Mammals, Mammary Glands and Milk: It's All About Lactation

Walt Hurley

Week 4

Coursera.org Search for Lactation Biology

Google: Lactation in Motion
Dr. Walter Hurley - *Lactation in motion*: the sow-litter ... - SwineCast

Video on milk ejection

http://youtu.be/ifPd6vU3SqA

Immunoglobulin Story

Immunoglobulin = antibody = gammaglobulin

Some mammals are born with extremely low levels of immunoglobulins in their blood - agammaglobulinemic

Neonate gets Ig by intestinal absorption of Ig from colostrum

- Bovine
- Porcine
- Ovine
- Caprine
- Equine
- Many others

Some mammals are born with normal levels of immunoglobulins in their blood

Newborn baby already had received the Ig by trans-placental transport from the mother during late pregnancy

Primates

Overall learning objective:

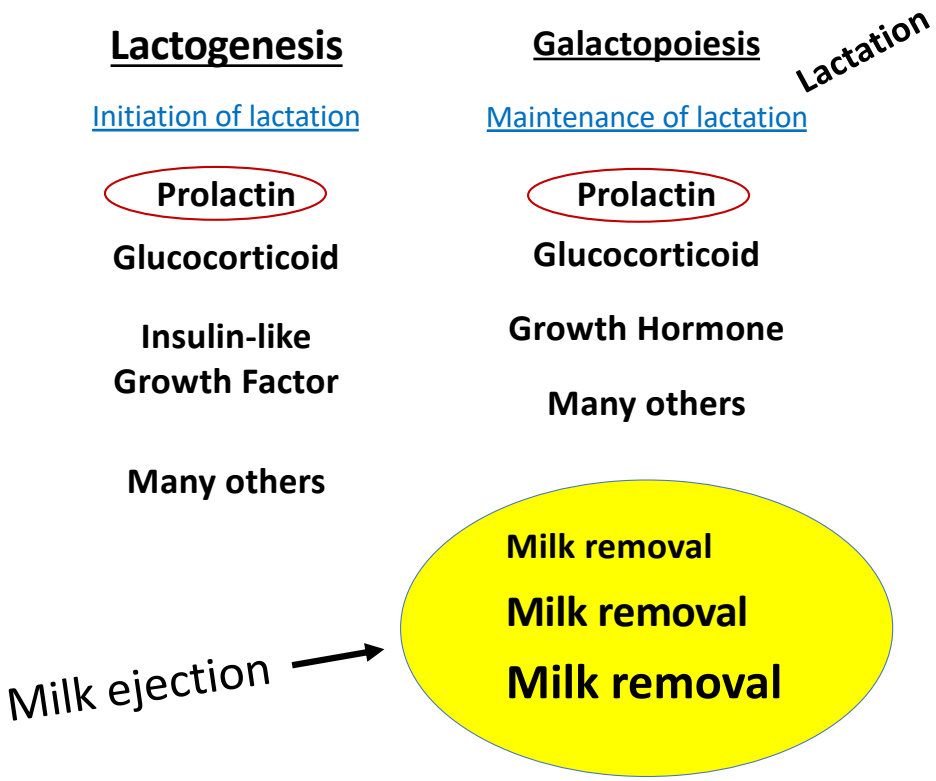
To start us thinking like a lactation biologist

[It's not just about milk]

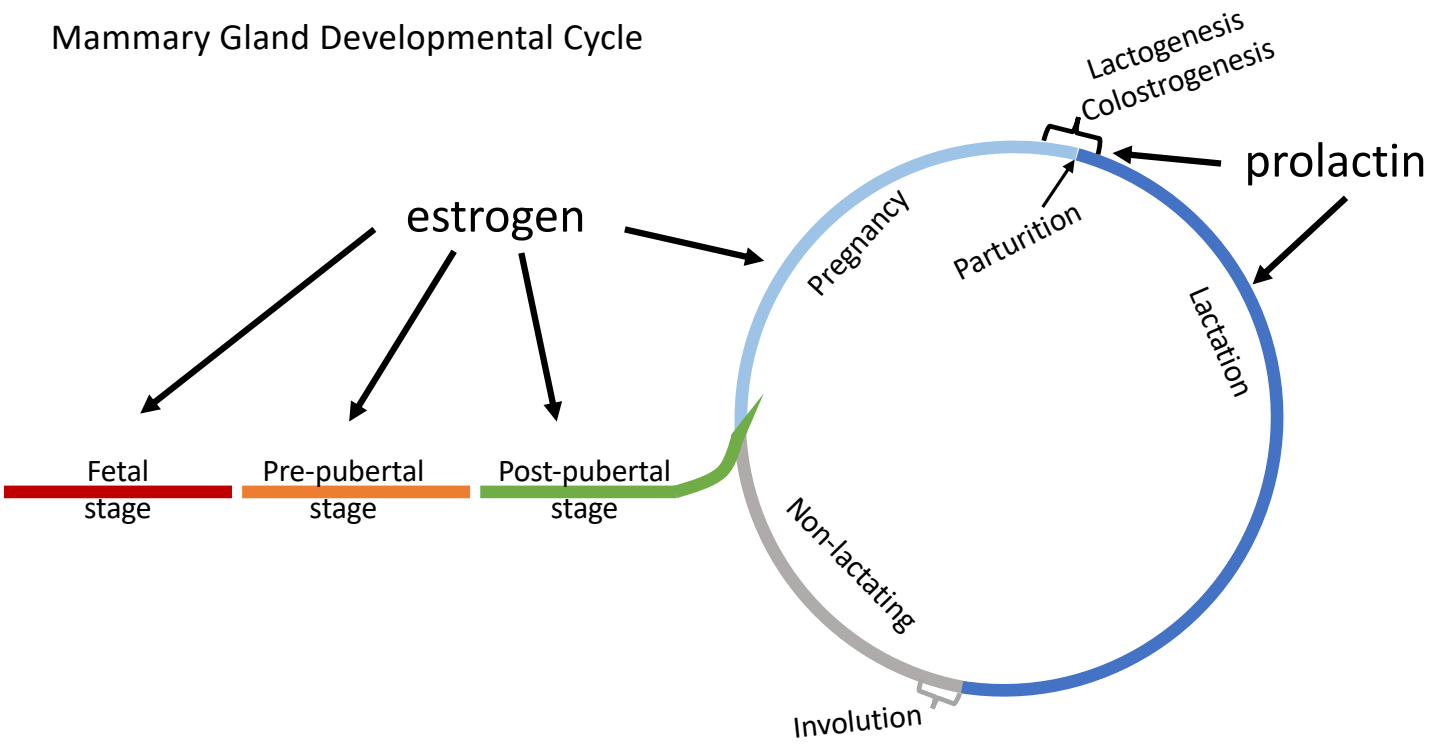
Today's learning objectives:

Contrast the normal mammary development with "atypical" development

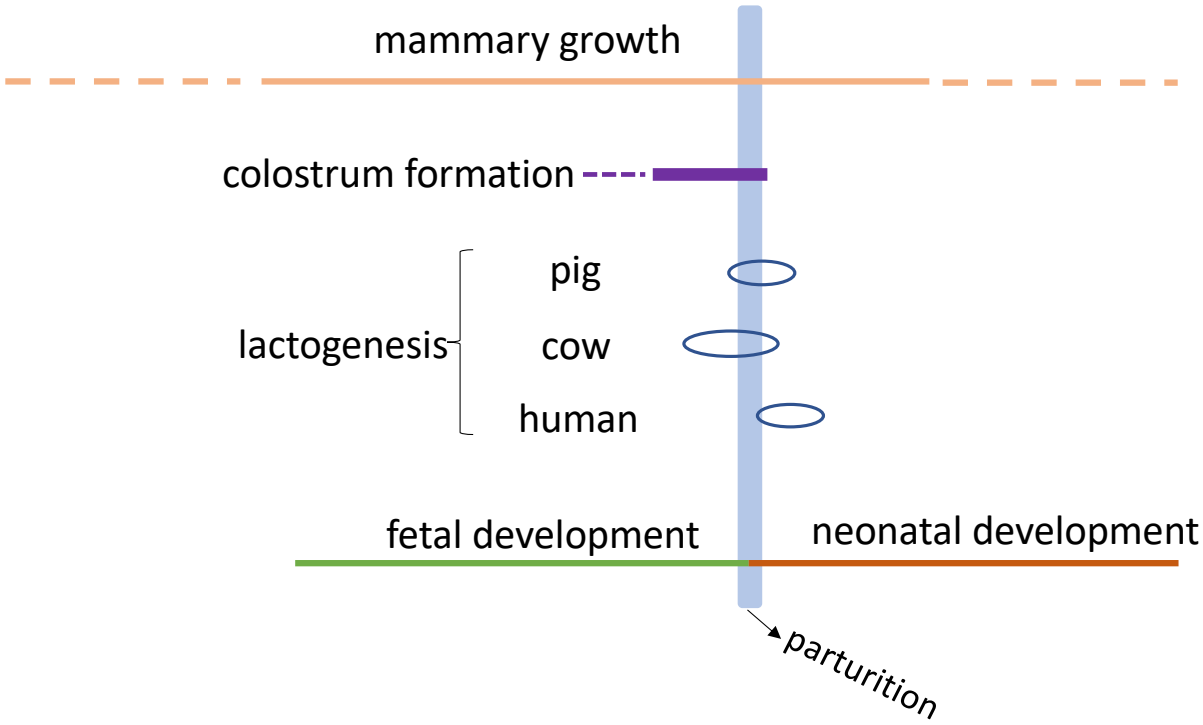
Contrast the normal lactation with "atypical" lactation



