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Preliminary analysis of the possibility of including longevity as a breeding goal of Malagueña goats

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SUMMARY - Different measures of longevity, their heritability and correlations with yield and trait-types, as well as the strategies to increase herd life through selection, are reviewed. Age structure of Malagueña goats in milk recorded herds, current culling policy, and relations between herd life of goats and their yields are described. Data show that, contrary to what farmers declare, there is some culling of animals based on yields. Relations between long herd life and genetic values for milk traits seem to be negative, but they are not very reliable. Causes of the low average productive life of goats, particularly diseases, are discussed in relation to the nature of longevity and its genetic variation. Consequences of a higher longevity on the genetic progress of yield traits, studied through simulation, are negative, but these effects are counteracted by the economic advantage of a longer herd life. Possibilities of selection for longevity under the present conditions of the selection scheme are limited, in the short term, to the "automatic" selection realized when leaving most of the replacements from older goats. However, early life indicators of adaptation to disease hazards should be sought.

Key words: Longevity, productivity, income, selection goals, goats.

RESUME - "Analyse préliminaire de la possibilité d'inclure la longévité comme objectif de sélection chez les chèvres Malagueña". On présente une revue bibliographique des différentes mesures de la longévité, de leur héritabilité et de leurs corrélations avec les caractères morphologiques et les caractères de production, ainsi que les stratégies pour augmenter la longévité des chèvres par sélection. On décrit également la structure d'âge des chèvres de race Malagueña dans les troupeaux inscrits au contrôle laitier, et la politique actuelle de réforme des animaux, ainsi que la relation entre leur longévité et leur niveau de production. Les données disponibles montrent que certaines chèvres sont réformées à cause de leur niveau de production, contrairement à ce qui est déclaré par les éleveurs. Apparemment, les relations entre la longévité et les valeurs génétiques des caractères de production laitière soient négatives, bien que les estimations disponibles sont peu précises. Les causes de la faible durée de vie moyenne des chèvres, les maladies particulièrement, sont discutées en rapport avec la nature et la variation génétique de la longévité. Les conséquences d'une longévité élevée sur le progrès génétique des caractères de production, étudiées par simulation, sont négatives ; mais elle sont compensées par l'avantage économique d'une durée de vie plus grande. Les possibilités de sélection pour la longévité sous les conditions du schéma actuel sont limitées, dans le court terme, à la sélection "automatique", qui consiste au renouvellement des troupeaux à partir de la descendance des chèvres âgées. Cependant, la recherche d'indicateurs précoces de l'adaptation aux risques de maladie doit être considérée.

Most-clés : Longévité, productivité, revenus, objectifs de sélection, caprins.

Introduction

Longevity has an important influence on the economic returns of dairy farms. The benefits of increasing longevity: a reduction of the share of rearing cost per year of productive life; a change of the herd age structure, with a higher proportion of mature animals with higher milk yields, and more opportunity for culling animals, have been described and discussed in early works (Rendel and Robertson, 1950), (*op. cited by Veerkamp et al., 1995*) and in many others up to the moment (Gill and Allaire, 1976; Balaine *et al.*, 1981; Burnside *et al.*, 1984; Congleton and King, 1984; Arendonk van, 1985; Rogers *et al.*, 1988; Madgwick and Goddard, 1989; Sölkner, 1989; Jairath *et al.*, 1994; Veerkamp *et al.*, 1995).

Herd life has a larger effect when feed costs are higher or prices of products (milk and meat from offspring) are low (Congleton and King, 1984; Raden van and Klaaskaten, 1993).

Relative economic weights of genetic merit for longevity (actually measured through satiability, a parameter defined below) vs genetic merit for milk production, obtained through a simulation done under Australian and USA conditions for net profits, are 1:2 (Burnside *et al.*, 1984). Other estimations of relative economic values of production to herd life (independent on production), expressed in genetic standard deviations, ranged from 1.4 to 8.0 (Congleton and King, 1984; Lobo and Allaire, 1995).

