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Reproduction characteristics of North Moroccan indigenous goats

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ABSTRACT

Goat production in North Morocco represents a livelihood base for resource-poor producers in need of technological change. Considering that reproduction aspects of these animals have not been assessed yet, this study characterized their main reproduction characteristics under the prevailing photoperiod at latitude 35°N: seasonal variation in females ($n = 18$) and bucks ($n = 6$), female puberty attainment ($n = 18$) and gestation ($n = 22$). Nutritional effects on female seasonality and age at puberty of female kids were tested under two levels of nutrition: L (low) and H (high), respectively. The L does ($n = 9$) were fed at maintenance requirements for adult goats whereas the H does ($n = 9$) at twice the maintenance requirements. The H female kids ($n = 9$) and the L female kids ($n = 9$) were fed with diets to support fast and slow average daily gains, respectively. Blood samples were regularly collected from does and female kids for progesterone assay to assess ovulation occurrence; from bucks to assess seasonal testosterone changes; from pregnant does to assess progesterone profiles during pregnancy. Does displayed a marked reproductive seasonality influenced by the photoperiod. Their ovulation and estrus occurrence diminished progressively starting at the winter solstice, was completely halted from April to June and progressively resumed at the summer solstice. The seasonal pattern was uninfluenced by the feeding level. In bucks, significant seasonal changes were observed in testis measurements (scrotal circumference, testicular diameter and length), sperm characteristics (volume of the ejaculate and sperm concentration) and plasmatic testosterone, with low values in winter that increased during the spring and peaked in the summer. Puberty in females was attained at an average body weight of 17.6 kg, regardless of the feeding level provided ($P > 0.05$) and with high incidence of abnormal estrus cycles (60%). However, improved feeding reduced significantly puberty age by 19 days (278 ± 8 vs. 297 ± 2 days, $P < 0.05$). Average pregnancy length was 149.7 days and slightly longer in does kidding singles than those kidding twins (151.0 ± 1.4 days vs. 148.3 ± 1.7 days; $P < 0.05$). Litter size did not affect progesterone plasma concentrations. The results obtained, offer important information to consider managerial changes to improve the productivity of the prevailing production systems under extensive and intensive production plans.

1. Introduction

Extensive range-based goat production systems in the North of Morocco generate low productivity and income to resource-poor farmers though they represent an important base for the livelihoods of a large population of goat producers (Chentouf et al., 2006, 2009). Productiv-

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ity enhancement in these systems requires adjustments in managerial aspects particularly those concerning reproduction. Little information on reproductive aspects is available on goats from this region. This paper reports the results of studies on reproductive seasonality, puberty and gestation conducted in North Moroccan goats maintained under natural photoperiod and controlled nutrition.

2. Materials and methods

2.1. Female seasonality

Eighteen female adult non-pregnant goats were maintained indoors under natural day length conditions (35°N) and monitored during 12 months. The animals were allocated to two experimental groups receiving two nutritional levels: L ($n = 9$) involving a basic maintenance diet for adult goats and H ($n = 9$) involving a diet containing twice the basic maintenance requirements. The groups were adjusted for live weights at the beginning of the study, with initial weights averaging 33.4 ± 4.1 kg and 33.3 ± 4.1 kg for groups H and L, respectively ($P > 0.05$). Vasectomized bucks were used twice daily to detect estrus and blood samples were collected trice weekly to determine plasma progesterone concentration by RIA Kits (PROG-CTRIA, Cisbio, Gif-sur-Yvette, France, lots 117 A and 121 A) to assess ovulation occurrence.

2.2. Buck seasonality

Six healthy mature adult bucks (18–24 months old) were maintained indoors under the natural photoperiod at 35°N and monitored during 12 months. Scrotal circumference, and testicular diameter and length were measured monthly. Semen samples were collected also monthly by using an artificial vagina to determine the ejaculate volume, sperm mass and individual motility, sperm concentration (Bürker) and the proportion of dead spermatozoa (by using the eosin–nigrosin technique). Blood samples were collected weekly for testosterone assay by RIA (Testo-CT2, CISBIO, Gif-sur-Yvette, France, lot 422/003) to assess seasonal changes in the profiles of this hormone. Four seasons were considered: autumn (October–December), winter (January–March), spring (April–June) and summer (July–September).

