ELSEVIER

Small Ruminant Research 33 (1999) 9–15

Small Ruminant Research

Effect of diet energy source on weight gain and carcass characteristics of lambs

G. Preziuso[a,*], C. Russo[a], L. Casarosa[a], G. Campodoni[b], S. Piloni[a], D. Cianci[a]

[a]*Dipartimento di Produzioni Animali, Università degli Studi di Pisa, V.le delle Piagge, 2 - 56124 Pisa, Italy*
[b]*Dipartimento di Scienze Zootecniche, Università degli Studi di Firenze, V.le delle Cascine, 50144 Firenze, Italy*

Accepted 25 November 1998

Abstract

The effect of different sources of energy (lipids and carbohydrates) was studied on 36 Apennine male lambs divided by age, weight and paternity into three homogeneous groups receiving three different diets: lambs on diet 1 received ad libitum lucerne hay + concentrate supplemented with barley flakes (9%) (BC); lambs on diet 2 received ad libitum lucerne hay + concentrate supplemented with maize oil (5%) (MC) while lambs on diet 3 received only the concentrate given in diet 2 (MC). The two concentrates were isoenergetic and isonitrogenous. Lambs were slaughtered at 105 days of age. The conversion indices were similar (4.52, 4.77 and 4.61 Meat FU/kg gain) for the three treatments, but the diet 3 led to heavier carcasses (17.57 kg), although with greater adipose covering, and better dressing percentages than the other two diets. The histological dissection of the proximal pelvic limb indicated a good tissue composition (total lean 56.16%) but confirmed the higher fat percentage (total fat 16.24%), particularly subcutaneous (11.44%), of the group receiving only MC. Animals on diet 3 gave carcasses with an adequate commercial weight at the age of 90–95 days and therefore it seems possible to anticipate slaughtering these animals earlier and perhaps obviate the excessive adiposity of the carcass. In general, this study further confirmed the good meat quality of Apennine carcasses slaughtered at 105 days.

Keywords: Lamb; Diet; Carcass quality

1. Introduction

In polygastric species the metabolism is complex because of the digestive processes which modify feed elements either partially or totally by the ruminal fermentation (Huerta-Leidenz et al., 1991; Solomon et al., 1992; Lough et al., 1993). Moreover, the inhibitory effect of unsaturated and polyunsaturated fatty acids of feeds on methanogenesis with an increase in the percentage of propionic acid at ruminal level, is well known which is probably due to the selective toxic influence on methane bacteria, which leads to a better productive performance (Van Nevel and Demeyer, 1988; Giorgetti and Lucifero, 1989; Lucifero et al., 1989; Van Nevel, 1991).

Despite this, experiments showed that the addition of vegetable oil in a feed ration can at least partially modify the acid profile of meat and depot fat (Rumsey

*Corresponding author. Tel.: +39-50-570-595; fax: +39-50-540-315.

0921-4488/99/$ – see front matter
PII: S0921-4488(98)00202-8

et al., 1972; Skelley et al., 1973; Garret et al., 1976; Field et al., 1978; Westerling and Hedrick, 1979; Busboom et al., 1981; Marmer et al., 1984; Larick and Turner, 1989; Bozzolo et al., 1991; Solomon et al., 1991, 1992; Lough et al., 1992, 1993; Murphy et al., 1994; Aharoni et al., 1995).

The main objective of this study was to test whether different sources of energy (lipids or carbohydrates) might influence growth and quality of the carcasses.

2. Materials and methods

Thirty six Apennine single-born male lambs taken from the same farm, sons of two rams and reared with their dams up to 45 days, were weighed and divided into three groups of 12, homogeneous for age, weight and paternity.

The trial was carried out during winter at the experimental stables of the Department of Animal Production at Pisa, housing the animals in three multiple pens on straw litter.

The three groups were given ad libitum water and ad libitum three different diets based on two isoenergetic and isonitrogenous concentrates. In the concentrate (BC) given in diet 1, barley flakes (9%) were added, while in concentrate (MC) given in diets 2 and 3, maize oil (5%) was added. The animals on diets 1 and 2 also received ad libitum lucerne hay.

Table 1 presents the formulation of the concentrates and the chemical composition of feeds.

