	**0.09±0.04‡**	0.79±0.21‡	0.81±0.15‡
ADG1	-0.03±0.04†	-	-	0.97±0.00†	-	-	0.83±0.11†	**0.05±0.03†**	-0.02±0.04†
	-0.20±0.08‡	0.40±0.03‡	0.70±0.02‡	0.99±0.01‡	0.87±0.02‡	0.80±0.02‡	0.66±0.02‡	**0.05±0.03‡**	0.00±0.04‡
ADG2	-0.03±0.05†	-	-	-0.02±0.04†	-	-	-0.16±0.31†	0.45±0.38†	**0.10±0.06†**
	0.80±0.07‡	0.08±0.05‡	0.10±0.04‡	0.00±0.04‡	0.20±0.04‡	0.40±0.04‡	0.74±0.02‡	0.23±0.44‡	**0.05±0.04‡**

†Animal model; ‡ Sire model; Heritability (diagonal); genetic correlations (above diagonal); phenotypic correlations (below diagonal).
Birth weight (BW); 30-d weight (W1); 60-d weight (W2); 90-d weight (W3); 120-d weight (W4); 150-d weight (W5) and 180-d weight (W6); ADG1, average daily gain from birth to 3 months (weaning) ; ADG2, average daily gain from weaning to 6 months.

Table 4
Summarised results from literature for heritability, genetic and phenotypic correlations estimates for growth traits in differents sheep breeds.

