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Impact of Photoperiodicity on Animal Activities

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Abstract – Day length (Photoperiod) is the most important and reliable one. It has been involved in regulation of seasonal cycles of reproduction and associated functions in several animals. Animals respond to the photoperiod (Long and short) to breed at a time in the year when the survival of the young ones is maximized. Accordingly, animals with short gestation periods (e.g. Birds) breed during summer, and those with long gestation period (e.g. Sheep) breed during the winter. These animals are thus called long day and short day breeders, respectively. Photoperiodism also linked with migration, hibernation, pelage growth and molt. The two endocrine secretions i.e. melatonin and thyroid hormone, also play key roles in regulating the seasonal physiology of birds and mammals.

Key Words: Photoperiod, Long Day and Short Day Breeders, Migration, Hibernation, Pelage Growth, Molt, Melatonin, Thyroid Hormone.

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INTRODUCTION

Due to the inclination of the Earth's rotation axis and Earth's translation along its orbit, the duration of daylight (photoperiod) varies along the year, and that such variation is more marked nearer the poles than near the Equator. Photoperiod is a very reliable predictor of future environmental condition, since it is a very constant environmental clue [1].

In most latitudes there are seasonal changes in the length of the photoperiod (i.e. changes in the length of the day). Only at the equator are the day lengths approximately LD 12:12 all through the year. There is therefore an advantage for organisms to be able to anticipate seasonal changes, so that environmental conditions are most suitable, e.g. breeding in spring or summer to take advantage of warmer temperatures, producing flowers at the right time of year to attract pollinators, change fur colour to camouflage against predators or migrate to avoid the harsher conditions of winter. Reproduction in many species occurs at specific times of the year. Animals reproduce in the spring and summer to take advantage of the warmer temperatures. Often reproduction is triggered by a critical photoperiod. In many male animals, testis size is affected by photoperiod. In hamsters and some birds, for example the testes are small in short days (i.e. in winters) but grow dramatically in long days. In hamsters the critical photoperiod is 12.5 hours, when the phoperiod drops below this, the testis reduce in size and stop producing sperms. When the photoperiod is longer than 12.5 hours, the testis enlarge (testicular recrudescence). Female hamsters have a similar critical day length so that the breeding cycle of both sexes coincides [2].

Besides photoperiod, food and temperature are also known to affect and regulate the seasonal responses. By and large, the photoperiod acts as a proximate factor initiating the seasonal responses in time, whereas food may act as the ultimate factor affecting actual time of the seasonal response e.g. reproduction [3],[4].

CIRCADIAN BASIS OF PHOTOPERIODIC INDUCTION

The interaction between the photoperiod and "Circadian" clock that reads the successive phases of light and dark, leads to the photoperiodic response. The circadian clocks that regulate the daily rhythms and circannual clocks that regulate the seasonal responses are self-sustained and allow the organism to anticipate changes in the environment. Both are synchronized by the photoperiod and light intensity. The circadian clocks are synchronized by the day and night cycles whereas the circannual clocks keep a track of changes in photoperiod from long days in summer to short days in winter [5].

THE PHOTOPERIODIC AXIS

The seasonal response (e.g. reproduction) is regulated by the interaction of photoperiod with the neuroendocrine components namely hypothalamus, pituitary gland and gonads (HPG) get together constitute the "photoperiodic axis"

In birds and mammals this photoperiodic axis is activated during breeding season. The photoperiodic activity perceived by photoreceptor induces the GnRH neuron in the hypothalamus to release the

gonadotropin releasing hormone (GnRH) that in turn causes the secretion of gonadotropins (LH and FSH) from the pituitary gland, which stimulates the gonads to recrudesce [6],[7],[8].

PHOTO TRANSDUCTION PATHWAY

The photoperiodic control of reproduction may be due to the hormone melatonin. This is produced by the pineal gland. Melatonin inhibits reproduction by blocking the hormone prolactin, which is a gonad stimulating hormone. Repression of prolactin causes gonad regression.

Melatonin is produced by a photo periodically controlled cycle. Its precursor serotonin is transformed to melatonin by a process that involved the enzyme N-acetyltransferase (NAT). NAT has a cycle that has amplitude that is suppressed by constant light but free runs in constant dark. Normally NAT and melatonin are produced at night [9].

In mammals unlike birds, eyes are the only photoreceptors and their removal abolishes the photoperiodic response, Light information from the eyes reaches the suprachiasmatic nucleus the master oscillator in mammals and from here the signals reach the pineal gland via superior cervical ganglion (SCG). Thus the melatonin secretion from pineal gland is under the control of SCN[10].

ROLE OF THYROID HORMONE

Besides melatonin and GnRH, various studies suggest that thyroid hormone (TH) T3 (tri-iodothyronine) and T4 (Tetra-iodothyronine) also play an important roles in the regulation of seasonal responses. The thyroidectomy affects seasonal reproduction has been shown in several birds and mammals [11],[12].

The two enzymes type-2 deiodinase (DIO2) and type-3 deiodinase (DIO3) synthesised in the ECs lining the III ventricle in MBH region are responsible for fine tuning the local levels of T3 and T4, [13]. Long days up-regulate DIO2 that converts T4 into T3 and short days up-regulate DIO3, that converts T4 and T3 into inactive reverse T3 and 3, 3 diiodothyronine (T2) respectively. T3 under short days induces the testis growth in a dose-dependent manner, whereas infusion of DIO2 inhibitor under long days inhibited the testis growth. Thus the local activation of thyroid hormone seems to have functional significance. The photoperiodic induction of DIO2 and DIO3 has been shown in some birds and mammals [14],[15],[16].

CONCLUSION

We can conclude from above results in many animals light initiates the annual breeding activities. Gonads of birds become active during summer which increased illumination. Mammals are short-day animals and can be brought to sexual activity with decrease in the length of exposure to day light. Birds breed during spring with lengthening of day and are, therefore, called long-day animals. Guinea pigs and squirrels are not at all affected by any light and are hence indifferent day-length animals. The response of an organism to the day length is termed as Photoperiodism. Although, the core mechanism of photoperiodic time measurement in both birds and mammals is the light reception followed by a cascade of downstream event, there is much more to be explored to understand the photoperiodic regulation of seasonal events.

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