Follicular Development, Estrus and Pregnancy Rate in Pre-Pubertal Goats Treated Melengestrol Acetate (MGA) in Rural Areas of Mexico

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***Abstract*—The aim of this study was to evaluate the effect of a Prolonged Melengestrol Acetate (MGA) treatment in pre-pubertal goats on the induction of ovarian activity, induction and synchronization of estrus and pregnancy rate. 10 pre-pubertal Saanen goats, 9 months of age, body condition of 2.1±0.32 (scale 1-5), a live weight of 30.44±1.93kg and size of 62.1±2.69cm were used. The treatment consisted on the administration of 0.22mg/goat/day of MGA orally, during 46 days. During the treatment, the ovaries were evaluated by rectal ultrasonography using a 7MHz transducer on days 15, 30 and 45 to observe the presence or absence of follicles. Once the treatment was completed, the sire was placed in the pen with the goats and estruses were detected during 10 days post-treatment. The pregnancy diagnosis was performed 45 days after breeding via transabdominal ultrasound using a 3.5 and 5MHz transducer. Since the first evaluation of ovarian activity, the 10 goats showed follicle development; in the right ovary an average of 9.66<4mm and 9.33≥4mm was observed and in the left ovary 11.33<4mm and 9.66≥4mm, without the presence of corpus luteum. 100% of the goats presented estrus and the pregnancy rate was 90%; concluding that the use of MGA at a dose of 0.22mg/goat/day in pre-pubertal goats during prolonged treatment induces follicular development, estrus synchronization and a high percentage of fertility by natural mating is obtained.**

***Index Terms*—pre-pubertal goats, melengestrol acetate, follicles, estrus, pregnancy, echography**

I. Introduction

In México, goat production takes place in rural areas (84% in ejido farming systems) with great advantages for its rusticity and use of available resources [1]. The production system is characterized by a single corral where the entire herd is together without differentiating physiological ages and stages, sustaining feeding mainly on corn stover; grazing on rangelands, hills and roadside, while feed supplementation in this system is scarce or absent [2].

Productive and reproductive rates are influenced by several factors, including: free mating (the male stays all year with goats) and no application of control techniques of ovarian activity [3]; hence, the need for proper reproductive management that achieves an increase in productivity and to enable the development of this sector, since the goats are an important economic livelihood of farm families in rural areas in México [1].

One of the factors influencing the efficiency of these production systems is the beginning of the reproductive activity of female goats. The age wing puberty, it has a huge impact on efficiency productive, reproductive and economic in goats by influencing the number of pups per female along its life time [4]. Puberty is defined as the manifestation of reproductive capacity, expressed in the animal's ability to ovulate an oocyte capable of being fertilized, accompanied by the expression of estrus and the later development and maintenance of a corpus luteum of length normal. Puberty is characterized by the development of the axis reproductive (hypothalamic-pituitary-ovarian) and the metabolism general of the animal. These changes happen gradually they are associated with variables production as are body weight, the amount of adipose tissue expressed in body condition, genetics of the animal and modifications endocrinological in the axis hypothalamic-pituitary-ovarian [5]

Puberty starts when they reach 60-75% of their mature body weight, as long as it is in a favorable breeding season. If the time of puberty coincides with the period of stationary anestrus, this start will be delayed until the next breeding season, with negative repercussions on the productivity of animals [6].

Goats are in a biological possibility to start their ovarian activity accompanied with the first estrus at 27 weeks of age with a body weight of 22.2kg [7]. However some researches reported that goats in mexican subtropics born in January and May begin their ovarian activity in September and December of the same year of his birth with an average live weight of 27kg [8], this indicates a pronounced effect of seasonality due the month of birth on the initiation of ovarian activity, but if it this is postponed by is extended to 18 to 20 months of age. Also if one considers that feeding goats in rural areas of Mexico it is based primarily on grazing and agricultural wastes, which is reflected in their body condition expressed in a pronounced start of the ovarian activity [2].

The shift from a prepubertal state to one pubertal considers marked changes in the function of axis hypothalamic-pituitary-gonadal. Before puberty, the

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secretion of Gonadotropin Releasing Hormone (GnRH) is inactive. To the onset of puberty, the release of GnRH is activated, the levels of the gonadotropic hormones Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH) are gradually increased by stimulating the development and maturation of follicles well as estrogen production in the ovaries [9], [10].