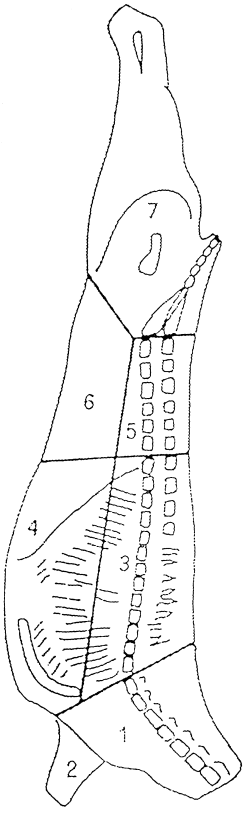
From weaning until slaughtered at 105 days of age the animals were weighed weekly and the feed consumption was recorded.

The lambs were weighed and slaughtered after a 12-h fast and the weights of the fifth quarter and of warm carcass (head and feet off) were recorded: the fifth quarter composition was: head, distal thoracic and pelvic limb (metacarpus and metatarsus), pelt, thoracic, abdominal and pelvic organs without kidneys, gastrointestinal tract (empty). After 24 h at +4°C, the carcasses were weighed again and the chilling loss was calculated; carcasses were compared on the basis of conformation (muscularity of proximal pelvic limb, loin and proximal thoracic limb) and state of fattening (fat covering of proximal pelvic limb, loin and kidney fat) (EEC, 1992). Then the carcasses were sectioned into two symmetric halves and then into the following cuts: neck, proximal thoracic limb, proximal pelvic limb, steaks + brisket, lumbar + abdominal region (Fig. 1) (ASPA, 1991), and the weight of each cut was recorded.

The right proximal pelvic limb was removed from each carcass, and was dissected into the

Table 1
Formulation of concentrates and chemical composition of the feeds

Components (%)	Concentrate with 5% of maize oil	Concentrate with 9% of barley flakes	Lucerne hay
Soybean	25	25	–
Maize	29	39	–
Barley	17	17	–
Bran	20	6	–
Maize oil	5	–	–
Barley flakes	–	9	–
Limestone	1.2	1.2	–
Calcium diphosphate	1.2	1.2	–
NaCl	0.6	0.6	–
Vitamin trace element supplement	1	1	–
Total	100	100	–
DM (%)	88.86	89.20	87.39
Crude protein (%)	18.26	17.69	12.34
Ether extract (%)	6.27	2.38	1.80
Crude fibre (%)	6.82	4.71	32.91
Ash (%)	8.71	8.49	7.57
NFE (%)	59.94	66.73	45.38
Meat FU (no/kg DM)	1.09	1.09	0.52



1) Neck
2) Proximal thoracic limb
3+4) Steaks + Brisket
5+6) Lumbar + Abdominal regions
7) Proximal pelvic limb

Fig. 1. Commercial cuts.

main tissue components (lean, subcutaneous and intermuscular fat, bone, and remainder). The ratio of various tissues on the total weight of proximal pelvic limb was calculated along with the lean/fat and lean/bone ratios.

We also estimated the total cost of feed given to the three groups, multiplying feed weight by their price. Live weight data were analyzed using Harvey (1990). All data underwent a variance analysis (Wilkinson, 1990).

3. Results and discussion

3.1. Growth

Diet 3 induced significantly higher daily weight gains ($P \leq 0.01$) than diet 2 (0.28 kg versus 0.24 kg), composed by same MC but with the addition of hay. Diet 1, BC and hay, gave intermediate results (0.26 kg). This result is not in agreement with Lough et al. (1993) who found that lambs fed a diet with palm oil have better average daily gains than lambs fed diet without palm oil.

Feed conversion ratios were similar for the three treatments: 4.52, 4.77, 4.61 Meat FU/kg gain, respectively on diet 1, 2 and 3.

Fig. 2 shows changes in live weight during the test. Until the lambs were 75 days old (weight 23–25 kg) there was no difference between the three diets, but thereafter the lambs receiving only MC (Diet 3) grew faster, and at slaughter had a higher, though not significant, average live weight than those on the other two diets.