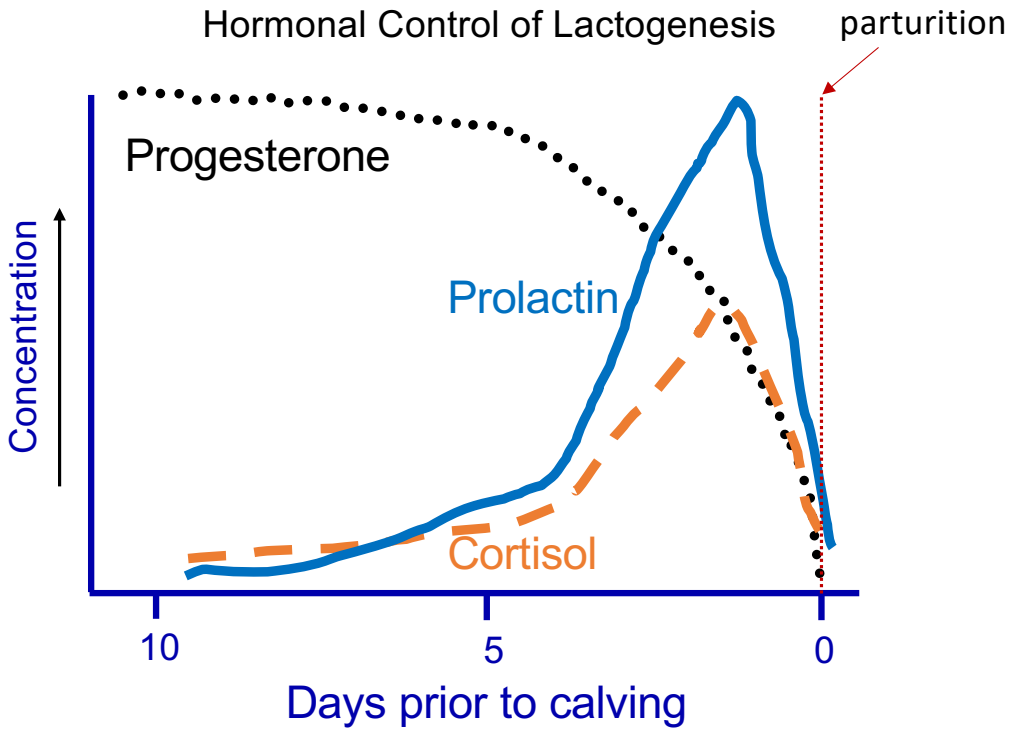
Mammary Gland Developmental Cycle



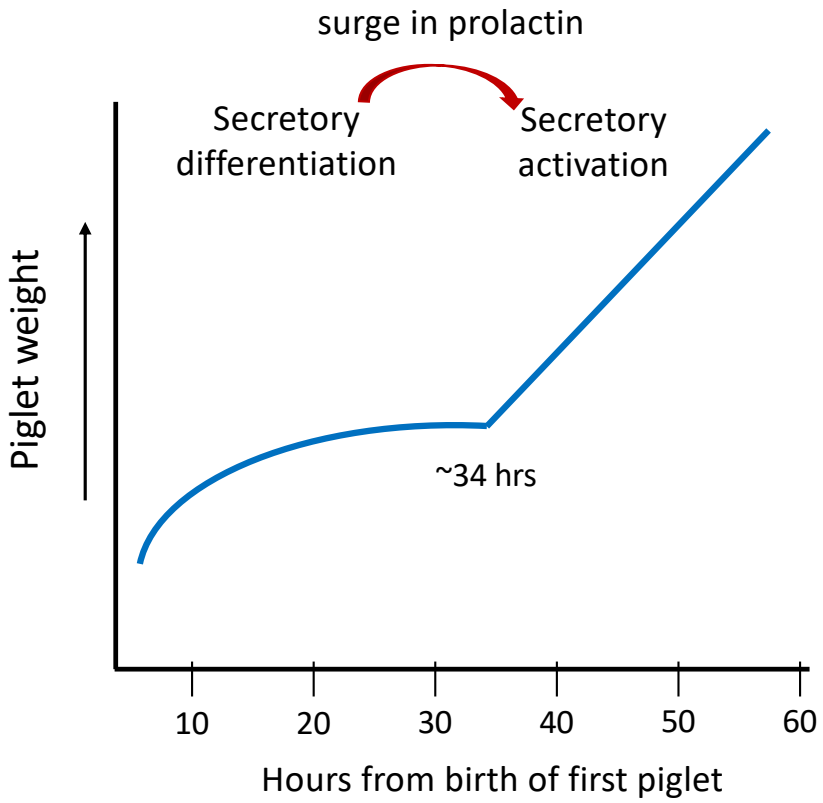
What is happening around the time of parturition?



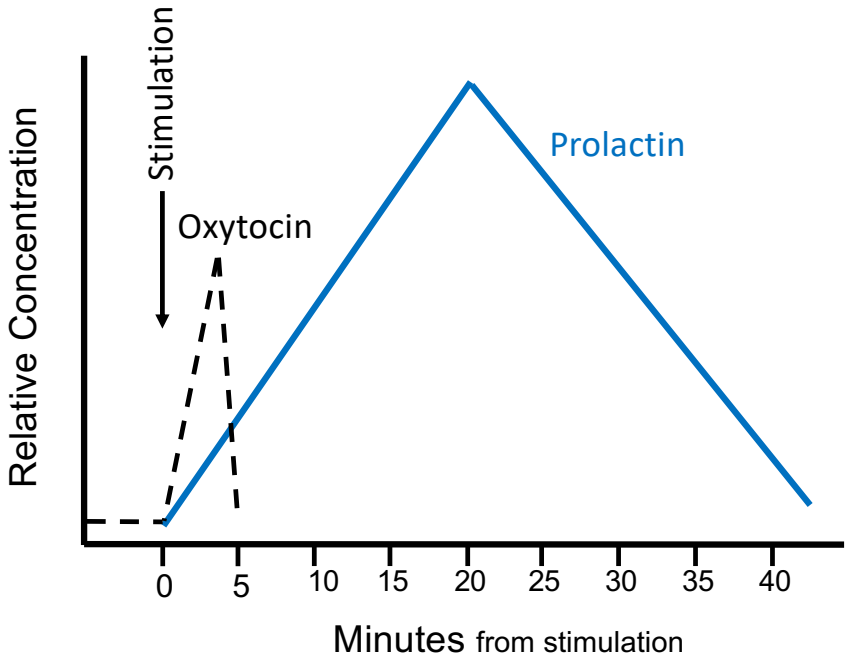
Cow


Hormonal Control of Lactogenesis
parturition
Progesterone
Concentration
Prolactin
Cortisol
10
5
0
Days prior to calving

Pig

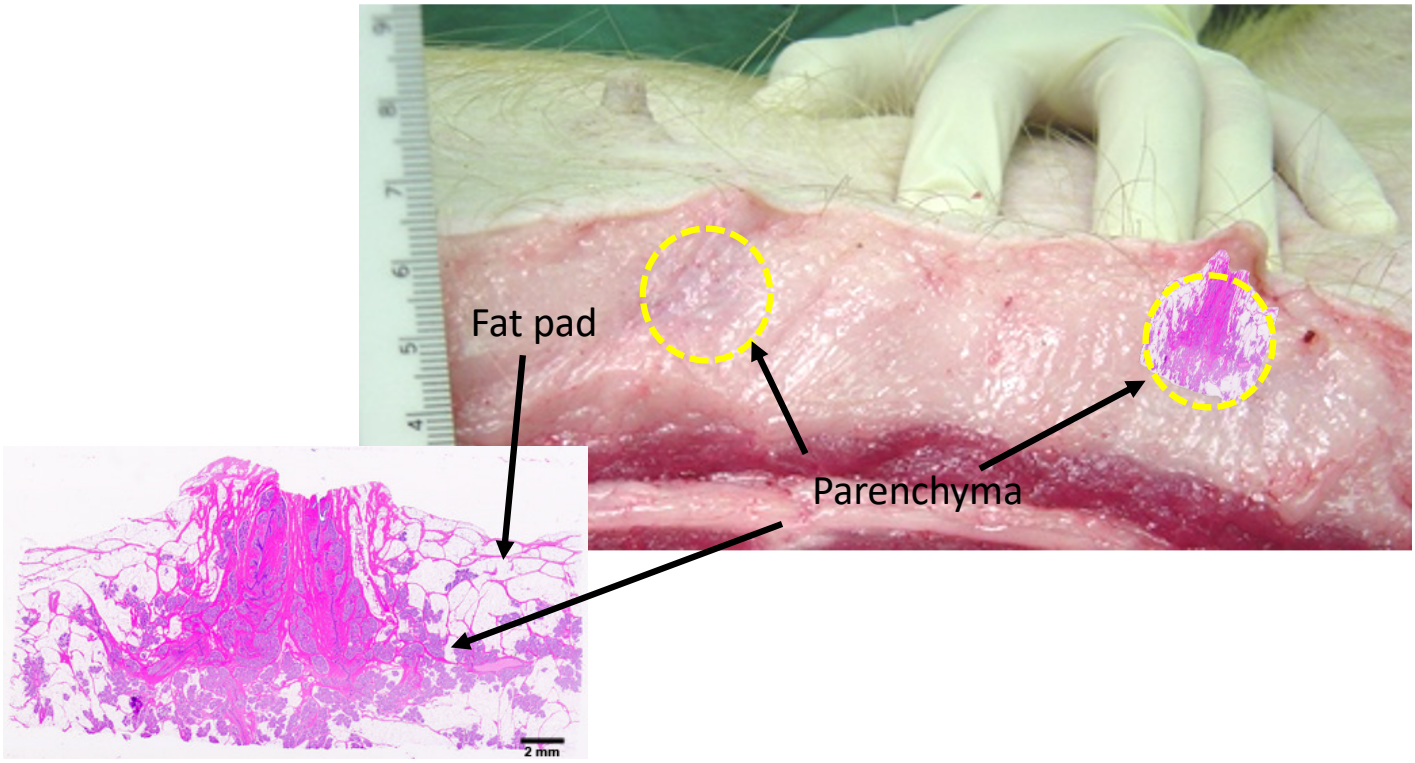

surge in prolactin
Secretory differentiation
Secretory activation
Piglet weight
~34 hrs
10
20
30
40
50
60
Hours from birth of first piglet