Before puberty, the system for feedback negative of steroids ovarian is particularly active, however, according advances stage pubertal the signal feedback positive of the steroids and highly efficient, observed, usually the establishment of an ovarian activity normal at the end of said step [11], [12]. The progesterone endogenous or exogenous plays a role in determining the capacity steroidogenic of follicles developing, by increasing production of estrogen of which participate in the development follicular end and ovulation [13]-[15].

The implementation of technical intensification of reproductive management, the use of hormonal protocols for reproductive control can offer advantages such as; shorten the reproductive seasonality, increase the productive life of the animal, improve fertility, group deliveries getting homogeneous lots of kids [16].

Progestogens constitute a group of hormones through which you can manipulate the estrous cycle of the goat, within this group Melengestrol Acetate (MGA) is located, is a synthetic progestational oral steroid used as a growth promoter [17] and to induce and synchronize estrus and ovulation [18]-[20] for their ability to inhibit estrus conduct, plus it is an extremely efficient, convenient and inexpensive method, ideal for rural goat production systems that will improve their reproductive and productive rates.

The purpose of any production system focused on the production of food is to use to animals destined for breeding as soon as possible, for the purpose of accelerate the onset of puberty and increase its life by reducing their production costs. In heifers a administration of progestins synthetic during the period pre-pubertal induced puberty [21], [22], in lambs are prepubertal administering a dose of 0.25 mg of MGA for 12 days, induction and accelerated development follicular up to phase pre-ovulatory, presenting puberty at 9 months of age [23]. In small ruminants is suggested than under practical conditions the administration of synthetic progestins like the MGA must be at 7 months or more of age and when the animals reach 60% of their adult weight for get a better response in the induction of ovarian activity and therefore in the induction and synchronization of oestrus.

Therefore, the aim of this study was to evaluate the effect of a prolonged treatment (46 days) with Melengestrol Acetate (MGA) in pre-pubertal goats on the induction of ovarian activity, induction and synchronization of estrus and pregnancy rate.

II. Material and Methods

10 pre-pubertal Saanen goats 9 months of age, body condition of 2.1±0.32 (scale 1-5), live weight of 30.44±1.93kg, height of 2.69±62.1cm were used. The goats were dewormed and vitaminized one month before the start of the experiment. The treatment consisted on the administration of 0.22mg/goat/day of MGA orally, for 46 days. All goats received the same management and were fed with a calculated diet based on a concentrate, ground corn stover, molasses and oil (DM 90.90%, EE 3.43%, CF 24.04%, CP 16.84%, ashes 5.73% y NFE 49.95%).

Before treatment an evaluation of ovarian activity was performed rectally using an Ultrasound in mode B (Draminski, profi animal model) equipped with a 7MHz sector scanner transducer to determine whether goats presented or not follicular structures. During treatment ovarian activity was evaluated on days 15, 30 and 45 for the presence or absence of follicles.

Once the treatment was concluded the sire was introduced into the corral with the goats and estrus was detected during 10 days post-treatment. The gestation diagnosis was performed 45 days after breeding by transabdominal ultrasound using a transducer with 3.5 and 5MHz. Data was analyzed using descriptive statistics techniques.

III. Results

During treatment, weight, height and body condition of goats was increased up to 38.1±3.48kg, 67.3cm and 3.1±0.21 BC respectively at 10 months of age. In the days of ovarian activity evaluation the 10 goats presented follicle development: in the right ovary was observed an average of 9.66<4mm and 9.33≥4mm and in left ovary 11.33<4mm and 9.66≥4mm, without the presence of corpus luteum (Table I).

TABLE I. Number of Follicles and Corpus Luteum during Treatment with MGA

Day	Right Ovary			Left Ovary		
	Follicle <4mm	Follicle ≥4mm	Corpus luteum	Follicle <4mm	Follicle ≥4mm	Corpus luteum
15	10	9	0	7	12	0
30	11	10	0	12	14	0
45	8	9	0	12	8	0

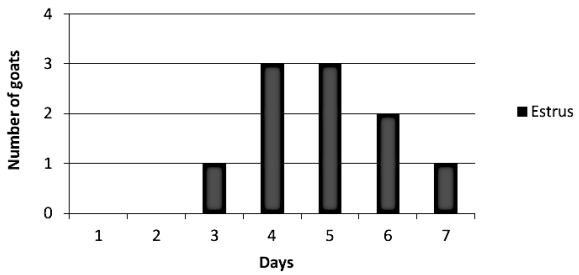

Figure 1. Distribution of presentation of estrus by oral post-treatment with MGA

The 10 goats presented estrus within a period of 5 days (from day 3 to 7 post-treatment). The presence of estrus was greater on days 4 and 5 (Fig. 1).

