rccp Revista Colombiana de Ciencias Pecuarias

Reproductive disorders in Portuguese Serrana goats and its effects on milk production¤

Incidencia de trastornos reproductivos en cabras de raza Serrana y su efecto en la producción de leche

Incidência de distúrbios reprodutivos em caprinos da raça Serrana e seu efeito na produção de leite

João Simões[1*], DVM, PhD; Alda FA Pires[2], DVM, MPVM, PhD, Dipl ACVPM.

[1]*CECAV, Departamento de Ciências Veterinárias, Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal.*

[2]*Department of Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis, USA.*

(Received: August 2, 2016; accepted: June 2, 2017)

doi: 10.17533/udea.rccp.v31n1a08

Abstract

Background: Abortions and parturitions with stillbirths are frequent in goat herds. However, the incidence of these events should remain low and their effects on subsequent lactation need to be assessed at breed level. **Objective:** To evaluate the incidence of abortions and parturitions with stillbirths (APS) in Portuguese Serrana goats breed ecotype Transmontano, and their association with milk production in subsequent lactation. **Methods:** Records of Serrana goats ecotype Transmontano from the pedigree book between 1997 and 2014 were used in order to determine the occurrence of APS. Goat level information, such as normal parturition and/or APS dates, number of fetuses, parity, and 150-d normalized milk production for each subsequent lactation, was considered. **Results:** The average incidence of APS was 8.7% (19,351/223,798). According to a multivariable logistic analysis, the year, month, parity, gemelarity, and their interactions were factors significantly ($p<0.001$) associated with APS. In overall, a higher APS incidence was observed in single births and primiparous goats. The 150-d normalized milk production was lower ($p<0.001$) in the APS group than in goats with normal parturitions. **Conclusion:** The APS incidence in Serrana goats ecotype Transmontano was higher than other ruminants, and APS had a negative effect on milk production considering the 150-d normalized lactation.

Keywords: *abortion, epidemiology, indigenous goats, lactation, parturition.*

¤ To cite this article: Simões J, Pires AF. Reproductive disorders in Portuguese Serrana goats and its effects on milk production. Rev Colomb Cienc Pecu 2017; 31(1):64-71.

* Corresponding author: João Simões. CECAV, Departamento de Ciências Veterinárias, Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal. Tel.: +351 259350666. E-mail: jsimoes@utad.pt

Resumen

Antecedentes: El aborto y nacimiento de mortinatos son hechos frecuentes en rebaños de cabras. Sin embargo, su impacto debe mantenerse en niveles bajos y su influencia en la siguiente lactación debe determinarse para cada raza. **Objetivo:** Determinar la incidencia de abortos y/o partos con muerte fetal (APS) en cabras Serrana ecotipo Transmontano, y su asociación con la producción de leche en la lactancia subsiguiente. **Métodos:** Se utilizó la información proveniente de la base de datos del registro genealógico de la raza Serrana ecotipo Transmontano entre 1997 y 2014. Como variables se incluyeron las fechas de partos normales y/o APS, el número de fetos, paridad, y la lactancia normalizada a los 150 d de cada cabra. **Resultados:** La incidencia promedio de APS fue del 8,7% (19.351/223.798). Mediante la aplicación de un modelo de análisis de logística multivariada para los factores año, mes, paridad y nacimientos múltiples, se observó un efecto significativo ($p<0,001$) de estas variables o sus interacciones en la incidencia de APS. En general, los partos no gemelares tuvieron una mayor incidencia, con un ligero énfasis en las cabras primíparas. Del mismo modo, las lactancias consecutivas a APS mostraron una menor producción de leche normalizada a 150 d que lactancias de partos normales ($p<0,001$). **Conclusión:** La incidencia observada fue mayor que el rango normal para la espécie. Los APS tuvieron un efecto negativo en la producción de leche en lactancia normalizada a 150 d.