Suckling/milking induced change in oxytocin and prolactin



Newborn

Pig – post-pubertal

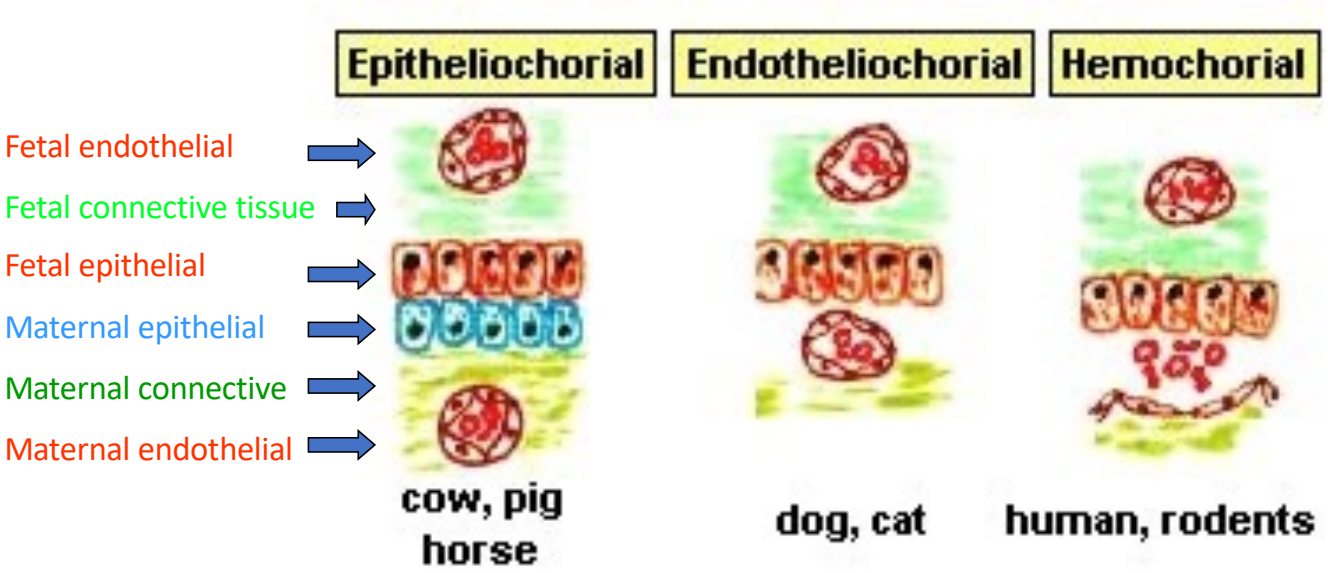


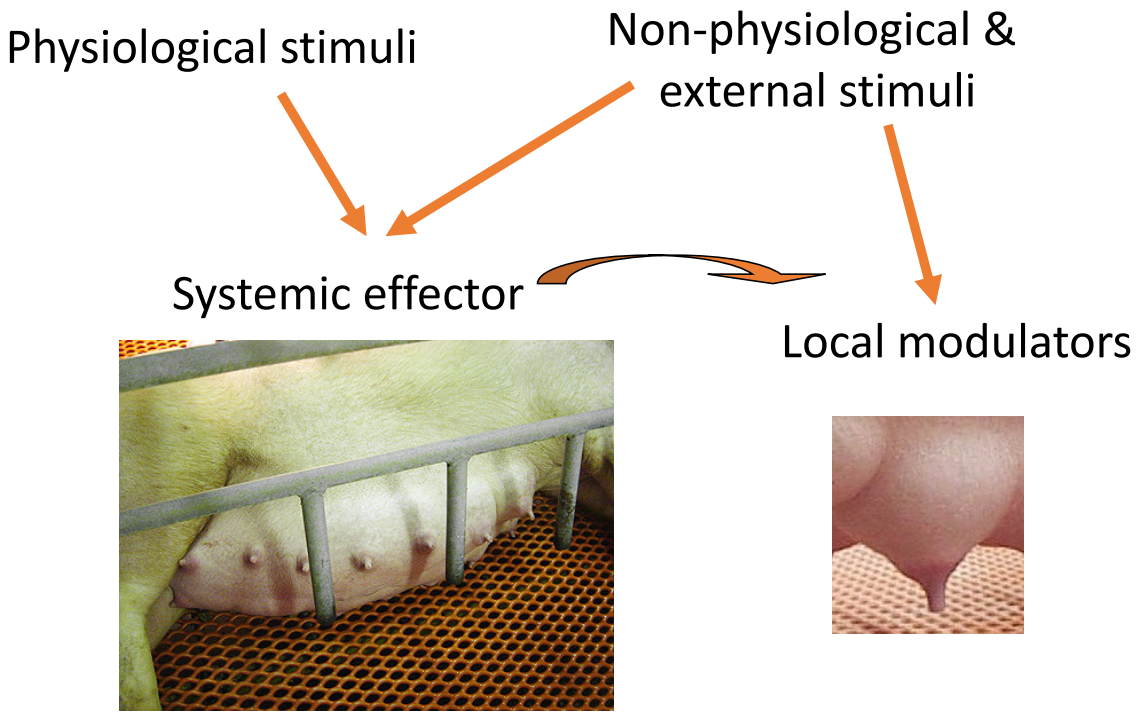
This means that if any mammary cells are present in the gland, then they can be induced to lactate by exposure to the correct set of <u>hormones</u>

How about some examples

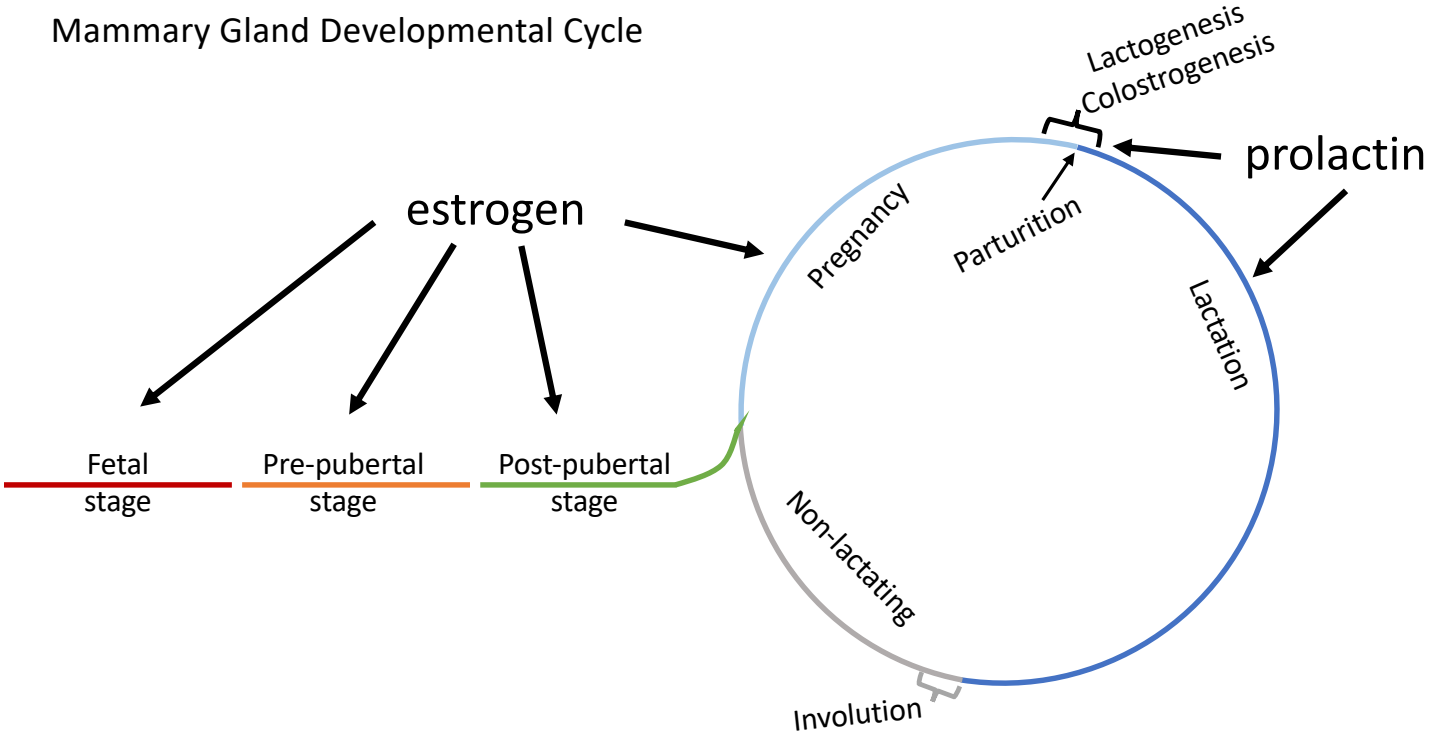
Witches Milk

- Newborn human infants
- Colostrum-like secretion
- Secretion starts 3 to 4 days postpartum
- Lasts 1 to 2 weeks
- Stimulation by maternal <u>hormones</u> prepartum





Mammary Gland Developmental Cycle



Lactation Induction

- Can be induced in absence of pregnancy.
- Can be induced by suckling stimulation.
- Requires hormonal stimulation.