From the perspective of a selection program, longevity increases the efficacy and intensity of selection and the generations intervals. The joint influence of these factors on the genetic progress is often negative. However, despite this negative influence on genetic progress, the optimum net benefit per productive female is obtained with high longevity (Lobo and Allaire, 1995).

Longevity has been defined as the age of the animal, or number of lactations when referring to dairy females, when it dies or it is culled (Madgwick and Goddard, 1989). This has also been called length of productive life or herd life. Frequently these measures refer to the time elapsed from first parturition to the date of removal from the herd (Lobo and Allaire, 1995).

The problem with these measures of longevity is that they can only be used when the animals are dead or culled. There will then be partial records, those of animals still alive or in the herd when finishing the study period (Ducrocq, 1994). Several definitions and their corresponding ways of measuring longevity have been proposed to solve this problem. One of them is the use of indirect measures or indicators of the presence of the animal in the herd at a given age or lactation number. Stayability and survival scores are two measures of this type.

Stayability is a measure of survival of animals in the herd to a predetermined age (for dairy cows, for example, ages of 36, 48, 60, 72 and 84 months, have been considered). The problem with this approach is that measuring the stayability at a certain age does not account for the information contained in later scores (Everett *et al.*, 1976; Madgwick and Goddard, 1989). To avoid this drawback of the method, series of survival scores, defined as $S_i=1$, if the animal survives from i to $i+1$ year after first calving or $S_i=0$, if the animal does not survive, have been proposed. An important advantage, among others, of these series of survival scores, is that animals entering the recording system late in life can still be considered (Madgwick and Goddard, 1989).

Another way to cope with the problem of partial records is to predict longevity through a multiple regression on early traits or extending incomplete records, as it is done with partial lactation records (Raden van and Klaaskaten, 1993).

Smith (1983), (*op. cited by Ducrocq, 1994*) proposed a method developed originally for medical research, based on the concept of hazard rate, which is the probability that an animal is alive at time t when it is still alive immediately prior to t . Several models have been derived using this concept: the proportional hazard model and the Weibull model. The advantage of these models is that, besides the baseline hazard function representing the ageing process, they also consider a positive function of the explanatory variables assumed to influence the culling rates.

Ducrocq *et al.* (1988) have distinguished between true longevity (or true stayability), which is the measure of longevity normally observed (depending, in the case of dairy cattle, mainly on productivity) and functional longevity, which is the ability to delay involuntary culling because of

diseases or reproductive problems. To obtain the measures of functional longevity it has been proposed, in the case of dairy cows, a measure of longevity corrected for milk production relative to herd average milk production (Vukasinovic *et al.*, 1995).

Longevity or herd life, as it has been said, has an important effect on lifetime production and benefits. Several ways of measuring these parameters have been used: lifetime production, actual income and expenses figures (Balaine *et al.*, 1981; Haan *et al.*, 1992), relative net income (RNI) (Haan *et al.*, 1992), which considers values of products, rearing costs and fixed and variable costs of maintenance of productive and non productive animals. A RNI adjusted for opportunity costs (RNIOC) (Haan *et al.*, 1992) has been considered adequate to reflect the cost of replacement of culled cows by an average cow from the herd, instead of by a cow of equal economic value.

Genetic control of longevity has been proven in many species, to a larger or lesser extent. In *Drosophila* nematode genes determining the trait, have been found (Dear *et al.*, 1992). Chromosomal regions controlling the trait have been described in mice (Dear *et al.*, 1992). Often the effect of these genes interacts with the environment (Yunis *et al.*, 1984; Clare and Luckinbill, 1985; Dear *et al.*, 1992). Higher longevity of heterozygotes is also a common finding (Yunis *et al.*, 1984). However, longevity, or life span, of laboratory animals is probably a different trait than herd life of farm animals, since the latter is more related to the culling of animals, and therefore to productive life, than to the natural death of the animal under certain environmental conditions.