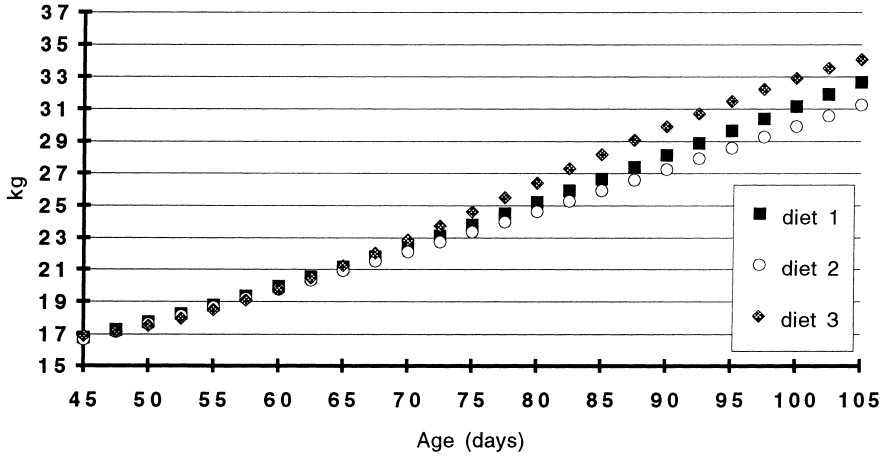


Fig. 2. Live weight trend.

Table 2
Slaughtering data: least square means

	Diet 1[1]	Diet 2[2]	Diet 3[3]	Error variance
Live weight (kg)	33.00	31.58	34.28	1.85
Cold carcass weight (kg)	16.17 AB	15.34 B	17.57 A	2.41
Chilling loss (%)	1.16	1.38	1.21	0.07
Dressing percentage (%)	49.54 B	49.24 B	51.87A	3.94
Fifth quarter (%)	35.42	36.45	35.33	2.46
Thoracic, abdominal and pelvic organs (%)	5.41	5.34	5.38	0.16
Bone* (%)	8.53 AB	9.04 A	8.31 B	0.24
Pelt (%)	10.67	10.95	10.46	0.55
Gastrointestinal tract (empty) (%)	10.81	11.11	11.18	0.58

[1] Diet 1: concentrate with barley flakes + hay.
[2] Diet 2: concentrate with maize oil + hay.
[3] Diet 3: concentrate with maize oil.
* Bone: distal thoracic and pelvic limb, head.
On the row: A, B: $P \leq 0.01$; a, b: $P \leq 0.05$.

3.2. Carcass results

Diet 3 caused heavier carcasses and better dressing percentage ($P \leq 0.01$) (Table 2). These results are confirmed by the lower percentage of the fifth quarter for those lambs as compared to diet 2, in terms of percentage of bone ($P \leq 0.01$). Diet 1 lambs, fed a BC and lucerne hay, gave intermediate results.

The chilling loss was similar for all three diets.

Carcass classification (EEC, 1992) highlights that diet 2 (MC + hay) gave the best carcasses in terms of conformation and state of fattening. Diet 1 produced carcasses with the same amount of fat covering as diet 2 but, on average, a worse conformation; diet 3 carcasses had a similar conformation to diet 2 carcasses but with notably more fat cover, in agreement with Chestnutt (1994) who found a significant effect of carcass weight on the level of carcass fat.

3.3. Commercial cuts

Lambs on diet 3 showed less proximal thoracic limb cuts than those on diet 1 and 2 ($P \leq 0.01$) (Table 3). However they tended to give better percentages in steaks + brisket and lumbar + abdominal region cuts, though this difference was not statistically significant.

Proximal pelvic limb cuts were higher ($P \leq 0.05$) in lambs on diet 2 than in diet 3, while diet 1 had intermediate values.

Considering that lambs on diet 3 reached heavier live weights, the different percentage of the cuts may be explained by the fact that generally proximal pelvic

Table 3
Commercial cuts: least square means

	Diet 1[1]	Diet 2[2]	Diet 3[3]	Error variance
Right half carcass weight (cold) (kg)	7.82 B	7.43 B	8.51 A	0.57
Neck (%)	10.79	10.74	10.57	0.94
Proximal thoracic limb (%)	17.77 A	17.87 A	16.75 B	1.02
Proximal pelvic limb (%)	32.05 ab	32.56 a	31.29 b	1.37
Steaks + brisket (%)	24.18	24.41	25.04	1.59
Lumbar + abdominal region (%)	11.76	11.46	11.90	0.87

[1] Diet 1: concentrate with barley flakes + hay.
[2] Diet 2: concentrate with maize oil + hay.
[3] Diet 3: concentrate with maize oil.
On the row: A, B: $P \leq 0.01$; a, b: $P \leq 0.05$.

