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Original article

Relationship between ewe body condition at mating and reproductive performance in the fat-tailed Barbarine breed

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Abstract — The relationship between reproduction performance in early May and ewe body weight (BW), body (or tail) condition score, the week before the rams were introduced into the flock, are presented for the Tunisian fat-tailed Barbarine breed grazing natural ranges in central Tunisia. During 2 contrasting years, 2 flocks (130 to 170 mature ewes each) differing by prolificacy (120%: Control and 160%: Prolific) and mature size (50 and 45 kg) were weighed and scored (according to 2 methods based on back fat thickness, BCS and on tail size, TCS), just before the introduction of rams. Rainfall during the pre-mating periods induced highly significant differences ($P < 0.01$) in animal body condition. In both flocks, fertility was equal to 75% and 92–96% for groups of ewes whose pre-mating BW was respectively lower or higher than 35 kg. Similarly, the group composed by the 123 leanest ewes (less than 1.5 BCS) was significantly less fertile than the remainder of the flocks: 86% versus 91–95%. In both flocks, the higher the ewe BW, BCS or TCS at the beginning of the mating period, the earlier the lambing date and the higher the litter size. The first and the last lambing ewes (first 2 weeks and third month) weighed over 50 kg and only 35–40 kg, respectively, when rams were introduced into the flock. According to BW, BCS or TCS classes, litter size varied from 1.0 to 1.3 and from 1.2 to 1.8, respectively, in the C and P flocks. Target BW, BCS and TCS at mating to obtain early lambing and adequate litter size in Barbarine flocks can be proposed. According to ewe size, the following values: 39 or 50 kg for BW, 2.1 or 3.0 for BCS and TCS, mean values of the group of ewes lambing during the second month, can be considered as minimal for the whole flock. A second method, taking into account the within-flock animal variability can be used. The percentage of too emaciated ewes (less than 35 kg BW and back and/or tail condition score < 1.5) must be lower than 4 to 10% for BW, 6 to 8% for BCS and 10 to 15% for TCS.

fat-tailed sheep / mating period / body condition / reproduction performances

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Résumé — État corporel, et reproduction chez la brebis Barbarine. L'étude présente les relations entre les performances de reproduction de brebis Barbarines de 2 troupeaux (troupeaux T et P : 120 et 160 % de prolificité, 50 et 45 kg de poids vif (PV) moyen) dont l'état corporel a été estimé par pesée et notation (NECd : dos ou NECq : queue) début mai, au cours de la semaine précédant l'introduction des béliers. Les différences de pluviosité entre les 2 années ont induit de très grands écarts ($P < 0,01$) d'état corporel. Dans les 2 troupeaux la fertilité passe de 75 % à 92–96 % ($P < 0,001$) lorsque le PV excède 35 kg. Les 123 brebis les plus maigres (NECd ou q < 1,5) sont moins fertiles que l'ensemble des autres (NEC > 1,5) : 86 et 91 ou 95 %, $P < 0,05$. La date d'agnelage est d'autant plus précoce et la prolificité des brebis plus élevée que celles-ci étaient en meilleur état en début de lutte. La prolificité a varié de 1,0 à 1,3 (T) et de 1,2 à 1,8 (P), $P < 0,001$ selon le PV ou la NEC des brebis. Deux méthodes sont possibles pour proposer des PV ou des NEC seuils en vue d'un agnelage précoce et d'une prolificité satisfaisante. Soit des valeurs moyennes minimales, celles des lots de brebis ayant agnelé au cours du 2^{e} mois, à savoir : un PV moyen de 39 à 50 kg et une NECd ou q de 2,0 à 3,0 selon le format du troupeau. Soit une fréquence maximum de brebis très maigres (PV < 35 kg, NECd et NECq < 1,5). Selon le critère utilisé, les valeurs proposées sont de 4 à 10 % pour le PV, de 6 à 8 % pour la NECd et de 10 à 15 % pour la NECq.

brebis Barbarine / queue grasse / état corporel / performances de reproduction / lutte à contre saison