In farm animals much less is known about the genetic control of herd life. Breed differences, as well as differences among different crosses, have been found in dairy cattle (Madgwick and Goddard, 1989), beef cattle (Rohrer *et al.*, 1988a; Arthur *et al.*, 1993; Randen van and Klaaskate, 1993; Davis *et al.*, 1994), sheep (Hohenboken and Clarke, 1981) and pigs (Jungst *et al.*, 1988). Environmental dependence of the results of these breeds and crossbreds comparisons have been reported (Hohenboken and Clarke, 1981; Rohrer *et al.*, 1988a). Heterotic effects have been also reported (Rohrer *et al.*, 1988a; Rohrer *et al.*, 1988b; Madgwick and Goddard, 1989; Arthur *et al.*, 1995), although combining ability described is of general type (Rohrer *et al.*, 1988b).

Heritability estimates of longevity, irrespective of the parameter used, are low. They range from 0 to 0.39, most frequent values being around 0.05 (Burnside *et al.*, 1984; Madgwick and Goddard, 1989; Jairath *et al.*, 1994). Estimates are somewhat higher for continuous than for discrete measures. For example, heritabilities for all undesirable disposal reasons studied by Westell *et al.* (1982), range between 0.09 and 0.25. Higher estimates (between 0.12 and 0.35) have been obtained for lifetime profits. Nonetheless, there exist many inconsistencies among different estimates of heritability in the literature. A reason could be the different methods used to get these estimates. Most times they have been obtained with ANOVA methods, but more recent estimates obtained with multitrait REML are of similar magnitude than those reported before (Jairath *et al.*, 1994).

Strategies to improve longevity depend on breeds and production systems. In selection programs of dairy cows, direct selection for longevity is never considered, because of the low heritability of the trait, its negative effect on generation interval and the scarce availability of records of longevity of ancestors. Large progeny groups, from 100 to 200 daughters, are necessary to detect sire differences on stayability or for accurate recording of disposal reasons (Burnside *et al.*, 1984). The same is true for lifetime performances (Jairath *et al.*, 1994). Emphasis has been put on indirect selection through correlated traits expressed early in the life of the animals. For this purpose, correlations of longevity with early yields and with type or conformational, particularly those which might be cause of disposal of animals, like udder and hoof traits among others, have been investigated.

A review of estimates obtained for phenotypic and genetic correlations between measures of longevity and first lactation milk yields, overall type appraisals in first lactations and between the latter with reproductive problems was done by Honnette *et al.* (1980). Genetic correlations with longevity reported for yields are, in general, positive and larger than phenotypic correlations. There are exception, however, like negative correlations between single lactation yields and longevity in dual purpose Austrian Simmentals found by Sölkner (1989). This author proposes using data on second and third lactations and some additional secondary traits to slow down the detrimental effect of selection for first lactations yield on longevity. Genetic correlations between lifetime performances and longevity are near unity (Jairath *et al.*, 1993).

Individual type components are only slightly related to longevity, but collectively they are as important as yields when related to this parameter. The components of type showing a higher association with longevity are: high, wide and firmly attached rear udders, strong udder support with well defined udder halves and correct placement and size of teats (Honnette *et al.*, 1980). However, (Burnside *et al.*, 1984) stated in a review that not a consistent pattern of correlations between conformation traits and longevity existed. Although some clear correlations have been found in some posterior studies: for example, udder depth and teats placement were found to be useful predictors of RNI (Haan *et al.*, 1992), and hoof angle and heel depth were correlated to stayability scores (Choi and McDaniel, 1993), type traits do not offer many opportunities to select for longevity, because of their relatively low correlations with herd life or stayability (Raden van *et al.*, 1993; Vukasinovic *et al.*, 1995). Veerkamp *et al.* (1995) analysed an index with complete multivariate predicted transmitting abilities (PTAs) for four linear type traits (angularity, foot angle, udder depth and teat length) and milk, fat and protein yield. They found that selecting with this index was expected to give a 2% higher genetic gain than selection only on milk yield.

Even when genetic correlations of first lactation yields and bull's breeding values predictions for their daughter's first lactations with longevity are generally positive, some authors discuss the possibility that higher yields might produce lower longevity (Jairath *et al.*, 1994). In fact, negative genetic and phenotypic trends for longevity have been found in dairy cattle (Everett *et al.*, 1976).

