

Photoperiod and its relationship to sheep reproduction

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ABSTRACT

Objective: To describe the seasonal variations throughout the year (day length), as one of the main environmental cues used by ewes to determine the most favorable time for breeding.

Design/methodology/approach: A description of the main factors affecting ewe reproduction (photoperiod, suckling, postpartum period, nutrition, sociosexual effects) was assessed by a review of documentary information.

Results: The inhibition of reproductive activity during one time of the year is a common process in most animal species to prevent births from occurring at an unfavorable time for the survival of the offspring. The seasonality of reproduction (northern latitude) allows births to occur in late winter or early spring when climatic conditions are the most favorable for the offspring development.

Limitations/implications: The duration of the anestrus season (seasonal or postpartum) is influenced by the photoperiod and other factors. In Mexico, a small percentage of Criollo and Pelibuey ewes show a short duration of seasonal anestrus; that is, they show almost continuous annual reproductive activity. Therefore, to improve the reproductive efficiency of ewes, it is important to precisely determine the factors that affect their reproduction to improve management and increase the profits in the production units.

Findings/Conclusions: Photoperiod is the main environmental factor regulating the annual reproductive cycle of the ewes, it occurs through very complex and varied mechanisms that communicate the visual system with the gonads through nervous and endocrine pathways.

Keywords: Photoperiod; seasonality; postpartum; reproduction; ewe; reproduction.

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INTRODUCTION

In sheep, a change from long days (spring) to short days (fall) initiates the reproductive season, the change from short to long days initiates seasonal anestrus (Martin, 2003). Photoperiod is one of the most important environmental factors in a herd's reproductive



management. It controls reproductive physiology through the light captured by the retina and transmitted to the pineal gland (Figure 1), which secretes melatonin in response, at a production rate high at night and low during the day (circadian). The duration of melatonin secretion coincides with the duration of the night and together with estradiol (E) regulates the pulsatile secretion of gonadotropin-releasing hormone (GnRH), which causes changes in the pulsatile secretion of luteinizing hormone (LH) and is responsible for ovulation or non-ovulation (depending on the time of year; Karsch *et al.*, 1984); however, melatonin does not act directly on GnRH-producing neurons, which involves the dopaminergic, serotonergic and excitatory amino acid systems (Malpaux *et al.*, 1999).

In sheep, reproduction is seasonal and is characterized by the alternation of a period of seasonal anestrus, which, at northern latitudes, occurs between spring and summer, and a period of reproductive activity that occurs in autumn and winter. It is important to mention the latitude effect: the higher the latitude, the longer the seasonal anestrus (photoperiod). For example, some European breeds, which develop in latitudes above 60° N, have reproductive activity between November and February, and in latitudes close to 35° N they have anestrus between March and June (Gómez-Brunet and López-Sebastián, 1991) and in tropical regions, where the variation of photoperiod is little (19° N), Creole