1. INTRODUCTION

Tunisian sheep production systems are, for the most part, extensive. They are based on natural Mediterranean ranges grazing supplemented in summer by cereal stubble, fallow and, more and more frequently, grain. Such systems are characterised by seasonal shortage and annual scarcity of food resources. If high mortality caused by starvation is, now, quite unusual, flock productivity remains limited except during exceptionally favourable years. Ewes face, at least partially, seasonal food shortage by body reserve utilisation and range supplementation by conserved roughage and/or concentrates allows to remedy to such a situation. But for different reasons (food availability and cost, as well as the low productivity of the breed), the level and duration of supplementation must remain limited. It is therefore essential to have early, simple and reliable indicators at hand, which allow to assess animal nutrition level and to decide when and how to supplement the whole flock or a part only. The body condition score method (BCS) is one of these indicators [9, 18, 20]. Used in different environments [7, 16, 17], it allows to establish a diagnosis for the flock [5, 6] and to suggest a strategy adapted to the breed and to its production environment. Such a method results in recommendations dealing with flock management and BCS threshold values for every phase of the production cycle: mean value and tolerable variation limits [3].

Thus, the aim of this study was to determine the relationship between BCS and/or body weight (BW) and reproduction performance in the fat-tailed Barbarine breed, the largest Tunisian breed for which such recommendations are still scarce [11].

2. MATERIALS AND METHODS

2.1. Animals and flock management

The present study, completed during 2 consecutive years (years 1 and 2), was performed on 2 flocks, each composed of 130 to 170 mature Barbarine ewes (3 to 6 years). The first flock (control flock C) consisted of ewes whose prolificacy, close to 120%, was typical of the breed, and the second flock (prolific flock P) by more prolific animals (160%) selected by INRAT [13].

These flocks were grown in central Tunisia, near Ouesslatia, in the lower semi-arid bioclimatic zone. Average annual rainfall during the 10 years surrounding the study was 374 ± 144 mm. Grazing natural Mediterranean ranges composed of *Artemisia Campestris* and annuals, or of *Rosmarisnu*s *Officinalis* and *Stipa Tenassissima*, is the basis of food supply for flocks. Grazing *Cynodon Dactylon* in the river bed lowlands [15], as well as fallow and stubble, completed the year-round feeding calendar.

The production system was based on a once-a-year mating period, beginning, out of season, on May 10th by the introduction of rams. The males, kept for 2 months in the flocks during normal years, stayed for 1 more month in the case of unfavourable climatic conditions (dry years such as the first one). The ewes began to lamb in the middle of October and milked their lambs during 4 to 5 months, up to mid-March.

2.2. Climatic conditions and ewe feeding during the 2 year-survey

If annual rainfall did not differ from one year to the other (272 and 298 mm), it was however lower than the decade average (374 mm) and varied very much during the months preceding mating periods. During year 1, spring followed a dry autumn and winter (respectively 37 and 28 mm of rain) which induced very low plant growth while during year 2, spring arrived after 2 wetter seasons (64 and 101 mm respectively), which was more favourable to range production. These contrasting rain distributions induced large differences in food resources before mating. They were not measured but the crops of the adjoining fields can serve as a reference. Barley harvest amounted to respectively 0 and 5.5 quintals per hectare for years 1 and 2, when forage output reached 4 and 20 balls of hay per hectare. From weaning, at the end of March, up to mid-July, the end of the mating period, both flocks followed the normal foraging programme during year 2, namely ranges, river beds and cereal stubble grazing. This programme had to be modified from mid-February during year 1. Forage and cereal fields, grazed in winter, compensated at least, partially the very poor production of the ranges.

Spring rainfall was favourable for plant production during both years: 114 and 169 mm, respectively. But, as a result of earlier showers (92 mm during May and June), ewes gained weight and body condition during year 1, whereas they had to use a part of their body reserves during the corresponding period in year 2.

2.3. Measurements performed on animals

A week before the introduction of rams, the ewes were weighed and scored according to 2 methods. The first method, BCS [20], can be applied to all sheep breeds and permits a comparison of our results with earlier published articles. The second method, TCS [2], exclusively based on fat-tail measurements, is more adapted to our breed and more suitable for extension services. Both are graded on a 5-step scale. Measurements were performed by 3 trained technicians and the adopted score value was determined in common agreement.

2.4. Utilisation of data and statistical treatments

The experienced and non-controlled nutritional conditions gave us the opportunity to collect 2 sets of contrasting reproduction data. However, these valuable results are biased insofar as they were obtained, as commonly practised in commercial flocks of the steppe, after mating periods differing in their length. That is why the data were analysed in 2 ways. We discarded late results (obtained from ewes lambing more than 60 days after the beginning of the lambing period) when we analysed the 'year effect' or when we established a relationship between ewe characteristics and reproduction. In contrast, we included these results in the analysis of relations between BCS and fertilisation or lambing dates, and then, we mentioned it clearly.

