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Effect of photoperiod on the performances of Buffaloes: A review

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Abstract
Photoperiod is defined as the duration of light an animal is exposed to within a 24-hour period or more precisely the relative duration of light and dark that an animal experiences within a 24 h period. The light is received through eyes, stimulates retinal photoreceptors that transmit an inhibitory signal to the pineal gland for the secretion of melatonin through a series of an endogenous process via the retino-hypothalamic tract. The melatonin hormone plays a significant role in the regulation of the circadian as well as of the annual rhythms in many species, from the more primitive species to man. There is an association of photoperiod length with the growth of calves and heifers along with the mammary tissue growth in heifers. The manipulation of photoperiod during lactation and dry period can offer an effective, non-invasive approach to stimulate the productive performance of seasonal animals like buffaloes. Though buffaloes are polyestrous in nature, their reproductive efficiency varied throughout the year. Reproductive seasonality does not seem to depend on diet, food availability or metabolic status, while it depends on climate and particularly on the photoperiod. However, there is a dispute regarding the effect of supplementary artificial light and features as duration and intensity on all aspects of dairy animal's behavior.

Keywords: Buffaloes, photoperiod, melatonin, lactation, reproduction

1. Introduction
Photoperiod is defined as the duration of light an animal is exposed to within a 24-hours (h) period or more precisely the relative duration of light and dark that an animal experiences within a 24 h period. A long day photoperiod (LDPP) represents a light exposure period of 16-18 h and 6-8 h of darkness in 24 h; whereas a short-day photoperiod (SDPP) is characterized by a light exposure period of 8 h and 16 h of darkness in 24 h [1]. In another way, it can also be defined as the ability of the animals to measure the environmental day length (photoperiod), which is so-called "biological calendar". The biological ability to measure day length permits organisms to ascertain the time of year and engage in seasonally appropriate adaptations [2]. Light and dark elicit contrasting effects on the secretion of melatonin from the pineal gland, such that the circulating melatonin is virtually absent during light exposure but rapidly increases upon exposure to darkness [3]. The Pineal gland is able to measure day length and adjust secretion of melatonin, which inhibits the secretion of gonadotropic hormones, luteinizing hormone (LH), and follicle stimulating hormone (FSH) from the anterior pituitary by inhibiting the release of GnRH from the hypothalamus. The response to photoperiod or the relative duration of light and dark exposure within a day is the most commonly adopted environmental cue used by animals to predict changes and alter physiological responses to shift in their physical environment. The melatonin secretion drives differential secretion of other hormones to influence circadian and seasonal processes. Due to this, the physiological reaction of organisms to the length of day or night is known as the photoperiodicity.

2. Light
The light is the electromagnetic radiation ranging from about 390 to 740 nm in wavelength which stimulates sight and makes things visible. Its intensity or luminance describes a flow of light on a surface and is expressed in foot-candles (FC) or Lux (Lx; metric) (10.76 Lx = 1 FC). This unit has been replaced in the International System by the Candela (1 lumen per square meter). It is found that the performance of the lighting system for livestock farm depends on the light intensity or illumination level, photoperiod (duration), color characteristics etc. [4].

For a light period, the light intensity should be 15 FC (15-20 FC) at a level of 3 Ft height from the surface. However, the responses have been also observed at intensities as low as 10 FC, but extra 5 FC gives a buffer for dirty lamps, burned out bulbs, etc. During a dark period the intensity should not more than 1 FC [5]. In addition, 5-10 Lx (0.5 - 1 FC) illumination level can be used during dark period without affecting normal physiology of animals [6]. In general, the domestic animals can perceive light with an intensity of 5 Lx, but they can also acclimatize to lower intensities overtimes [1]. At night hours animals are generally able to find water and feed, so it is not necessary to keep lights on during the night, however, if animals are observed or moved at night, a low-intensity red light (7.5 - 15 W bulbs at 20 - 30 Ft interval) should be used [5].

