PUBERTY AND SEXUAL MATURITY

Dr. Krishan Yadav
Assistant professor
Department of Veterinary Gynaecology and Obstetrics
MJFCVAS, Chomu

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Puberty: It is defined as the age when first estrus is accompanied with spontaneous fertile ovulation. Puberty in females may be attained when the heifers have gained 35-45% of their mature body weight but the breeding should be allowed when the female has gained 55% of adult body weight.

The puberty is different in different species and breeds. The age is decided genetically. Before attaining puberty majority of pre-pubertal heifers may exhibit anovulatory or silent heat. This anovulatory heat is exhibited about 6 months before the actual age of puberty. Because below this weight if achieves pregnancy later it will lead to dystocia. Puberty should not be considered as sexual maturity. Sexual maturity is attained at later stage when heifer has gained mature body weight specific to that particular breed.

Hormonal control of Puberty: Before attaining puberty there is pulsatile release of GnRH from hypothalamus. It causes release of FSH and LH from anterior pituitary. When puberty is attained there is increased secretion of GnRH which causes high level of FSH and LH and these results in induction of estrus. The increased amount of GnRH released at time of puberty is due to decreased sensitivity of hypothalamus to ovarian steroids. Full reproductive efficiency is not attained in any species at the first estrus. The age at puberty can be affected by many factors.

These factors may be either genetic or environmental.

a) Breed and genotype: Age at puberty is different in different species because it is decided genetically. The average weight at the time of puberty depends upon the mature body weight of that species. e.g. Jersey breed attain puberty at age of 8 months when body weight is 160kg whereas Holstein Friesen attain puberty at age of 11 months and body weight is 270kg.

b) Nutrition: If nutrition is not proper the body weight gain is slow and puberty is delayed.

c) Climate: If external temperature is high or adverse then due to low metabolic rate puberty is delayed.

d) Body condition and sanitation: If hygiene and body condition are not good the animal is prone to illness and delayed puberty.

e) Vicinity of male: If male is introduced few months before the actual age of attaining puberty, the female attains puberty at an early stage. This effect is more in sheep, goat and sow.

Age of puberty

Cow	**10-24**
Riverine buffalo	24-36
Horses	18-24
Sheep	7-10
Doe	6-8
Sow	5-8
Bitch	6-12
Queen	5-12

GONADOSTAT THEORY OF PUBERTY:

The gonadostat theory was proposed by Hohlweg (1931). According to it:

1. During prepuberty, sensitivity to the negative feedback actions of gonadal steroids is highest, resulting in a low release of GnRH and gonadotropins.

2. Initiation of puberty is secondary to a decrease in sensitivity to gonadal steroid feedback inhibition, resulting in increased GnRH and gonadotropin release, until a new equilibrium level is reached in adulthood.

SEASONAL BREEDING

Regulation in seasonal long day breeders: As the name says these animals specifically breed during long periods of day light or long photo periods. In long day breeders the inhibitory effect of the pineal gland occurs during the short days of winter. This is the reason for which mares, stallions and other equids remain in anestrous during the short days.

Once the season changes with increasing photoperiod into long days, the pineal gland becomes less active and thereby the secretion of melatonin is also reduced considerably and the inhibitory influence on the hypothalamus is removed. As a result of which the hypothalamic releasing factors (GnRH) and anterior pituitary hormones (FSH, LH) are also secreted to initiate the reproductive process for the onset of breeding. The young ones are produced during spring and summer.

Seasonal short day breeders: Changing photoperiod from longer day light to shorter days with more periods of darkness initiates the reproductive activity in sheep and goat due to increase in melatonin secretion. The increased melatonin secretion reaching the hypothalamus, then stimulates the pulsatile secretion of GnRH. Subsequently, FSH and LH secretion from the pituitary gland increases, which in turn results in the onset of ovarian activity and the commencement of the breeding season. Sheep and goat experience an annual period of reproductive quiescence in response to increased photoperiod.

The non-breeding season is characterized by a reduction in the pulsatile secretion of GnRH, in part because of an increase in negative feedback activity of estrogen On the way changing season from short days to long days forces them to experience an annual period of other reproductive quiescence in response to increased photoperiod.

