

Puberty in domestic animals

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Importance of Puberty

- The rearing of replacement heifers is a major financial investment for both beef and dairy cattle producers. The investment expenses do not begin to be recovered until after first calving so having heifers calve at an optimal age is paramount to enterprise profitability. For this to occur it is essential that operators know when their heifers have attained **puberty** and become eligible for breeding.

Definition of Puberty

- **Puberty** is defined as the age at which the female or male gonads become capable of releasing the gametes (Oocytes or Spermatozoa).
- Puberty in females is defined as the age at which they first express estrus with ovulation.
- Regarding heifers, puberty has been defined as the first estrus that is followed by a normal luteal phase. If animals are bred at puberty, a high percentage will have difficulty with parturition.

- It is now accepted that puberty and first ovulation are not necessarily coincident since in most heifers “silent” ovulations and short luteal phases may occur during the peripubertal phase. Pubertal heifers might have very short estrus period
- The first ovulation is not synonymous with puberty and the first luteal phase is usually of short duration. Prostaglandin (PG)F₂α released from the endometrium is responsible for the reduction in luteal lifespan (premature luteolysis) following the first ovulation in heifers. Presumably, this occurs because of an abundance of endometrial oxytocin receptors that mediate release of PGF₂α. Subsequently, endometrial oxytocin receptor concentration is downregulated by exposure to progesterone for 12–14 days.

- The peri-pubertal period begins about 50 days before puberty.

Sexual maturity

- Sexual maturity is the age at which the male or female attains full reproductive capacity after puberty.

Age at puberty

- Age at puberty is affected by both genetic and environmental factors.
- Genetic factors can be seen by comparing species or **breeds** within a **species**.
- Average age at puberty is:
- 7 to 18 months for exotic or crossbred cows (**Maturity: 30 months**)
- 4 to 5 months for does (**Maturity: 6-8 months**)
- 7 to 10 months for ewes (**Maturity: 12-18 months**)
- 12 to 24 months for mares (**Maturity: 36 months**)
- **Bitch :6-20 month queen 7-12 month**

Age at puberty in males

Species	Age at puberty
Bull	9 to 12 Months (range 6-18 months) Age at puberty in males
Stallion	18 Months (range 12 to 24 months)
Boar	5 to 7 Months (range 4 to 8 months)
Ram and Buck	7 to 8 Months (range 4 to 12 months)
Dog	7 to 10 months (range 5 to 12 months)
Cat	8 to 10 months (range 6 to 15 months)

Mechanisms of Puberty onset

- Puberty encompasses the transition from the anovular state to one of regular ovulations.
- Various physiological factors like Nutrition, environment, photoperiod and endocrine factors like GH, IGF-1, leptin, Neuropeptide-Y (NPY) are important in the induction of puberty. Studies on puberty have mostly focused on sheep and cattle.
- The **gonadostat** hypothesis, states that a decrease in response to the inhibitory feedback action of gonadal steroids occurs during puberty.
- The low levels of estrogens before puberty inhibits the surge center of hypothalamus and the tonic release of LH is not sufficient for maturation of follicles.
- The positive feedback effect of increasing levels of estrogens produced by the growing follicles on the hypothalamus occurs at the pubertal onset which stimulates the LH surge centers triggering follicular maturation