3. Endogenous rhythms of light signal receptors

The light is absorbed through eyes, which stimulates retinal photoreceptors that transmit an inhibitory signal to the pineal gland for secretion of melatonin through a series of an endogenous process via the retino hypo-thalamic tract [3]. The light that is exposed to retina is first relayed to the suprachiasmatic nucleus (SCN) of hypothalamus, commonly known as mammalian "biological clock and then to pineal gland through paraventricular nucleus (PVN) of the hypothalamus. The signal from PVN leaves brain through intermediolateral cells (IML) of the upper spinal cord, and then through superior cervical ganglion (SCG) to reach destination site of the pineal gland [2]. The pineal gland secretes a number of hormones, but indoleamine melatonin is generally accepted as an active mediator of photoperiodic responses [3]. The pineal gland is able to measure day length and adjust secretion of melatonin accordingly and primarily secreted during night. Melatonin inhibits secretion of gonadotropic hormones, luteinizing hormone, and follicle stimulating hormone from the anterior pituitary by inhibiting the release of GnRH from the hypothalamus [7].

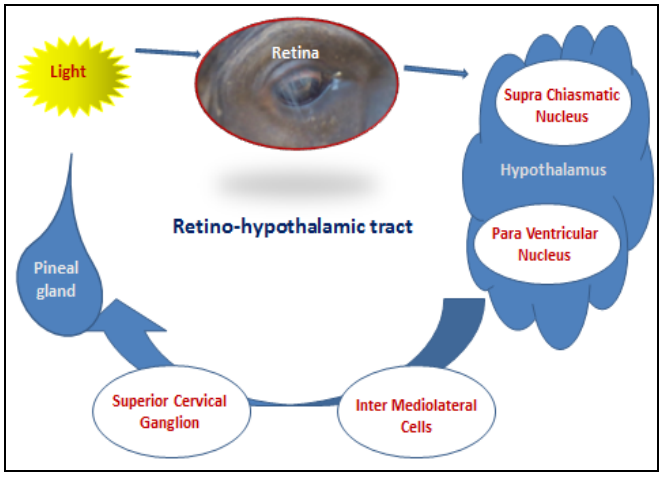

Fig 1: The retino-hypothalamic tract of melatonin secretion

4. Melatonin

Melatonin is a hormone of the brain, produced and stored in the pineal gland during the daytime and secreted during the dark, starting after sunset and ending at sunrise. Its secretion is the endocrine signal of the light-dark rhythm. The best-known role of melatonin in the regulation of circadian rhythm as well as the annual cycle in many species, from the more primitive to the man. In the endocrinology of ruminants, its role has been studied to induce ovarian cyclicity in seasonal animals such as goats and sheep, especially at higher latitudes [8]. Although buffaloes are polyoestrous, their reproductive efficiency shows wide variation throughout the year; in fact, buffalo cows exhibit a distinct seasonal change in displaying estrus, conception rate and calving rate [9]. It is reported that the reproductive seasonality does not seem to depend on diet, food availability or metabolic status, while climate and particularly photoperiod, depending on melatonin secretion, play a pivotal role [10, 11]. Borghese *et al*. [12] also reported the melatonin trend shows remarkable differences between seasons. In June at the summer solstice, the lowest values and less persistence of melatonin peak were found because of the shortest night, while the highest values were noted at the equinoxes, particularly in September, the month corresponding to the start of hypothalamus-pituitary-ovarian axis activity, in the Northern hemisphere. The heifers showed significantly higher values during the day than in cows and in September also during the night, probably because they were close to the onset of puberty [13]. These data suggest a relationship between photosensitivity and the seasonal reproductive trend in this species.