FOLLICULAR DYNAMICS

The process of continual growth of ovarian follicle leading to preovulatory size and its regression or ovulation, is known as follicular dynamics. Follicular development in is characterized by a wave-like pattern Immediately after recruitment, a selection phase begins in which a single follicle emerges from the pool of recruited follicles and continues to grow, whereas other recruited follicles are inhibited from reaching ovulatory size. This selected follicle grows faster and is termed as dominant follicle. Next to dominant is sub-dominant follicle. An active dominant follicle prevents the recruitment and growth of other follicles in the ovary. The progression of follicular development is a sequence of organized events. The cyclic pattern of growth of antral follicles is termed as Wave and the wave pattern of follicular development has been reported in prepubertal, cycling and postpartum animals.

Each wave is characterized by wave emergence, growth, dominance and atresia or ovulation. Once the growth of primordial follicle is initiated, it is a continuous process until the follicle ovulates or become atretic and finally about 1% of antral follicle ovulates.

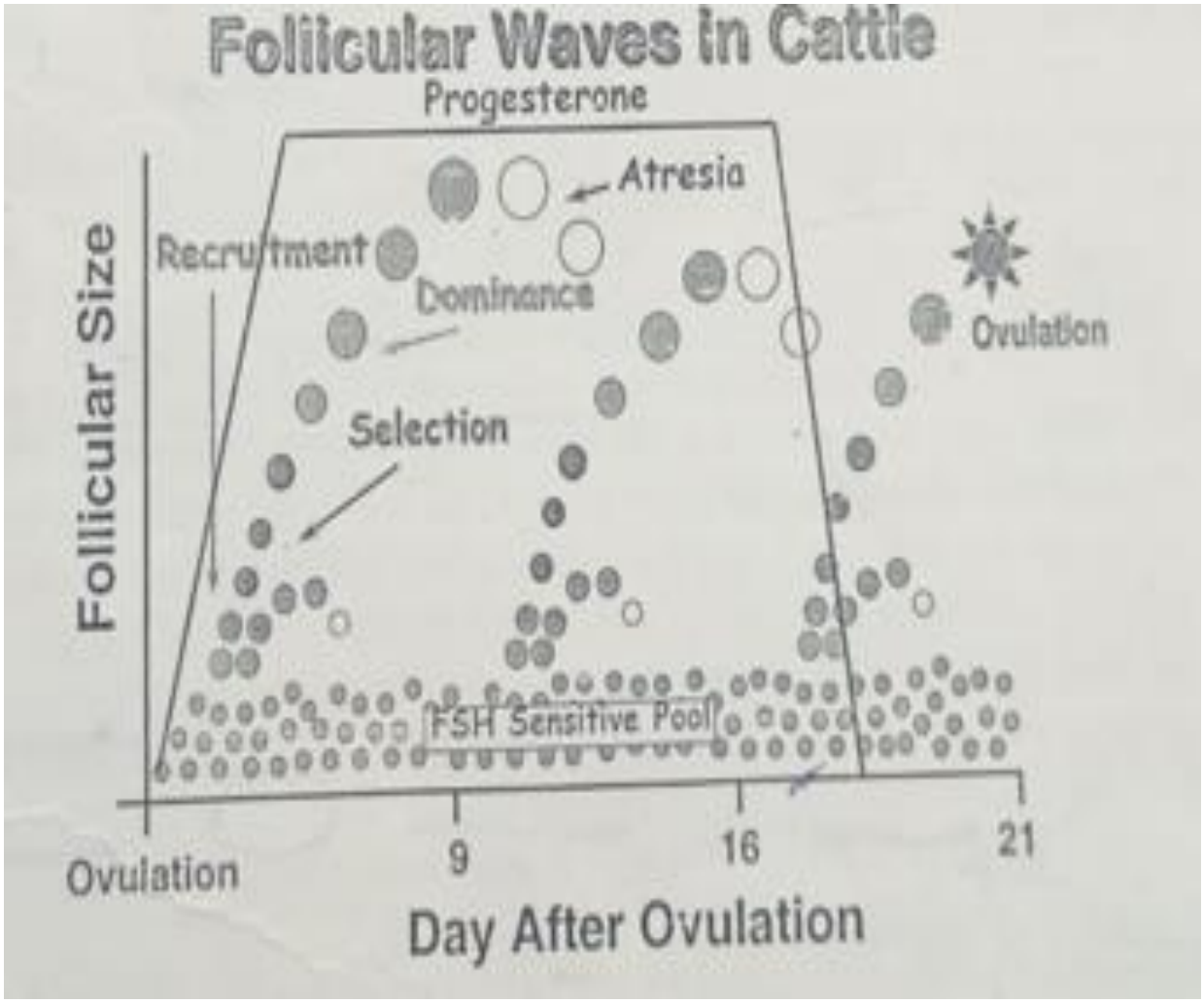
Throughout the estrous cycle, during pregnancy and other reproductive stages, there is continuous follicular activity with growth and atresia. In horse, cattle, sheep, goat and buffalo follicular development during normal cyclical ovarian activity or in case of camelids during period of reproductive activity, well organised wave like patterns occurs. In cattle and sheep numbers of waves are 2 or 3 While in goats it ranges from 2 to 7 with predominantly 4. Buffaloes have oestrous cycles with 1-wave (3.3 %), 2-waves (63.3%) or 3-waves (33.3%) of follicular growth with the first wave beginning on day 1, the second around day 9-11 while the third wave appear on day 17 of the oestrous cycle.