The selected reproduction criteria: fertility (percentage of lambing ewes), prolificacy or litter size and fertilisation date (deducted from lambing date) were treated by SAS in a variance-covariance analysis including BW, BCS or TCS, as well as year and ewe genetic type (C or P). Frequency distributions according to BW, BCS or TCS were compared with the χ^2-test.

3. RESULTS AND DISCUSSION

3.1. Year effects on body weight and body condition

Average ewe characteristics at the beginning of the 2 mating periods and the corresponding reproduction performance are reported in Table I. All indicators of animal condition were different ($P < 0.01$) between years and corresponded to a very different distribution of ewes within BW, BCS or TCS classes. Thus in the first year, ewes weighing less than 35 kg represented 18% of the total population and none weighed more than 50 kg, while 4% only of ewes weighed less than 35 kg and 74% more than 50 kg at the beginning of the second mating period. Likewise, BCS was lower than 2 for 70% of the ewes and exceeded 3.5 for 10% only of the animals in mid-May of year 1; while the values varied from at least 2 to more than 3.5 for 53% of the ewes at the same period of year 2.

Nevertheless, as a result of rain effect on range production during the first year, ewe body condition remained fairly constant from the beginning of the mating period up to the first lambing (respectively 1.97 and 1.87 in flock P, 1.88 and 1.83 in flock C), while it decreased from 3.03 to 2.66 ($P < 0.05$) in flock P and from 4.1 to 2.5 ($P < 0.01$) in flock C during year 2. Similar variations and BW losses between mating and lambing have already been observed in Tunisia [1, 8, 11]. The between-flock BW, BCS or TCS differences, very limited in year 1 were, on the contrary, highly significant in year 2. Body weight then exceeded 55 kg for 98% of the flock C ewes when 55% only of flock P ewes reached this weight. These differences were more a result of body size disparity than of management discrepancies.

Table I. Characteristics of ewes at the beginning of the mating period and reproduction performance according to flock and year.

Flock	Year	Number of ewes	Live weight (kg)	Body condition		Fertility* (per 100)	Prolificacy* (per 100)	Average lambing date
				Back (BCS)	Tail (TCS)			
Prolific	1	169	38.1 ± 6.0	2.0 ± 0.7	1.8 ± 0.8	76 [88]	141 [140]	1 Nov. ± 7
	2	130	49.8 ± 3.8	3.0 ± 0.8	3.4 ± 0.9	95	163	27 Oct. ± 7
Control	1	131	40.8 ± 5.0	1.9 ± 0.7	1.8 ± 0.8	73 [86]	124 [121]	8 Nov. ± 13
	2	139	56.7 ± 6.5	4.1 ± 0.7	4.2 ± 0.7	93	126	25 Oct. ± 11

* Values [x] correspond to results obtained after 3 months of ram presence.

3.2. Year effects on reproduction performance

Climatic conditions induced huge differences in reproduction performance of both flocks. They influenced fertility and prolificacy rates as well as oestrus and conception dates (assessed by lambing date).

3.2.1. Fertility and prolificacy

In both flocks, and after the same mating period duration (2 months), fertility rate was significantly lower the first year than the second (74.5% vs. 94.0, $P < 0.001$, Tab. I). Retaining the rams one more month with the females improved fertility by 12 to 13 points but this was not enough to fully compensate the effects of initial poor body condition. Indeed, during the first year, fertility reached only 88% (flock P) and 86% (flock C) after the rams had been present for 3 months when the corresponding values were respectively 95 and 93% after 2 months only, during the more favourable year ($P < 0.05$ for P and $P < 0.10$ for C). Average group body condition significantly influenced prolificacy in the P flock only (140 vs. 163%, $P < 0.01$).

3.2.2. Lambing date distribution and ewe body condition

Initial body weight (and body condition) not only influenced fertility but also had a very strong effect on lambing date distribution. Although, on average 80% of births occurred during the first month of the lambing period, this mean value varied from 56% (year 1) to 84% (year 2). The heavier the ewes were at the beginning of the mating period, the earlier they were fertilised and lambed.

