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Induction and synchronization of estrus with exogenous hormones and sexual biostimulation in multiparous sows at weaning

Inducción y sincronización del estro con hormonas exógenas y bioestimulación sexual en cerdas multíparas al destete

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ABSTRACT

The aim of the present study was to evaluate whether boar biostimulation is sufficient to stimulate the sexual response of multiparous sows at weaning. In general, independently of the experimental group, 70% of the sows responded to estrus. The percentage of females that responded to estrus was higher in the control group (CG), than in the biostimulated group (BG) ($P < 0.05$). The vocalizations and nudging were higher in the CG than in the BG, on days 3 and 5 ($P < 0.05$). On the other hand, the sexual behavior of the boar was greater when were exposed to CG than to BG of females ($P < 0.05$). There was an increase in days 3 and 5 in the nudging, anogenital sniffing, vocalizations and mounting without or with ejaculation in the male exposed to the females of the CG than to the BG ($P < 0.05$). In conclusion, the boar's sexual biostimulation is not enough to provoke the sexual response of sows during weaning.

Keywords: Sexual bioestimulation, behavior, lateral attacks, pheromones, salivation.

RESUMEN

El objetivo del presente estudio fue evaluar si la bioestimulación del verraco es suficiente para estimular la respuesta sexual de las cerdas multíparas al destete. En general, independientemente del grupo experimental el 70% de las cerdas respondieron al estro. El porcentaje de hembras que respondieron al estro fue mayor en el grupo testigo (GT), que en el grupo bioestimulado (GB) ($P < 0.05$). Las vocalizaciones y aproximaciones laterales fueron superiores en el GT que en el GB, en los días 3 y 5 ($P < 0.05$). Por su parte, la longitud del estro fue similar en las hembras de ambos grupos ($P > 0.05$). Por otro lado, el comportamiento sexual del verraco fue mayor cuando se expuso al GT que al GB de hembras ($P < 0.05$). Existió un incremento en los días 3 y 5 en las aproximaciones laterales, olfateos anogenitales, vocalizaciones y montas sin o con eyaculación en el macho expuesto a las hembras del GT que al GB ($P < 0.05$). En conclusión, la bioestimulación sexual del verraco no es suficiente para provocar la respuesta sexual de las cerdas durante el destete.

Palabras clave: Bioestimulación sexual, comportamiento, embates laterales, feromonas, salivación.

INTRODUCTION

The world pork production grew 1.6% from 2007 to 2016, in 2017 it reached the historical maximum of 111 million tons of meat, which represents an annual increase of 2.6% (FIRA, 2017). In 2016, China was the main producer of pork (47.9%), followed by the European Union (21.6%), the United States (10.4%) and Brazil (3.4%); together, they contributed 83.4% of total production (USDA-ERS, 2017).

For its part, Mexico only contributed 1.3% of world production, and it is in ninth place, with a production of 1.45 million tons (FIRA, 2017). 76.5% of the national production (millions of tons) was concentrated in Jalisco states (20.7%), Sonora (17.3%), Puebla (11.9%), Yucatán (9.8%), Veracruz (8.8%) and Guanajuato (8.1%) (USDA-FAS, 2017).

Currently imports account for 32% of national consumption, observing a shortage of domestic production. In this context, the state of Oaxaca has a low production (27.9% of meat) and a low number of pigs (201 125 pigs) (FND, 2014, SIAP, 2016). The state's pork industry presents problems of a reproductive nature, which is why it is common to use estrogen synchronization protocols with exogenous hormones to increase the productivity of the sow (Hemsworth and Tilbrook, 2007). There are studies where they mention that more than 90% of the sows synchronized with synthetic hormones (PG-600®) that contain lyophilized serum gonadotropin and freeze-dried chorionic gonadotropin come into heat in a shorter time (Casida, 1935, Estienne *et al*., 2001 Breen *et al*., 2006; Ulguim *et al*., 2018). However, this reproductive technology increases production costs. Therefore, biotechnologies that allow the total or partial reduction of the use of hormones in the pork industry are required. Thus, it has been found that the combination of hormanas with the stimulation of the male causes an improvement in the sexual response of the sows during the breeding (Signoret, 1974, Hughes et al., 1990, Weaver et al., 2014).