Palabras clave: *aborto, epidemiología, lactancia, parto, razas de cabras locales.*

Resumo

Antecedentes: O aborto e os partos com nado-mortos são ocorrências normais nos rebanhos de caprinos. No entanto, a sua incidência deve manter-se em níveis baixos e a sua influência sobre a lactação subsequente deve ser determinada ao nível de cada raça. **Objetivo:** Determinar a incidência de abortos e/ou partos com nado-mortos (APS) em cabras da raça Serrana ecótipo Transmontano, e a sua associação com a produção de leite na lactação subsequente. **Métodos:** Foram usados todos os registos constantes na base de dados do livro genealógico da raça caprina Serrana, entre 1997 y 2014. Como variáveis, identificaram-se as datas de parto normal e/ou APS, número de fetos, número de partições, e a lactação subsequente normalizada aos 150 d de cada cabra. **Resultados:** Observou-se uma incidência média de APS de 8,7% (19.351/223.798). Ao aplicar um modelo de análise logística multivariada para os fatores ano, mês, paridade e gemelaridade, observou-se um efeito significativo ($p<0,001$) destas variáveis, quer das suas interações, sobre a incidência em estudo. Globalmente, os partos provenientes de gestações simples, com ligeiro destaque para as cabras primíparas apresentaram incidências mais elevadas. De igual modo, lactações consecutivas a partos com nado-mortos ou abortos apresentaram uma lactação acumulada aos 150 d menor ($p<0,001$) que de lactações provenientes de partos normais. **Conclusão:** A incidência apresentada foi maior que os limites normais para a espécie. Os APS tiveram um efeito negativo na produção de leite da lactação normalizada aos 150 d.

Palavras chave: *aborto, epidemiologia, lactação, parto, raças caprinas locais.*

Introduction

Goat milk is an important food source worldwide due to its high nutritional value, as it provides high quality protein, fat, carbohydrates and vitamins. Goat milk production is a growing industry in many countries, therefore there is a need to assess the factors that affect milk production. It is known that milk yield and composition is affected by numerous non-infectious and infectious factors (e.g. genetic, physiological, nutritional, environmental, and animal management conditions, and goat health status during lactation or even during the previous pregnancy; Goetsch *et al.,* 2011; Mellado and Garcia, 2014; Ibnelbachyr *et al.,* 2015). Nevertheless, the effects of these factors are not well understood in some goat breeds.

Serrana goats are the most representative goat breed reared for dual purposes (i.e., milk and meat), with the prevailing ecotype Transmontano raised in Portuguese mountains. According to the pedigree book, adult Serrana females weigh 25 to 40 Kg, and measure, in average, 64 cm at the withers. An average body condition score of 3.2 for lactating females was reported by Lima *et al.* (2012). These authors also observed that body condition score in Serrana goats is negatively affected ($p<0.05$) by milk yield and parasitism, suggesting that metabolic energy balance and general health status of this rustic breed

are important factors in these well-adapted goats to local environmental conditions.

Abortions, as well as assisted or non-assisted parturitions with stillbirths and fetal mummifications, are responsible for important reproductive and economic losses in goat herds. The etiology of abortion, when stillbirths at parturition are included and neonatal asphyxia is excluded, is wide-ranging and multifactorial, comprising single or multiple infectious and non-infectious (Menzies, 2011) causes, including toxic plants (Dantas *et al.,* 2012; Santos dos Reis *et al.,* 2016).

Normally, infectious causes of abortion, including stillbirths at parturition, are associated with specific enzootic or epizootic (outbreak) events. The major infectious agents reported in goats are *Brucella melitensis*, *Chlamydia abortus*, *Campylobacter* spp, *Coxiella burnetii*, *Bluetongue*, *Neospora caninum*, *Toxoplasma gondii*, *Yersinia pseudotuberculosis*, *Listeria* spp, and in some countries, Peste des petits ruminants virus and Border disease virus (Menzies, 2011; van den Brom *et al.,* 2012; Ababneh *et al.,* 2014; Lafi *et al.,* 2014; Rosamilia *et al.,* 2014; Rodolakis and Laroucau, 2015; Anastácio *et al.,* 2016; Bauer *et al.,* 2016; Gazzonisa *et al.,* 2016; Kardjadj *et al.,* 2016). Due to the potential multifactorial etiology, a definitive diagnosis can be difficult and expensive to obtain. Moreover, clinical signs of abortion may not be specific regarding etiology.