How to induce lactation:

Administer high levels of estrogen/progesterone for several days

stimulates mammary growth & stimulate prolactin secretion

Stimulate prolactin secretion with some sort of drug

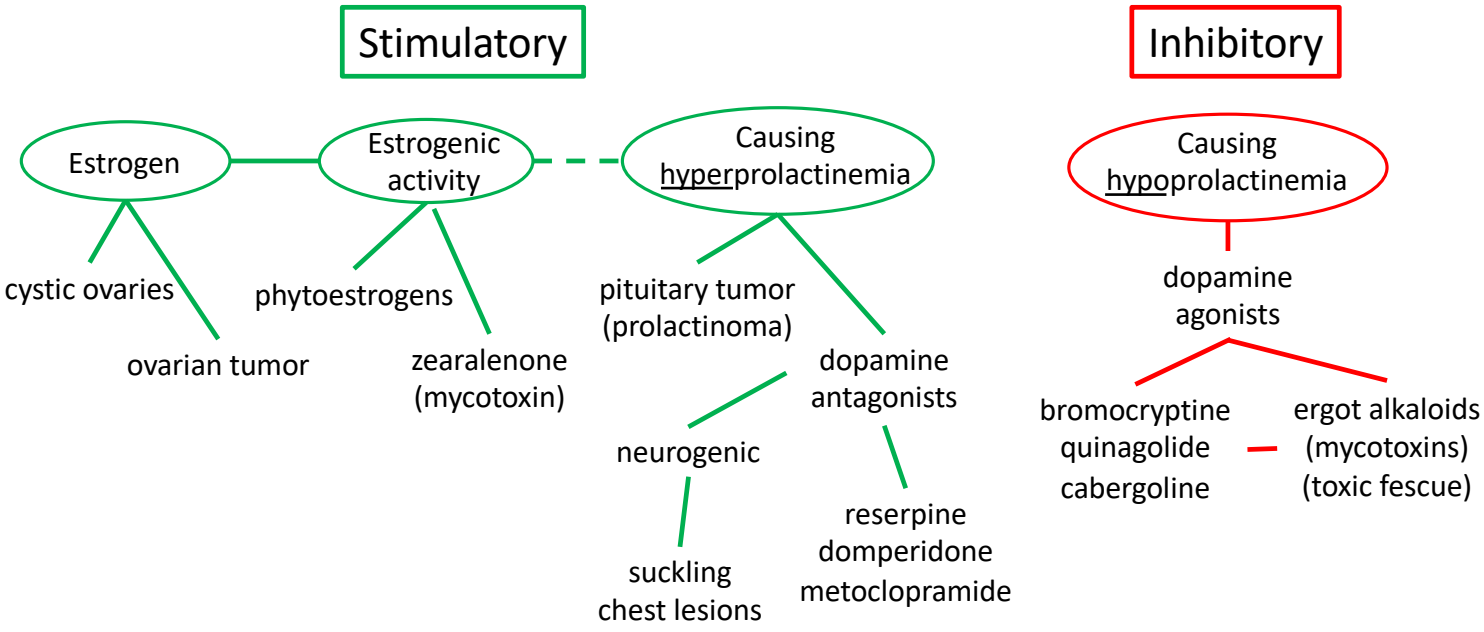
Stimulates lactogenesis (differentiation ⟶ activation)

[some methods also try to stimulate glucocorticoid secretion]

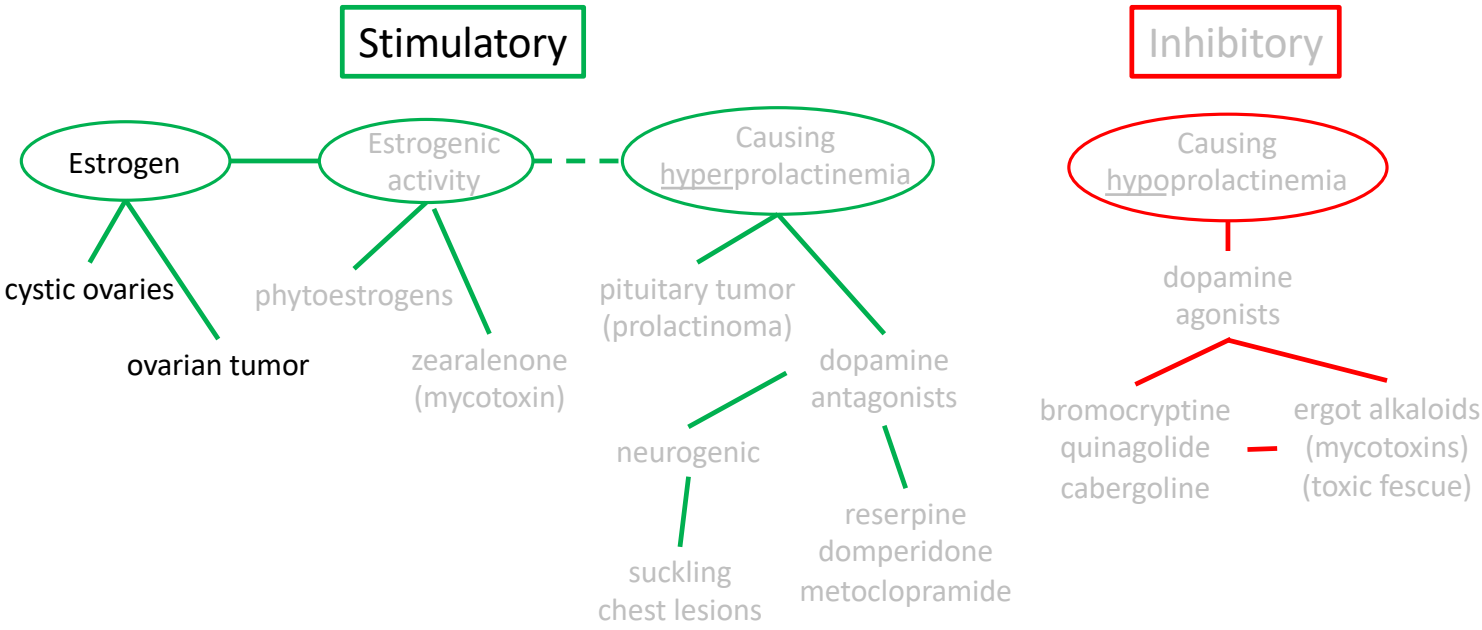
Wait – be patient

Start removing the mammary secretions

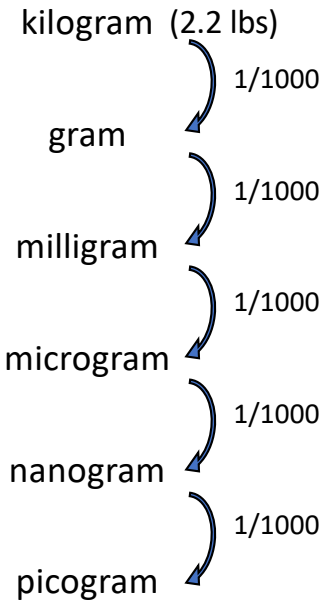
Endocrine modulators potentially affecting mammary development or lactation



Endocrine modulators potentially affecting mammary development or lactation



Endogenous Sources of Estrogen



Estradiol from **ovary** – follicular phase
10 to 50 pg/ml
Few days

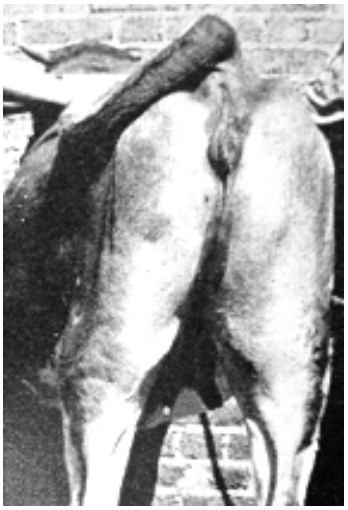
Estradiol during **pregnancy**
450 pg/ml
Extended period

Estradiol from bovine **follicular cysts**
4 - 10 picogram/milliliter
Extended period

Example: 15-mos old open Guernsey heifer has an enlarged udder; it has been enlarging 2 months

She also has:

- sacrosciatic ligaments that are relaxing
- an elevated tail head
- a swollen vulva
- chronic nymphomania (in estrus for 4-5 days at a time)



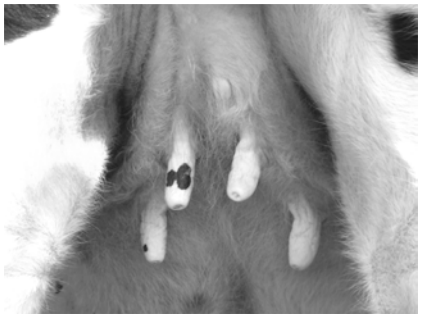
What is the cause?