The percentage of goats in gestation was 90%.

IV. Discussion

Despite the nutritional content of the diet during the treatment, the goats did not reach the ideal first serve size:

70cm [24] or 70-75cm [25], due to the traditional system of production characterizing rural areas of goat production in México and the late onset of supplementation of the diet; however, weight gain was adequate, by showing a balance expressed in a body condition score of 3.1±0.21 (scale 1-5) [8], [26].

During treatment with MGA follicles of different sizes were observed, similar results observed [23] in pre-pubertal ewes, who to the administer a dose of 0.25 mg of MGA for 12 days, observed that MGA induces and accelerates development follicular up to the phase pre-ovulatory, presenting puberty at 9 months of age. The results in both studies can it be explained due to the administration of synthetic progestins like the MGA plays a role in determining the capacity steroidogenic of follicles developing, by increasing production of estrogen of which participate in the development follicular end and ovulation

During treatment none of the goats ovulated, indicating that the dose of 0.22mg/goat/day of MGA administered over a prolonged treatment was sufficient to suppress ovulation, and corpus luteum was not observed during the treatment. Previous researches indicates that an appropriate dose of the progestogen reduces the release of Releasing Hormone Gonadotropin (GnRH), which in turn decreases the production of Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH), but does not suppresses it, so follicular development is presented until it reaches a dominant follicle [27]; this follicle does not ovulate because of the lack of the preovulatory LH peak, but does not suppress FSH secretion, which explains the development of follicles [28].

The same study reported that the dose 0.22mg/ewe/day of MGA during prolonged treatment, suppresses ovulation without affecting follicular dynamics, allowing normal follicular development in waves [27]. The results obtained in this study with the same dose (0.22mg/animal/day) was able to induce ovarian follicular development and maintained it in pre-pubertal goats 15 days after treatment initiation, suppressing ovulation during the 46 days of treatment with MGA.

After treatment with MGA concluded and before the goats were 11 months age, 100% of them expressed estrus in a short period of 5 days from day 3 post-treatment. This must to the discontinue treatment with MGA it is eliminated the blocking of peak GnRH and therefore the peak of LH what triggers the process hormonal characteristics of the cycle estrous, allowing he development follicular up to stage final (follicle pre-ovulatory) and ovulation [27].

These results are similar to those obtained by other researchers [29] who used 37 ewes in an equal dose of MGA, where they found estrus percentage of 90%, which makes evident the dose efficiency of 0.22mg per animal for induction and synchronization of estrus. Meanwhile, some authors [30] used a similar dose of MGA to that of this study (0.25mg/goat/day) for 10 days in 22 goats and found that 84% of the goats presented estrus.

To evaluate the effect of MGA on the induction of estrus in ewes in an anestric stage, used a dose of 0.45mg of MGA/ewe/day orally for 17 days, observed that 100% of MGA treatment ewes presented estrus, which makes evident that the administration of MGA during prolonged [31] treatment as administered in this study is effective in inducing and synchronizing estrus.

Some researches report that when using a dose of 0.22mg of MGA in combination with an intramuscular injection of 300 IU of Pregnant Mare Serum Gonadotrophin (PMSG) for nine days, 100% of the animals presented estrus [32].

In a different research which used a low dose of 0.125mg MGA for 9 days, observed in 286 ewes that the response to the presentation of estrus was 62%, and when the same dose was administered for 12 days in 130 ewes observed that the response to the presentation of estrus was 89% [19]. This indicates that the response to the presentation of estrus is associated with the duration of the treatment.

The response obtained in goats to the treatment with MGA to induce follicular development and synchronize estrus in pre-pubertal goats under a traditional management in rural areas in México was acceptable, before the goats reached the age of 11 months were served by the sire. Commonly in rural areas in México, the goats get to have a healthy weight for their first service at a late age (18-20 months), because their feed is based mainly in corn stover; well as grazing on rangeland, disassembled mountains and roadside, for at that nutritional supplementation in this sector is scarce or absent, therefore impacts on that animals do not reach the proper weight and size [1], [8] and therefore delays the start of activity ovarian (puberty).