Studying the sexual behavior of the stallion during the breeding season is important, since its activity is indicative of whether or not it has adequate plasma levels of testosterone and a high libido, consequently if the sperm are suitable for fecundating the female (Hemsworth and Tilbrook, 2007). There is little evidence of the sexual behavior of commercially used boars, although some studies mention that these males are eliminated when they have problems copulating and because of the low sperm quality (Melrose, 1966, Rasbech, 1969, Hemsworth and Tilbrook, 2007, Kaneko and Koketsu , 2012). It should be noted that the sexual behavior of the male is very varied, although the essential feature is pelvic thrust and penetration with ejaculation. Other components of the boar are attacks towards the posterior region and the flanks; On the other hand, in the goats and rams, anogenital sniffing, flehmen, tongue movement and vocalizations are important (Booth, 1988, Ladewing *et al*., 1980, Fraser and Broom, 1997, Fernández *et al.,* 2018). On the whole, the sexual behavior of the male is essential to stimulate the female irrespective of whether or not synthetic hormones are used.

In the literature there is information on the use of the boar to advance puberty in virgin sows (Brooks and Cole, 1970, Kaneko and Koketsu, 2012); but not to stimulate estrus to multiparous sows at weaning. With this alternative, as in sheep (Martin et al., 2004), goats (Shelton, 1960) and bovines (Roberson *et al*., 1987), the concept can be coined: green, clean and ethical; and with this decrease the use of synthetic hormones and increase animal welfare in pigs (Montossi *et al*., 2014). For the aforementioned, the objective of the present study was to evaluate if boar biostimulation is sufficient to stimulate the sexual response of multiparous sows at weaning.

MATERIAL AND METHODS

Study area

The present study was conducted in the "Rio Grande" community, Villa de Tututepec municipality, Juquila district of Oaxaca state, Mexico. The climate of this region is tropical, the average annual temperature is 27 °C, precipitation of 1,309 mm and coordinates: 16 ° 00'41"LN, 97 ° 30'13"LW (García, 1973).

Animals and treatments

In the experiment a total of 10 sows from 3 to 4 Landrace x Yorkshire calves with 30 d of calving were used; Likewise, two males of the Duroc breed were used. The females were divided into two groups: a control group (GT; n = 5) and a biostimulated group (GB; n = 5); both groups stayed without a male for a month prior to the start of the study. At the beginning of the experiment the GB was separated more than 300 meters away from the GT. In addition, the GT was applied an estrus synchronization protocol, while the GB remained intact. The protocol consisted in the application of a dose of PG-600® (Intervet America Inc., the hormone contains 400 IU of lyophilized serum gonadotropin and 200 IU of lyophilized chorionic gonadotropin) intramuscularly (im), 24 h after the application of the hormone (day one) a male was introduced into both groups of females. At that time and for 6 consecutive days were registered the variables of sexual behavior of females (response to estrus, length of estrus, vocalizations and lateral approaches) and males (attempts to mount, ride with penetration, anogenital sniffs, lateral approaches and vocalizations). The sexual behavior of both sexes was observed and recorded for one hour per group by a previously trained person.

Food and lodging

During the experimental phase the animals were fed a formulated diet and mixed manually (Table 1), provided in the morning (07.00 h, 4.00 kg) and in the afternoon (17:00 h, 4.00 kg), also he provided them with free access water. The animals were housed in pens 2.5 m wide by 6 m long, roofed with asbestos lamina, concrete floor, provided with drinking troughs and feeders.

Table 1. Ingredients of the diet offered to the breeding sows during the experiment.

Ingredients	Value in kilograms
Maize	63.50
Soy	12.00
[1]DDG	6.00
Wheat bran	17.00
Minerals	1.50
	100.00

Mix of ingredients for the diet. 16 % of crude protein (PC). [1]DDG: distillery grains.

Statistical analysis

All data presented in the submitted manuscript were analyzed with the statistical program SYSTAT 13, under a completely randomized design in which each animal was considered as an experimental unit. The data of the sexual behavior variables of the females, the males, and the observation days were analyzed with the Krukal-Wallis test of non-parametric statistics. To compare the means, the Mann-Whitney U test was used (Siegel and Castellan, 1994).