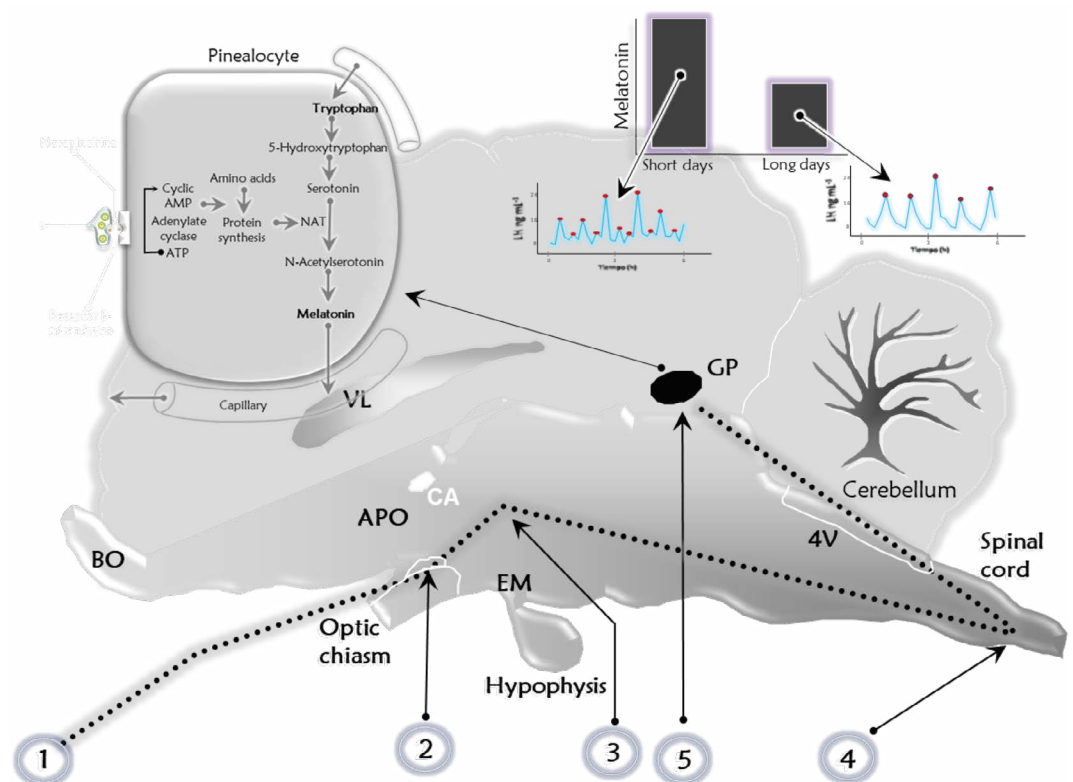


Figure 1. Schematic representation of a sagittal section of the sheep brain. The black dotted line represents the light information path of the eye (1) to the pineal gland (5) through the supraoptic nucleus (2), paraventricular nucleus of the hypothalamu (3) and the superior cervical ganglion (4). Preoptic area (APO), previous commissure (CA), lateral ventricle (VL), median eminence (EM), pineal gland (GP), olfactory bulb (BO), fourth ventricle (4V). Modified from Malpaux *et al.* (1997).

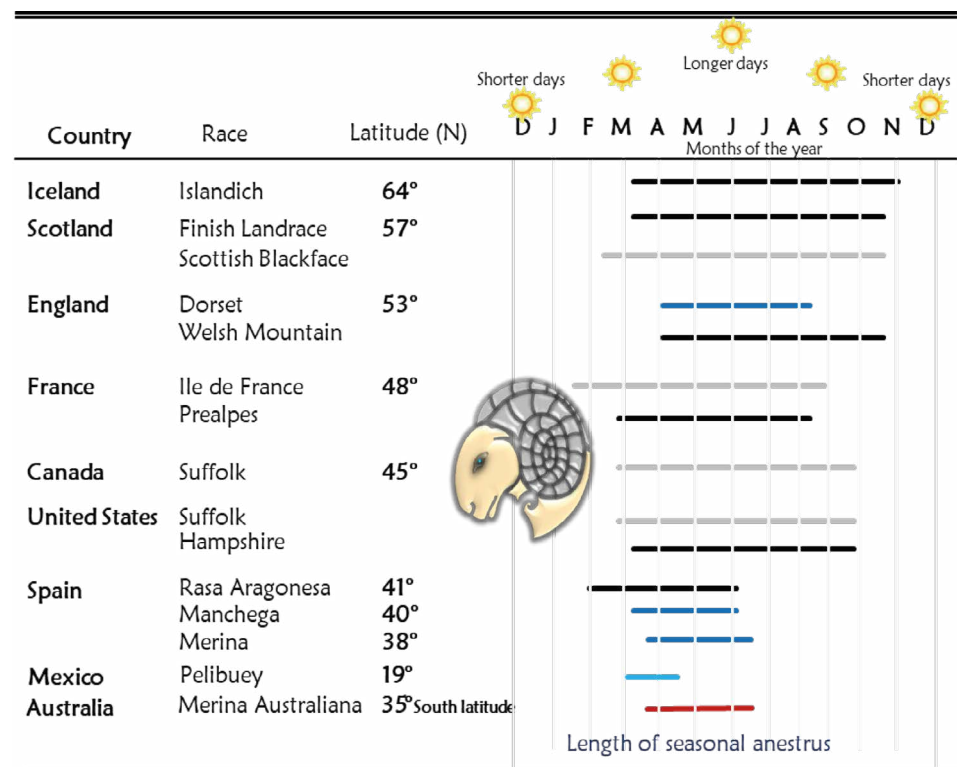
and hair sheep breeds maintain cyclic activity, almost all year round (Arroyo *et al.*, 2007; Arroyo, 2011). In tropical and subtropical regions (latitudes below 30°), there are other environmental factors that determine the reproductive activity of sheep, mainly those related to the rainy season (feeding), “norte” (north) climatic event and temperature.