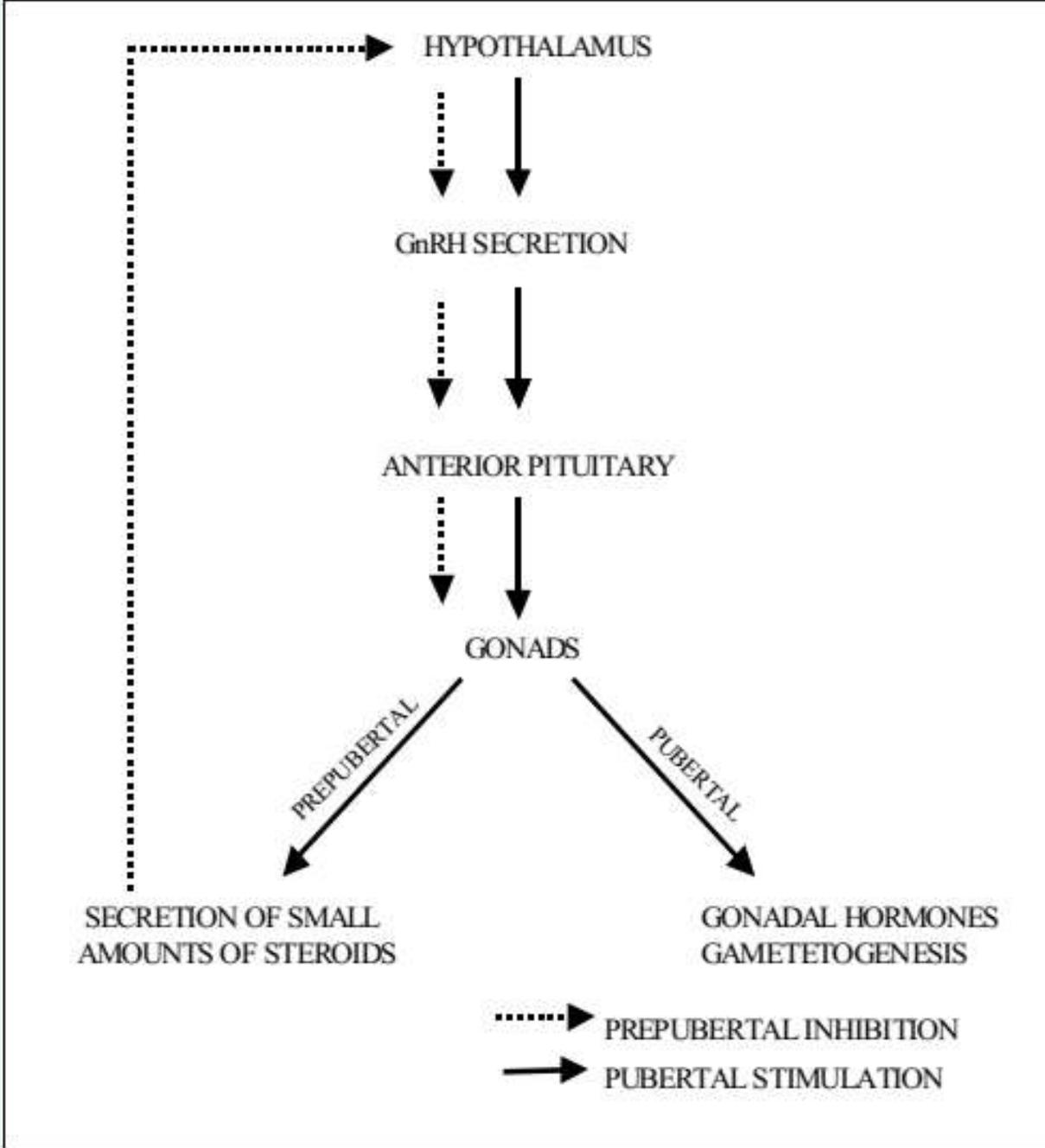


Fig 1: Neuroendocrine events in the initiation of Puberty

Factors That Influence Hypothalamic Sensitivity to Estradiol Feedback

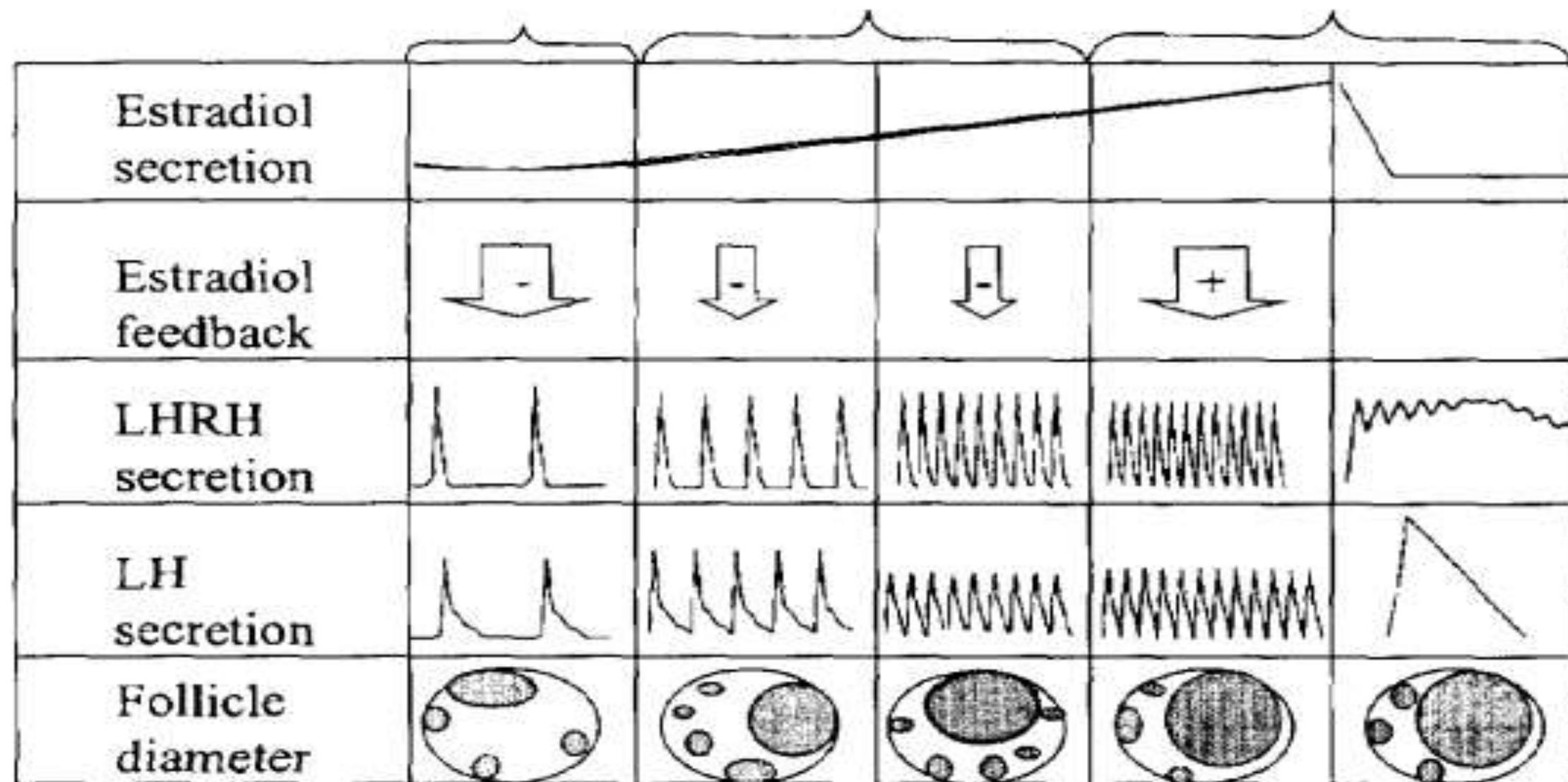
- Alterations in hypothalamic function probably result from changes in either the LHRH neurons themselves, in the systems that control LHRH neuronal function, or perhaps both. Several lines of evidence suggest that modifications in the morphology of the LHRH-containing neurons occur during the prepubertal period.

Model for Endocrine Control of Puberty

Prepubertal

Peripubertal

Pubertal



- Species differences do exist in the mechanisms of onset of puberty. In Primates the onset of puberty appears to be different from sheep and cattle.
- Recent studies suggest that in **primates** during the prepubertal period an inhibitory neuronal system suppresses LHRH release and that during the subsequent maturation of the hypothalamus this prepubertal inhibition is removed, allowing the adult pattern of pulsatile LHRH release. Some of the identified inhibitory neurotransmitters include gamma-aminobutyric acid (**GABA**), neuropeptide-Y (**NPY**), **melatonin** and endogenous opioids (**EOI**). However, many of these findings are not fully proven. Some of these neurotransmitters have been also found in cattle and sheep yet their clear role in puberty is yet to be identified