RESULTS AND DISCUSSION

Sexual response of females

In general, independently of the experimental group, 70% of the sows responded to estrus. In fact, the percentage of females that responded to estrus was higher in the GT (5/5, 100%), than in the GB (2/5, 40%, $P < 0.05$). The vocalizations and lateral nudging were superior in the GT (29.8 ± 0.21 and 27.6 ± 0.18 occasions) on days 3 (17.2 ± 0.57), 4 (20 ± 0.56) and 5 (29.8 ± 1.8 occasions), than in the GB (7.8 ± 2.04 and 11 ± 2.28 occasions) days 1 (5.8 ± 1.16), 3 (4 ± 0.94) and 5 (1.2 ± 0.26 occasions, $P < 0.05$). On the other hand, the length of estrus in the females of both groups was similar (44 vs. 49 h, $P > 0.05$).

The results of the present study are consistent with those reported in other studies where they show that the majority of multiparous sows synchronized with PG-600® responded to estrus in the first 48 h after the application of the hormone (Estienne *et al*., 2001 Breen *et al*., 2006; Ulguim *et al*., 2018). Contrary to these results were reported by Trujillo *et al*., (1997) since only 23.33% of the females showed estrus.

On the other hand, estrus length was similar to that observed naturally (36 h, Soede *et al*., 2011), but different from that reported by other authors when they synchronize estrus with progestogens (Degenstein *et al*., 2008). In the case of vocalizations in pigs and goats are very important at the time of courtship to trigger a sexual response (Booth, 1988, Vielma *et al*., 2009, Martinez *et al*., 2014). In the same way, the lateral approximations are indicative of a high libido in males and very important during sexual biostimulation in sheep and goats (Delgadillo *et al*., 2009, Fernández *et al*., 2018). For example, in sows the vocalizations of the male act synergistically with the olfactory and tactile signals (lateral nudging) in the immobilization of the female to facilitate the copulation, in the red deer it has been demonstrated that the vocalizations of the male advance the moment so that the females enter estrus (Davies, 1986; Signoret, 1974; Tilbrook and Hemmsworth, 1990; Garcia *et al*., 2013).

The results reported in these investigations are consistent with those of the present study in the case of vocalizations and lateral nudging. In the case of the GT of the present study, they were higher in the days while the females were approaching the moment of estrus; this is probably due to the pheromones released by the females. Contrarily in the GB they occurred in the first 3 days of contact, evidently it was presented in the only females that presented estrus. These results are interesting since the presentation of estrus allows a greater stimulation of the male and synergistically this potentiates the stimulation of the sow to display an intense sexual behavior.

Sexual behavior of males

The sexual behavior was greater in the boar exposed to the GT of females than to the GB ($P < 0.05$). In fact, there was an increase on days 3 and 5 in the lateral nudging, anogenital sniffing, vocalizations and mounts without and with ejaculation in the male exposed to the females of the GT that, at GB, anogenital sniffing and vocalizations ($P < 0.05$; Figure 1).

The sexual behavior of the male is very varied, although the essential characteristic is pelvic thrust and penetration with ejaculation. Other components such as anogenital sniffing, flehmen, tongue movement and vocalizations are indicative of goats and rams (Ladewing *et al.,* 1980, Fraser and Broom, 1997, Martínez *et al*., 2014, Damián *et al*., 2018). . In effect, these results are similar to the sexual behavior displayed by the photo-stimulated goats when they are exposed to anestric goats. The number of lateral nudging and the anogenital sniffing increase in the first days of contact between both sexes, (Ponce *et al*., 2014, Fernández *et al*., 2018).