On other hand, dystocia may lead to fetal death due to neonatal asphyxia (Probo *et al.*, 2011), which cannot be accurately differentiated from other abnormal conditions without veterinary assistance or further diagnostic testing. To our knowledge, no studies have been conducted to evaluate these reproductive problems and their effect on subsequent milk production in Portuguese Serrana goats.

The aims of the present study were to evaluate the incidence of abortions and parturitions with stillbirths (APS) in Portuguese Serrana goats breed ecotype Transmontano and their association with milk production in the following lactation.

Materials and methods

Animal records

Animal records from 1997 to 2014 were obtained from the pedigree book (Genpro, Ruralbit, Portugal) of Serrana goats ecotype Transmontano, located at Trás-os-Montes e Alto Douro region (latitude 41º29′0′′ N and longitude 7°11′0′′ W; Mirandela City). Serrana goats ecotype Transmontano were historically used to graze mainly in the mountain zones of northern Portugal. In 2013, each farm raised on average 70 adult animals according to the pedigree book. Reproductive management included natural mating, in some herds with bucks separated from females. Two annual parturation peaks occured in January and October (Simões, 2016). Depending on each farm, lactating goats were hand-milked once or twice per day. Prophylatic practices included periodical deworming and vaccination against common bacterial diseases (i.e. enterotoxemia and brucellosis) and, more recently, paratuberculosis.

The farms were periodically visited by technicians of the agricultural association responsible for the pedigree book (Associação Nacional de Caprinicultores da Raça Serrana, ANCRAS) to record goat data. These records included adult individual identification, date and number of parturitions (parity), number of kids per parturition (prolificacy), and abnormal reproductive occurrences. Abnormal reproductive occurrences were defined as abortion, identified by farmers normally during the second half of pregnancy, and the presence of at least one stillborn or mummified fetus at the time of parturition. However, these anomalies were obtained from the pedigree records without distinction between them. The number of does and bucks were periodically reported by the farmer, and registered in the pedigree records.

Cumulative milk production (L) for each lactation was recorded by the technicians. The estimated 150-d normalized milk production (i.e. cumulative L produced in each lactation until 150 d), was also recorded in the pedigree records, and this estimation was determined from periodical measurement of milk at milking time according to ANCRAS guidelines.

The parturition dependent variable was classified as normal in the presence of parturitions without stillborn(s) or abortions, with a subsequent new lactation, or abnormal when parturition had at least one stillbirth, including mummified fetus and dystocia.

Parity was classified as primiparous or multiparous in females with a single parturition and two or more parturitions, respectively. Prolificacy of females in each parturition or abortion was classified as single (one fetus) and multiple (more than one fetus) according to the number of fetuses and denominated gemelarity.

Statistical analysis

Associations between the presence or absence of APS and the effect of year, month, parity and gemelarity variables, including all two-way interactions, were evaluated using a multivariable logistic regression analysis.

A Van der Waerden test was used for comparison of APS between parturitions of primiparous and multiparous goats or parturitions of goats with a single fetus and with multiple fetuses. This test was also used for comparison of 150-d normalized milk production between primiparous and multiparous groups with or without the above-described reproductive abnormalities.

Differences were considered significant at a p-value level of 0.05. All statistical analyses were performed with the JMP® statistical software of SAS, version 10 (SAS, Institute Inc. 2012; Cary, NC, USA).

Results

The overall incidence of APS between 1997 and 2014 was 8.7% (19,351/223,798; 95% confidence interval from 8.6 to 8.8%) for all parturitions. A higher incidence of APS was observed in parturitions of primiparous (12.9%; 6,919/53,838) compared with multiparous (7.3%; 12,432/169,960; $p<0.001$) goats. The incidence of APS was also higher in parturitions of a single fetus (14.0%; 18,414/131,222) than multiple fetuses (1.0%; 937/92,576; $p<0.001$).

According to the multiple logistic regression analysis, the incidence of APS was associated with year, month, parity and gemelarity ($p<0.001$), and their interactions ($p<0.01$), except for the interaction between gemelarity and parity ($p = 0.08$). Results are presented in Figures 1 and 2.