Despite some contradictory results, most authors coincide in pointing at first lactation milk yields as the best early indicators of longevity; however, additional information, particularly that of lifetime performances of half sisters and close ancestors, should be included in the evaluation of young sires (Jairath *et al.*, 1994). Incorporating survival analysis techniques to predict length of productive life, and to estimate time-specific probabilities of health disorders might help farmers to take better culling decisions on type traits and, finally, to improve herd life of animals (Beaudeau *et al.*, 1995).

Natural selection is another mechanism acting on longevity, particularly through involuntary culling of animals (death produced by diseases and age) (Raden van *et al.*, 1993). Artificial "automatic" selection for longevity takes constantly place due to the usual policy of farmers of leaving replacement from older females (Burnside *et al.*, 1984; Jairath *et al.*, 1994).

Longevity, its heredity and correlations with different traits and the possibilities of increasing longevity through selection have been thoroughly studied in dairy cattle, but not in other dairy animals, like goats. We intend to make a first approximation to discuss these topics in relation to a specific breed of goats. The objectives of this work are:

(i) To describe the present situation of herds in the milk recording scheme of Malagueña goats with respect to herd life and the criteria for culling animals.

(ii) To analyse relationships between herd life of goats and their milk yields at different lactations.

(iii) To make a first approach to the study of the effects of different average herd lives of goats on the genetic progress attained through selection and on the net benefits obtained by farmers.

(iv) To discuss the possibilities of genetic improvement of longevity in Malagueña goats.

Material and methods

Data on milk records of the breed from 1986 to 1996 have been used to get the age structure of goats in the milk recording scheme and to generate another data base with only records of goats which herd life is known. This data base comprises 7,829 lactations of 4,189 goats in 22 herds. Unfortunately, most of the recorded goats do not have records throughout their whole productive life. This data base has been used to:

(i) Compute average milk yield per lactation and average number of days in milk of goat grouped by their herd life.

(ii) Compare least squares means of milk yields of first to tenth lactations of goats reaching different herd lives (3 to 10 lactations). The model used to estimate LS means was: $y_{ij} = HL_i + e_{ij}$, where y_{ij} is milk yield of the considered lactation (from first to tenth) of goat j whose last lactation is lactation number i , and HL_i is the effect of having number of the last lactation i .

(iii) Estimate the effects of number of lactation (LN), number of kids born (KN), year (Y) and season (S) of kidding and herd (H), considered as fixed factors in the model: $y_{ijklmn} = LN_j + KN_k + Y_l + S_m + H_n + e_{ijklmn}$. These effects were used in the simulations described further below.

(iv) Obtain BLUP of breeding values of goats for milk yields (standardized to 240 days) using an animal model with the fixed effects described above.

Simulations were done to compare the phenotypic and genetic progress attained through twenty years of selection for milk yields (using actual breeding values as selection criterion). Simulated values of milk yields were obtained using the effects of fixed factors, described above, and values for random effects (additive genetic, permanent and error effects) randomly chosen in a population of values with the variances estimated in a population of a similar breed (Analla *et al.*, 1996), following the methodology described by Analla *et al.* (1995). The selection scheme considered was based on within herd selection of kids for replacement of females and males, non planned natural service, and therefore only maternal recording and non connected herds, as it is in the actual selection scheme of the breed. A base population of 10,724 goats distributed in 100 herds and twenty cycles of selection (years) keeping constant population size were simulated. Five different simulations, for five different maximum herd lives (3, 5, 7, 10 and 13 lactations), with ten replicates each, were carried out.

Finally, genetic gains in monetary units, obtained in formerly described simulations, referred to a herd of 100 goats, were compared to incomes obtained with such a herd under the different situations of age structure considered in the simulations. Average yield of first lactations and of the rest of lactations have been assumed to be 337 kg and 449 kg, respectively. No differences have been considered among yields of lactations after the first. Average litter sizes of 1.4 and 1.8 have been taken for first and later kiddings, respectively. Prices of 66 ptas/kg for milk (Fernández-Rebollo, 1995) and 6,200 ptas for kids (Sánchez-Osuna, 1996) were assumed.