TABLE 2 Summary of key inhibitory neurotransmitters before puberty in primates (Adapted from Reasawa and Fernandez, 2001)

GABA Supporting evidence (female monkeys)

- GABA release in the S-ME decreases at the onset of puberty.
- Infusion of GAGA into the S-ME suppresses LHRH release only after the onset of puberty.
- Infusion of bicuculline, a GABA_A antagonist, or antisense oligonucleotides for GAD mRNA, into the S-ME stimulates greater LHRH release in prepubertal than in pubertal monkeys.
- Chronic infusion of bicuculline into the base of the third ventricle induces precocious puberty.

NPY Supporting evidence (male monkeys)

- NPY mRNA decreases at the onset of puberty.
- NPY antagonist infusion into the lateral ventricle stimulates LH release in prepubertal monkeys.

Melatonin Supporting evidence (humans and monkeys)

- Some human patients with pineal tumors exhibit precocious puberty.
- Circulating melatonin concentration is elevated in early childhood, declines during late childhood, and remains stable from the early pubertal period to adulthood in humans and monkeys
- Circadian melatonin rhythm in blind men differs from normal men and timing of puberty in blind boys is delayed.

Opioids Supporting evidence (humans and monkeys)

- 1. Endogenous opioids are important for inhibition of pulsatile LHRH/LH release in adults.