2.3. Puberty

Eighteen North Moroccan female kids were maintained indoors under natural daylight (at 35°N). At weaning, the kids were divided into two groups: L ($n = 9$), a low nutrition group receiving a diet that allowed a slow average daily weight gain (ADG, 50 g/day) and H ($n = 9$) a high nutrition group receiving a diet that allowed a fast ADG (150 g/d). All kids were monitored from weaning (3 months old) until they showed at least one estrus period. The groups were adjusted for live weight at the beginning of the study and averaged 11.2 ± 2.5 kg and 11.0 ± 2.1 kg in the H and L groups, respectively ($P > 0.05$). Estrus behavior was checked twice a day with vasectomized buck and blood samples were collected thrice weekly to determine progesterone concentration in order to assess ovulation occurrence by following the same protocol indicated for adult does. The age at puberty was defined as the date of first estrus followed by luteal function. After puberty, the estrous cycles were observed and ranked, based on the length of the luteal phase, as short (<11 days), normal (11–19 days) or long (>19 days).

2.4. Pregnancy

During the reproductive season, 22 adult does were kept in pens under the prevailing photoperiod and temperature at latitude 35°N. Estrus was synchronized by insertion of intra-vaginal sponges (FGA 45 mg; Chronogest®, Intervet, Boxmeer, the Netherlands) for 11 days. On day 9, a Prostaglandin F2 α (PGF2α) analogue (7.5 mg, i.m.; Prosolvin®, Intervet, Boxmeer, the Netherlands) and eCG (200 IU, i.m.; Folligon®, Intervet, Boxmeer, the Netherlands) were administered. After sponge removal, each doe was mated naturally during the estrus period. The mating day was considered as day 0 to estimate gestation length. On day 50 of pregnancy, all goats were checked for pregnancy using a real-time ultrasound scanner with a 5 MHz linear-array transducer (Ultrascan 900; Alliance Medical Inc., Lachine, Quebec, Canada). This diagnosis revealed 14 pregnant and 7 non-pregnant does. Non-pregnant does were excluded from the assay. Blood was collected daily during the first month of gestation and then three times a week until the end of pregnancy. Immediately after collection, the blood samples were centrifuged at 2000 × *g* for 20 min and the plasma was stored at −20 °C until progesterone assay by the procedure described above to assess profiles of this hormone during pregnancy.

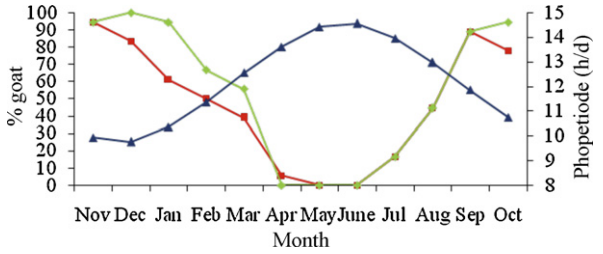

Fig. 1. Fluctuations in photoperiod (▲), and monthly distribution of ovulations (♦) and estruses (■) in North Moroccan indigenous goats.

2.5. Statistical analysis

Statistical analyses were conducted using SAS software v. 8.01 procedures (SAS Institute Inc., Cary, NC). The effect of diets on anestrus and anovulation duration was analyzed by SAS GLM procedures using a linear model with diets as fixed effect. All variables involved in the buck seasonality study were analyzed with a linear model including seasons as fixed effect. Fixed effects in linear models to assess age and weights at puberty; gestation lengths and progesterone level during pregnancy, included diets and litter size, respectively.

3. Results and discussion

3.1. Female seasonality

During the year, the proportion of ovulating animals increased gradually from July to December (the number of ovulating does out of total observed does varying from 3/18 to 18/18) then declined gradually between January and March (the number of ovulating does out of total observed does varying from 17/18 to 10/18). No ovulations were recorded from April to June. A similar distribution was observed in relation to estrus occurrence. This pattern was closely related to the variation of the photoperiod: maximal and minimal periods of sexual activity were associated with winter and summer solstices, respectively (Fig. 1). At farm level, this situation may induce seasonality and consequently market availability of goat products which may negatively affect the farm economy and development. These results are comparable to those reported for Mediterranean goat breeds such as the Bédouine from Algeria (Charallah et al., 2000), Maure from Tunisia (Lassoued and Rekik, 2005), Payoya from Spain (Zarazaga et al., 2005) and Serrana from Portugal (Mascarenhas et al., 2006).

The high plane of nutrition enhanced the does' growth, so that live weights were higher at the end of the experiment in the H group compared to the L group: 40.6 ± 7.3 kg and. 34.2 ± 4.8 kg, respectively ($P < 0.05$). In contrast, the levels of nutrition did not cause significant change between the H and L groups with regard to anestrus duration (216 ± 36 days vs. 200 ± 67 days) and anovulation periods (206 ± 59 days vs. 195 ± 29 days). A dissimilar result was reported by Zarazaga et al. (2005) for Mediterranean Pay-

Table 1
Seasonal variation of testis measurement, sperm characteristics and testosterone plasma level in North Moroccan indigenous bucks.