The 150-d normalized milk production was also lower in goats experiencing abnormal parturition with stillbirths or abortion compared to goats with normal parturition (Table 1).

Table 1. Comparison of the mean (± SEM) 150-d normalized milk production between primiparous and multiparous goats with or without abortion and/or stillbirth(s).

Goat parturitions	Abortions and/or stillbirth(s)	At 150 d (L)	p-value
Primiparous	Yes (n = 4,797)	79.4 ± 0.5	p<0.001
	No (n = 29,450)	90.8 ± 0.2	
Multiparous	Yes (n = 8,715)	92.9 ± 0.4	p<0.001
	No (n = 101,959)	98.8 ± 0.1	

Moreover, when only APS were considered with regards to offspring that did not make it to term, a lower 150-d normalized milk production was observed in females with multiple offspring (85.2 ± 1.5 L ± SEM; n = 604) compared to females with single offspring (93.4 ± 0.5 L; n = 8111; $p<0.001$). These differences were not significant for primiparous goats (multiple offspring: 77.5 ± 2.5 L; n = 120 vs single offspring: 79.5 ± 0.5 L; n = 4677; $p>0.05$).

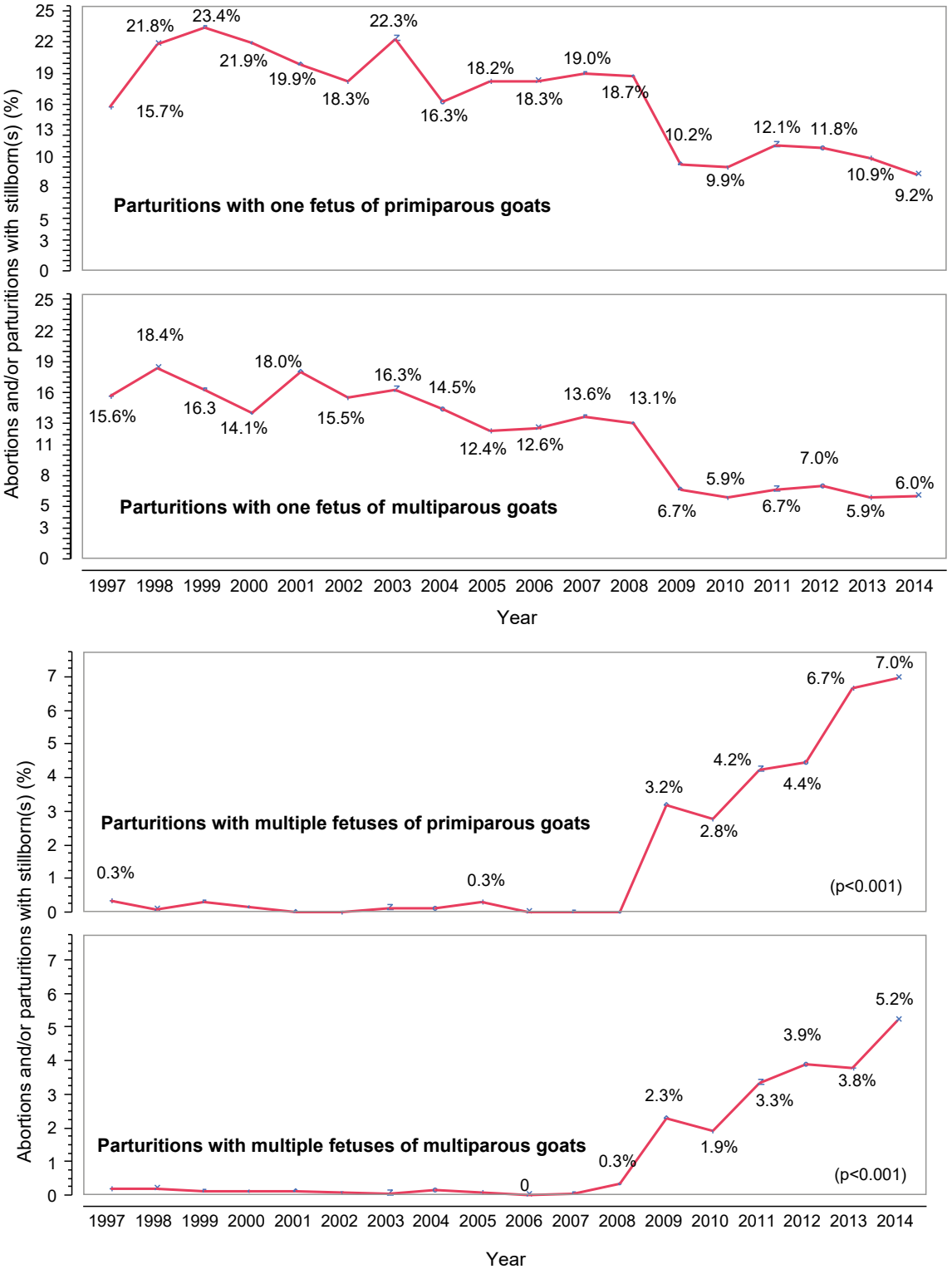

Figure 1. Annual incidence of abortions and/or parturitions with stillbirths according to parturition type (single vs. multiple) and parity (primiparous vs multiparous goats; p<0.001).

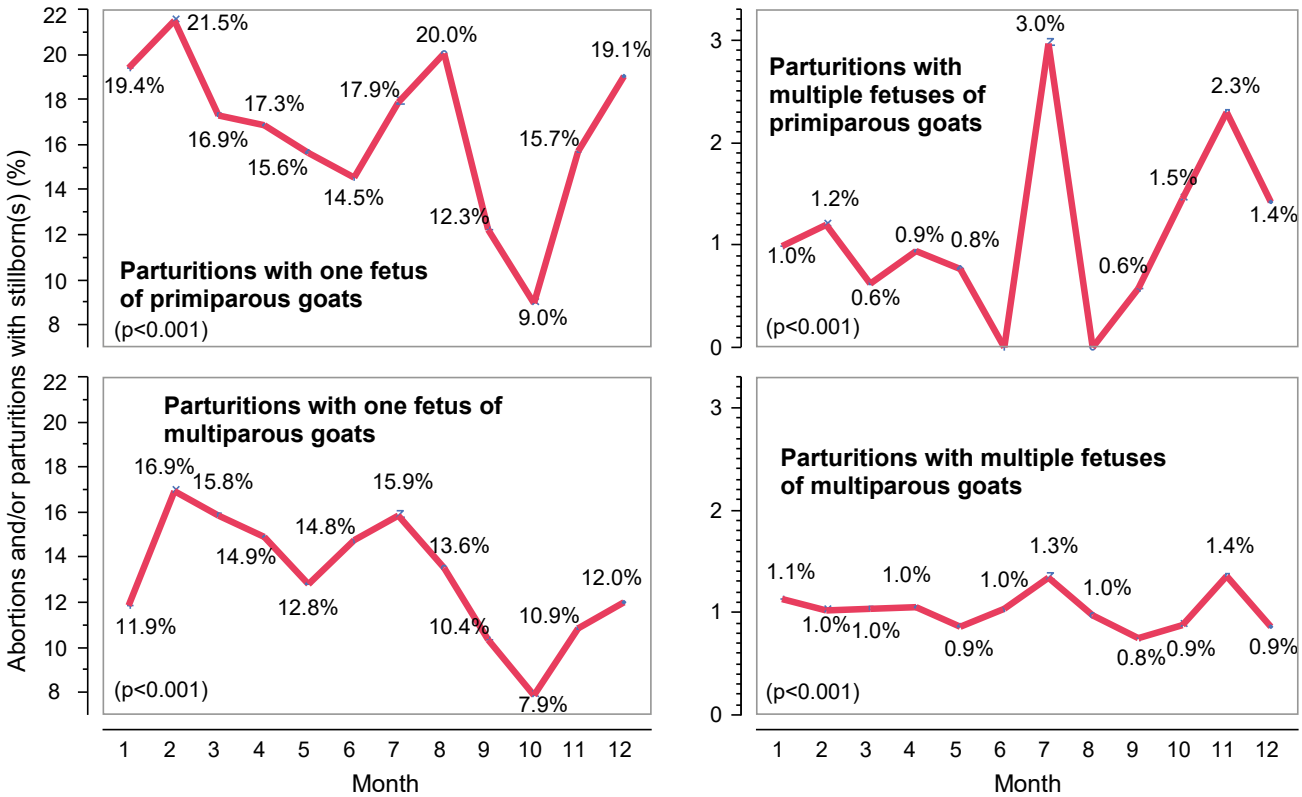

Figure 2. Monthly incidence of abortions and/or parturitions with stillbirths according to the type of parturition (single vs. multiple), and parity of females (primiparous vs. multiparous goats; p<0.001).