Buffalo has predominance of 2 follicular waves (1st day 0 & 2nd day 9-10), whereas cattle has predominance of 3 follicular waves (1st day 1, 2nd day 10 & 3rd day 19). There are antral follicles close in size to those which are just preovulatory, throughout the oestrous cycle including the luteal phase. However, in sow there is no evidence of a wave like pattern, but the presence of 30-50 intermediate follicles (2-7mm in diameter), from which on average about 20 which are destined to ovulate start to grow on day 14-16 of the oestrous cycle, when the CL are starting to regress. Folliculogenesis includes:

1) Recruitment-Gonadotrophin stimulation of a pool of rapidly growing follicles.

2) Selection: A process whereby one or more of the recruited follicles are selected to develop further.

3) Dominance: The mechanism whereby one (the dominant follicle) or several follicles undergo rapid development in an environment where the growth and development of other follicles is suppressed.


Follicular Waves in Cattle
Progesterone
Atresia
Recruitment
Dominance
Ovulation
Selection
Follicular Size
FSH Sensitive Pool
Ovulation
9
16
21
Day After Ovulation

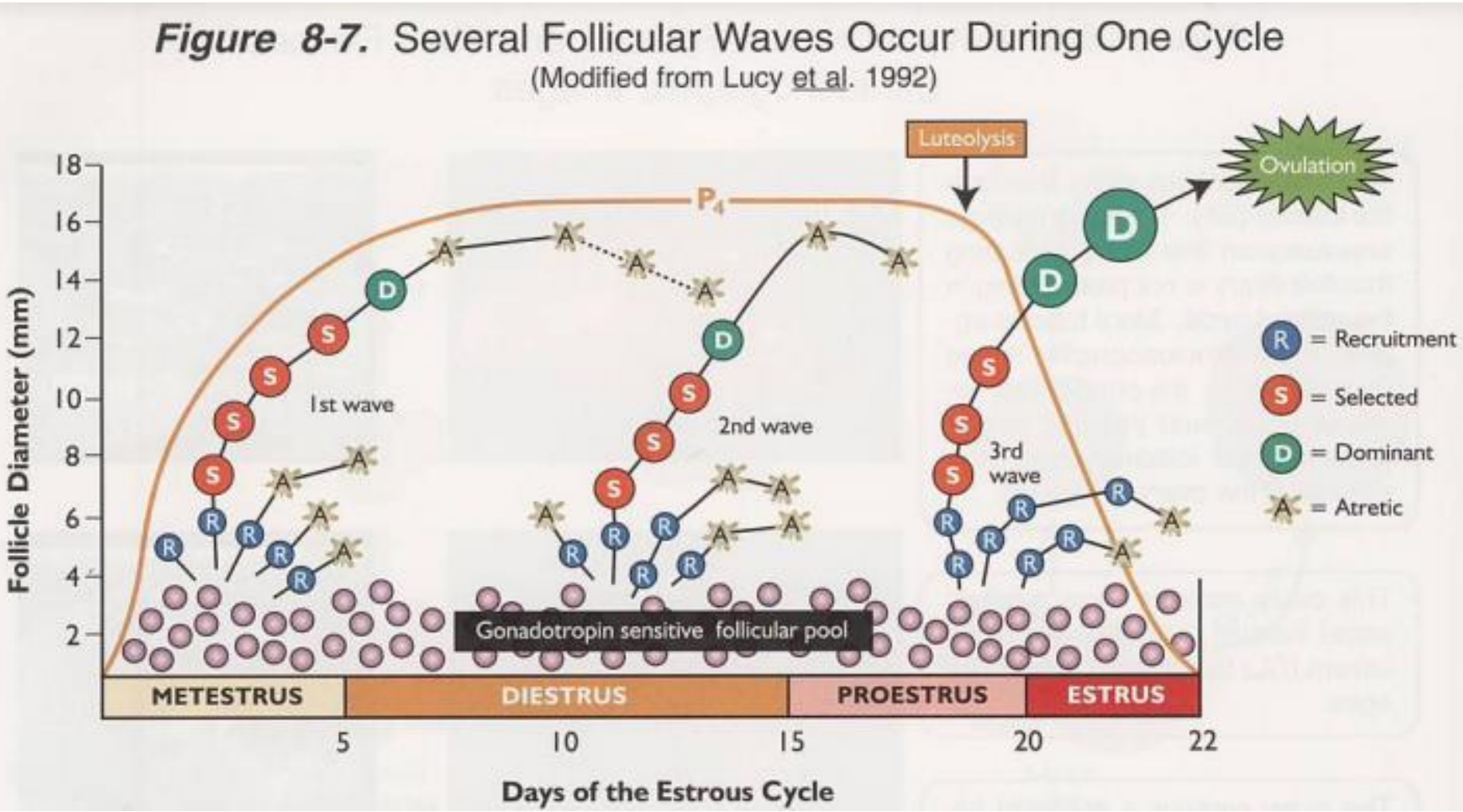


Figure 8-7. Several Follicular Waves Occur During One Cycle
(Modified from Lucy et al. 1992)
Luteolysis
Ovulation
P_4
1st wave
2nd wave
3rd wave
R = Recruitment
S = Selected
D = Dominant
A = Atretic
Gonadotropin sensitive follicular pool
METESTRUS
DIESTRUS
PROESTRUS
ESTRUS
Follicle Diameter (mm)
Days of the Estrous Cycle
18
16
14
12
10
8
6
4
2
5
10
15
20
22

The pattern of follicular dynamics in ruminants can be summarized as follows:

a) Follicles grow in wave like pattern.

b) Periodic surges in circulating FSH are associated with follicular wave emergence.

c) Selection of dominant follicles involves the decline in FSH and acquisition of LH responsiveness

d) Periodic anovulatory follicular waves continue to emerge until the occurrence of an LH surge. e) Progesterone is suppressive to LH secretion and the growth of the dominant follicle.

f) The duration of the inter-wave interval is a function of follicular dominance and is negatively correlated with circulating FSH.

g) Follicular dominance in all species is more pronounced during the first and last follicular waves of the oestrous cycle.

h) Pregnancy, the prepubertal period and seasonal anoestrous are characterized by regular, periodic surges of FSH and emergence of anovulatory follicular waves.

Follicular dynamics in mare

In mare follicular waves have been classified into major and minor waves as follows:

a) Major waves: Follicles diverge into a dominant follicle and sub-dominant follicles as in case of cattle. These are further sub-divided into primary and secondary waves.

Primary waves: in this the dominant follicle ovulates.

Secondary waves: In this case the dominant follicle is either anovulatory or ovulation is delayed to after the end of estrus.

b) Minor waves: There is no divergence. Minor and secondary waves tend to occur most frequently during the transitional phase at the beginning of the breeding season.

Some facts:

- In sow, there is no evidence of wave like pattern, but the presence of 30-50 intermediate sized follicles (2-7mm in diameter) from which on average about 20 are destined to ovulate.
- The CL is rapidly formed from the graffian follicle after ovulation primarily from the granulosa and thecal cells.
- The primary site for initiation of luteolysis is through the large luteal cells which become smaller, followed by the small luteal cells.
- The onset of heat after foaling occurs on 5-10th day, this first heat after foaling is known as Foal heat. It is traditional to cover (mating in mare is k/a Covering) a mare on day 9 post foaling.