Reproductive seasonality in sheep

Reproductive seasonality is a strategy to improve reproductive efficiency by matching the time of lambing with the most favorable time of the year, which is spring in northern latitudes, when temperature and food abundance maximize the offspring survival. It is known that photoperiod interacts with breed, postpartum anestrus, nutrition, sociosexual effects and other environmental factors to determine the ideal time to initiate reproduction.

Over time, many breeds have been selected with different reproductive characteristics depending on their place of origin. Many breeds have been and are selected to improve some productive variables such as ovulation rate, prolificacy, milk production, duration of seasonal anestrus, among others. For example, Table 1 shows the duration of the reproductive season in different breeds and different latitudes, it is observed that breeds originating from temperate latitudes (>35°) present a greater reproductive seasonality (López-Sebastián *et al.*, 2005) than breeds of Mediterranean or equatorial origin, which present a reduced seasonal anestrus and sometimes it is nonexistent (See Table 1; Porras, 1999; Valencia *et al.*, 2006; Arroyo *et al.*, 2007; Arroyo, 2011).

Table 1. Duration of the seasonal anestrus in sheep in relation to their breed and latitude (Modified from López-Sebastián *et al.*, 2005).



Modified from López-Sebastián *et al.* (2005)

Postpartum anestrus and its effect on reproduction

It is the period that elapses from the parturition until the female shows her first estrus. The duration of the postpartum period is one of the factors that determines reproductive efficiency and is conditioned by several interactions, among which are suckling, milk production, body condition, time of year at the time of parturition, uterine involution, breed, age and the presence or absence of the male (López-Sebastián *et al.*, 2005). In most sheep breeds located in temperate regions, the timing for lambing is largely determined by the photoperiod (Figure 2); meaning that, when lambing occurs late in the reproductive season, the duration of postpartum anestrus can be confused with seasonal anestrus, whereas when lambing occurs during the reproductive season, postpartum anestrus can last approximately 30 days (Amir and Gacitua, 1987). Also, it is known that if suckling is controlled (decreasing the contact of the calf with the dam), the postpartum anestrus duration in hair ewes decreases (Morales-Terán *et al.*, 2004). In addition, endocrine profiles during postpartum and the response to exogenously applied hormonal treatments in non-lactating ewes have been determined a phase of ovarian inactivity between approximately 21 and 25 days in duration (early postpartum) and a second phase of variable duration that is determined by the effect of continuous nursing have been observed; that is, the presence of the lamb delays the resumption of ovarian activity and its total or partial separation causes the manifestations of estrus and the first postpartum ovulation (Castillo-Maldonado *et al.*, 2013).