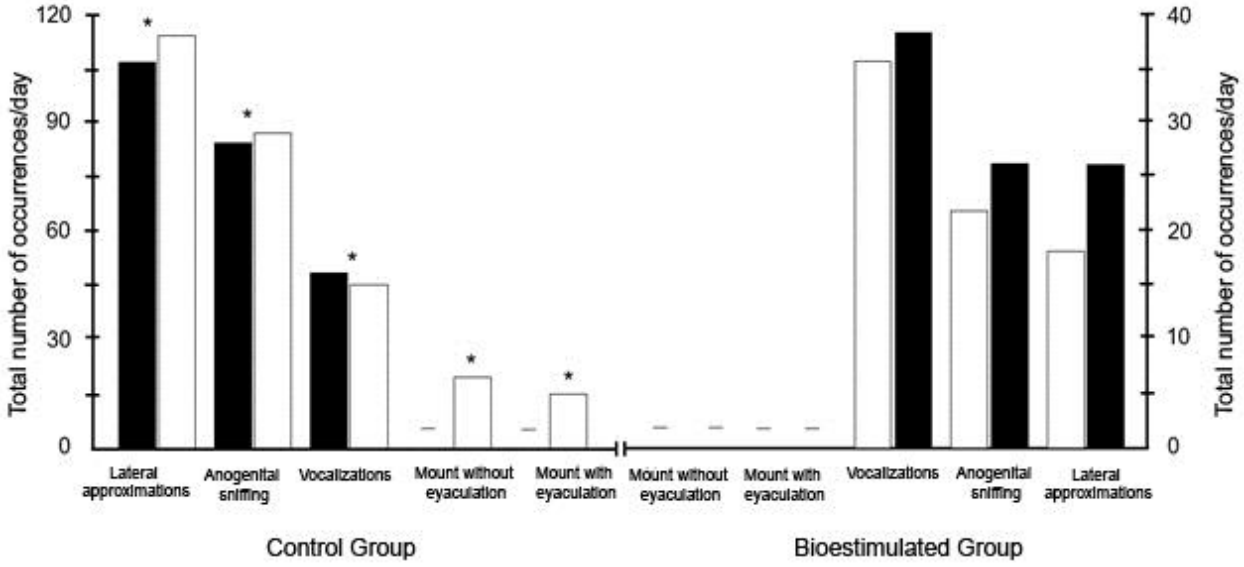

Figure 1. Sexual behavior displayed by the boar days 3 (■) and 5 (□) contact between the sexes, for each variable (lateral nudging, anogenital sniffing, vocalizations and mount without and with ejaculation). The control group on the left side and the biostimulated group on the right side, the - indicates zero behavior, * represents significant difference between groups (P <0.05).

In the case of the boar this happened as well since the sexual behavior was more intense on days 3 and 5 after the introduction; the high sexual behavior displayed by the GT males in these first days was probably due to the olfactory motivation perceived by the male due to the release of pheromones by the females since it coincided with the occurrence of estrus in all the sows (Booth, 1988 Petrulis, 2013). Likewise, the vocalizations are similar to those reported in synchronized sows put in contact with a boar (Signoret, 1974). This was because at that time there was greater social interaction between the two sexes, therefore, they had good auditory stimulation that allowed them to respond in this way. The findings found in this study are outstanding since the presence of the male potentiates the sexual response of the females provided they are previously synchronized with exogenous hormones. It would be interesting to look for alternatives to increase the response of the sows to the male stimulation , this in order to decrease the application of synthetic hormones and increase animal welfare.

CONCLUSION

The boar's sexual biostimulation is not enough to provoke the sexual response of the sows. However, the combination of exogenous hormones with the boar's sexual biostimulation stimulates the sexual response of multiparous sows at weaning.

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BIBLIOGRAPHY

BOOTH WD. 1988. Hormones, pheromones and sexual behavior in the boar. *Pig News and Information.* 9:251–255. DOI: 10.1677/joe.0.1180047

BREEN SM, Rodriguez-Zas SL, Knox RV. 2006. Effect of PG600 and adjusted mating times on reproductive performance in weaned sows. *Animal Reproduction Science.* 93:157–163. DOI: 10.1016/j.anireprosci.2005.06.010

BROOKS PH, Cole DJA. 1970. The effect of the presence of a boar on the attainment of puberty in gilts. *Journal of Reproduction and Fertility*. 23:435–440. DOI: 10.1530/jrf.0.0230435

CASIDA LE. 1935. Prepubertal development of the pig ovary and its relation to stimulation with gonadotrophic hormones. *Anatomical Record.* 61:389. DOI: 10.1002/ar.1090610403

DAMIÁN JP, Beracochea F, Machado S, Hötzel MJ, Banchero G, Ungerfeld R. 2018. Growing without a mother results in poorer sexual behaviour in adult rams. *Animal*. 12:98–105. DOI: 10.1017/S1751731117001574.

DAVIES OD. 1986. Effect of using vasectomized boars for additional mating on sow reproductive performance. Winter Meeting of the British Society of Animal Production, 17-29 March, Trawsgood. UK, Pap. No. 123. *British Society Animal Production,* 17.