Discussion

One of the major limitations of this study was the inability to differentiate goats with dystocia due to neonatal asphyxia (Sobiraj, 1994) or mummified fetuses at parturition from goats experiencing abortion. Moreover, misclassification of dystocia might have occurred if unobserved stillborn or mummified fetuses were classified as normal parturition. The second major limitation is the potential lack of agreement on APS classification used by the different technicians between 1997 and 2014. On the other hand, the fact that a new lactation occurred after an abortion was indicative of a late pregnancy phase, that was concomitant with the dry period in goats with at least one parturition in primiparous or multiparous goats.

Overall, the incidence of APS (8.7%) was higher than the normal values reported in the literature. The critical level of abortion incidence in small farms range from 2 to 5% (Menzies, 2011), and incidence of dystocia from 3 to 5% is considered normal in goats (Braun, 2007). However, because no distintion between the two occurrences was possible in our study, comparision with other reports should be interpreted with caution.

Interestingly, after 2009 the incidence of abortion increased in pregnancies with multiple fetuses as opposed to singletons for both primiparous and multiparous goats. Probably this increment was due to different criteria used by technicians throughout the years considered in the present study (1997-2014). However, abortion incidence was higher in nulliparous than in multiparous goats. In cows, the incidence of neonatal mortality was reported as approximately 4%, with a higher incidence in nulliparous than in multiparous cows (Mee *et al.,* 2011). In the present study, it was not possible to address the etiology of APS (i.e. the distinction between infectious disease causes). This should be investigated in future studies. For example, the impact of caprine Chlamydiosis and Q fever, two diseases reported as important causes of APS in other countries (Menzies, 2011)

should be further investigated. In order to control brucellosis in goats, the Trás-os-Montes e Alto Douro region has implemented a vaccination program using conjunctival vaccination with live *B. melitensis* Rev.1 strain (Olsen, 2013) for those counties with a herd-level prevalence greater than 2.5%. This prevention program may have changed the abortion rate due to the expected effect in the epidemiology of this bacterium among vaccinated flocks.

The Q fever has been reported in goats raised in Portugal (Anastácio *et al.,* 2013), but a large herd screening of small ruminants is required in the northeast region, as has been conducted in dairy cattle (Pimenta *et al.,* 2015). It is agreed that prophylactic measures, including active immunization against several infectious agents with reproductive impact other than *B. melitensis* (Lacasta *et al.,* 2015) are needed in this region. Without significant epidemiological studies regarding the incidence and etiology of reproductive diseases and dystocia occurrence, it is difficult to advance a consistent explanation for the findings observed in the present study.

One other important question concerning the annual variation can be tentatively connected to climate change. In fact, the effect of climate change on reproductive events has been reported in sheep (Sejian *et al.*, 2013). Marino *et al*. (2016) conducted an extensive literature review on climate change impact on the epidemiology of several diseases affecting the reproductive system of small ruminants. Climate has also been associated with decreased rates of fertility after artificial insemination in goats (Arrébola *et al.*, 2016).

In our study, APS prevalence was higher in parturitions with singletons than parturitions with twins or more fetuses. This finding should be interpreted with caution. Firstly, the data were obtained over several years by different technicians, and recording of observations may have varied among technicians. Secondly, the recording of stillbirth and live fetuses may have been more easily noticed in the presence of singletons than multiple fetuses. In fact, a stillbirth can be omitted or undetected by farmers. Moreover, when abortion occurs in the dry period, a new lactation can be promoted by milking. Finally, there is seasonality to parturition in goats, and recording errors may be more common during the kidding season due to more intensive labor required by farmers or technicians. In fact, in October, during one of the main peaks of parturition (Simões, 2016), a low incidence of singleton abortion or stillbirth was observed in the present study. Moreover, a significant number of farmers also engage in other agricultural activities that require more intensity during this same season of the year and consequently less attention may be given to goats.