The high pregnancy rate (90%) was higher than that reported by other authors [31] who obtained a pregnancy rate of 70% in hair sheep, which were administered a dose of 0.45mg MGA during a prolonged treatment (17 days), using a dose of 0.5mg MGA for 10 days in goats a fertility rate of 74% was achieved [33], and with a dose of 0.4mg of MGA for 12 days a fertility rate of 45% was obtained [34]. For its part [17], in ewes to the administering a dose of 0.125 mg of MGA during 12 days, they obtained a rate fertility of 41%. These results may be due to peripheral levels of progesterone is it endogenous or exogenous regulating the patterns of growth follicular through of the feedback negative towards pulsatile secretion of LH [35]. When are administered doses high of MGA the suppression of LH it can be so intense that decreases their concentration and it has an effect negative in recruitment and development follicular; when are administered doses low, it is generated an increase in the frequency of pulses of LH which increase your concentration and triggers the development of follicles persistent [36]-[38], in both cases it is affects directly the rate fertility

In a study in goats [30], at administer a dose of MGA similar (0.25mg) to this work during 10 days; they obtained a pregnancy rate of 58%. This result may be due to treatment duration was for a short period compared with of this research work it was during a long period, since in animals that are found with activity ovarian, the

administration of progestogen synthetic s like the MGA it must be greater or equal to the average life of the corpus luteum (goats of 17 days) to permit occurs lysis of the corpus luteum naturally independently at the stage of the estrous cycle on which this takes place, since if the animal is found in follicular phase at initiation of treatment (proestrus, estrus) the progestogen blocks ovulation, so the corpus luteum is not formed. If you encounter on stage of metestrus the formation corpus luteum is altered shortening their average life. If the stage of the cycle the start of the treatment coincides with the dexterous, the corpus luteum suffers luteolysis at the time that corresponds naturally without being affected by the treatment and finally if the animal is found in anestrous or at the stage pre-pubertal is induced activity ovarian (development follicular) as it was observed in this study [39].

Hence, the dose of MGA used in this study it proved to be efficient for inducing development follicular for his role in the determination of the capacity steroidogenic, induce and synchronize estrus by their ability to inhibit peak GnRH and LH during treatment obtaining a percentage of fertility high, representing a strategy reproductive to maximize goat production rural areas in Mexico.

V. Conclusion

It's concluded that the use of MGA at a dose of 0.22mg/animal/day in pre-pubertal goats during a prolonged treatment of 46 days, induces follicular development, estrus synchronization and a high percentage of fertility by natural mating is obtained, which represents a viable alternative for the development of goat raising in rural areas of México, since this activity is still a very important economic livelihood of farming families.

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References

[1] M. M. Guerrero. (July 2010). La caprinocultura en Mexico, una estrategia de desarrollo. *Revista Univercitaria de Cincias Sociales RUDICS*. [Online]. 1(1), pp. 1-7. Available: http://www.cuautitlan.unam.mx/rudics/ejemplares/0101/pdf/art06.pdf

[2] E. Sánchez, L. M. Wurzinger, M. P. López, F. S. Homero, and S. J. Iñiguez, "La cabra y los sistemas de producción caprina de los pequeños productores de la comarca lagunera, en el norte de México," *Revista Chapingo*, vol. 17, pp. 235-246, April 2011.

[3] J. Arroyo, "Estacionalidad reproductiva en ovejas," *Tropical and Subtropical Agroecosystems*, vol. 14, pp. 829-845, April 2011.

[4] C. P. Bagley, "Nutritional management of replacement beef heifers: A review," *Journal of Animal Science*, vol. 71, no. 11, pp 3155-3163, 1993.

[5] M. Maquivar, "Estrategias nutricionales y hormonales para la inducción a la pubertad en vaquillonas de carne y su impacto en la fertilidad," *Sitio Argentino de Producción Animal*, vol. 13, no. 52, pp. 4-33, September 2011.

[6] E. S. E. Hafez and B. Hafez, *Reproducción e Inseminación Artificial en Animales*, 7th ed., México: McGraw-Hill Interamericana, 2002, pp. 1-519.

[7] K. Sakurai, S. Ohkura, S. Matsuyama, K. Katoh, Y. Obara, and H. Okamura, "Body growth and plasma concentrations of metabolites and metabolic hormones during the pubertal period in female shiba goats," *Journal Reproduction Development*, vol. 50, no. 2, pp. 197-205, April 2004.