DEGENSTEIN KL, O´Donoghue RO, Patterson JL, Beltranena E, Ambrose DJ, Foxcroft GR, Dyck MK. (2008). Synchronization of ovulation in cyclic gilts with porcine luteinizing hormone (pLH) and its effects on reproductive function. *Theriogenology.* 70:1075–1085. DOI: 10.1016/j.theriogenology.2008.06.027

DELGADILLO JA, Gelez H, Ungerfeld R, Hawken PAR, Martin GB. 2009. The “male effect” in sheep and goats: revisiting the dogmas. *Behavioural Brain Research.* 200:304–314. DOI: 10.1016/j.bbr.2009.02.004

ESTIENNE MJ, Harper AF, Horsley BR, Estienne CE, Knight W. 2001. Effects of P.G. 600 on the onset of estrus and ovulation rate in gilts treated with regu-mate. *Journal of Animal Science.* 79:2757–2761. DOI: 10.2527/2001.79112757x

FERNÁNDEZ GIG, Flores-Medina E, Flores JA, Hernández H, Vielma J, Fitz-Rodríguez G, Duarte G. 2018. Absence of previous sexual experience did not modify the response of anoestrous goats to photo-stimulated bucks in spring. *Italian Journal of Animal Science*. 17:306–311. DOI: 10.1080/1828051X.2017.1384335

Fideicomisos Instituidos en Relación con la Agricultura (FIRA; 2017). Panorama Agroalimentario, Dirección de Investigación y Evaluación Económica y Sectorial; Carne de cerdo 2017. Disponible en:

http://www.ugrpg.org.mx/pdfs/Panorama%20Agroalimentario%20Carne%20de%20cerdo%202017.pdf

Financiera Nacional de Desarrollo (FND; 2014). Avances trimestrales de los Programas de Apoyo de la FND 2014. Disponible en: https://www.gob.mx/fnd/documentos/avances-trimestrales-de-los-programas-de-apoyo-de-la-fnd-2014

FRASER AF, Broom DM. 1997. Farm Animal Behaviour and Welfare. CAB International, Oxon, U.K. Disponible en: https://www.cabdirect.org/cabdirect/abstract/19962214501

GARCÍA E. 1973. Modificaciones al sistema de clasificación climática de Köeppen. 2da ed. Instituto de Geografía, Universidad Nacional Autónoma de México, México, D.F, México. pp: 11-90. Disponible en: http://www.scielo.org.mx/scielo.php?pid=S0188-46111974000100001&script=sci_arttext

GARCÍA M, Charlton BD, Wyman MT, Fitch TW, Reby D. 2013. Do red deer (cervus elaphus) use roar fundamental frequency (F0) to asses rivals? *PLOS ONE.* 8:e83946. DOI: 10.1371/journal.pone.0083946

HEMSWORTH PH, Tilbrook AT. 2007. Sexual behavior of male pigs. *Hormones and Behavior.* 52:39–44. DOI: 10.1016/j.yhbeh.2007.03.013

HUGHES PE, Pearce GP, Patterson AM. 1990. Mechanisms mediating the stimulatory effects of the boar on gilt reproduction in: Cole DJA, Foxcroft GR and Weir JJ (Editors). Control of Pig Reproduction III. *Journal Reporduction and Fertility.* (Suppl) 40:323–341. Disponible en: https://www.cabdirect.org/cabdirect/abstract/19900178840

KANEKO M, Koketsu Y. 2012. Gilt development and matin in comercial swine herds with varying reproductive performance. *Theriogenology.* 77:840–846. DOI: 10.1016/j.theriogenology.2011.09.006

LADEWING J, Price EO, Hart BL. 1980. Flehmen in male goats: Role in sexual behavior. *Behavioral and Neural Biology*. 30:312–322. DOI: 10.1016/S0163-1047(80)91198-X

MARTÍNEZ-Alfaro JC, Hernández H, Flores JA, Duarte, G, Fitz-Rodríguez G, Fernández IG, Bedos M, Chemineau P, Keller M, Delgadillo JA, Vielma J. 2014. Importance of intense male sexual behavior for inducing the preovulatory LH surge and ovulation in seasonally anovulatory female goats. *Theriogenology.* 82:1028–1035. DOI: 10.1016/j.theriogenology.2014.07.024

MARTIN GB, Milton JTB, Davidson RH, Banchero-Hunzicker GE, Lindsay DR, Blache D. 2004. Natural methods for increasing reproductive efficiency in small ruminants. *Animal Reproduction Science.* 82-83:231–246. DOI: 10.1016/j.anireprosci.2004.05.014

MELROSE DF. 1966. A review of progress and of possible developments in artificial insemination of pigs. *Veterinary Record.* 78:159–168. Disponible en: https://www.ncbi.nlm.nih.gov/pubmed/5903968