	Autumn	Winter	Spring	Summer
Scrotal circumference (cm)	24.0^{c}	24.3^{c}	26.3^{b}	27.7^{a}
Testicular diameter (cm)	5.0^{b}	4.6^{c}	5.3^{b}	5.6^{a}
Testicular length (cm)	8.8^{a}	7.7^{b}	8.1^{b}	9.0^{a}
Ejaculate volume (ml)	0.85^{a}	0.44^{b}	0.82^{a}	0.92^{a}
Concentration (10^{9}/ml)	2.79^{b}	1.89^{c}	3.61^{a}	3.43^{ab}
Plasma testosterone (ng/ml)	9.2^{a}	2.0^{b}	3.8^{b}	14.2^{a}
Mass motility	3.96	3.45	3.63	3.64
Individual motility (%)	74.8	73.1	77.0	75.2
Live sperm (%)	72.2	70.0	72.6	76.1

Values in the same row with different letters differ significantly ($P < 0.05$).

oya goats (at 37°N) that reduced their periods of anestrus and anovulation by 32 and 27 days, respectively, if fed with diets 150% above maintenance requirements for adult does.

The mean dates of the first estrus and ovulation occurred on September 1st and September 5th, respectively whereas the mean dates of the latest estrus and ovulation occurred on February 4th and February 17th, respectively. These dates were within the range reported for the same occurrence of events in two Mediterranean goats raised at latitude ranging from 36°N to 37°N, including the Payoya goat (Zarazaga et al., 2005) and the Malagueña goat (Gómez Brunet et al., 2003).

3.2. Buck seasonality

Testis measurements (scrotal circumference, testicular diameter and length), sperm characteristics (volume of the ejaculate and sperm concentration) and plasma testosterone level showed a marked and significant seasonal effect. Lowest values were observed during winter, increasing through the spring and summer (Table 1), in agreement with patterns observed in the Atlas Moroccan goat (Douk, 1996) and those of goats from latitudes between 30° and 40°N such as the Murciano-Granadina goat (Roca et al., 1992), Malagueña and Verata goats (Pérez and Mateos, 1996), Damascus goat (Al-Ghalban et al., 2004) and Rayani goat (Zamiri and Heidari, 2006).

No seasonal effects were observed with regard to semen quality assessed by mass and individual motility and the proportion of dead spermatozoa. Though these results parallel the observations of Pérez and Mateos (1996) in the Malagueña goat (37°N), they contrast with a number of other studies involving Mediterranean goats such as Murciano-granadina (Roca et al., 1992), Verata (Pérez and Mateos, 1996), Damascus (Al-Ghalban et al., 2004), Zairi (Barkawi et al., 2006), Rayani (Zamiri and Heidari, 2006) and Payoya (Zarazaga et al., 2009a).

3.3. Puberty

Goat kids in the H and L groups attained puberty between 278 ± 8 and 297 ± 2 days, respectively ($P < 0.05$), showing that an improved level of nutrition could promote a difference of at least 19 days in reaching puberty. This result contrasts with that reported by Zarazaga et al. (2009b) who observed no difference between age at puberty of goats also receiving diets with different

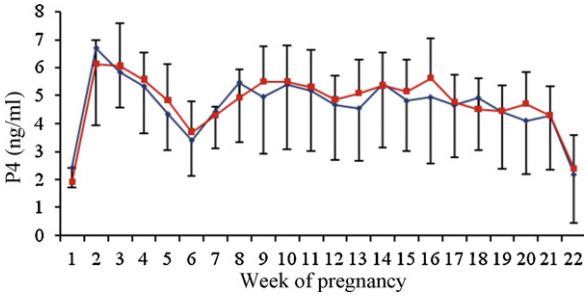

Fig. 2. Progesterone pattern during pregnancy of North Morrocan indigenous goats carrying singles (■, $n = 7$) and twins (♦, $n = 7$).

nutritional level. Though the H group averaged better weights at puberty in relation to the L group (18.6 ± 3.5 kg vs. 16.1 ± 1.4 kg), these differences did not reach a significant level. Overall, post-weaning ADG values were lower than expected and averaged 36.0 ± 6.0 g/day and 20.0 ± 7.0 g/days in the H and L groups, respectively ($P < 0.05$). In average, kids reached puberty at an estimated live weight of 17.6 kg corresponding to 46% of adult weight, a proportion comparable to the Saanen goat (Freitas et al., 2004) and the Payoya goat (Zarazaga et al., 2009b).