5. Effects on the performance of buffaloes

5.1 Effects on growth performance

The Photoperiod (PP) length is directly associated with the growth of calves and heifers, and also with the mammary tissue growth in case of heifers. The exposure of calves to long day photoperiod (LDPP) during growth phase yields larger, leaner animals at maturity. It is found that during early post-natal period (birth to 2 months) calves under LDPP had greater starter intake and average daily gain (ADG) before weaning and this effect is more pronounced after 4 weeks of age compared with calves under short-day photoperiod (SDPP) [1, 14, 15]. Kennedy *et al*. [16] have found that the Feed efficiency improved by 9% in CB beef heifers by extending photoperiod during the winter season. The Heifers exposed to LDPP (16-18 h) had greater growth and earlier onset of puberty [17]. The LDPP has been shown to promote mammary parenchymal growth before and after puberty [18]. The LDPP manipulation during pre-pubertal growth phase results in greater milk secretion during 1st lactation relative to SDPP [19]. The underlying mechanism of these pro-growth effects by LDPP is consistent with the observed effects of LDPP on IGF-I and PRL, the positive effect of those endocrine factors on mammary and lean tissue growth [1]. Due to this, the manipulation of photoperiod offers a management tool that could enhance growth and accelerate the onset of puberty in the animals.

5.2 Effects on reproductive performance

The exposure of light for a longer duration (18 h) during autumn and winter improves reproductive traits in buffaloes. It is also found that prolonged PP (16 L: 8 D) improved the reproductive status by reducing service period by 22 days and no. of inseminations to conception by 0.6 [20]. The reason for this was attributed to increased blood Ca, P, Vit. A and Vit. D, total protein, hemoglobin, erythrocytes and γ globulins concentration in the blood [15]. In heifer, lowered age at 1st ovulation and better expression of estrus behavior are found by extending the photoperiod length than normal day length [21, 22].

5.3 Effects on milk production

The photoperiod (PP) manipulation during lactation and dry

period offers an effective, non-invasive approach to stimulate milk yield and performance of the animals [23]. Abrosimova, [24] have found that adequate light intensity (min. 60-80 Lx) during milking could shorten the process by 8-12%. This intensity of light assists milk letdown and increases labor efficiency of milkers. Proper lighting could influence oxytocin release and ultimately letdown of milk. The LDPP (16 to 18 h light) is galactopoietic in dairy cows and the increased photoperiod (16 L: 8 D) during lactation have increased milk yield by 13% with a slight depression in fat % [3, 15, 25]. It is found that increased light intensity (from 101 to 529 Lx) triggered changes in milk composition related to lower milk protein [26]. Due to this very reason, the manipulation of photoperiod during the dry period elicits an effect on mammary growth between 3-6 weeks before parturition [27]. It is also found that the SDPP during the dry period enhances the immune system of animals, with a lower occurrence of mastitis and metritis during 1st 10 postpartum days [27]. The exposure of dry animals to SDPP (8 L: 16 D) produced 3.5 kg more milk in subsequent lactation than animals exposed to LDPP [28]. In contrast to lactating cows, multiparous cows in the dry period and primiparous cows in late pregnancy benefit from exposure to SDPP followed by LDPP or natural photoperiod after calving [29].

5.4 Effects on Seasonality

Along with nutritional and management factors, Photoperiod also exerts seasonality in buffaloes breeding cycle. The duration and intensity of light to which the animals have exposed influence the onset of the estrous cycle [11] and information regarding photoperiod are conveyed to the neuroendocrine system by the circadian secretion of melatonin from the pineal gland [30]. The Photoperiodism can be defined as the physiologic response of animals to the variations of light and darkness. It is a product of and a necessity derived from species evolution. The relation between the breeding season and gestation length is such as to allow parturition in a particular species at a time of the year when nutrition and temperature are favorable to the survival of both the mother and her offspring. Photoperiodic information has been shown to be the strongest synchronizer of seasonal functions in most species of mammals [31] and in addition to regulating annual reproductive cycles, photoperiod can also control the timing of seasonal shedding. Temperate mammals may be short-day (early spring) or long-day (spring and summer) breeders. Both short-day and long-day breeders may go through a period of photo refractoriness (non-responsiveness to day length) that may interact with circannual rhythmicity. Long day breeders cease reproduction either through the action of decreasing day lengths or through the action of long days, themselves inducing a photorefractory state (inability of long days to sustain reproduction) followed by gonadal regression. Buffaloes are polyestrous continuous species and show estrous all year round, however, a seasonal pattern has been reported from different countries of the world [32]. Such characteristic is more related to the ambient temperature, feed supply, and photoperiod duration. The use of photoperiod in addition with hormonal therapy, the seasonal pattern can be overcome and the animals can be bred through the synchronization of the estrus around the year [33].

