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Recent advances on synchronization of ovulation in goats, out of season, for a more sustainable production

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ABSTRACT

Goats show marked progressive seasonal reproduction at latitude > 25 ° and reproductive management should be adapted to market demands. The present review aimed to discuss the synchronization of ovulation for timed artificial insemination concerning new insights regarding a clean, green and ethical meat and milk production. Today, the induction of ovulation during breeding season or transitions periods is mainly based on progestagens/progesterone (P4) devices intravaginally inserted on females, at least during 11 days, plus equine chorionic gonadotropin (eCG) and prostaglandin F2 alfa administration. In last years a reduction to 20 mg of fluorogestone acetate was made and the successful reutilization of devices containing 0.3 g of P4 indicates a possible reduction of their levels. Shortening the period of exogenous progestagens/P4 priming (5 to 7 days) is critical for a rational use of hormones. Moreover, the eCG exchange by socio-sexual cues (male effect) seems to see a great advance, even if a previous photoperiod treatment, or equivalent method, being necessary in high latitudes. Research trends on these subjects are expected in future using different goats breeds in distinct regions of world.

1. Introduction

Goats, as well ewes, are spontaneously ovulating and commonly considered as seasonally polyestrous animals under temperate climatic conditions[1]. The photoperiod is one of the major factors that influence the reproductive activity in small ruminants[2,3]. Gradually, from subtropical regions to higher latitudes, most of local breeds show successive alternated breeding and non-breeding (anoestrous) seasons. This particularity have a great impact on reproductive and production management of flocks[1] and can imply different approaches between regions from different latitudes, breeds and seasons according meat and milk market demands during whole year.

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The artificial insemination is a major vehicle for genetic improvement of animal breeds and a reproductive management tool for farmers[4]. Females are normally inseminated following the hormonal synchronization of ovulation in flocks[5,6]. In the last decades, synchronization of ovulation protocols, out of season, are commonly based on controlled internal drug release (CIDR) or intravaginal polyurethane sponges impregnated with progesterone (P4), or their synthetic analogues (progestogens) mainly medroxyprogesterone, melengestrol and fluorogestone acetate forms, plus equine chorionic gonadotropin (eCG) and prostaglandin F2 alfa (PGF2) or even estrogenic pharmacologic active substances[6−12]. These protocols are dependent of country availability of licensed hormones [12,13].

The kidding rate can reach 65% after timed artificial insemination with frozen straws (100 × 10^6 spermatozoids/0.2 mL) in goats presenting estrus following a 11-day progestagen priming + eCG + PGF2 protocol and inseminated 43 to 46 hours after sponge withdrawal[14,15]. This fertility rate can be obtained during anoestrous season in regions with high latitude and mainly on

intensive dairy herds. Moreover, the possibility to use of sex-sorted spermatozoa in goats was also recently reported[16]. However, other worldwide extensive and semi-extensive production systems, concerning milk and/or meat products[17], also can profit with these reproductive tools, which should be adapted to the different local realities.

Today, the redesigning animal production systems for sustainable agriculture with a lower environmental impact and the adaptation to new hazards, such as the global climate changes, are significant challenges[18]. Animal welfare focused in reproductive management, should be also improved[19].

The use of hormones in animal production was strictly regulated, from last two decades, in several countries. For example, in European Union (directives 96/22/EC, 2003/74/EC and 2008/97/EC) the use of oestradiol 17 β (E2) in food-producing animals was banned and P4 utilization was limited, reducing hormones residues on food chain and environment, with potential benefices for public health. Consequently, a decrease from 45 mg to 20 mg of fluorogestone acetate in each sponge was approved, without apparent negative impact on goat fertility[20].