The 150-days normalized milk production observed in subsequent lactations was lower in the presence of APS than after normal parturitions (Table 1), and these findings are in agreement with those reported by Neves and Almendra (1996). This result emphasizes the adverse effect of APS occurrence upon subsequent lactation. Consequentely, APS should be reduced in order to minimize these situations.

In conclusion, the APS incidence reported in the present study seems to be higher for this species and was affected by year, month, parity, and gemelarity. These occurrences induced lower milk production. A more detailed study recording dystocia and abortion separately is warranted to distinguish the cause and factors affecting these two reproductive problems.

Acknowledgements

Authors would like to thank Manuel Silveira (Ruralbit) and Francisco Pereira (ANCRAS) for the full access to pedigree records of Serrana Goats. This work was supported by the Foundation for Science and Technology (FCT), project nº UID/CVT/00772/2013. The final revision, including English language correction, was performed by Amy Bauer (Department of Comparative Pathobiology, College of Veterinary Medicine, Purdue University, West Lafayette, IN, USA), and Laura Patterson (Department of Population Health and Reproduction, School of Veterinary Medicine, University of California Davis, CA, USA).

Conflict of interests

The authors declare they have no conflicts of interest with regard to the work presented in this report.

References

Ababneh HS, Ababneh MM, Hananeh WM, Alsheyab FM, Jawasreh KI, Al-Gharaibeh MA, Ababneh MM. Molecular identification of chlamydial cause of abortion in small ruminants in Jordan. Trop Anim Health Prod 2014; 46:1407-1412.

Anastácio S, Tavares N, Carolino N, Sidi-Boumedine K, da Silva GJ. Serological evidence of exposure to Coxiella burnetii in sheep and goats in central Portugal. Vet Microbiol 2013; 167:500-505.

Arrébola F, Sánchez M, López MD, Rodríguez M, Pardo B, Palacios C, Abecia, JA. Effects of weather and management factors on fertility after artificial insemination in Florida goats: A ten-year study. Small Ruminant Res 2016; 137:47-52.

Bauer AE, Hubbard KR, Johnson AJ, Messick JB, Weng HY, Pogranichniy RM. A cross sectional study evaluating the prevalence of *Coxiella burnetii*, potential risk factors for infection, and agreement between diagnostic methods in goats in Indiana. Prev Vet Med 2016; 126:131-137.

Braun W. Parturition and dystocia in the goat. In: Younquist RS, Threlfall WR (eds), Current Therapy in Theriogenology 2. 2007. Saunders, St. Louis, pp. 555-558.

Dantas AF, Riet-Correa F, Medeiros RM, Lopes JR, Gardner DR, Panter K, Mota RA. Embryonic death in goats caused by the ingestion of *Mimosa tenuiflora*. Toxicon 2012; 59:555-557.

Gazzonisa AL, Garcia GA, Zanzania SA, Mora LMO, Invernizzi A, Manfredi MT. Neospora caninum infection in sheep and goats from north-eastern Italy and associated risk factors. Small Ruminant Res 2016; 140:7-12.

Goetsch AL, Zeng SS, Gipson TA. Factors affecting goat milk production and quality. Small Ruminant Res 2011; 101:55-63.

Ibnelbachyr M, Boujenane I, Chikhi A, Noutfia Y. Effect of some non-genetic factors on milk yield and composition of Draa indigenous goats under an intensive system of three kiddings in 2 years. Trop Anim Health Prod 2015; 47:727-33.

Kardjadj M, Kouidri B, Metref D, Luka PD, Ben-Mahdi MH. Abortion and various associated risk factors in small ruminants in Algeria. Prev Vet Med 2016; 123:97-101.

Lacasta D, Ferrer LM, Ramos JJ, González JM, Ortín A, Fthenakis GC. Vaccination schedules in small ruminant farms. Vet Microbiol 2015; 181:34-46.