At puberty, the proportion of abnormal short first estrous cycles was high (60%). These short cycles were linked to low progesterone concentrations (mean progesterone level of 1.89 ng/ml corresponding to first luteal phase), suggesting an inadequate luteal development. These findings are consistent with those of Greyling and Van Niekerk (1987) who reported that puberty in goats is characterized by a high incidence of cycles with abnormal duration.

3.4. Pregnancy

Litter size averaged 1.5 kids per kidding as half of the goats kidded singles and the remaining half kidded twins, after a period of 149.7 ± 2.0 days of pregnancy. The length of pregnancy in females kidding singles was higher than those kidding twins (151.0 ± 1.4 days vs. 148.3 ± 1.7 days; $P < 0.05$). The effect of the litter size on the length of pregnancy was reported previously by Sousa et al. (1999), Lehloenya et al. (2005) and Khanum et al. (2006). These authors sustained that in pregnancies involving multiple fetuses, the increased weight and litter size, and the consequent decrease of uterine space availability, causes stress to fetuses and trigger an earlier parturition compared to pregnancies involving singles.

Litter size had no significant effect on progesterone level during pregnancy, as the progesterone profile in females kidding singles and those kidding twins were similar; a result that is in agreement with Sousa et al. (1999). According to Jarell and Dziuk (1991), the plasma progesterone levels during early corpus luteum formation are related to ovulation rate and not necessarily to litter size; in addition, the number of fetuses and corpora lutea do not affect progesterone level once the pregnancy is established.

Progesterone plasma levels decreased between the 2nd and 6th week of pregnancy and then increased between the 6th and 9th week (Fig. 2), a similar pattern reported for

goats by Capezzuto et al. (2008). Increasing levels of progesterone after 6 weeks of gestation is probably due to the early secretion of cPL, which is the main luteotrophic factor during pregnancy in goats (Buttle, 1983) and is detectable in the peripheral circulatory system from the 44th day of gestation (Currie et al., 1990).

4. Conclusion

Male and female North Moroccan goats show reproductive seasonality related to photoperiod in a similar pattern than other Mediterranean goats. In females, this pattern was not affected by different nutritional levels offered to the animals. It is expected that this seasonal effect induces an enhanced meat and milk production variability through the year and thus impacts negatively on farm productivity/economy and efforts to improvement it. Based on these results it is recommended to experiment strategies to reduce this variability by stimulating reproduction during the anestrus season in accordance to availability of feeding resources, market opportunities and the context of climate change. To this end, simple low cost techniques such as the use of the buck effect, commonly practiced in subtropical regions, could be tested. Improved feeding significantly reduced the age at puberty of female kids, hence specific managerial strategies could be developed in accordance to the type of production systems targeted by farmers. In example improved feeding to enhance the female kids' growth to reach puberty earlier, if farmers are targeting an intensification of their production systems.

Conflict of interest

None of the authors (M. Chentouf, J.L. Bister, B. Boulanouar) have a financial or personal relationship with other people or organisations that could inappropriately influence or bias the paper entitled "Reproduction characteristics of North Moroccan indigenous goats"

References

Al-Ghalban, A.M., Tabbaa, M.J., Kridli, R.T., 2004. Factors affecting semen characteristics and scrotal circumference in Damascus bucks. Small Rum. Res. 53, 141–149.

Barkawi, A.H., Elsayed, E.H., Ashour, G., Shehata, E., 2006. Seasonal changes in semen characteristics, hormonal profiles and testicular activity in Zaraibi goats. Small Rum. Res. 66, 209–213.

Buttle, H.L., 1983. The luteotrophic complex in hysterectomized and pregnant goats. J. Physiol. 342, 399–407.

Capezzuto, A., Chelini, M.O.M., Felippe, E.C.G., Oliveira, C.A., 2008. Correlation between serum and fecal concentrations of reproductive steroids throughout gestation in goats. Anim. Reprod. Sci. 103, 78–86.

Charallah, S., Khammara, F., Amirat, Z., Lakhdari, Y., 2000. Evaluation de l'activité sexuelle mâle et femelle: caractérisation zootechnique et nutritionnelle chez la chèvre Bédouine. In: Gruner, L., Chabert, Y. (Eds.), Proceeding 7e conférence internationale sur les caprins. Tours, France, p. 460.

Chentouf, M., Ben Bati, M., Zantar, S., Boulanouar, B., Bister, J.L., 2006. Evaluation des performances des élevages caprins extensifs dans le nord du Maroc. Options Méditerranéennes 70, 87–94.