The fertilisation date of ewes varied according to the year and was 14 days earlier in the second year ($P < 0.01$, Tab. I). Merely 15% of the ewes lambed during the first fortnight of the lambing period in the first year, that is twice less than during the same period of year 2 (Fig. 1). These proportions reached 34 and 63% after 3 weeks. This uneven distribution of births corresponded to contrasting physiological conditions at the beginning of the mating period. The ewes lambing during the first fortnight were in a very good body condition in early May (BCS higher than 3 for 75% of them, Fig. 2), so they were already cyclic and became pregnant within the first 2 weeks. The ram effect induced into oestrus a group of females which had been mated between the 17th and 24th days after introduction of males and lambed during the 3rd week. Their body condition was lower than in the first group (BCS equal to or lower than 3 for 57% of them, Fig. 2). Early lambing was mainly observed during year 2 but the ram effect was also effective during year 1. However, as a result of very poor nutrition, most of the ewes then had a too low body weight (or body condition) to respond to the ram effect as observed previously by Khaldi [12]. It is only a month later, in mid-June, after plentiful spring rains (124 mm from March till June) that the females reached a minimum body weight and body conditions favouring oestrus and conception. During the first year lambing period, 66% of ewes lambed during the second month, nearly twice as much as during the corresponding period of the second year (37%).

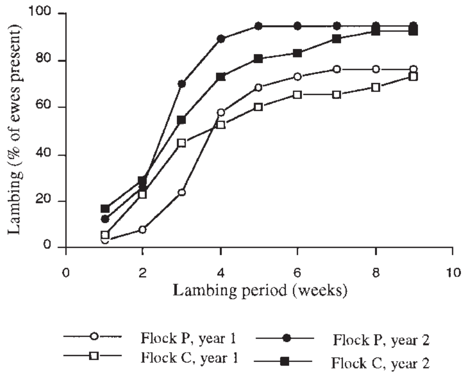

Figure 1. Weekly lambing distribution during the 2 years.

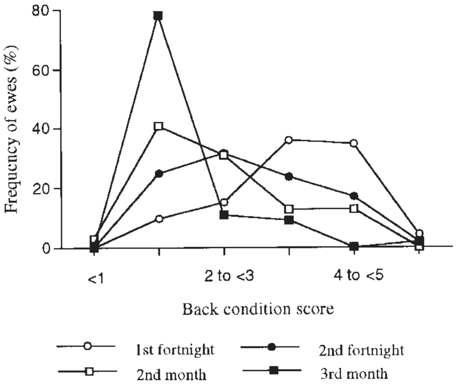

Figure 2. Distribution of ewes lambing during different periods, according to their body condition.

The 94 ewes not yet pregnant 2 months after the introduction of rams (16% of the total population), weighed on average 7 kg less than the fertile ewes, and their BCS was 0.5 to 1.0 point lower (Tab. II). This group can itself be divided into 2 classes (Fig. 2): class 1, emaciated animals (54 ewes, BCS lower than 2 for 78% of them), appearing during year 1 only and of which nearly 75% will be fertilised late, during the 3rd month of the mating period and class 2 made up of animals in fairly good condition (BW, BCS and TCS higher than flock mean values). These unfertile animals represented a nearly constant proportion (6 to 8%) of the flocks, whatever the year and their genotype. Their barrenness seemed independent from nutritional conditions.

3.3. Relation between body condition and reproduction performance

Considering previous remarks (Sect. 2.4), all the lambing ewes are included in this analysis.

3.3.1. Fertility

For both flocks, the 35-kg body weight at mating seemed a threshold for fertility, which, even after a 3-month mating period, varied from 75% in the lighter ewe group

Table II. Characteristics of ewes at the beginning of the mating period and corresponding reproductive performance according to their lambing date (data of 2 years pooled).

Lambing period	Flock	Number of ewes	Lambing date	Body condition: Body	Body condition: Tail	Live weight (kg)	Prolificacy (per 100)
1st fortnight		67	19 Oct.	2.9 ± 0.9	3.2 ± 1.1	48.9 ± 6.5	154 ± 63
2nd fortnight	Prolific	169	30 Oct.	2.4 ± 0.6	2.4 ± 1.1	43.3 ± 6.9	154 ± 57
2nd month		17	14 Nov.	2.1 ± 0.6	2.1 ± 1.1	38.4 ± 8.9	125 ± 43
Empty(1)		47	–	2.0 ± 0.8	1.7 ± 1.1	37.3 ± 7.1	–
3rd month(2)		*21*	*8 Jan.*	*1.6 ±0.5*	*1.3 ±0.8*	*35.0 ±4.2*	*133 ±50*
Empty(2)		*26*	–	*2.3 ±0.9*	*2.1 ±1.2*	*39.1 ±8.3*	–
1st fortnight		100	20 Oct.	3.2 ± 1.2	3.2 ± 1.4	49.6 ± 8.6	133 ± 50
2nd fortnight	Control	90	31 Oct.	3.3 ± 1.3	3.3 ± 1.3	51.8 ± 9.4	123 ± 42
2nd month		33	21 Nov.	3.0 ± 1.4	3.0 ± 1.4	49.5 ± 0.4	112 ± 30
Empty(1)		47	–	2.1 ± 1.1	2.1 ± 1.1	43.4 ± 10.6	–
3rd month(2)		*19*	*8 Jan.*	*1.7 ±0.7*	*1.7 ±0.7*	*38.7 ±5.6*	*105 ±20*
Empty(2)		*28*		*2.4 ±1.2*	*2.5 ±1.4*	*47.2 ±12.1*	–