- Sow exhibits estrus within 48 hours after parturition but there is no ovulation.
- The largest follicle is responsible for most estrogen secretion by the ovary at estrus. Stigma formation for ovulation: A thin area of follicular apex, the whole apical wall become thin prior to ovulation inner layers of the follicular wall protrude through a gap to form a papilla. Stigma thins out, bulges on ovarian surface, the vascularity of follicular surface increases except at its centre, which seems devoid of blood vessels and this avascular area is the future point of rupture. Progesterone is involved in stimulating the collagenase activity follicular wall. At ovulation the bulging stigma ruptures at the apex, releasing some of the follicular fluid.PGF2a is involved in follicular rupture and PGE2 in the remodelling of the follicular layers, terminating in corpus luteum formation. Theca is predominant site prostaglandin production.

- Endomethacin can block follicular rupture by inhibiting prostaglandin production

OOGENESIS

It is development and maturation of the ovum It starts during the prenatal period. During prenatal period primary germ cells/oogonia are produced from the embryonic gut cells which migrate to cortex of embryonic gonads. The oogonium is diploid (2N) and formed at day 25-35 of gestation. Then, oogonia divide by mitosis and produce primary oocytes. The primary oocyte divide by meiosis but the division is arrested at prophase stage immediately after birth. At the time of birth in most of the farm animals, the ovaries contain primary oocyte. This primary oocyte from the birth till the puberty remains dormant and is known as Dictyate oocyte.

When puberty is attained gonadotrophins (FSH, LI) are released which initiate the first meiotic division (first maturation division) and the primary oocyte result into secondary oocyte (N) and a polar body. The polar body is retained in the perivitelline space i.e between zona pellucida and vitelline membrane). After this division, the number of chromosomes is reduced and it becomes haploid. Second meiotic division starts immediately after completion of 1" meiotic division. But it is again arrested at metaphase stage and is not completed till fertilization occurs. After entry of spermatozoa the second meiotic division is completed and it forms the zygote and second polar body. So, in farm animals true ovum does not exist because true ovum is a product of 2nd meiotic division which should have occurred before fertilization.

In rabbit, ferret, mink and hamster the ovaries contain oogonium at birth whereas primary oocyte in most of mammals. In case of bitch and fox the ovulation occurs at primary oocyte stage whereas in most of mammals it occurs at secondary oocyte stage. In cow, ewe and sow the first meiotic division is completed just before ovulation whereas in mare, it is completed after ovulation.