[8] J. A. Delgadillo, M. A. D. Santiago, and E. Carrillo, "Season of birth modifies puberty in female and male goats raised under subtropical conditions," *Animal*, vol. 1, no. 6, pp. 858-864, July 2007.

[9] I. E. Messinis, "From menarche to regular menstruation: Endocrinological background," *Annals of the New York Academy of Sciences*, vol. 1092, no. 1, pp. 49-56, Jan. 2006.

[10] S. R. Ojeda, *et al.*, "Neuroendocrine mechanisms controlling female puberty: New approaches, new concepts," *International Journal of Androlog*, vol. 29, no. 1, pp. 286-290, February 2006.

[11] E. Teresawa, "Role of GABA in the mechanism of the onset of puberty in non-human primates," *International Review of Neurobiology*, vol. 71, pp. 113-129, June 2005.

[12] J. Clarkson and A. E. Herbison, "Development of GABA and glutamate signaling at the GnRH Neurin in relation to puberty," *Molecular and Cellular Endocrinology*, vol. 254-255, pp. 32-38, July 2006.

[13] S. Atkinson, N. R. Adams, and G. B. Martin, **"**Role of progesterone in ovarian follicular growth and development in the sheep," *Animal Production in Australia*, vol. 22, pp. 233-236, July 1998.

[14] M. Endo, K. Kimura, T. Kuwayama, Y. Monji, and H. Iwata, "Effect of estradiol during culture of bovine oocyte-granulosa cell complexes on the mitochondrial DNA copies of oocytes and telomere length of granulosa cells," *Zygote*, vol. 22, no. 4, pp. 431-439, December 2014.

[15] N. Kubo, I. S. Cayo-Colca, and T. Miyano, "Effect of estradiol 17β during *in vitro* growth cultura on the growth, maturation, cumulus expansion and development of porcine oocytes from early antral follicles," *Animal Science Journal*, vol. 86, no. 3, pp. 251-259, June 2015.

[16] I. A. L. Cordoba, G. Ruiz, O. J. Saltijeral, G. F. Pérez, and D. T. Degefa, "Inducción y sincronización de celo en ovejas criollas anestricas estacionales con esponjas vaginales impregnadas en FGA y PMSG inyectadas," *Revista Archivos de Zootecnia*, vol. 48, no. 184, pp. 437-440, March 1999.

[17] B. Schiffer, "Mobility of the growth promoters trembolone and melengestrol acetate in agricultural soil: Columnstudies," *Science of the Total Environment*, vol. 326, pp. 225-237, June 2004.

[18] G. Perry, W. V. Welshorns, and M. F. B. Smith, "Basis of melengestrol acetateaction as a progestin," *Domestic Animal Endocrinology*, vol. 2, no. 28, pp. 147-161, February 2005.

[19] E. Emsen, D. C. Giménez, M. Kutuca, and F. Koycegiz, "Reproductive response of ewes synchronized with different lengths of MGA treatments in intrauterine insemination program," *Animal Reproduction Science*, vol. 126, pp. 57-60, June 2011.

[20] G. Salas, J. A. Rojo, E. Gutiérrez, A. Juárez, R. Garcidueñas, and J. L. Espinoza, "Follicular dynamic in ewes during Melengestrol Acetate (MGA) treatment," *International Journal of Bioscience, Biochemistry and Bioinformatics*, vol. 3, no. 4, pp. 360-362, July 2013.

[21] P. Gonzalez, E. R. Ruiz, D. Lefever, A. Denham, and J. N. Witbank, "Puberty in beef heifers. III. Induction of fertile estrus," *Journal of Animal Science*, vol. 40, no. 6, pp. 110-1118, June 1995.

[22] R. E. Short, R. A. Bellows, J. B. Carr, R. B. Staigmiller, and R. D. Randel, "Induction synchronized puberty in heifers," *Journal of Animal Science*, vol. 43, no. 6, pp. 1254-1258, December 1996.

[23] E. Ebru, A. Csrlos, and G. Diaz, "Melengestrol Acetate (MGA) induced puberty in Awassi ewe lambs," *Journal of Animal and Veterinary Advances*, vol. 4, no. 6, pp. 570-571, 2005.

[24] R. F. Duran, *Manual de Explotación y Reproducción en Caprinos*, 2nd ed., Grupo Latino de Editores, 2007, vol. 1, pp. 203-206.

[25] B. Cofre, *Producción de Cabras Lecheras*, 1st ed., Chillán, Chile: INIA, 2001, vol. 66, pp. 1-200.