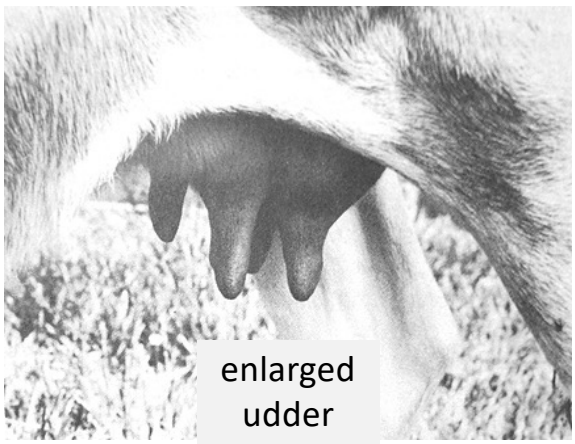
Ovarian cysts on her right ovary

Example:

- 11-mos old open Jersey heifer with precocious lactation
- Udder was distended with fluid
- Teats equivalent in size of an adult lactating cow
- 1 L of milk was stripped out of the udder
- Rectal palpation revealed a large abdominal mass (basketball sized) at the end of the right uterine horn
- Both uterine horns were of normal size, left ovary was small
- Serum hormones concentrations were progesterone = 5.6 ng/ml, and estrogen = 1446 pg/ml
- Normal estrogen concentrations are 5-30 pg/ml for pubertal heifers

normal



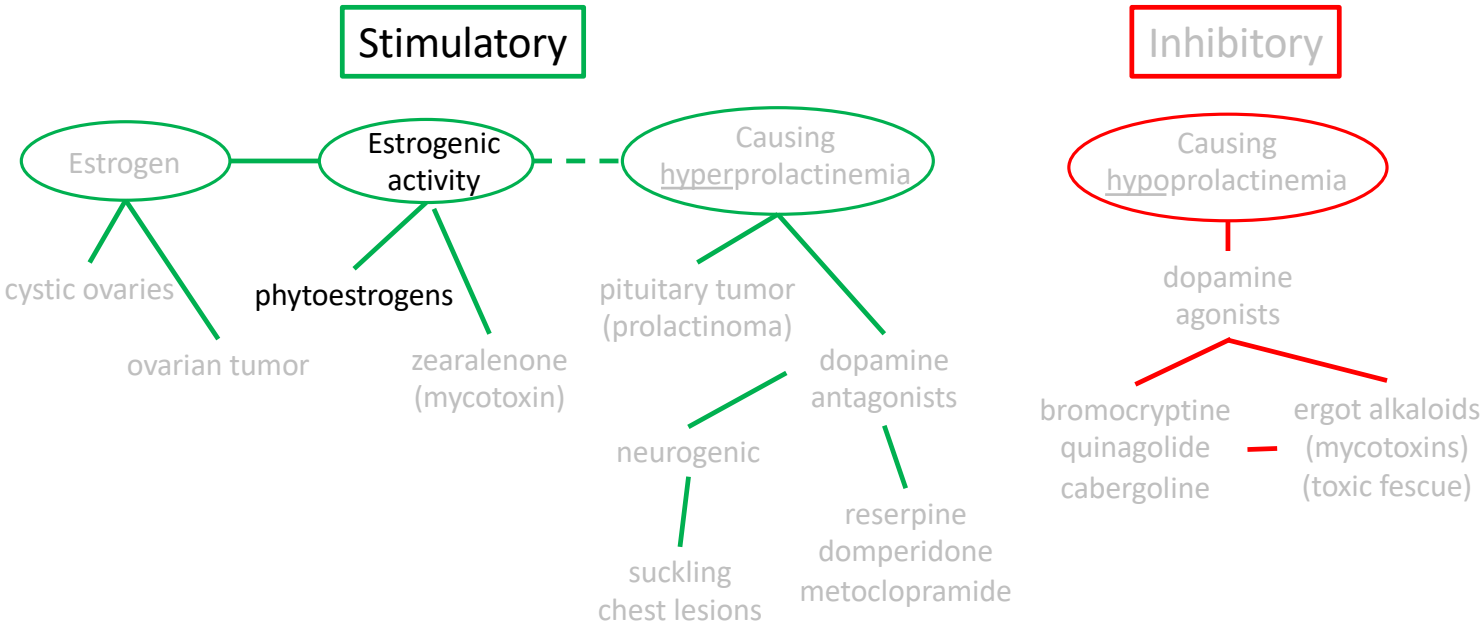


enlarged udder

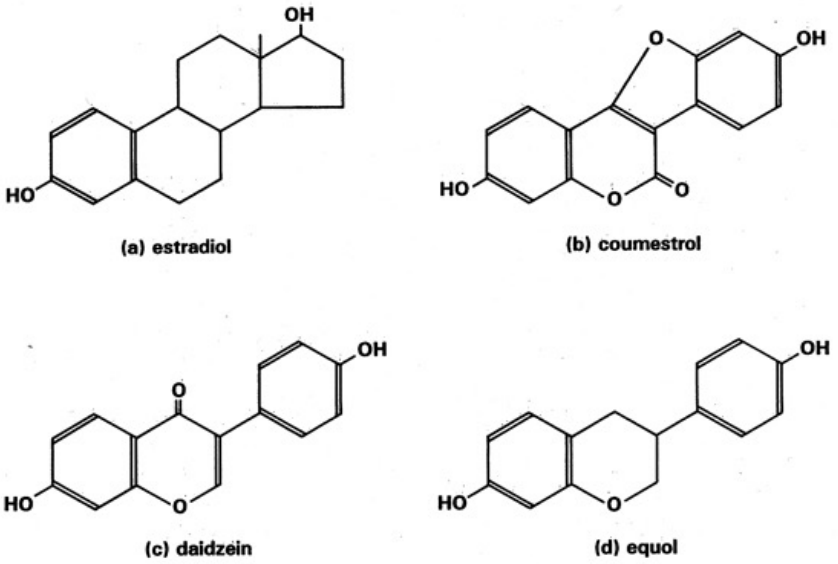
What is the cause?

Sex cord-stromal ovarian tumor

Endocrine modulators potentially affecting mammary development or lactation



Phytoestrogens in Legumes



Subterranean clover

Sheep grazing nothing but this clover were infertile

Had significant mammary development

Contains a lot of **phytoestrogen**

Phytoestrogen plant list

A partial list of plants which contain estrogenic compounds:

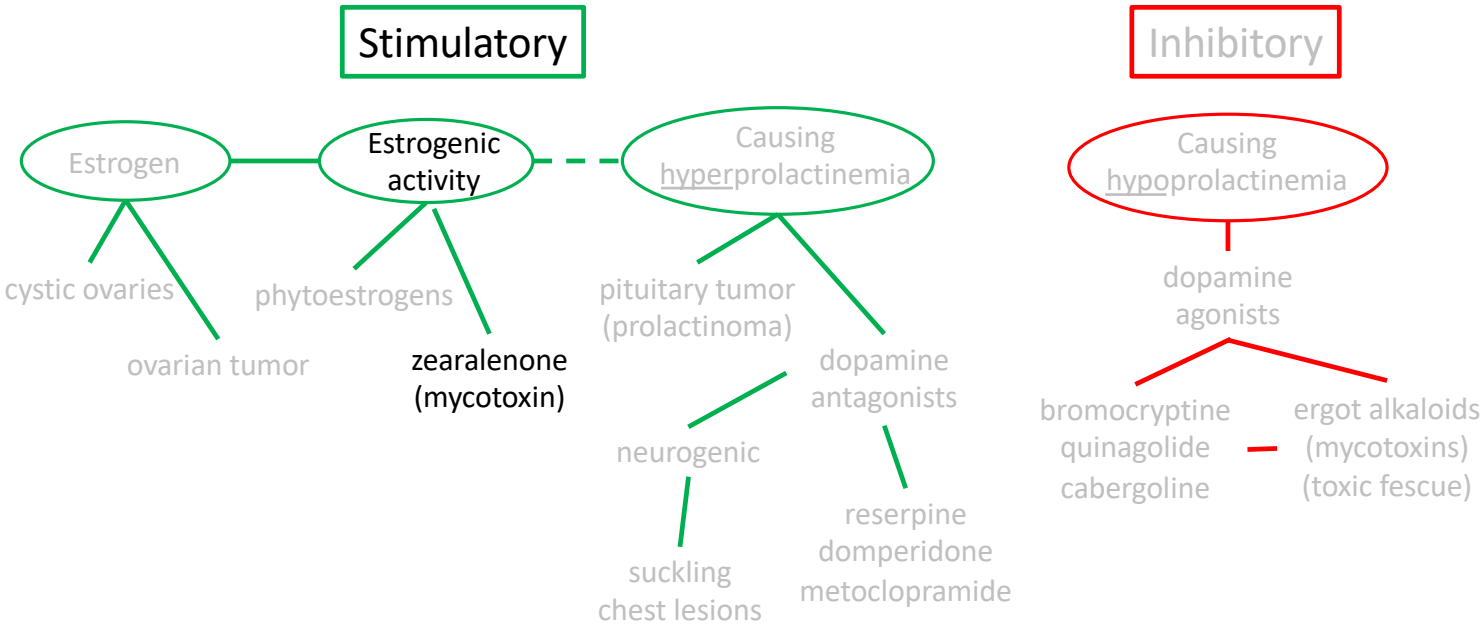
Alfalfa	Anise	Grapefruit	Rape
Ladino clover	Apple	Green beans	Red beans
Red clover	Black tea	Green tea	Red wine
Sorghum	Cabbage	Hops	Rice
Soybeans	Carrot	Kudzu root	Rye
Subterranean clover	Cherry	Liquorice	Sage
	Coffee	Marijuana	Sesame
Barley	Date palm	Palmetto grass	Soya sprouts
Blue grass	Fennel	Parsley	Strawberry
Oats	Flax seed	Peas	Sunflower seed
Orchard grass	French beans	Pomegranate	Tomato
Wheat	Garlic	Potato	

Phytoprogestins plant list

A partial list of plants with progesterone receptor-binding components:

Red clover	Damiana	Thyme	Fennel
	Pennyroyal	Calamus root	Camomille
Bloodroot	Verbena	Goldenseal	Cloves
Ocotillo	Nutmeg	Licorice	
Mandrake	Tumeric	Mistletoe	
Oregano	Yucca	Cumin	

Endocrine modulators potentially affecting mammary development or lactation



Example:

Two heifers with unusually enlarged udders

Udders are soft, and not hot to the touch (not infected)

Udder secretions like skim milk

Estrus had not been observed in either heifer

Have normal prepubertal genital tracts

Housed with 18 other heifers, 6 to 14 months old

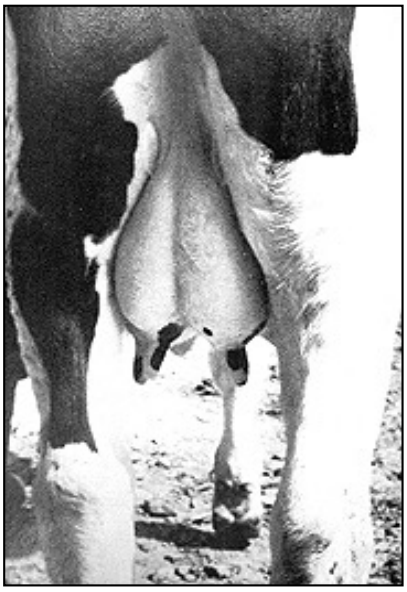
All heifers in this group are open (not pregnant)

Most have varying degrees of mammary development

Heifers may have 1, 2 or 4 quarters enlarged

normal

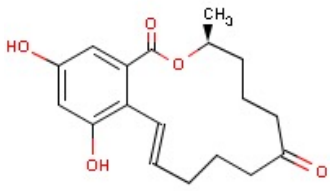
enlarged udder

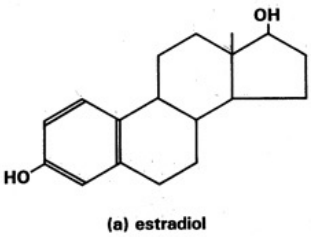


What is the cause?