Due to the advent of the ultrasonography and molecular endocrinology as tools, animal welfare improvement and fertility increment of flocks, minimizing economic expanses, several researches were focused to shorten the duration period of intravaginal progestagen/ P4 device exposition from 11 or more days to 5-7 days in females[21], reutilize the intravaginal devices[22,23] or reduce the oxidative stress due to the device contact with the vaginal mucosa[24]. However, recently, a great attention was done to knowledge concerning the natural stimulations of ovulation, especially socio-sexual cues such as the male effect t[25] and even the female effect[26].

In the present paper, we discussed more significant recent advances concerning the synchronization of ovulation with potential impact on reproduction management systems, during the anoestrous season, at the specific goat reproduction contexts. The ultimate purpose was demonstrate that the lucid use of P4 or progestogens and male effect as a tool can achieve good practices of reproductive management in goats, compatible with a sustainable production.

2. Reproductive seasonality and anoestrous season

Goats and ewes are species presenting a reproductive seasonality, mainly according genotypes[27,28] and photoperiod stimulation[3,27,28]. Most of breeds originated from Latitude > 35° North or South and someone's in subtropical region, located between Latitude 35° and 25°, show a breeding season[15]. Toward to tropical regions, the reproductive seasonally of local small ruminants tends to disappear[29,30] and other factors, such as nutrition and environmental thermic stress (or other stressors), take place[31]. However, Delgadillo *et al*[25] recently observed that the continuous presence of sexually active bucks can prevent the display of seasonal anestrus of goats in Mexico (L 26° N). According these researchers, further studies are need in order to clarify the degree of the photoperiodic influence and other non-photoperiodic environmental factors, especially socio-sexual cues, on seasonality of goats.

At latitude > 45° N (temperate and polar regions), the onset of the breeding and non-breeding seasons of local breeds occur at the end of January/February/early Mars and late August/ September/early October presenting a transition period between seasons[1,32]. From Mars to September all goats remain without ovulatory activity[27]. In hemisphere south, anoestrous season occurs between October and January, like the reported by Rivera *et al*[33] in Argentina (L 30° S).

The annual patterns of reproduction activity is related with spring and winter solicits causing a progressive variation of daily light/dark duration. Light signals were detected by retina and processed by suprachiasmatic nucleus; signals arrives by sympathetic neurons via to pineal gland which produces melatonin, a key hormone, during short days/ darkness periods[35-37]. A neuronal network mediated by neurotransmission (dopamine, serotonin and other amino acids) is stimulated by melatonin in order to modulate the hypothalamic secretion of gonadotropin-releasing hormone (GnRH)[37]. There are several evidences that these photoperiod variations entraining an endogenous circannual rhythm, and the end and onset of breeding season were due to refractoriness to short and long days, respectively, entraining a circannual endogenous rhyming[38-40]. Is necessary approximately 40 days for the (re)stimulation of luteinizing hormone (LH) pulse activity by melatonin[41], but can reach approximately 66 days according breeds[42].

Chemineau *et al*[41] observed an increase of frequency and amplitude of LH secretion toward the breeding season, in Saanen goats, but the low plasmatic E2 levels remained constants suggesting a decrease of hypothalamic/pituitary sensibility to their inhibitory effects. The GnRH secretory neurons represents the output of the neural network responding to homeostatic and environmental stimulus which regulate the pituitary LH and follicle-stimulating hormone (FSH) secretion and both P4 and E2 hormones are also related with this system[43].

Above Latitude < 45° N, the anoestrous intensity, i.e. the degree of hypothalamic–pituitary-gonadal axis inhibition, indirectly measured during the non-breeding season according the percentage of females presenting spontaneous ovulations, gradually decrease[44]. The percentage of spontaneous ovulations were very well characterized in Blanca Andaluza goats by Gallego-Calvo *et al*[45] in Spain (L 37° N; Figure 1) and contrast with the 0% of spontaneous ovulations observed in France[27]. The anoestrous season is shortened, approximately from February/Mars to August like the reported in goats and ewes by some researchers[46,47], but a variable percentage of goats can ovulate before (June and July)[47], including during whole non-breeding season[45].