Table 4
Histological dissection of proximal pelvic limb

	Diet 1[1]	Diet 2[2]	Diet 3[3]	Error variance
Proximal pelvic limb (kg)	2.49 AB	2.41 B	2.64 A	37.56
Total lean (%)	58.97 a	57.11 ab	56.16 b	5.76
Subcutaneous fat (%)	8.55 B	8.26 B	11.44 A	3.29
Intermuscular fat (%)	4.64	5.01	4.79	1.58
Total fat (%)	13.19 B	13.27 B	16.24 A	3.47
Bone (%)	20.64	21.79	20.10	4.64
Other tissue (%)	4.71	5.31	4.96	1.46
Lean/fat ratio	4.59 A	4.38 A	3.51 B	0.46
Lean/bone ratio	2.86	2.65	2.85	0.12

[1] Diet 1: concentrate with barley flakes + hay.
[2] Diet 2: concenrate with maize oil + hay.
[3] Diet 3: concentrate with maize oil.
On the row: A, B: $P \leq 0.01$; a, b: $P \leq 0.05$.

and thoracic limb have an allometric coefficient lower than 1, while steaks + brisket and lumbar + abdominal region cuts show a relatively greater growth (Boccard and Dumont, 1976; Gigli et al., 1988; Sarti et al., 1991).

3.4. Histological dissection

The proximal pelvic limb underwent histological dissection as it is considered to be the most representative cut of the tissue composition of the entire carcass (Nitter and Parvaneh, 1975; Gigli et al., 1982; (see also Zezza et al., 1978); Piccolo et al., 1993) (Table 4).

The weight of proximal pelvic limb was statistically greater ($P \leq 0.01$) in lambs on diet 3 than on the other diets. The histological dissection indicated that animals on diet 3 had a higher ($P \leq 0.01$) adiposity than the others, due to a higher deposition of subcutaneous fat, while the intermuscular fat was similar for the three diets. This is in agreement with Murray and Slezacek (1976), who found that high growth rate was associated with more subcutaneous and less intermuscular fat, but not totally with Chestnutt (1994) who found that all measures of fat increase significantly with increasing weight. In lambs on diet 3 a lower percentage of lean was found and consequently a significantly unfavourable lean/fat ratio ($P \leq 0.01$). This confirms that a fatty diet without hay induces greater adiposity, as was seen when assessing the carcasses. Lean/bone ratio was similar in the three diets but the values were lower than those found by Hopkins (1996), probably due to the different carcass weight of the lambs used in the two trials.

The histological dissection of the proximal pelvic limb confirmed the good tissue composition of Apennine lambs slaughtered at 105 days, whichever diet was given because of their meaty carcasses evidenced by the favourable lean/bone and lean/fat ratio.

4. Conclusions

The use of concentrate with maize oil (MC) without hay (diet 3) for lamb feeding did not have an adverse effect during the time period of 105 days and seemed to favour the growth with respect to both diet 1 and diet 2.

Animals on diet 3 gave carcasses with an adequate commercial weight at the age of 90–95 days and therefore it seems possible to anticipate slaughtering these animals earlier and perhaps obviate the excessive adiposity of the carcass. In general, this study further confirmed the good meat quality of Apennine carcasses slaughtered at 105 days.

Analysis of feeding costs showed that exclusive feeding with concentrates is not more costly than a mixed diet and, if hay is bought at market price, even more advantageous. In addition, the only use of concentrate, giving the possibility to anticipate slaughtering at the age of 90–95 days will induce a smaller rearing cost.

References

Aharoni, Y., Nachtomi, E., Holstein, P., Brosh, A., Holzer, Z., Nitsan, Z., 1995. Dietary effects on fat deposition and fatty acid profile in muscles and fat depots on Friesian Bull Calves. J. Anim. Sci. 73, 2717–2720.

ASPA (Associazione Scientifica Produzione Animale – Scientific Association of Animal production), 1991. Metodologie relative alla macellazione degli animali di interesse zootecnico e alla valutazione e dissezione della loro carcassa. (Methodologies about cattle slaughtering and carcasses evaluation and dissection.) ISMEA, Rome, pp. 40–47.

Boccard, R., Dumont, B.L., 1976. La qualité des carcasses ovines. (Ovine quality carcass.) Proc. 2me journées de la recherche ovine e caprine. Croissance, engrassement et qualité des carcasses. I.N.R.A., pp. 44–78.