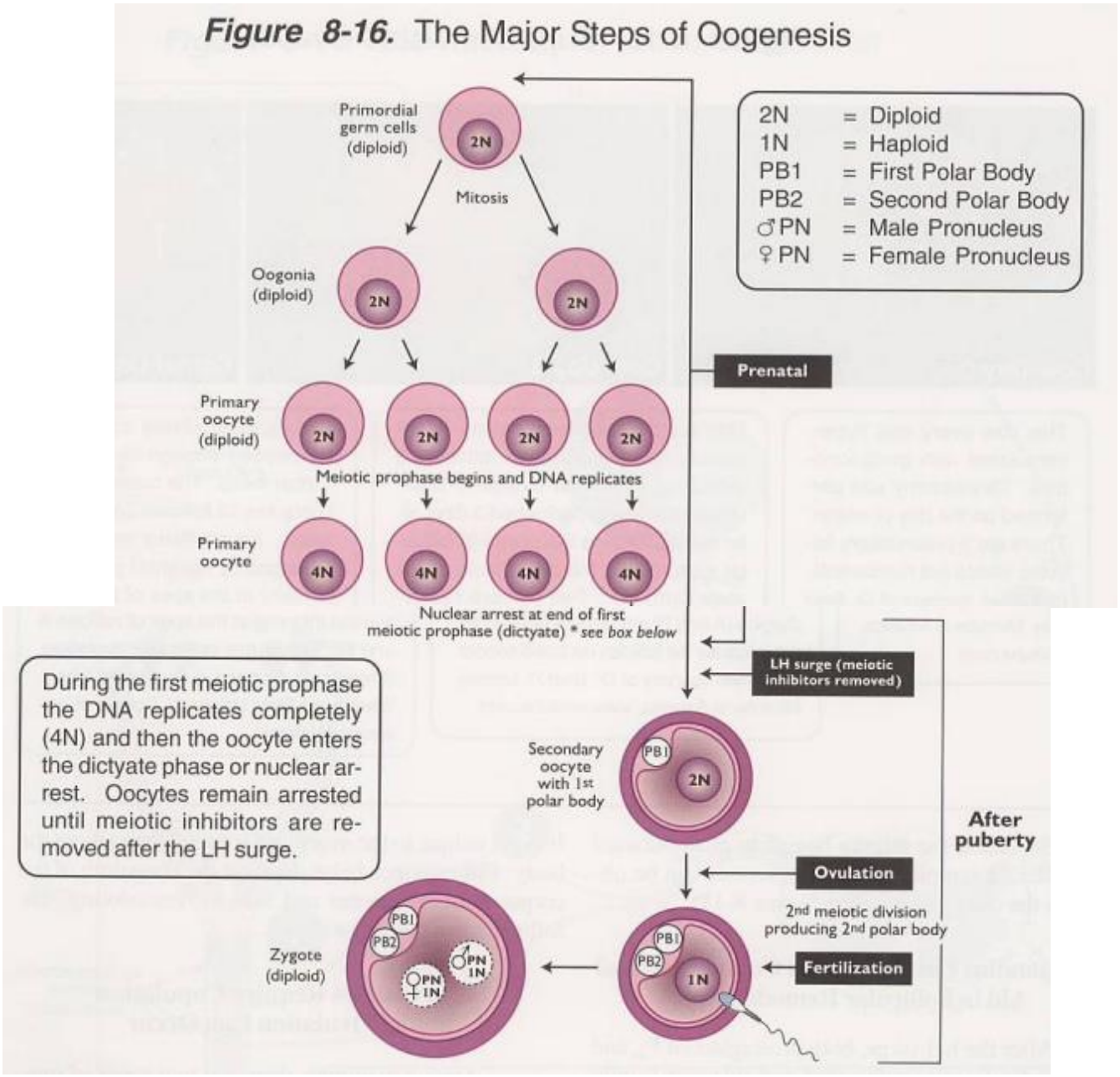