Endogenous opioid peptides (EOP's) are known to be released acutely or chronically during alertness periods, stress events and lactation in females; they are implicated in the inhibition of ovulation during the postpartum period, as they act together with E and GnRH-producing neurons, they cause a decrease in the frequency of secretion of GnRH/LH pulses. For example, continuous nursing causes a delay in the reestablishment of postpartum ovarian activity, inhibiting ovulation, compared to ewes lambing at the same time, but weaned (Pérez-Hernández *et al.*, 2009). Also, there is a direct relationship

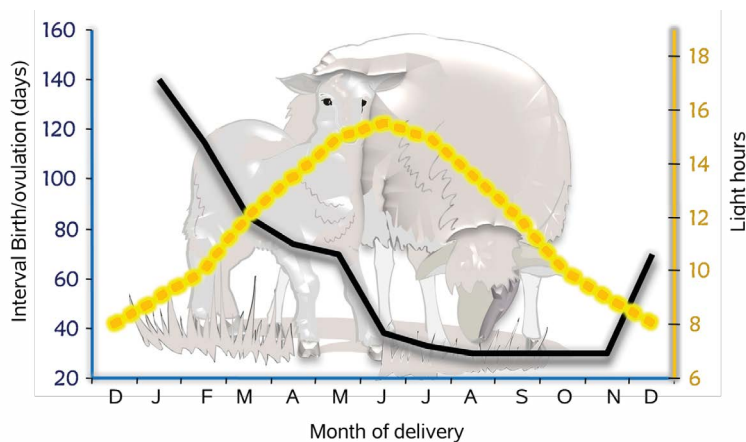


Figure 2. Interval between lambing and first ovulation according to the month in which lambing occurs in Manchego sheep (40° north latitude), it can be observed that ewes lambing in January (E) with approximately 9 hours of daylight per day, the duration of the post-lambing period is approximately 140 days (López-Sebastián *et al.*, 2005).

between the type of weaning, the intensity/frequency of nursing and milk production with the duration of postpartum anestrus (Gómez-Brunet *et al.*, 1992). The reestablishment of cyclic ovarian activity after parturition is frequently preceded by one or more short cycles (short half-life corpora lutea) with low progesterone secretion and ovulations without estrus manifestations (silent estrus). It is now known that normal progesterone concentrations during the luteal phase, are a requirement for the manifestation of estrous signs and occur in weaned females approximately between 20 and 25 days after parturition, in lactating females with controlled lactation (30 min in the morning and 30 min in the afternoon) approximately between 25 and 35 days postpartum and in females with continuous lactation the first ovulation occurs approximately between 45 and 55 days after parturition (Morales-Terán *et al.*, 2004).

In reproductive terms, and taking into account the age of the females at first lambing, the lambing-first estrus interval and lambing-first insemination, are variables that must be taken into account, mainly when analyzing ewe's reproductive efficiency. Some handling strategies can help to reduce the duration of anestrus (seasonal or postpartum), adequate feeding in the last third of gestation or targeted feeding (according to the physiological state of the ewe), early weaning, controlled nursing, avoiding losses of body condition at the end of the reproductive period, stimulating the ewe with the male effect (López-Sebastián *et al.*, 1984; Morales-Terán *et al.*, 2011) are easy to implement practices that reduce the calving interval and do not cause large extra capital outlays.

Nutrition and its effect on reproduction

Sheep feeding, from an economic point of view, is one of the variables that have the greatest impact on production costs, so that overfeeding has an additional cost, so using this strategy should provide maximum benefits to justify its use. Nutritional management (ration balancing based on the physiological state of the females) is a practice that improves the reproductive efficiency of the herd and guarantees efficient ration consumption (Martin *et al.*, 2004). However, it is difficult to dissociate the specific effect of nutrition on reproductive behavior from its effect on reproductive physiology and even more difficult to dissociate the effect of nutrition from the effect of photoperiod on the annual reproductive activity of sheep. For example, the presentation of puberty in ewes depends on their weight and age, in malnourished adult ewes, flushing increases the number of ovulations without the presentation of estrus and reduces the duration of the reproductive season. Yet, its effect is different and largely depends on the breed and photoperiod (long days) inhibits reproductive activity and so far, there is no dietary strategy to reestablish reproductive activity during seasonal anestrus without using exogenously hormones. The strategic use of feed supplements is employed as a tool in sheep production systems, implying that there is a positive correlation between the availability of supplements and the reproductive and/or physiological events that determine the success of a production unit. In such a way, that strategic feeding, refers specifically to feed supplements provided to sheep for a short period of time (3 to 7 days in females and in males from 6 to 8 weeks before mating) and that impact, mainly in a positive way, the reproductive and survival events of the animals and that ensures