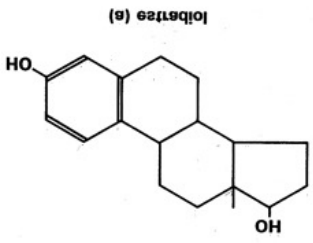
exposure to estrogenic mycotoxins in the feed (Fusarium spp.; **<u>zearalenone</u>**)

<u>Fusarium</u> on ear corn





(a) estradiol



<u>Zearalenone</u>

Factors affecting animal response to ingestion of plant endocrine modulators :

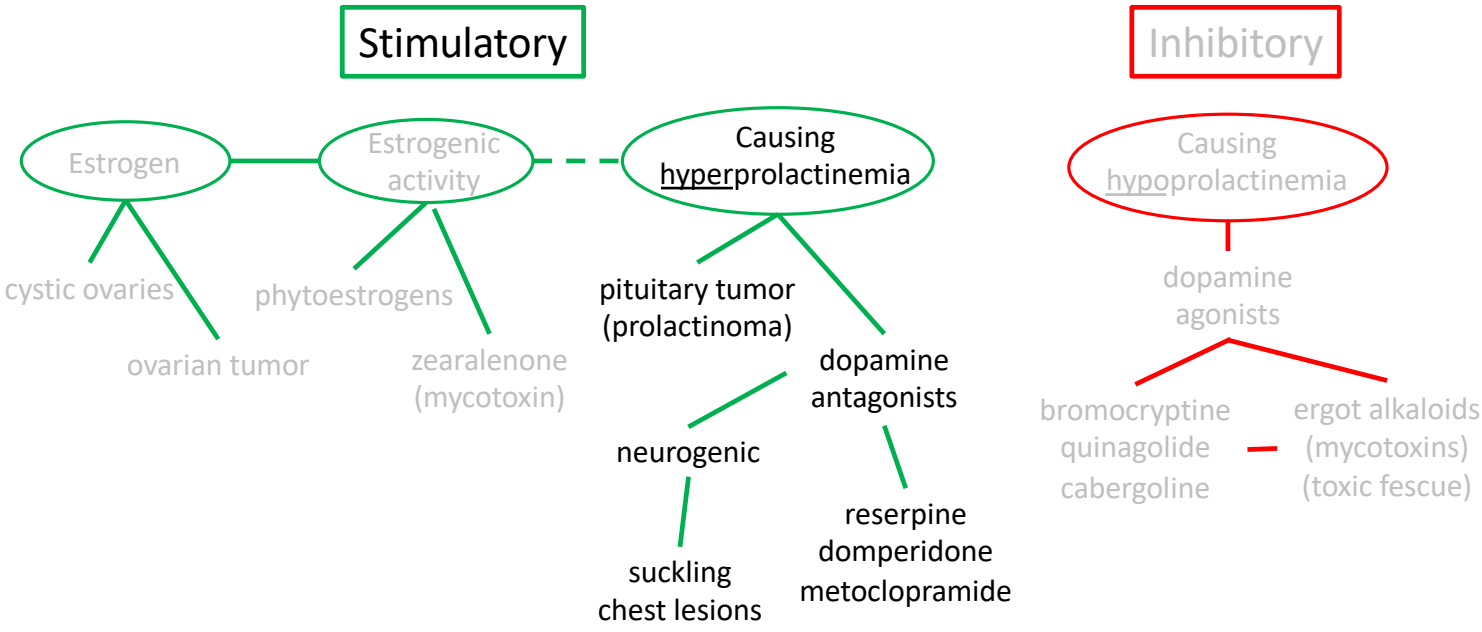
- Plant species
- Plant strain
- Growing conditions
- Quantities ingested
- Animal metabolism
- Ratios of phytoestr.
- Tissue sensitivity

<u>Phytoestrogens are weak estrogens</u>

Phytoestrogens are 1/1000 to 1/10,000 as potent as estradiol 17ß.

Preferentially bind to the ß-estrogen receptor compared with binding the α-receptor.

Endocrine modulators potentially affecting mammary development or lactation



Sources of prolactin: Pituitary Placenta

Hyperprolactinemia – persistently or excessively elevated blood prolactin

Some causes of hyperprolactinemia:

galactogogues

Drugs – Dopamine antagonists such as:
- Metoclopramide, sulpiride, domperidone, cimetidine
- Anti-depressants
- Anti-hypertensives (reserpine)
- Estrogens, opiates, others