MONTOSSI F, Font-i-Furnols M, del Campo M, San Julián R, Brito G, Sañudo C. 2014. Sustainable sheep production and consumer preference treds: Compatibilities, contradictions, and unresolved dilemas. *Meat Science.* 95:772–779. DOI: 10.1016/j.meatsci.2013.04.048

PETRULIS A. 2013. Chemosignals and hormones in the neural control of mammalian sexual behavior. *Frontiers in Neuroendocrinology.* 34:255–267. DOI: 10.1016/j.yfrne.2013.07.007

PONCE JL, Velázquez H, Duarte G, Bedos M, Hernández H, Keller M, Chemineau P, Delgadillo JA. 2014. Reducing exposure to long days from 75 to 30 days of extra-ligth treatment does not decrease the capacity of male gots to stimulate ovulatory activity in seasonally anovulatory females. *Domestic Animal Endocrinology.* 48:119–125. DOI: 10.1016/j.domaniend.2014.03.002

RASBECH NO. 1969. A review of the causes of reproductive failure in swine. *Bristish veterinary Jornal.* 125:599–614. Disponible en: https://www.ncbi.nlm.nih.gov/pubmed/4916873

ROBERSON MS, Ansotegui RP, Berardinelli JG, Whitman RW, McInerney MJ. 1987. Influence of biostimulation by mature bulls on occurrence of puberty in beef heifers. *Journal of Animal Science.* 64:1601–1605. DOI: 10.2527/jas1987.6461601x

SHELTON M. 1960. Influence of the presence of a male goat on the initiation of estrous cycling and ovulation of Angora does. *Journal of Animal Science.* 19:368–375. DOI: 10.2527/jas1960.192368x

SIAP. 2016. Producción ganadera. Sistema de Información Agroalimentaria y Pesquera. México. Disponible en: https://www.gob.mx/siap/acciones-y-programas/produccion-pecuaria

SIEGEL S, Castellan NJ. 1994. Estadística no paramétrica aplicada a las ciencias de la conducta. Trillas, México, 437 pp.

SIGNORET JP. 1974. Rôle des différentes informations sensorielles dansl.attraction de la femelle en oestrus par le mâle chez les porcins. *Annales De Biolgie Animale, Biochimie, Biophysique*. 14:747-755. Disponible en: https://hal.archives-ouvertes.fr/hal-00896917/document

SOEDE N, Langendijk P, Kemp B. 2011. Reproductive cycles in pigs. *Animal Reproduction Science.* 124:251–258. DOI: 10.1016/j.anireprosci.2011.02.025

TILBROOK AJ, Hemsworth PH. 1990. Detection of oestrus in gilts housed adjacent or opposite boars or exposed to exogenous boar stimuli. *Applied Animal Behaviour Science.* 28:233–245. DOI: 10.1016/0168-1591(90)90102-J

TRUJILLO-Ortega ME, Doporto-Díaz JM. 1997. Sincronización del estro en cerdas nulíparas y primíparas. *Veterinaria México.* 28:325–331. Disponible en: http://www.medigraphic.com/pdfs/vetmex/vm-1997/vm974i.pdf

ULGUIM RR, Bortolozzo FP, Wentz I, Johnston M, Webel SK, Arend L, Knox RV. 2018. Ovulation and fertility responses for sows receiving once daily boar exposure after weaning and OvuGel® followed by a single fixed time post cervical artificial insemination. *Theriogenology.* 105:27-33. DOI: 10.1016/j.theriogenology.2017.09.005

USDA-FAS. Livestock and products semi-annual México, March (2017). Fecha de consulta: 26 febrero de 2018. Disponible en: https://www.fas.usda.gov/data/mexico-livestock-and-products-semi-annual-1

VIELMA J, Chemineau P, Poindron P, Malpaux B, Delgadillo JA. 2009. Male sexual behavior contributes to the maintenance of high LH pulsatility in anestrous female goats. *Hormones and Behavior.* 56:444–449. DOI: 10.1016/j.yhbeh.2009.07.015

WEAVER AC, Kind KL, William BR, van Welttere HEJ. 2014. Effects of lactation length and boar contact in early lactation on expression of oestrus in multiparous sows. *Animal Reproduction Acience.* 149:238–244. DOI: 10.1016/j.anireprosci.2014.06.031