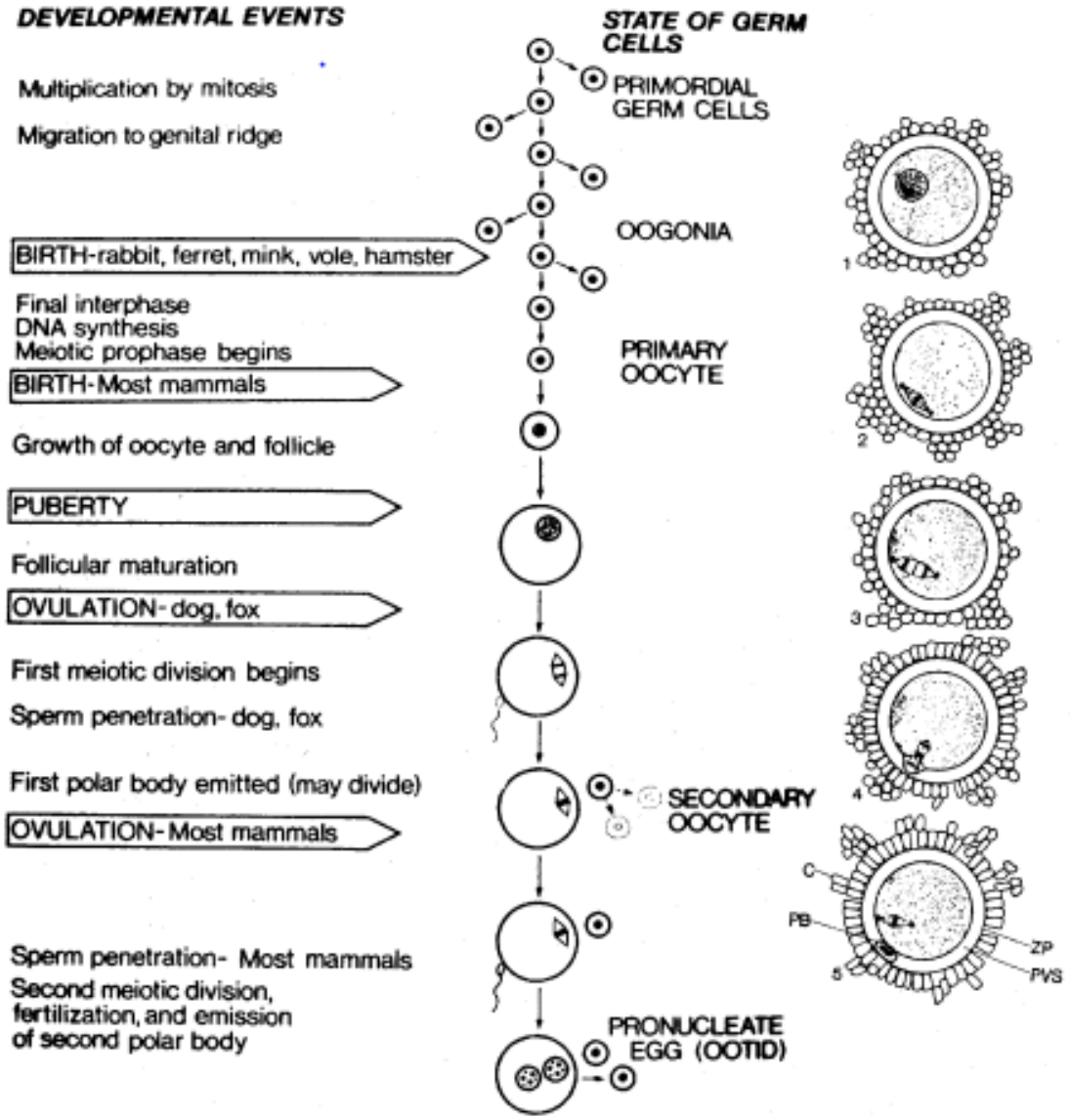