(1), (2) The same ewes are present on lines (1) and (2) in italics. The animals on line (1) were considered empty after 2 months with the rams. Some of them were fertilised during the third month (*3rd month*, in the table), while the others remained empty (*Empty*, in the table).

to 92–96% in the others ($P < 0.001$). Similarly, a non significant trend to fertility reduction beyond 55 kg could be observed. Such a result has already been reported by Lassoued and Khaldi [14] and by Abdennebi and Khaldi [1] in the Tunisian Barbarine breed and by Thomson and Bahadi [21] with Syrian Awassi ewes. The latter authors, which observed a regular fertility rate improvement with body weight increase from 36 to 50 kg, or BCS from 1.5 to 2.5, linked them by a curvilinear relation. Similarly, distribution of flock C data into 5 BCS or TCS classes allowed to separate animals into 2 groups with different fertility levels. Fertility of the leanest ewe group (BCS < 1.5, 123 animals) reached 86% and was close to 96% for the remaining animals (year 1: $P < 0.05$; year 2: $P < 0.1$ and $P < 0.001$ for the pooled data of both years). Such a relation was not observed in the P flock.

The relationship between body weight or body condition and fertility varies according to the method used to estimate animal condition. When for each year, we assigned the ewes into 5-kg BW or 1-point BCS or TCS classes, the most significant relations linking mean fertility to class average value are curvilinear with BW, linear and very close to one the other, with BCS or TCS as explaining variables. Such relations are presented in Figures 3 and 4 (for the latter we used BCS in flock C and TCS in flock P to illustrate relation similarity, at least for fertility). These relations explain 56 to 95% of the total variance observed in flock C ($P < 0.01$ with BW, $P < 0.1$ with BCS or TCS) but only 52 to 56% in flock P where they are not significant.

3.3.2. Prolificacy

The prolificacy of ewes pooled as exposed earlier (Sect. 2.4) increased with BW, BCS or TCS, reached a maximum value in the 50–55 kg BW and 3.5–4.0 BCS or TCS classes and then decreased. The accuracy of relations between prolificacy and body conditions varied from one year to

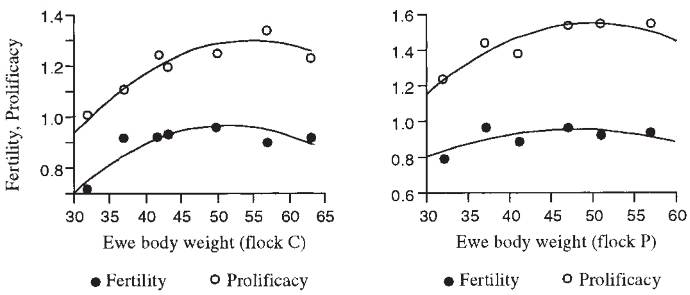

Figure 3. Ewes fertility and prolificacy according to body weight at mating (5-kg classes).

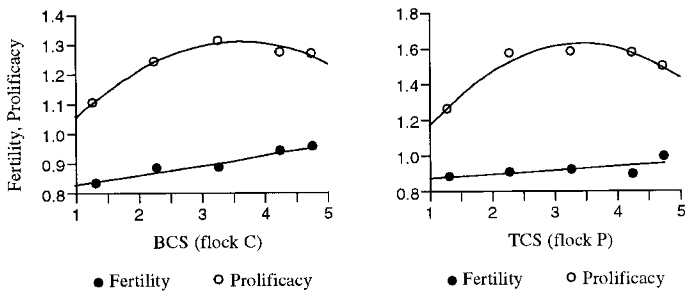

Figure 4. Ewe fertility and prolificacy according to body score at mating (BCS, back condition score; TCS, tail condition score).