Results

Age structure and culling criteria

Figure 1 shows the age structure of the population of Malagueña goats in the milk recording scheme, in terms of percentages of goats in each ordinal number of lactation or parturition. Differences between two consecutive lactations is larger for second-third lactations and remain similar up to the sixth-seventh lactations. Almost the same proportion of goats keep producing from the ninth up to the thirteen lactation. Less than 10% of the goats have more than 6 lactations, and only 1% reach to have more than ten. The average number of lactations per goat is very low (2.58).

An indication of the criteria used by farmers for culling, obtained from an informal inquiry made in a sample of farms in the milk recording scheme, showed that most farmers use milk yield in second and/or third lactations as criteria to cull the least productive goats. But almost no farmers makes further culling subsequently. Most goats are kept kidding and lactating until they die as a consequence of disease, or less frequently accidents, or natural causes. Since the average number of lactations per goat is very low and very few goats reach more than ten lactations, it is suggested that there is a very high mortality as a result of diseases and, probably, there is also some genetic variation for resistance to these diseases or for general adaptation to disease hazards which, finally, accounts for differences on longevity.

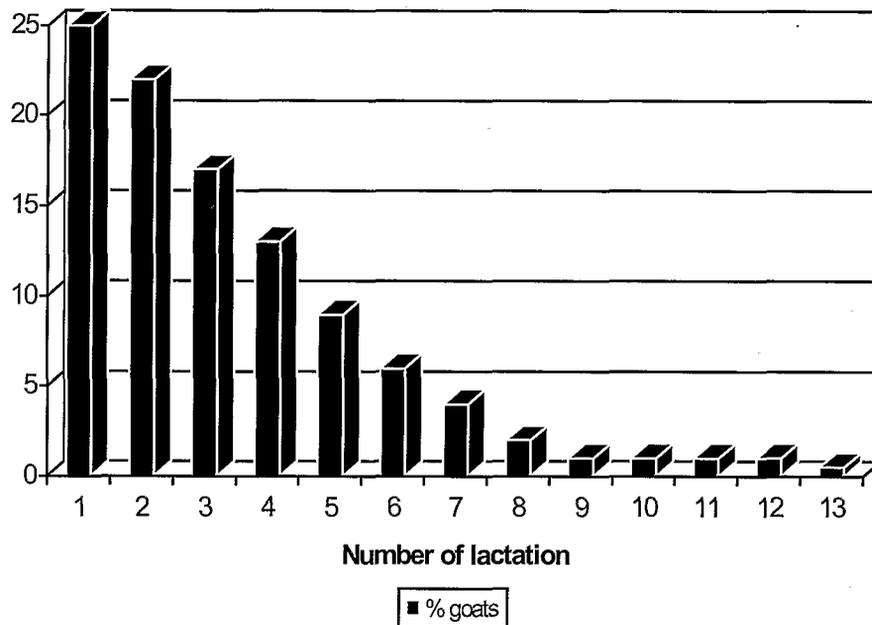


Fig. 1. Age structure of the population of Malagueña goats.

Relation between herd life and milk yields

Table 1 shows the average milk yield per lactation and average number of days in milk of each last lactation (one to thirteen) of goats for which no more registered lactations exist at the moment of the analysis.

Table 1. Average milk yield and days in milk

LLAC [†]	AMYL ^{††} (kg)	ANDM ^{†††} (days)	NA ^{††††}	ANL ^{†††††}
1	374	233	1116	1
2	465	242	856	1
3	498	255	607	2
4	509	260	501	2
5	506	262	431	2
6	509	269	257	3
7	476	259	184	3
8	492	292	101	4
9	466	268	66	3
10	406	258	46	3
11	425	259	26	3
12	418	248	3	4
13	453	249	5	5

[†]LLAC: Last lactation of goats for which no more registered lactations exist at the moment of the analysis