5.5 Effects on behavioral pattern

The effect of supplementary artificial light and features as duration and intensity on all aspects of dairy animal behavior is still disputed. The visits of animals on the feeding manger largely depend on photoperiod duration [34]. The additional artificial light (16 L: 8 D) especially on feeding alley, have stimulated feed intake and increased the milk yield of the animals [35]. Abrosimova, [24] have also found that the amount of used oxygen and released carbon dioxide by cows increased proportionally to light intensity. However, prolonged exposure to constant PP induces photo refractoriness, which is the state of being refractory to light stimulus, causing spontaneous reversion in physiology to that of previous PP state [4].

6. Conclusion

Taken together the length of photoperiod is one of the important environmental factors which plays a significant role in regulating the performance of farm animals like buffaloes. As it influences the growth of calf and heifers, also the mammary tissues, its use can be guaranteed to increase the performances of the buffaloes. The effect of photoperiod on reproduction is very much beneficial as economic point of view. The manipulation of photoperiod duration during lactation and dry period offers an effective, non-invasive approach to stimulate milk yield and performance of the animals.

7. References

1. Dahl GE, Tao S, Thompson IM. Lactation Biology Symposium: Effects of photoperiod on mammary gland development and lactation. Journal of Animal Science. 2012; 90(3):755-760.
2. Walton JC, Weil ZM, Nelson RJ. Influence of photoperiod on hormones, behavior, and immune function. Frontiers in Neuroendocrinology. 2011; 32(3):303-319.
3. Dahl GE, Buchanan BA, Tucker HA. Photoperiodic effects on dairy cattle: A review. Journal of Dairy Science. 2000; 83(4):885-893.
4. Hamadani H, Mus H, Khan A. Effect of photoperiod in domestic animals. International Journal Modern Plant Animal Science. 2013; 30:116-122.
5. Buyserie AC, Dahl GE, Gamroth MJ. Managing light in dairy barns for increased milk production. Oregon State University Extension Service, 2001.
6. Muthuramalingam P, Kennedy AD, Berry RJ. Plasma melatonin and insulin-like growth factor-1 responses to dim light at night in dairy heifers. Journal of Pineal Research. 2006; 40(3):225-229.
7. Johnson MH. Essential reproduction. John Wiley and Sons, 2012.
8. Rosa HJD, Bryant MJ. Seasonality of reproduction in sheep. Small Ruminant Research. 2003; 48(3):155-171.
9. Barile VL. Reproductive efficiency in female buffaloes. Buffalo Production and Research. FAO Technical Series, 2005, 77-108.
10. Di Palo R, Parmeggiani A, Spadetta M. Influence of changing farm on repeatability of melatonin plasma level in Italian Mediterranean buffalo. Proc. Fifth World Buffalo Congress, Caserta, Italy, 1997, 758-61.
11. Zicarelli L. Reproductive seasonality in Buffalo. Proc. of the Third Course on Biotechnology of Reproduction in Buffaloes, Caserta, Italy. 1997; 2:29-52.
12. Borghese A, Barile VL, Terzano GM, Pilla AM, Parmeggiani A. Melatonin trend during seasons in heifers and buffalo cows (Bubalus bubalis). 1995; 1:61-64.