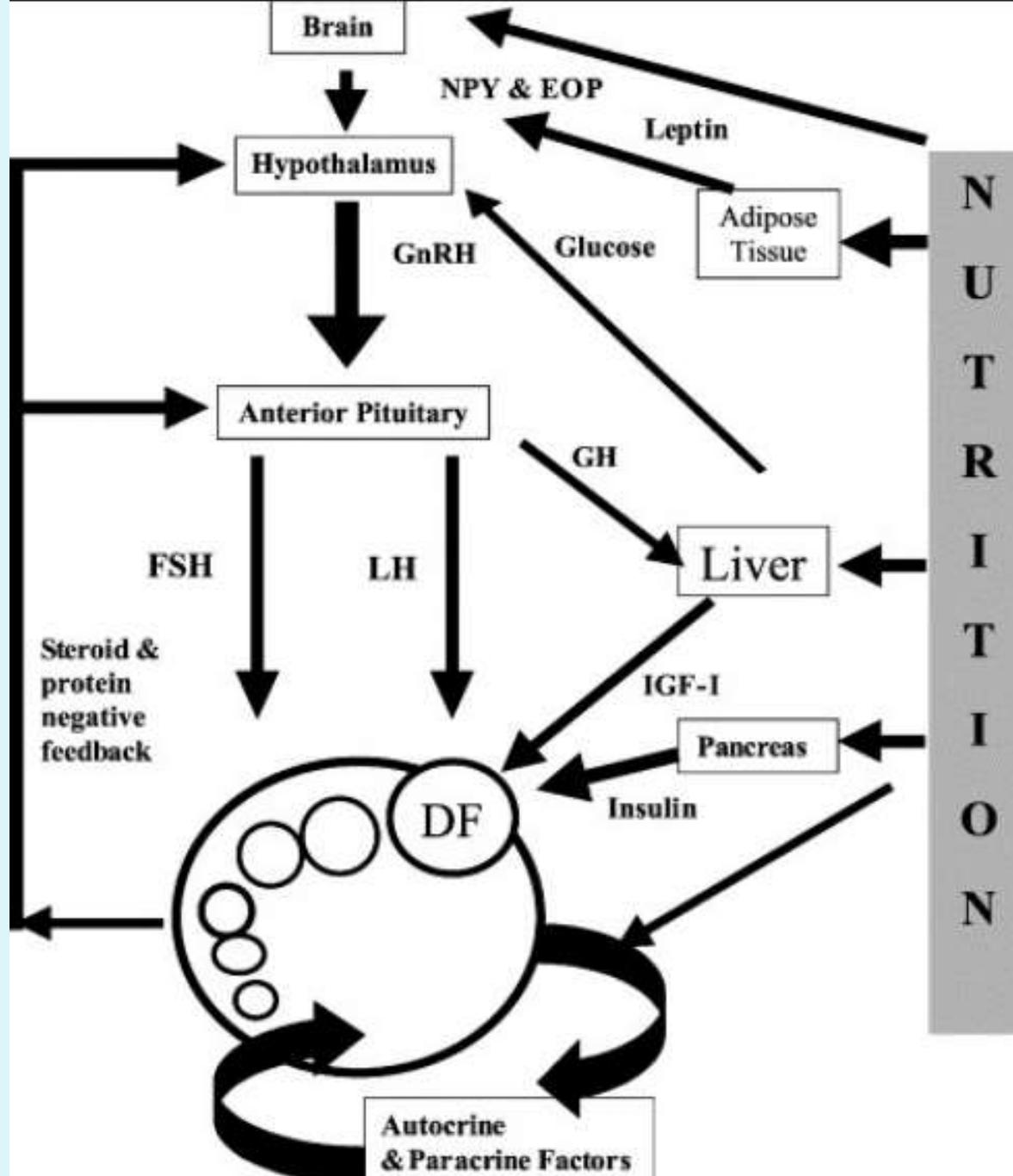
Physiological Factors affecting puberty

- While neuroendocrine mechanisms play an important role in the onset of puberty yet there are other genetic, environmental, nutritional and other factors that affect onset of puberty. Some of these are described sequentially.

Nutrition

Nutrition affects synthesis and release of GnRH, FSH, LH and GH due to its action on hypothalamus and anterior pituitary respectively.

The effects of nutrition on the onset of puberty



Genetics and Breed

- Age of puberty is moderately heritable and in cattle it ranges between 0.16 to 0.57.
- Crossbreeding with some breeds results into decrease in age at puberty.
- Generally, breeds of a larger size at maturity are older and heavier when reaching puberty.

- **Environment**

Pubertal onset in beef heifers was dependent on the birth time. Heifers born in autumn attain puberty earlier compared to spring-born heifers. Autumn and winter environments during first six months of life accelerate the pubertal onset while the same conditions after six months delay it. A similar effect of environment has been observed in sheep, goats and other species.

Interaction among season and other environmental factors affecting puberty include environmental temperatures, rainfall, humidity, etc. The season may affect puberty in cattle by affecting the levels of LH, prolactin or growth rate. Such effects are more profound in seasonally breeding species such as sheep, buffalo, camel.

- **Age and body weight**

The effect of age and weight at puberty onset differs among various breeds of cattle, buffalo and other species. It is generally considered that heifers attain puberty when they attain 55 to 60 % of adult weight.

Photoperiod

Photoperiod has a profound effect on puberty in the seasonal species however it has some role in the non-seasonal species also.

Other factors affecting puberty

- **Leptins**

Leptins are produced primarily by the adipose tissue with other sites being stomach, skeletal muscle, fetal cartilage, pituitary, mammary tissue and placenta. They are molecules that signal the nutritional status of the animal to the central reproductive axis. Studies have shown that prepubertal heifers with higher plasma leptins attain puberty earlier.

Growth hormone and Insulin

- GH pulses are known to increase just before puberty
- The role of Insulin in setting pace for the pubertal onset has been addressed in many studies and so also the role of Insulin-like growth factor-1 on nutritional mediators of puberty have been found in many studies on cattle and other species.
- Pubertal onset is known to be positively associated with circulatory IGF-I independent of growth rate, leptin concentrations, and body fat.

Neuropeptide-Y and melatonin

- The significance of NPY and melatonin on primate puberty has been mentioned and in a few experiments their role in puberty in cattle and seasonal species have been evaluated.
- A clear role of NPY, melatonin and GABA is yet to be elucidated for most domestic animal species.

Enhancement of Puberty

- Improved nutrition
- Growth promoting implants
- Use of progestins
- Use of Somatotropins
- Bio-stimulation

THANK YOU