Lafi SQ, Giadinis ND , Papadopoulos E, Filioussis G, Koutsoumpas A, Ovine and caprine toxoplasmosis: experimental study. Pak Vet J 2014; 34:50-53.

Lima JP, Carolino N, Crespo MV, Pardal. Influência da idade, da produção de leite e do grau de parasitismo na condição corporal da cabra Serrana – ecótipo Ribatejano. Proccedings of Congresso de Investigação e desenvolvimento do IPS, 8 e 9 de Fevereiro, ESA, Santarém, pp. 214-223.

Marino R, Atzori AS, D'Andrea M, Iovane G, Trabalza-Marinucci M, Rinaldi L. Climate change: Production performance, health issues, greenhouse gas emissions and mitigation strategies in sheep and goat farming. Small Ruminant Res 2016; 135:50-59.

Mee JF, Berry DP, Cromie AR. Risk factors for calving assistance and dystocia in pasture-based Holstein-Friesian heifers and cows in Ireland. Vet J 2011; 187:189-194.

Mellado M, Garcia JE. Effects of abortion and stage of lactation on chemical composition and mineral content of goat milk from mixed-breed goat on rangeland. APCBEE Procedia 2014; 8:1-5.

Menzies PI. Control of important causes of infectious abortion in sheep and goats. Vet Clin North Am Food Anim Pract 2011; 27:81-93.

Neves A, Almendra L. Estudo da produção leiteira da raça caprina Serrana nos concelhos mais representativos do ecotipo Transmontano em sistemas de produção extensivos tradicionais. Sociedade Portuguesa de Ovinotecnia e Caprinotecnia. 1996. [Access date: September 5, 2015]. URL: http://www.ovinosecaprinos.com/bibliografia/neves96.PDF

Olsen SC. Recent developments in livestock and wildlife brucellosis vaccination. Rev Sci Tech 2013; 32:207-217.

Pimenta L, Alegria N, Anastácio S, Sidi-Boumedine K, da Silva G, Rabiço Â, Simões J. Prevalence of *Coxiella burnetii* antibodies in Portuguese dairy cattle herds. Trop Anim Health Prod 2015; 47:227-230.

Probo M, Cairoli F, Kindahl H, Faustini M, Galeati G, Veronesi MC. Peripartal hormonal changes in Alpine goats: a comparison between physiological and pathological parturition. Reprod Domest Anim 2011; 46:1004-1010.

Rodolakis A, Laroucau K. Chlamydiaceae and chlamydial infections in sheep or goats. Vet Microbiol 2015; 181:107-118.

Rosamilia A, Grattarola C, Caruso C, Peletto S, Gobbi E, Tarello V, Caroggio P, Dondo A, Masoero L, Acutis PL. Detection of border disease virus (BDV) genotype 3 in Italian goat herds. Vet J 2014; 199:446-450.

Santos dos Reis SD, de Oliveira RS, Correia Marcelino SA, Silva Almeida e Macêdo JT, Riet-Correa F, da Anunciação Pimentel L, Ocampos Pedroso PM. Congenital malformations and other reproductive losses in goats due to poisoning by *Poincianella pyramidalis* (Tul.) L.P. Queiroz (=*Caesalpinia pyramidalis* Tul.). Toxicon 2016; 118:91-94.

JMP®. Using JMP 10. Version 10.0.1 Ed. SAS Institute Inc. Cary, NC, USA: 2012.

Sejian V, Maurya VP, Kumar K, Naqvi SM. Effect of multiple stresses on growth and adaptive capability of Malpura ewes under semi-arid tropical environment. Trop Anim Health Prod 2013; 45:107-116.

Simões J. Synchronization of ovulation in goats using prostaglandin F2α based protocols during the breeding season. J Coast Life Med 2016; 4:240-243.

Sobiraj A. Birth difficulties in sheep and goats--evaluation of patient outcome from seven lambing periods in an obstetrical clinic. Dtsch Tierarztl Wochenschr 1994; 101:471-476.

Van den Brom R, Lievaart-Peterson K, Luttikholt S, Peperkamp K, Wouda W, Vellema P. Abortion in small ruminants in the Netherlands between 2006 and 2011. Tijdschr Diergeneeskd 2012; 137:450-457.