Figure 8-16. The Major Steps of Oogenesis
Primordial germ cells (diploid)
2N
Mitosis
Oogonia (diploid)
2N
2N
Primary oocyte (diploid)
2N
2N
2N
2N
Meiotic prophase begins and DNA replicates
Primary oocyte
4N
4N
4N
4N
Nuclear arrest at end of first meiotic prophase (dictyate) * see box below
2N = Diploid
1N = Haploid
PB1 = First Polar Body
PB2 = Second Polar Body
♂PN = Male Pronucleus
♀PN = Female Pronucleus
Prenatal
During the first meiotic prophase the DNA replicates completely (4N) and then the oocyte enters the dictyate phase or nuclear arrest. Oocytes remain arrested until meiotic inhibitors are removed after the LH surge.
LH surge (meiotic inhibitors removed)
Secondary oocyte with 1st polar body
PB1
2N
After puberty
Ovulation
2nd meiotic division producing 2nd polar body
PB1
PB2
1N
Fertilization
Zygote (diploid)
PB1
PB2
♀PN 1N
♂PN 1N


DEVELOPMENTAL EVENTS
STATE OF GERM CELLS
Multiplication by mitosis
Migration to genital ridge
PRIMORDIAL GERM CELLS
OOGONIA
BIRTH-rabbit, ferret, mink, vole, hamster
Final interphase
DNA synthesis
Meiotic prophase begins
PRIMARY OOCYTE
BIRTH-Most mammals
Growth of oocyte and follicle
PUBERTY
Follicular maturation
OVULATION-dog, fox
First meiotic division begins
Sperm penetration-dog, fox
First polar body emitted (may divide)
SECONDARY OOCYTE
OVULATION-Most mammals
Sperm penetration- Most mammals
Second meiotic division, fertilization, and emission of second polar body
PRONUCLEATE EGG (OOTID)
1
2
3
4
5
PB
ZP
PVS

Species	Time of ovulation	Time of AI/Service
Cattle/buffalo	10-12 hour after end of estrus	10-12 hour after end of estrus(mid to end of estrus)
Mare	1-2 day before the end of estrus	2-4 day after onset of estrus
Sheep	24-30 hour after onset estrus(towards the end of estrus)	12-24 hour after onset of estrus
Goat	24-40 hours after onset of estrus (towards end of estrus)	24-36 hours after onset of estrus
Sow	30-40 hours after onset of estrus(towards the end of estrus)	24-36 hours after onset of estrus

GAMETE TRANSPORT

Transport of ovum and spermatozoa at the site of fertilization is an essential event. The ovum and spermatozoa are [transported in opposite directions. Ovum from the ovary is transported downward to the oviduct or fallopian tube whereas spermatozoa after ejaculation are transported upward through the cervix and uterus to the oviduct.