[26] A. Salvador, I. Contreras, G. Martínez, and M. Hahn, "Relación entre el peso corporal, medidas corporales y edad en el crecimiento de caprinos mestizos canarios desde el nacimiento hasta el año de edad en el trópico," *Universidad Central de Venezuela*, vol. 27, no. 3, pp. 299-307, September 2009.

[27] G. Salas, J. A. Rojo, R. Garcidueñas, and J. L. Espinoza, "Effect of an intermediate dose of Melengestrol Acetate (MGA) on

ovulation inhibition in ewes," *International Journal of Bioscience, Biochemistry and Bioinformatics*, vol. 4, no. 3, pp. 171-174, May 2014.

[28] E. C. L. Bleach, R. G. Glencross, and P. G. Knight, "Association between ovarian follicle development and pregnancy rate in dairy cows undergoing spontaneous estrous cycles," *Reproduction*, vol. 5, no. 127, pp. 621-629, May 2004.

[29] T. Q. Quispe, Q. L. Zarco, H. A. Ortiz, and M. J. Valencia, "Sincronización de estros en ovejas mediante un tratamiento cortó con Acetato de Melengestrol (MGA) combinado con cipionato de estradiol (ECP)," *Revista Veterinaria México*, vol. 26, no. 1, pp. 23-28, October 1995.

[30] D. J. Jackson, C. M. Fletcher, D. H. Keisler, and N. C. Whitley, "Effect of Melengestrol Acetate (MGA) treatment or temporary kid removal on reproductive efficiency in meat goats," *Small Ruminant Research*, vol. 66, pp. 253-257, November 2006.

[31] G. Salas, F. Mata, M. Perea, R. Garciduenas, E. Gutiérrez, A. Caratachea, and J. P. Flores, "Estrus grouping in sheep treated with Melengestrol Acetate (MGA)," *Journal of Agricultural Science and Technology*, vol. 1, pp. 1295-1296, December 2011.

[32] L. Álvarez, W. A. Ducoing, Q. L. Zarco, and G. A. Trujillo, "Conducta estral, concentraciones de LH y función lútea en cabras en anestro estacional inducidas a ciclar mediante el contacto con cabras en estro," *Veterinaria México*, vol. 30, no. 1, pp. 25-31, February 1999.

[33] J. N. Valenzuela, C. J. Hernández, M. C. Murcia, M. R. Rodríguez, and C. G. Gutiérrez, "Efecto del benzoato de estradiol en la presentación del pico preovulatorio de LH, momento de ovulación y fertilidad en cabras sincronizadas con acetato de melengestrol," *Agrociencia*, vol. 38, no. 6, pp. 603-311, October 2004.

[34] F. Castonguay, G. Leduc, and Goulet, "Use of melengestrol for estrus synchronization in an artificial insemination program in ewe," *Journal Animal Science*, vol. 80, no. 1, pp. 268-269, July 2002.

[35] C. Viñoles, M. Forsberg, G. Banchero, and E. Rubianes, "Effect of longterm and short-term progestagen treatment on folicular development and pregnancy rate in cylic ewes," *Theriogenology*, vol. 55, no. 1, pp. 993-1004, March 2001.

[36] F. M. Rhodes, C. R. Burke, B. A. Clark, M. L. Day, and K. L. Macmillan, "Effect of treatment with progesterone and oestradiol benzoate on ovarian follicular turnover in postpartum anoestrous cows and cows which have resumed oestrus cycles," *Animal Reproduction Science*, vol. 69, no. 3-4, pp. 139-150, June 2002.

[37] M. G. Colazo, R. J. Mapletoft, M. F. Martínez, and J. P. Kastelic, "El uso de tratamientos hormonales (MGA) para sincronizar el celo y la ovulación en vaquillonas," *Ciencia Veterinaria*, vol. 9, no. 1, pp. 4-16, April 2007.

[38] A. J. Ruiz, M. E. Carballo, J. E. Anta, C. J. Díaz, and A. A. Kably, "Utilidad de las concentraciones de la hormona luteinizante para determinar la calidad ovocitaria," *Ginecol Obstet Mexico*, vol. 73, no. 4, pp. 28-35, January 2005.

[39] C. Galina and J. Valencia, *Reproducción de Animales Domésticos*, 3rd ed., Mexico: Limusa, 2015, pp. 1-578.

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