^{††}AMYL: Average milk yield per lactation

^{†††}ANDM: Average number of days in milk

^{††††}NA: Number of animals

^{†††††}ANL: Average number of lactation per animal

First lactation, as expected, has the lowest value. Higher values correspond to goats with last lactation registered at the moment of the analysis between the third and the eighth. Second and ninth last known lactations had slightly lower values. There is a clear decline in values after the tenth lactation, with the exception of the thirteenth, which was not a very reliable value as it was computed for very few animals. These data correspond to goats for which no more registered lactations exist at the moment of the analysis, but not for goats ending their productive live at those lactations. Only from the sixth last registered lactation onward do both concepts coincide in most of the observations. Therefore, it is only from the sixth to the thirteen last lactations that we can derive proper conclusions. Furthermore, values for goats with last registered lactation number higher than six have been computed with last three to five lactations only. This can account for the lower values obtained for goats ending their productive lives later than ninth lactation. In conclusion, no reliable indications exist that there are differences of average productivity per lactation related to herd life in the population studied. If this is confirmed in further analysis, it means that overall productivity of goats with longer productive lives would be larger.

In order to corroborate this last conclusion, two types of analysis were made: a comparison of LS means values for each lactation of goats with different herd lives and an analysis of the position of goats with longer herd lives in the ranking of BLUP of breeding values.

Table 2 shows the results of the comparing the LS means estimation of yields of each lactation number of goats ending their productive life at lactation (GEPLL) one to eleven. Only LS means for values differing significantly ($P < 0.05$) have been included in the Table.

Table 2. LS means (kg) for each lactation of goats ending their productive life at lactation (GEPLL) 1 to 11 (Only values differing significantly have been included)

LAC†	GEPLL	LS means	GEPLL							
			3	4	5	6	7	8	9	10
2	6	583	495	514	550					
3	6	597	517	507						
	7	510	517	507						
	8	593	517	507						
4	7	589		511						
	8	647		511	531	525				
5	8	562			473	482	465			
	9	676			473	482	465			
6	7	430				487				
7	11	577					440	413	413	
8	11	596							408	359

†LAC: Number of lactation

In the first lactation there were no differences between goats with longer herd lives and the rest of the goats. However, differences exist for second and third lactations yields between goats ending their productive lives at lower lactation numbers (3, 4 and 5 compared to those with 6, 7 and 8 lactations). Differences also exist, in general, in later lactations (fifth to eighth) in favour of goats with longer herd lives. Three conclusions can be derived from these results:

- (i) Goats with longer herd lives do not necessarily have lower or higher yields during their early life.

(ii) Differences of second and third lactation yields between goats ending their lives early (third or fourth lactation) and late, may reflect the culling of goats that most farmers admit making at those ages of goats on the basis of production.

(iii) There seem to be a certain culling of goats on the basis of their production at later lactations (seventh and eighth), remaining in the herds only the most productive goats. This last conclusion, if true, contradicts what most farmers say with respect to culling of old animals with production criteria, although we do not know to what extent farmers might do this culling.

The first result is very important. It reflects that a not very effective selection, based on first lactation yields, is being made at present, contrary to the situation in cows (Honnette *et al.*, 1980). It also shows that the type of semiextensive system of production prevailing in this breed (Sánchez-Palma and Serradilla, 1996) does not allow for the whole genetic potentiality of goats to be expressed and, therefore, more productive animals are not at their physiological limits, which gives them longer productive life than could be expected (Burnside *et al.*, 1984).

The position of goats with very long herd lives (from 11th lactation onward) in the ranking of BLUP of breeding values within herds and in the whole population evaluated are shown in Table 3.

Table 3. Position of goats with herd lives longer than 11 lactations in the ranking of BLUP values

	1 st quartile	2 nd quartile	3 rd quartile	4 th quartile
RDG†	16%	16%	43%	25%
RT††	16%	12.5%	50%	21.5%

†RDG: Ranking of BLUP values within herds

††RT: Ranking of BLUP values in the whole population

Sixty eight percent of very long-living goats are positioned in the second half of the ranking of breeding values, when classified within their respective herds, and 71.5% are in the second half of the ranking of breeding values when classified in the whole of the population evaluated. There seems to be a negative correlation between very long herd life and breeding values obtained with an animal model. This conclusion has to be taken cautiously, taking into account that due to the poor genealogical information in the original data, goats are evaluated mostly on their yields and goats with longer herd lives have been evaluated only with their latter lactations. However, the correction effect of the fixed factor lactation number should partially compensate for this. Furthermore, we are considering only extreme cases of long herd lives.