13. Afify AA, Hassan Z, Hoda SI, Kassim N, El-Habaeib A. Effect of photoperiod on productive and reproductive performance of primiparous buffaloes. Annals Agric Sci, Moshtohor, Zagazig Univ, Egypt. 2004; 42(4):1537-47.
14. Osborne VR, Odongo NE, Edwards AM, McBride BW. Effects of photoperiod and glucose-supplemented drinking water on the performance of dairy calves. Journal of Dairy Science. 2007; 90(11):5199-5207.
15. Penev T, Radev V, Slavov T, Kirov V, Dimov D, Atanassov A, *et al*. Effect of lighting on the growth, development, behavior, production and reproduction traits in dairy cows. International Journal of Current Microbiology and Applied Sciences. 2014; 3(11):798-810.
16. Kennedy AD, Bergen RD, Lawson TJ, Small JA, Veira DM. Effects of evening feeding and extended photoperiod on growth, feed efficiency, live animal carcass traits and plasma prolactin of beef heifers housed outdoors during two Manitoba winters. Canadian Journal of Animal Science. 2004; 84(3):491-500.
17. Rius AG, Connor EE, Capuco AV, Kendall PE, Auchtung-Montgomery TL, Dahl GE. Long-day photoperiod that enhances puberty does not limit body growth in Holstein heifers. Journal of Dairy Science. 2005; 88(12):4356-4365.
18. Petitclerc D, Kineman RD, Zinn SA, Tucker HA. Mammary growth response of Holstein heifers to photoperiod. Journal of Dairy Science. 1985; 68(1):86-90.
19. Rius AG, Dahl GE. Exposure to long-day photoperiod prepubertally may increase milk yield in first-lactation cows. Journal of Dairy Science. 2006; 89(6):2080-2083.
20. Bodurov N. Effect of supplementary artificial illumination with visible rays on biochemical indices in the blood serum, milk yields, and fertilization during lactation. Veterinarno-Meditsinski Nauki. 1978; 16(6):58-65.
21. Kassim NS, Afify AA, Hassan HZ. Effect of photoperiod length on some reproductive traits and hormonal profiles in buffalo heifers. American-Eurasian Journal of Agricultural and Environmental Sciences. 2008; 3(4):646-655.
22. Roy AK, Singh M, Kumar P, Kumar BB. Effect of extended photoperiod during winter on growth and onset of puberty in Murrah buffalo heifers. Veterinary World. 2016; 9(2):216.
23. Dahl GE. Effect of photoperiod on feed intake and animal performance. In Proceedings of Tri-State Dairy Nutrition Conference, Fort Wayne. Ohio State University, Ohio, USA. 2006; 4:25-26.
24. Abrosimova R. Effect of lighting on gaseous exchange and productivity in large ruminants. Animal Science, 1978.
25. Evans NM, Hacker RR. Effect of Chronobiological manipulation of lactation in the dairy cow. Journal of Dairy Science. 1989; 72(11):2921-2927.
26. Phillips CJC, Schofield SA. The effect of supplementary light on the production and behavior of dairy cows. Animal Production. 1989; 48(2):293-303.
27. Auchtung TL, Rius AG, Kendall PE, McFadden TB, Dahl GE. Effects of photoperiod during the dry period on prolactin, prolactin receptor, and milk production of dairy cows. Journal of Dairy Science. 2005; 88(1):121-127.
28. Miller ARE, Erdman RA, Douglass LW, Dahl GE. Effects of photoperiodic manipulation during the dry period of dairy cows. Journal of Dairy Science. 2000; 83(5):962-967.
29. Pampori ZA, Haq M, Ganie AA, Singh AK. Physiology, metabolism and nutritional requirements in early lactation to augment milk production in cattle-A review. Agricultural Reviews. 2012; 33(3):181-191.
30. Morgan PJ, Williams LM. Central melatonin receptors: implications for a mode of action. Experientia. 1989; 45(10):955-965.
31. Hofman MA. The brain's calendar: neural mechanisms of seasonal timing. Biological Reviews. 2004; 79(1):61-77.
32. Gangwar PC. Climate and reproduction in buffaloes-a review. Indian Journal of Dairy Science. 1980; 33(4):419-426.
33. Vale WG. Effects of environment on buffalo reproduction. Italian Journal of Animal Science. 2007; 6(2):130-142.
34. Karvetski KE, Velasco JM, Reid ED, Salak-Johnson JL, Dahl GE. Behavioral time budget of dry cows: Photoperiod alters distribution of maintenance behaviors. Journal of Animal Science. 2006; 84:410-410.
35. Peters RR, Chapin LT, Emery RS, Tucker HA. Milk yield, feed intake, prolactin, growth hormone, and glucocorticoid response of cows to supplemented light. Journal of Dairy Science. 1981; 64(8):1671-1678.