a higher economic income for producers (Martin *et al.*, 2004; Martin and Kadokawa, 2006; Martin and Rosales-Nieto, 2014).

Other factors controlling reproductive activity

Humans, through time, have tried to control the environmental factors related to sheep reproduction, since herd's fertility depends on them and to a great extent, on the capability to define and manage those factors.

Temperature and its relationship to reproductive activity

The heat stress effects on animals and production are multifactorial and complex. Variations in temperature are known to have a direct effect on reproduction. For example, prolonged exposure to high temperatures inhibit reproductive activity in rams and ewes, inhibits estrus manifestations or reduces its duration if high temperatures occur at the end of the luteal phase (Maloney, 2003). It is clear that some aspects of heat balance are easier to manipulate than others and that manipulating the animal's response to heat to maintain adequate production can lead to positive feedback cycles (Maloney, 2003). Currently the effect of global warming (direct effects of heat) on animal production implies a negative effect on animal reproduction.

Sociosexual effects on reproduction

Sexual behavior appears during adult life, however, there is evidence that it may begin during the early life and incorporated into, what will be, the final organization (Kendrick *et al.*, 1998). The sudden introduction of rams to the ewe's pens during anestrus (seasonal or postpartum) induces ovulation, a phenomenon known as "male effect". If prior to mating, a group of ewes in estrus are introduced to the rams' pens, the ovulatory response of the ewes' during anestrus is enhanced, suggesting their estrus induction, through the produced pheromones, the reproductive behavior of the rams, which improves their ability to induce ovulation (female effect; Walkden-Brown *et al.*, 1999; Álvarez-Ramírez and Zarco-Quintero, 2001; Martin *et al.*, 2014). However, we must have certain considerations, mainly in natural environments, since reproduction and, in particular that of males, is not equally distributed among individuals in a herd, *i.e.*, dominant males, which are usually the best nourished and the strongest, have priority access to females in estrus (Preston *et al.*, 2003). Sexual behavior expressed by young males or females is less expressive than in adults. In addition, young males are clumsier in mounting females and getting them. Also, pregnant, young females are receptive for less time than adult ewes, however, the receptivity level is similar to that of adult ewes (Fabre-Nys and Venier, 1990). It has also been shown that contact of prepubertal males with females in estrus stimulates their activity (female effect; Price *et al.*, 1996). During sexual behavior displaying, there are other factors that can affect the reproductive efficiency of the production unit, such as the proportion of females (many) per male, avoiding contact between males and females during the development phase, the allocation of fixed spaces during development (unfamiliarity with other pens), the type of grazing area (topography) can have negative effects at the time of displaying all male's sexual behavior (Petherick, 2005).

CONCLUSIONS

The photoperiod is the main environmental factor regulating the annual reproductive cycle of the ewes, occurring through varied and complex mechanisms that communicate the visual system to the gonads through nervous and endocrine pathways. Annual physiological variations in the synthesis and secretion of hormones, neurotransmitters and metabolites influence the onset or termination of the reproductive season. Also, the length of the anestrus season (seasonal or postpartum) is influenced by breed, whether or not the ewe is lactating, the postpartum period, nutrition and sociosexual effects. In Mexico, a small percentage of Creole ewes and Pelibuey ewes have a short seasonal anestrus; that is, they show an almost continuous annual reproductive activity.

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