Consequences of average herd life on genetic progress attained through selection

By means of the simulation programs described in the material and methods, genetic and phenotypic progresses obtained through 20 years of selection under different age structures have been estimated. These values, for situations where GEPLL is the third, fifth, seventh, tenth and thirteen, are given in Table 4. Figures are very high, because the selection criterion used in simulations to generate replacements is the actual additive genetic value for milk yield. However, using another criterion more realistic, such as BLUP of breeding values obtained with an animal model, would unlikely change the relationships between the cases studied.

The smaller the number of the last lactation reached by goats, the larger the genetic and phenotypic progress attained. Replacement rates range from 38%, in the case of the third lactation being the last possible lactation, to 24%, in the case of last possible lactation number being thirteen. The positive effect on genetic progress of the larger selection intensity associated to longer herd lives does not compensate for the negative effect of a large generation interval. If estimated breeding values had been used as the selection criterion, we would have to take into account the effect of longer herd lives which means more information available for genetic evaluations, on the accuracy of

these estimations. However, this effect would favour goats with longer herd life and, therefore, it would not change substantially our results. We can conclude that, from the point of view of genetic progress attained through selection it is better to have a fast replacement of goats.

Table 4. Genetic and phenotypic progresses obtained through different age structures, goats ending their productive life at lactation (GEPLL) is the third, fifth, seventh, tenth and thirteen)

	GEPLL				
	3	5	7	10	13
ΔG^\dagger (kg)	203 ± 5	195 ± 3	189 ± 5	188 ± 4	186 ± 4
$\Delta P^{\dagger\dagger}$ (kg)	227 ± 5	221 ± 4	213 ± 4	212 ± 4	210 ± 4

$\dagger\Delta P$: Phenotypic progresses

$\dagger\dagger\Delta G$: Genetic progresses

Consequences of herd life on farm incomes

However, even a simple approximation to the economic point of view shows the opposite conclusion. Incomes obtained in the different herd life situations considered are compared with the benefits expected from selection in each case in Table 5. All values are related to the present situation with a maximum lactation number of thirteen.

Table 5. Incomes obtained in the different herd life compared with the benefits expected from selection in each case

GELPL \dagger	IH †† (ptas)	BS ††† (ptas)	$\Delta I^{\dagger\dagger\dagger\dagger}$ (ptas)	$\Delta B^{\dagger\dagger\dagger\dagger}$ (ptas)
3	3,483,424	33,000	-202,928	2,310
5	3,571,412	31,515	-114,940	825
7	3,658,248	31,185	-28,104	495
10	3,666,920	31,020	-17,152	330
13	3,686,352	30,690	-	-

\dagger GEPLL = Goats ending their productive life at lactation

$\dagger\dagger$ IH: Incomes obtained in the herd

$\dagger\dagger\dagger$ BS: Benefits expected from selection

$\dagger\dagger\dagger\dagger\Delta I$: Decreases of incomes when reducing the maximum herd of animals (referred to GEPLL=13)

$\dagger\dagger\dagger\dagger\Delta B$: Increments of benefits expected from selection when reducing the maximum herd lives of animals (referred to GEPLL=13)

The longer the time that goats remain producing in the herd, the larger the income obtained by the farmer, since the proportion of goats having smaller milk yields and fewer kids (first kidding goats) becomes smaller. The differences shown in Table 5 would be greater if the cost of raising kids to a productive age was taken into account, since the share of this cost among productive years would be lower for goats with longer herd life.

Comparing increments of incomes coming from genetic gains when reducing maximum herd lives of animals with decreases of income originated with the lowest amount of sold products produced by this reduction of herd lives (columns third and fourth in Table 5), shows the clear advantage of having the longest the possible herd life.