the other. In both flocks, they were highly significant during year 1 (*P* < 0.001) and not significant during year 2 (*P* > 0.05). Pooling the data of the 2 years allows to establish relations based on larger BW, BCS or TCS variations. Ewes of flock P produced on average 0.2–0.3 more lambs per litter than ewes of flock C. Maximum discrepancy between the 2 flocks was observed for groups of 40 to 45 kg live weight or fat females (BCS close to 4). A similar relation between body condition, ovulation rate and litter size has been known for many years [4]. Data indicating a prolificacy decrease when BW or BCS exceeds a threshold value are scarce with North Country Cheviott [10], with Greyface [19], and with Awassi [21] in spite of the low prolificacy of the latter breed.

A very important point, whose origin is not know, must be underlined. It deals with low levels of relation (or even lack of relation) between body weight and/or body condition and fertility in flock P. Selection for larger litter size, which increased ovulation rate, could possibly have also reduced embryonic losses and reduced links between these 2 reproduction components and nutrition. This remains a hypothesis and has to be verified.

4. CONCLUSION AND RECOMMENDATIONS

The present observations outline the effects of a natural spring climatic environment in central Tunisia and its frequent contrasted variations, on ewe body condition at mating and on their subsequent productivity. We can match these observations to results obtained earlier by many authors after controlled experiments planned to clarify relations between body weight (static effect) and nutrition during pre-mating weeks (dynamic effect) on the one hand, and ovulation rate, embryonic losses, fertility and prolificacy on the other hand. Year 1 can be assimilated to a Low-High treatment while year 2 simulated a High-Low one. Moreover, insofar as they agree with earlier relations, we can infer from these observations management recommendations adapted to Barbarine ewes bred in the steppe.

Two methods are available to establish such recommendations. The first method considers only average BW, BCS or TCS values (Tab. II), while the second method takes into account the within-flock variability (data used to draw Fig. 2). As early lambing is essential, in both cases, the body condition of ewes lambing during the second month can be considered as a minimum. According to the first method, management of animals during the spring period must allow flocks to reach, on average and at least, 39 to 45 kg BW and 2.0 to 2.4 as BCS or TCS according to ewe size. Such values, which do not take into account animal variability, are difficult to utilise either because they require separating animals on many occasions and feeding them differentially or overfeeding the whole flock to improve the body condition of a minority.

However it is also possible to take advantage of the ability of ewes to keep their reproduction performance at a fairly good and steady level even when food scarcity induces marked BW losses. It is then possible to reason over ewe distribution and to suggest, as before-mating management targets, not a BW or BCS mean value for the whole flock, but a maximum frequency of ewes with poor or even bad body conditions. For that, we must take into account the main constraints of such systems, breed characteristics and production purposes. In most situations, as a consequence of the low prolificacy of commercial flocks, and in agreement with Thomson and Bahhadi [21], high fertility and an early conception date (to rear lambs before summer drought and high temperatures) can be considered as the key of a successful mating period. If 2 months is considered as a limit for mating period duration, the maximum frequency of ewes in poor condition is that observed in the group of ewes lambing during the second month (Fig. 2). According to average ewe mature size and mean prolificacy, the following frequencies can be considered as thresholds for the mating period: no more than 4 to 10% of ewes weighing less than 35 kg; 6 to 8% of animals with a BCS lower or equal to 1.5 or, at last, 10 to 15% with a TCS lower or equal to 1.5. This method presents 2 advantages, it allows to bear in mind the variability of animal response to the level of feeding, but also breed specificity. Indeed, these trials have shown that although Barbarine ewes are able to tolerate poor nutritional conditions without a huge decline of performances, at least for fertility, conversely (except for flock P which is still experimental, and not yet observed in commercial farms) the improvement of feeding level has a limited effect on litter size. Indeed, huge BW or BCS differences (10 kg and 0.8 points, corresponding to mean values observed in groups of ewes lambing during the first month, or later, during the 2nd and 3rd months) induced only a small difference in prolificacy (0.15 lambs per litter) in flock C, closer to private herds than P. Supplementation of such animals is difficult to justify on an economic basis.

These recommendations constitute targets for farmers who, weeks before introducing the rams into their flocks, must adapt, and eventually improve their range management or feeding policy in order to reach these targets in early or mid-May at the beginning of the mating period.

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