1. Transport of ovum: After ovulation, the oocyte is picked up by the infundibulum which has ciliated mucosa and the cilia beat toward the direction of uterus. This helps in transport of ovum towards the ampulla of oviduct. In the ampulla again the mucosa is also ciliated and the cilia beat towards the uterus. Along with this there is oviductal fluid which also moves toward the uterus. Due to these movements the ovum passes to ampullary isthmic junction for fertilization, At this junction ovum remains for 2-3 days.

2. Transport of spermatozoa: The transport of spermatozoa can be:

a). Rapid transport: Due to rapid transport the sperms reach to the internal-os within.5-3 minutes after mating. This rapid transport occurs due to release of oxytocin which occurs due to stimulation of external os of cervix either by natural mating or by artificial insemination. This oxytocin causes contractions of vagina, cervix, and uterus. These contractions are also caused by PGF2a present in the semen. During rapid transport the sperms are transported to the oviduct through micelles of cervical mucus. Rapidly transported sperms don't take part in fertilization because they are no capacitated

b). Colonization of sperm reservoirs: During natural mating billions of spermatozoa are deposited in vagina in case of cow, buffalo, sheep and goat and cervix acts as the largest barrier, Massive numbers of sperms are trapped in the complex mucosal folds of the cervical crypts and cervical mucus also acts as barrier for dead spermatozoa. This process is facilitated by the fact that the micelles of the cervical mucus direct sperm to the cervical crypts where the reservoir is formed. The more sperm that enter the cervical reservoir the more that will reach the oviduct, thus increasing the chance of fertilization.

In artificial insemination cervix is bypassed because semen is directly deposited in body of uterus. In mare and sow semen is deposited in uterus, therefore the cervix does not act as a barrier.

Besides, cattle, buffalo, sheep and goat, in species in which ejaculation occurs in the uterus, sperm reservoirs are also formed in the uterotubal junction or in the endometrial glands in bitch.

Almost equal number of spermatozoa are transported to both the oviducts but slightly more towards the ovulating site Uterotubal junction is another barrier after cervix.

c). Slow release and transport: After adequate sperm reservoirs formation in the female reproductive tract, the sperms are release sequentially for a prolonged period. This slow release involves (innate motility of sperms and the contractile activity of the myometrium and mesosalpinx that ensure the continued availability of entry to the oviduct for fertilization of the egg.

Egg transport in the oviduct:

In cattle, sheep and swine the transport time ranges from 72 to 90 hours. The unfertilized ova are retained in the oviduct of the mare for several months.

Fertile life of ovum and sperm (in female genital tract):

Species	Sperm	Ovum
Cattle	30-48 hrs	20-24 hrs
Horse	72-120 hrs	6-8 hrs
Sheep	30-48 hrs	16-24 hrs
Swine	24-72 hrs	8-10 hrs
Dog	4-7 days	4-7 days

Number of ovulations and birth numbers:

Ovulation rate	Cattle/ Buffalo	Mare	Ewe	Doe	Sow	Bitch	Cat
	01	01	1-2	2-3	10-20	6-12	1-12
Birth numbers	01	01	1-2	1-3	6-12	1-12	1-8

Gestation: It is the period that starts with fertilization or conception, and ends with parturition. Gestation length is longer if fetus is male than female and shorter in case of twins. Early zygote takes nutrition from the uterine milk/histotroph and after attachment in uterus from the placenta.

Gestation length in different species:

Cat	58-65	
Bitch	59-68	2 months±2days
Sow	112-115	4 months±4days
Sheep	144-151	5 months±5days
Goat	146-151	5 months±5days
Cow	278-293	9 months±9days
Buffalo	305-320	10 months±10days
Mare	330-345	11 months±11days
Camel	375-415	13 months±13days
Elephant		4 months±24days

Abortion: The expulsion of dead embryo or fetus that has reached recognizable size is called an abortion (Roberts) 1971)

In case of cattle and buffalo, it may also be defined as production of one or more calves between 152 and 270 days of gestation; they either are born dead or survive for less than 24 hours (Noakes et al., 2009)

Still birth: Delivery of dead fetus at full term. It is common in swine and bitch (Polytocus species).

Premature Birth: Delivery of live fetus before full term.

Male donkey (Jack) x Female horse (Mare): Mule

Female donkey (Jenny) x Male horse (Stallion): Hinny

Thank you