Discussion on the possibilities of genetically improving herd life of Malagueña goats

Although no information is available at present on the heritability of herd life (or any other parameter related to life time production) either in this breed or in any other breed of goats, we can infer from the abundant estimations obtained for dairy cows (Burnside *et al.*, 1984) that heritability of this trait is very low, probably lower than for cows, due to the larger environmental variation present in this breed. Estimations of heritability of milk yield, obtained by Analla *et al.* (1996) in a breed under a similar system of production, are lower than those reported for dairy cows. Furthermore, the very poor genealogical information in the milk recording scheme of the breed makes unlikely to have good genetic evaluations through ancestors for this trait. Therefore, very little opportunity to direct selection for this trait would be expected.

Indirect selection through a genetically correlated trait, like first lactation yield, frequently proposed for dairy cows (Raden van and Klaaskate, 1993), would not be adequate in this case, since genetic relationships of herd life and these traits are not known and phenotypic relationships seem to be null. However, other type of traits related to production and benefits, like net benefit per lactation, which can be estimated early in the life of the goat and even projected to late lactations in life should be investigated.

Other early indicators of herd life, like many type and conformation traits which have been considered in dairy cows are mostly related to voluntary culling of animals caused by problems related to these traits. If culling of goats due to these reasons is not common in this breed, as farmers tend to say, these traits cannot be used for indirect selection of herd life. However, our results showed (Table 2) that some culling of animals at advanced lactations might be taking place. Most probably this culling is based upon milk yields. Nevertheless, further studies of the problem would shed some light on the reasons for these cullings and on the important traits related to herd life.

If not much culling of old goats is taking place in farms and average herd life is rather low, we would expect many losses produced by diseases; particularly at late ages (higher incidence of Bovine leukaemia at late ages have been reported in dairy cattle, for example, by Yang Da *et al.*, 1993). This agrees with the farmers answers to the informal inquiry mentioned above. Therefore, long herd lives might be associated with disease resistance and, more generally, to general adaptation of some animals to harsh environmental conditions (particularly disease hazards). If this is true, the type of longevity that we are looking at is closer to the natural longevity studied in laboratory animals, more related to involuntary culling. This kind of longevity is submitted to the action of natural selection Raden van and Klaaskate (1993) mentioned this natural selection acting on longevity in dairy cows). Not much additive genetic variance could be expected in this type of traits related to fitness, however, there is possibly more non additive genetic variance (Falconer, 1981). It is not easy to envisage how crossbreeding methods normally used to take advantage of this type of genetic variance could be applied to dairy goat systems, but the problem certainly deserves some research. Another approach would be to find out which are the diseases causing the highest number of deaths and trying to find genetic resistance. However this is an even more difficult task.

The only reasonable option in the short term seems to be leaving most of the replacement from the older goats, which is what more farmers are, more or less, doing at the moment. In this way, any additive genetic aptitude to survive longer, whatever its causes might be, is being selected indirectly, although probably not very efficiently. This is called automatic selection for longevity by Burnside *et al.* (1984).

Conclusions

Malagueña goats in milk recorded herds show a rather skewed age distribution, with very few goats getting to have more than 6 or 7 lactations and a very low average (2.58) number of lactations during their lives. The main cause of this low average herd life of goats seems to be deaths caused by diseases, since, according to farmers reports, none or very little voluntary culling of old animals takes place.

Increasing herd life is economically desirable even when it has a negative impact on genetic progress through selection. Direct selection of herd life would not be feasible in the present selection scheme of Malagueña goats and, even if possible, not much selection response could be expected.

There are no estimations of phenotypic correlations between yields of first lactations and herd life. No evidence have been found of correlations between milk yields in first lactations and herd life. Therefore, these production traits could not be used for indirect selection of herd life. Other types of traits, like conformational traits could be studied as possible early predictors of herd life.

Herd life of Malagueña goats is a trait more related to general adaptation to a harsh environment, and therefore to fitness, than to voluntary culling of old animals. Therefore, not much additive genetic variation is to be expected. Ways of using non additive genetic variation could be investigated.

The only feasible way of indirect selection of herd life in the short term is to select replacements from older goats, as it is commonly practiced, in general, by farmers at present.

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