Bozzolo, G., Bouillier-Oudot, M., Aoun, M., 1991. Incidence des acides gras alimentaires à chaîne moyenne, incorporès dans le règime de transition en post-sevrage, sur les caractèristiques de croissance et de carcasse d'agneaux sevrès prècocement et engraissés intensivement en bergerie en été. (Influence of the incorporation of medium-chain fatty acids in post-weaning diet upon growth scores and carcass characteristics of early weaned lambs intensively fattened in the pen during summer). Ann. Zootech. 40, 85–104.

Busboom, J.R., Miller, G.J., Field, R.A., Crouse, J.D., Riley, M.L., Nelms, G.E., Ferrell, C.L., 1981. Characteristics of fat from heavy ram and wether lambs. J. Anim. Sci. 52, 83–92.

Chestnutt, D.M.B., 1994. Effect of lamb growth rate and growth pattern on carcass fat levels. Anim. Prod. 58, 77–85.

EEC, 1992. Tabella comunitaria di classificazione delle carcasse di ovini. (Table of carcass of sheep.) Regolamento No. 2137/92.

Field, R.A., Williams, J.C., Ferrel, C.L., Crouse, J.D., Kiensam, J.E., 1978. Dietary alteration of palatability and fatty acids in meat from light and heavy weight ram lambs. J. Anim. Sci. 47, 858–864.

Garret, W.N., Yang, T.Y., Dunkley, W.L., Smith, L.M., 1976. Energy utilization, feedlot performance and fatty acid composition of beef steers fed protein encapsulated tallow on vegetable oils. J. Anim. Sci. 42, 845–853.

Gigli, S., Romita, A., Borghese, A., Mormile, M., 1982. Dati alla macellazione ed alla dissezione di agnelloni meticci di 105 giorni su base Sopravissana. (Slaughtering and dissection data on lamb crossbred × Sopravvissana at 105 days of age.) Proc. S.I.S.Vet. (Società Italiana Scienze Veteterinarie – Italian Society of Veterinary Science) 36, pp. 426–428.

Gigli, S., Carretta, A., Terzano, G.M., Romita, A., 1988. Valutazione della crescita relativa in ovini di razza Sopravissana e meticci Bergamasca × Sopravissana. II – Gruppi muscolari, ossa e depositi adiposi della coscia. (Allometry in Sopravissana and Bergamasca × Sopravissana lambs. II – Muscles, bones and fat depots of leg.) Proc. 8° SIPAOC (Società Italiana Patologia e Allevamento Ovini e Caprini – Italian Society of Pathology and Breeding of Ovine and Goat), pp. 247–255.

Giorgetti, A., Lucifero, M., 1989. Effetto dell' aggiunta di olii vegetali sulla digeribilità microbica ruminale in vitro di alcuni alimenti. (Effect of the addition of vegetable oils on the in vitro ruminal microbic palatability of some feedlots). Agr. Ric. 11(95), 71–74.

Harvey, W.R., 1990. Mixed Model Least-Squares and Maximum Likelihood Computer Program – 1 Version. Dep. Dairy Sci., Ohio State University, Columbus.

Hopkins, D.L., 1996. The relationship between muscularity, muscle:bone ratio and cut dimension in male and female lamb carcasses and the measurement of muscularity using image analysis. Meat Sci. 44, 307–317.

Huerta-Leidenz, N.O., Cross, H.R., Lung, D.K., Pelton, C.S., Savell, J.W., Smith, S.B., 1991. Growth, carcass traits and fatty acid profiles of adipose tissues from steers fed whole cottonseed. J. Anim. Sci. 69, 3665–3672.

Larick, D.K., Turner, B.E., 1989. Influence of finishing diet on the phospholipid composition and fatty acid profile of individual phospholipids in lean muscle of beef cattle. J. Anim. Sci. 67, 2282–2293.

Lough, D.S., Solomon, M.B., Rumsey, T.S., Elsasser, T.H., Slyter, L.L., Kahl, S., Lynch, G.P., 1992. Effects of dietary canola seed and soy lecithin in high-forage diets on cholesterol content and fatty acid composition of carcass tissues of growing ram lambs. J. Anim. Sci. 70, 1153–1158.

Lough, D.S., Solomon, M.B., Rumsey, T.S., Kahl, S., Slyter, L.L., 1993. Effects of high-forage diets with added palm oil on performance, plasma lipids and carcass characteristics of ram and ewe lambs. J. Anim. Sci. 71, 1171–1176.