Chentouf, M., Arrebola Molina, F., Boulanouar, B., Mesbahi, H., Terradillos, A., Caravaca, F., Casas, C., Bister, J.L., 2009. Caractérisation des systèmes de production caprine semi-extensifs en Andalousie et au nord du Maroc: analyse comparative. Options Méditerranéennes 91, 37–42.

Currie, W.B., Card, C.E., Michel, F.J., Ignotiz, G., 1990. Purification and partial characterization, and development of a specific radioimmunoassay for goat placental lactogen. J. Reprod. Fertil. 90, 25–36.

Douk, A., 1996. Variations saisonnières de la taille testiculaire et des caractéristiques du sperme chez le caprin noir de montagne. Thèse de doctorat vétérinaire. I.A.V. Hassan II, Rabat, Maroc.

Freitas, V.J.F., Lopes-junior, E.S., Rondina, D., Salmito-Vanderley, C.S.B., Salles, H.O., Simplicio, A.A., Baril, G., Saumande, J., 2004. Puberty in Anglo-Nubian and Saanen female kids raised in the semi-arid of North-eastern Brazil. Small Rum. Res. 53, 167–172.

Gómez Brunet, A., Santiago Moreno, J., Micheo, J.M., Sanchez, A., González Bulnes, A., López Sebastián, A., 2003. Variación anual de la actividad ovulatoria en la cabra de raza Malagueña. In: Sánchez, M.E., Díaz, M.E., Gallego, F.L., Díaz, F.J.M., García, P., Ledesma Vega, A.R., Alfranca, I.S. (Eds.), Proceedings del 28 Congreso Anual de la Sociedad Española de Ovinotecnia y Caprinotecnia. Badajoz, España, pp. 178–180.

Greyling, J.P.C., Van Niekerk, C.H., 1987. Occurrence of oestrus in the Boer goat doe. S. Afr. J. Anim. Sci. 17, 147–149.

Jarell, V.L., Dziuk, P.J., 1991. Effect of number of corpora lutea and fetuses on concentrations of progesterone in blood of goats. J. Anim. Sci. 69, 770–773.

Khanum, S.A., Hussain, M., Kausar, R., 2006. Manipulation of estrous cycle in Dwarf goat (*Capra hircus*) using estrumate under different management conditions. Anim. Reprod. Sci. 92, 97–106.

Lassoued, N., Rekik, M., 2005. Variations saisonnières de l'oestrus et de l'ovulation chez la chèvre locale Maure en Tunisie. Élev. Méd. vét. Pays trop. 58, 69–73.

Lehloenya, K.C., Greyling, J.P.C., Schwalbach, L.M.J., 2005. Reproductive performance of South African indigenous goats following oestrous synchronisation and AI. Small Rum. Res. 57, 115–120.

Mascarenhas, R., Fresno, M., Milena, A., Avdi, M., Terqui, M., 2006. Estacionalidad de la actividad sexual de las razas caprinas autóctonas del Sur de Europa. REDVET 4, 1–7.

Pérez, B., Mateos, E., 1996. Effect of photoperiod on semen production and quality in bucks of Verata and Malagueña breeds. Small Rum. Res. 22, 163–168.

Roca, J., Martinez, E., Vazquez, J.M., Coy, P., 1992. Characteristics and seasonal variations in the semen of Murciano-Granadina goats in the Mediterranean area. Anim. Reprod. Sci. 29, 255–262.

Sousa, N.M., Garbayo, J.M., Figueiredo, J.R., Sulon, J., Gonçalvez, P.B.D., Beckers, J.F., 1999. Pregnancy-associated glycoprotein and progesterone profiles during pregnancy and postpartum in native goat from the north-east of Brazil. Small Rum. Res. 32, 137–147.

Zamiri, M.J., Heidari, A.H., 2006. Reproductive characteristics of Rayini male goats of Kerman province in Iran. Anim. Reprod. Sci. 96, 176–185.

Zarazaga, L.A., Guzmán, J.L., Domínguez, C., Pérez, M.C., Prieto, R., 2005. Effect of plane of nutrition on seasonality of reproduction in Spanish Payoya goats. Anim. Reprod. Sci. 87, 253–267.

Zarazaga, L.A., Guzmán, J.L., Domínguez, C., Pérez, M.C., Prieto, R., 2009a. Effects of season and feeding level on reproductive activity and semen quality in Payoya buck goats. Theriogenology 71, 1316–1325.

Zarazaga, L.A., Guzmán, J.L., Domínguez, C., Pérez, M.C., Prieto, R., Sánchez, J., 2009b. Nutrition level and season of birth do not modify puberty of Payoya goat kids. Animal 3, 79–86.