Hypothalamic disorders

Pituitary disorders - prolactinomas

Primary hypothyroidism

Neurogenic – chest lesions, breast or nipple stimulation

Stress

Prolactinomas

Hyperprolactinemia – persistently or excessively elevated blood prolactin

Accounts for ~40% of all pituitary tumors

Galactorrhea observed in 30-80% of women

with hyperprolactinemia, which is associated with pituitary tumors

Observed in adult females and males

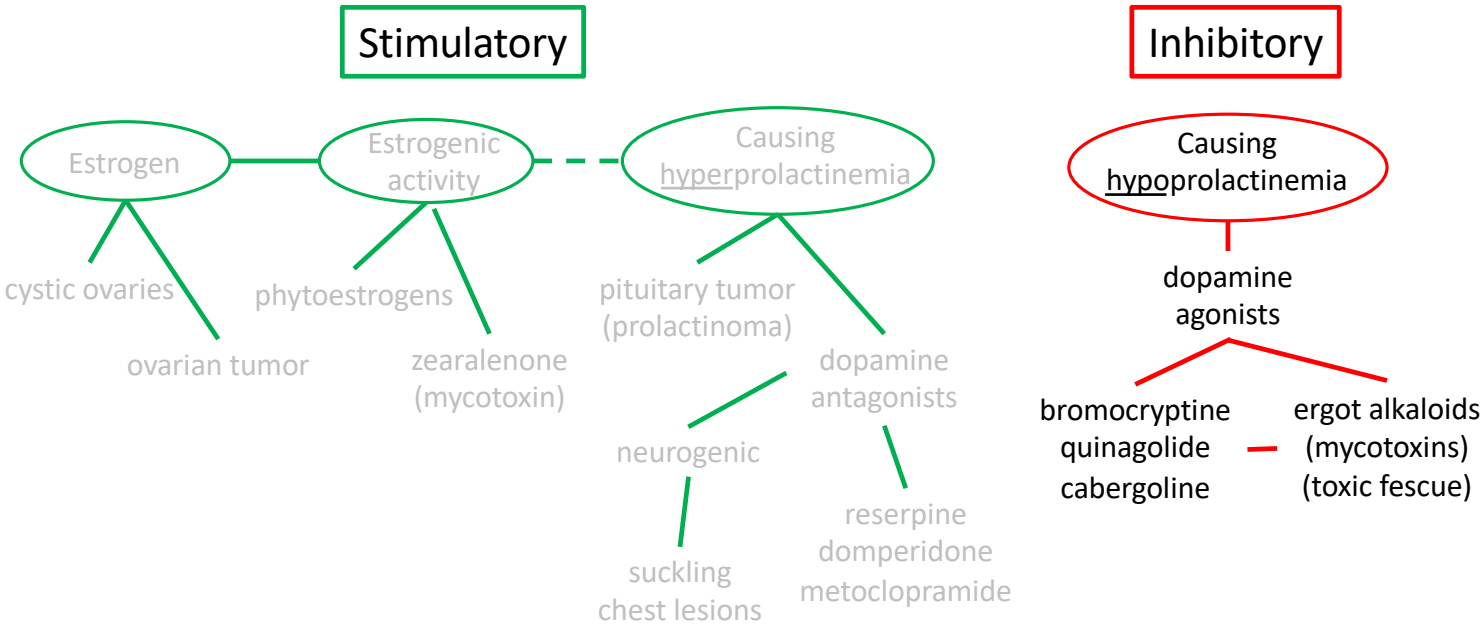
Less common in children and adolescents

Clinical manifestations include infertility, gonadal and sexual dysfunction

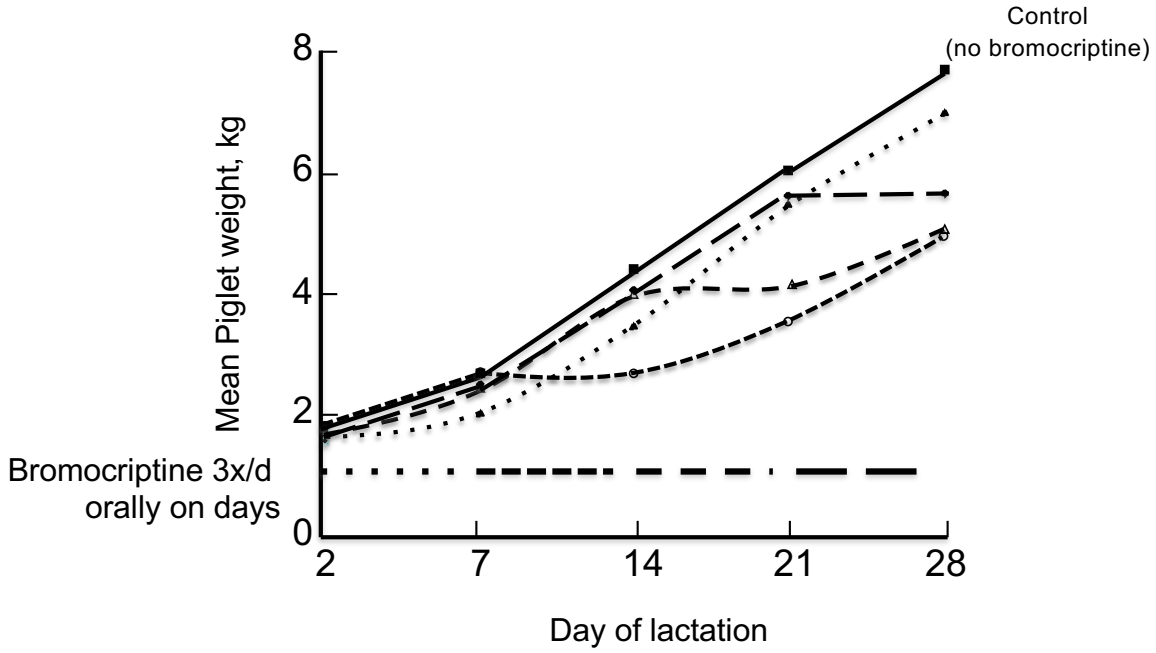
Treatment – dopamine agonists

bromocriptine, quinagolide, cabergoline

Endocrine modulators potentially affecting mammary development or lactation



Effect of lowered PRL on sow lactation:



From: Farmer etal 1998

Suckling Induced Lactation

- Lactation in the absence of pregnancy
- Several species: women, rhesus monkeys, dolphins, dwarf mongoose, others
- Communal nursing
- Suckling stimulus
- Maintained over a period of weeks
- Young must have other milk source

Lactation in Males

- Can be induced by hormones
- Limited mammary development
- Limited milk production

Male Goat

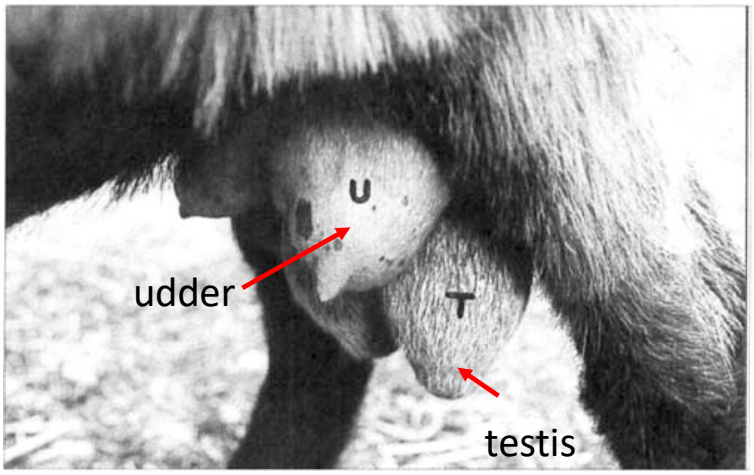
A 4-year-old Shami goat buck had a fully developed udder and galactorrhea. Palpation of the udder and testes indicated a healthy, functioning, fully developed, female mammary gland and normal mature testes.

Milk secretion and letdown was easily stimulated by hand milking

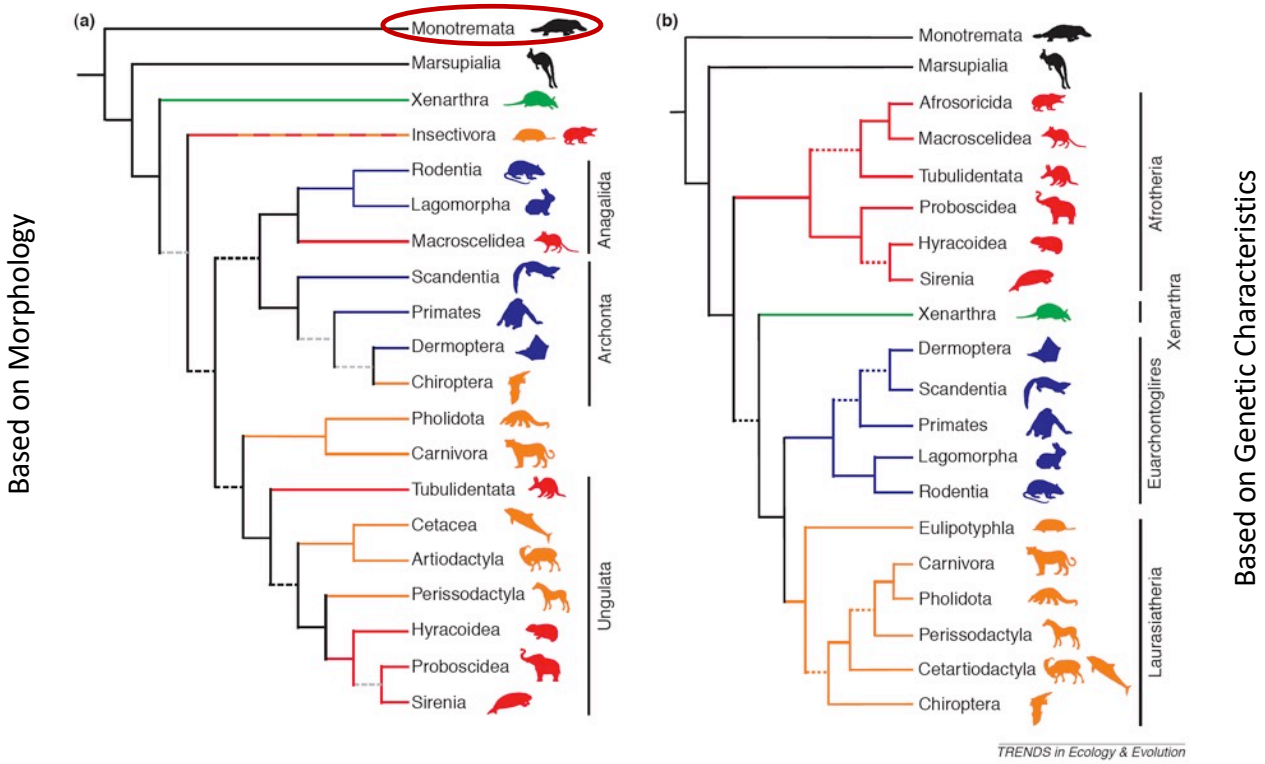
Milk had 5.1**%** protein, 2.7% fat

Typical goat milk has 2.9**%** protein, 4.5% fat

The buck's sexual behavior was typical of normal males and had normal offspring



Evolution of Mammals



Monotremes

Egg laying mammals

Duckbilled platypus *Ornithorhynchus anatinus*

4 species of Echidna

Tachyglossus aculeatus

Australia New Guinea

Genetic evidence indicates monotremes first evolved 180 – 210 mya

Oldest fossil is from only 120 mya

Platypus and echidna diverged between 19 and 48 mya

Male's spurs deliver a venom

The Echidna "Pouch"

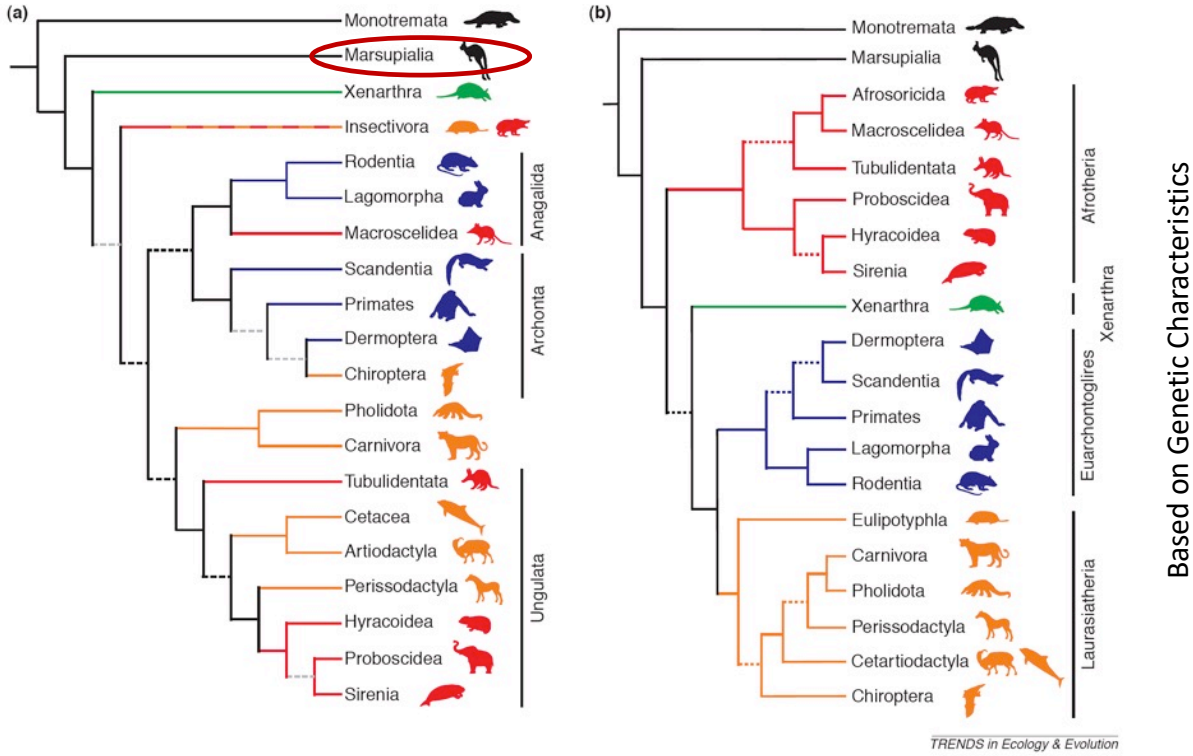
Do not have a permanent pouch. Have contracting muscles in the abdomen, which forms a pouch-like fold.