Lucifero, M., Giorgetti, A., Lupi, P., Martini, A., 1989. Influenza dell'olio di arachide sull'accrescimento e le caratteristiche delle carcasse di agnelli Massesi. (Influence of groundnut oil on the growth and characteristics of Massese lamb carcasses). Agr. Ric. 11(95), 75–78.

Marmer, W.N., Maxwell, R.J., Williams, J.E., 1984. Effects of dietary regimen and tissue site on bovine fatty acid profiles. J. Anim. Sci. 59, 109–121.

Murphy, T.A., Loerch, S.C., McClure, K.E., Solomon, M.B., 1994. Effects of restricted feeding on growth performance and carcass composition of lambs. J. Anim. Sci. 72, 3131–3137.

Murray, D.M., Slezacek, O., 1976. Growth rate and its effect on empty body weight, carcass weight and dissected carcass composition of sheep. J. Agr. Sci. 87, 171–179.

Nitter, G., Parvaneh, B., 1975. Untersuchungen über die Absehätzung der Schlachtkörperzusammensetzung von Lämmern aus Hilfsmerkmalen. (Studies about the determination of carcass composition of lambs with judging aids). Züchtungskunde 47, 336–349.

Piccolo,V., Pinna,W., Lai, P., Cappio Borlino, A., Ferrari, G., 1993. Correlazioni tra contenuti di carne, grasso e ossa della mezzena e delle regioni anatomiche in agnelli di latte di razza Sarda. (Relationship between meat, fat and bone contents of half carcass and anatomical regions in Sardinian breed milk lambs.) Proc. S.I.S.Vet. (Società Italiana Scienze Veterinarie – Italian Society of Veterinary Science) 47, pp. 2011–2014.

Rumsey, T.S., Oltjen, R.R., Bouard, K.D., Priode, B.M., 1972. Influence of widely diverse finishing regimes and breeding on depot fat composition in beef cattle. J. Anim. Sci. 35, 1069–1075.

Sarti, D.M., Morbidini, L., Panella, F., 1991. Caratteristiche quantitative e qualitative delle carcasse di agnelli di razza Appenninica macellati a diverse età ed alimentati con differenti diete. (Quantitative and qualitative characteristics of Apennine lamb carcasses slaughtered at different ages and fed with different diets.) Proc. ASPA (Associazione Scientifica Produzione Animale – Scientific Association of Animal Production) 9, pp. 1029–1041.

Skelley, G.C., Stanford, W.C., Edwards, R.L., 1973. Bovine fat composition and its relation to animal diet and carcass characteristics. J. Anim. Sci. 36, 576–580.

Solomon, M.B., Lynch, G.P., Paroczay, E., Norton, S., 1991. Influence of rapeseed meal, whole rapeseed, and soybean meal on fatty acid composition and cholesterol content of muscle and adipose tissue from ram lambs. J. Anim. Sci. 69, 4055–4061.

Solomon, M.B., Lynch, G.P., Lough, D.S., 1992. Influence of dietary palm oil supplementation on serum lipid metabolites, carcass characteristics and lipid composition of carcass tissues of growing ram and ewe lambs. J. Anim. Sci. 70, 2746–2751.

Van Nevel, Demeyer, 1988. Manipulation of rumen fermentation, quoted in Hobson P.N., 1988. The rumen microbial ecosystem. Elsevier, London, 13, pp. 387–443.

Van Nevel, 1991. Modification of rumen fermentation by the use of additives, quoted in Jouany J.P., 1991. Rumen microbial metabolism and ruminant digestion. I.N.R.A., Paris, pp. 263–280.

Westerling, D.B., Hedrick, H.B., 1979. Fatty acid composition on bovine lipids by diet, sex and anatomical location and relationship to sensory characteristics. J. Anim. Sci. 48, 1343–1348.

Wilkinson, L., 1990. Systat: The system for statistics. Systat Inc., Evanston, IL, USA, pp. 191–317.

Zezza, L., Muscio, A., Celi, R., Centoducati P., Crollo, R., Nicastro, F., 1978. L'incrocio di prima generazione e la qualità della carcassa negli ovini. (First generation crossbreeding and the quality of the carcass in ovine.) Ann. Fac. Agr. Bari. XXX, 761–785.