Traits	Heritability	Breed sheep	Authors	Traits	Heritability	Correlations		Breed sheep	Authors
						Genetic	Phenotypic		
BW	0.02	D'man x Timahdite	El Fadili et al. (2000)	ADG1	0.18			D'man x Timahdite	El Fadili et al. (2000)
BW	0.04	Romanov	Maria et al. (1993)	ADG1	0.19			Muzaffarnagari	Mandal et al. (2003)
BW	0.05	Yankasa	Osinowo et al. (1993)	ADG1	0.25			Timahdite	El Fadili et al. (2000)
BW	0.07	Muzaffarnagari	Mandal et al. (2003)	ADG (35 days)	0.35			Chios	Mavrogenis et al. (1980)
BW	0.07	Romanov	Tosh and Kemp (1994)	ADG (50 days)	0.47			Suffolk	Shrestha et al. (1985)
BW	0.07	Finewool	Näsholm and Danell (1986)	ADG (3-12 months)	0.20			Muzaffarnagari	Mandal et al. (2003)
BW	0.07	Timahdite	El Fadili et al. (2000)	ADG (5 months)	0.56			Chios	Mavrogenis et al. (1980)
BW	0.12	Dorset	Tosh and Kemp (1994)	BW-W3		0.40	0.39	Baluchi	Yazdi et al. (1997)
BW	0.12	Merino	Cloete et al. (2003)	BW-W3		0.45	0.25	Horro	Abegaz et al. (2001)
BW	0.17	Baluchi	Yazdi et al. (1997)	BW-W3		0.59	0.35	Muzaffarnagari	Mandal et al. (2003)
BW	0.17-0.31	Horro	Abegaz et al. (2001)	BW-100d Weight		0.63	0.32	Merino	Cloete et al. (2003)
BW	0.20	Outaouais	Shrestha and Heaney (2003)	BW-W3		0.78	0.50	D'man x Timahdite	El Fadili et al. (2000)
BW	0.22	Rideau	Shrestha and Heaney (2003)	BW-W3		0.85	0.40	Timahdite	El Fadili et al. (2000)
BW	0.22	Afrino	Snyman et al. (1995)	BW-W4		0.52		Targhee	Hanford et al.(2003)
BW	0.25	Targhee	Hanford et al. (2003)	BW-W4		0.56		Columbia	Hanford et al.(2002)
BW	0.39	Hampshire	Tosh and Kemp (1994)	BW-W6		0.26	0.32	Baluchi	Yazdi et al. (1997)
BW	0.60	Fulbe sheep	Ebangui et al. (2001)	BW-W6		0.33	0.20	Horro	Abegaz et al. (2001)
21 d-Weight	0.22 - 0.24	Rideau and Outaouais	Shrestha and Heaney (2003)	BW-W6		0.60	0.30	Muzaffarnagari	Mandal et al. (2003)
W1	0.30	WAD	Poivey et al. (1982)	BW-W6		0.61	0.36	Baluchi	Yazdi et al. (1997)
49 d-Weight	0.20 - 0.22	Rideau and Outaouais	Shrestha and Heaney (2003)	BW-ADG1		0.51	0.18	Muzaffarnagari	Mandal et al. (2003)
50 d-Weight	0.46	Suffolk	Shrestha et al. (1985)	BW-ADG1		0.60	0.16	Timahdite	El Fadili et al. (2000)
W2	0.34	WAD	Poivey et al. (1982)	BW-ADG1		0.61	0.28	D'man x Timahdite	El Fadili et al. (2000)
70 d-Weight	0.22 - 0.27	Rideau and Outaouais	Shrestha and Heaney (2003)	BW-ADG(3-12months)		0.19	-0.09	Muzaffarnagari	Mandal et al. (2003)
W3	0.07	Polypay	Notter (1998)	50 d-100d weight		0.89	0.76	Suffolk	Shrestha et al.(1985)
W3	0.09	Romanov	Maria et al. (1993)	W1-W2		1,00		WAD	Poivey et al. (1982)
W3	0.16	D'man x Timahdite	El Fadili et al. (2000)	W1-W3		0.96		WAD	Poivey et al. (1982)
W3	0.18	Muzaffarnagari	Mandal et al. (2003)	W1-W4		0.88		WAD	Poivey et al. (1982)
W3	0.21	Timahdite	El Fadili et al. (2000)	W2-W3		0.99		WAD	Poivey et al. (1982)
W3	0.21	Suffolk	Notter (1998)	W2-W4		0.92		WAD	Poivey et al. (1982)
W3	0.46	WAD	Poivey et al. (1982)	100 d weight - ADG		0.80	0.73	Suffolk	Shrestha et al.(1985)
100d-Weight	0.13	Merino	Cloete et al. (2003)	W3-W4		0.96		WAD	Poivey et al. (1982)
100d-Weight	0.43	Suffolk	Shrestha et al. (1985)	W3-W6		0.80	0.77	Muzaffarnagari	Mandal et al. (2003)
W4	0.32	WAD	Poivey et al. (1982)	W3-W6		0.85 - 0.95	0.76	Baluchi	Yazdi et al. (1997)
W5	0.38	Afrino	Snyman et al. (1995)	W3-W6		0.97	0.73	Horro	Abegaz et al. (2001)
W6	0.16-0.26	Horro	Abegaz et al. (2001)	W3-ADG1		0.78	0.75	Muzaffarnagari	Mandal et al. (2003)
W6	0.19	Muzaffarnagari	Mandal et al. (2003)	W3-ADG1		0.94	0.85	Timahdite	El Fadili et al. (2000)
W6	0.21	Finewool	Näsholm and Danell (1986)	W3-ADG1		0.97	0.88	D'man x Timahdite	El Fadili et al. (2000)
W6	0.23	Baluchi	Yazdi et al. (1997)	W3-ADG1		0.99	0.98	Muzaffarnagari	Mandal et al. (2003)
W6	0.23	Ossimi	Shaat et al. (2004)	W3-ADG (3–12months)		0.23	-0.08	Muzaffarnagari	Mandal et al. (2003)
W6	0.46	Rahmani	Shaat et al. (2004)	W6-ADG1		0.78	0.75	Muzaffarnagari	Mandal et al. (2003)
W6	0.47	Afrino	Snyman et al. (1995)	W6-ADG (3–2months)		0.57	0.24	Muzaffarnagari	Mandal et al. (2003)
				ADG1-ADG(3-12months)		0.19	-0.09	Muzaffarnagari	Mandal et al. (2003)

Birth weight (BW); 90-d weight (W3); 120-d weight (W4), 150-d weight (W5) and 180-d weight (W6); ADG1, average daily gain from birh to 3 months; ADG2, average daily gain from weaning to 6 months.