Both male and female echidnas can form a pouch.

Milk ejected onto the skin

Evolution of Mammals

Based on Morphology



Based on Genetic Characteristics

Marsupials

334 species:

- kangaroos
- wallabys
- koala
- possums
- wombats
- Tasmanian devil
- others

Young born live, but very immature

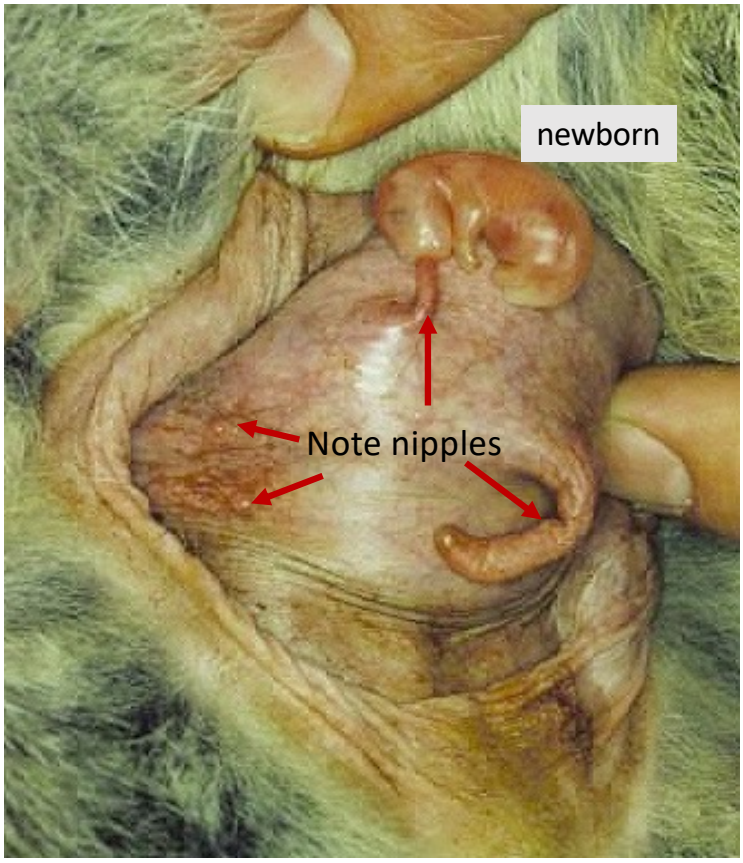
Nurse in a pouch

Marsupials have lactation lengths 5-10 times longer than placental mammals of comparable body weight

Australia
New Guinea
South America
Central America
North America

Tammar Wallaby
Macropus eugenii

Tammar Wallaby
Mammary gland



Tammar Wallaby

Macropus eugenii

Born at ~28 days

Climbs unaided into the mother's pouch

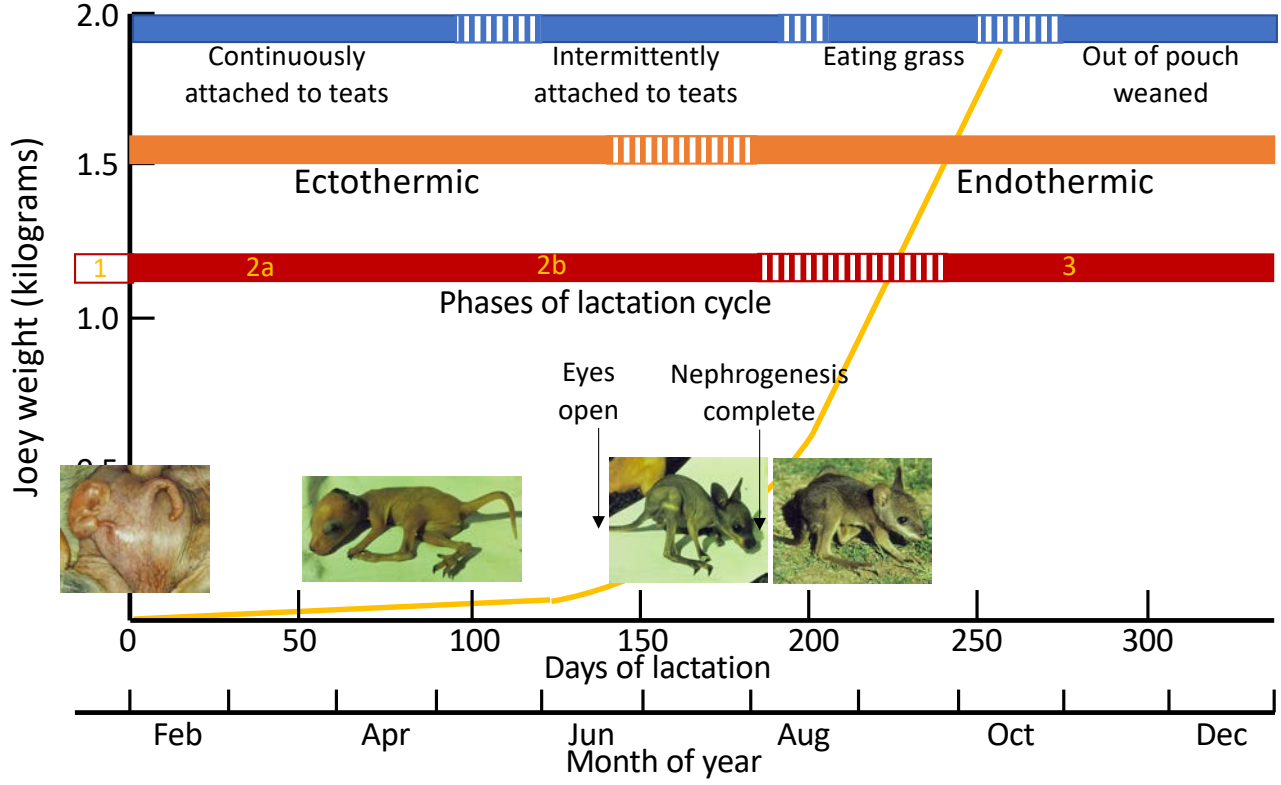
Swallows a nipple

Detaches from the nipple at ~100-125 days, but remains in the pouch

Begins to leave the pouch ~200 days

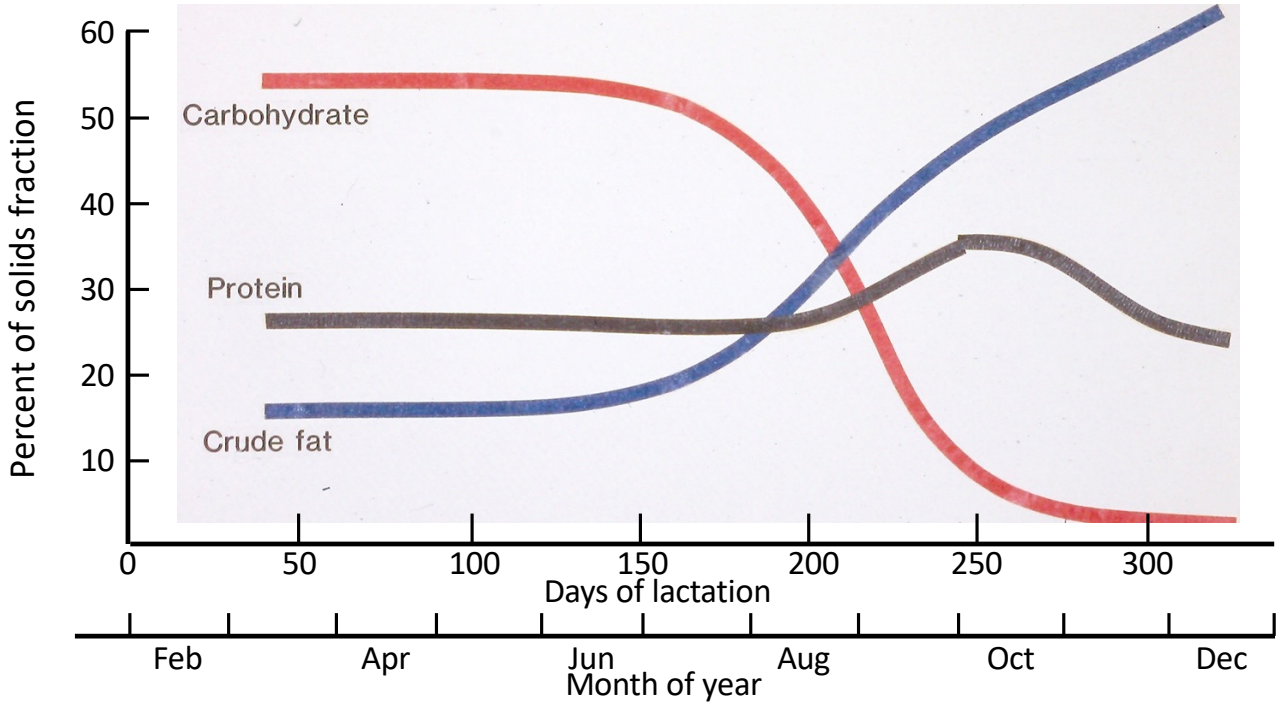
Weaned at about 300-350 days

Tammar Wallaby



Tammar Wallaby

Solids % ranges between ~13% to 35%



Tammar Wal