4-H 185

Equine Reproduction and Genetics

FOR SUMMER 2023
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THE OHIO STATE UNIVERSITY EXTENSION

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Figures 4 and 5 were based on figures in Ginther, O. J. Reproductive Biology of the Mare. McNaughton and Gunn Incorporated, Ann Arbor, Michigan, 1979. Figures redrawn with permission.

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Objectives from the National 4-H Council

1. Promote love for and humane treatment of animals.

2. Acquire safety skills to prevent injury to people and animals.

3. Develop sportsmanship, cooperation, decision-making ability, and public-speaking skills through participation in demonstrations, tours, judging, and/or exhibits.

4. Learn horsemanship skills and understand breeding, training, and raising of horses as a business.

5. Acquire skills in horse management by owing a horse or a pony and being responsible for its care.

6. Appreciate riding as recreation.

18 USC 707

4-H Members Project Guide

Project Background

This advanced-level project is designed for members 14 to 18 years of age. Younger members may be capable of working at this level after completing the beginning level project, 4-H 174, and one or more of the intermediate level projects. The intermediate-level project 4-H 177, *Basic Horse Training,* is highly recommended before doing the Equine Reproduction project. The advanced-level project, *Horse Nutrition,* would also be a good project to take before doing this project. There is no time limit to complete this project. It is recommended that this be finished section by section over two to three years.

This project should be considered an opportunity to increase subject-matter knowledge in the area of horse reproduction and to explore career opportunities. Remember to check county project guidelines (if any) for additional requirements, especially if you choose to show project animals at the county fair. Please note that a member does not have to take part in the county fair to complete this project. Participation is simply one way to expand your project experience.

Project Guidelines

1. Complete the *Planning Your Project* section of this guide.
2. Explore one of the three major *Interest Areas* for each year of the project.
3. Select at least three *Things To Do* within each lesson of your selected *Interest Area. (Interest Areas* may be repeated.)
4. Take part in at least three *Project Learning Activities.*
5. Become involved in at least three *Leadership/Citizenship Activities.*
6. Maintain a project diary or scrapbook telling what was done and learned through this project.
7. Have access to a horse.

Planning Your Project

This planning section (Steps 1– 4) is designed to be re-used when repeating the project.

Step 1: Interest Areas

During each year, explore one of the three major Interest Areas listed here. As you begin to explore the lessons, place the current date (month and year) next to each.

Date Started (Mo./Yr.) Interest Areas

Equine Breeding Principles

__________ 1. Mare’s estrous cycle and hormonal control, pages 21-26.

__________ 2. Stallion’s reproductive anatomy, castration, and sperm output, pages 26-31.

__________ 3. Breeding recommendations and the stallion breeding soundness exam, pages 31-32.

__________ 4. Artificial insemination, cooled and frozen semen, pages 32-35.

__________ 5. Training stallions to breed on a phantom and teasing horses, pages 36-38.

__________ 6. Preparation for breeding, foal-heat breeding, mare breeding problems, pages 39-42.

__________ 7. Techniques and instruments used in breeding: palpation and ultrasound, pages 42-44.

__________ 8. Stallion breeding contracts, pages 44-45.

Mare and Foal Management

__________ 1. Brood mare management, foaling management, pages 45-48.

__________ 2. Post-foaling problems: mare and foal, pages 48-52.

__________ 3. Lactation, weaning, and foal growth, pages 53-55.

Genetics

__________ 1. Maternal effects and genetics terminology, pages 56-57.

__________ 2. Qualitative and quantitative inheritance, pages 57-60.

__________ 3. Factors affecting genetic progress, breeding records, selection systems, pages 60-63.

__________ 4. Breeding systems, pedigrees, color inheritance, pages 64-70.

Step 2: Things To Do

On the following pages within your selected *Interest Area,* place a check mark in the box next to the three activities you plan to do for each lesson. A check mark [✔] printed in this publication indicates that the activity is required and must be included in your selections. Activities may be added or changed at any time. Guidelines may also be met by planning your own activities for the lessons in your *Interest Area*. Have your parent or advisor initial and date what you complete.

Equine Breeding Principles

Lesson 1. Mare's Estrous Cycle and Hormonal Control

✔ Record (manually or with a computer) and print data on at least three estrous cycles in a mare(s). Describe to an adult experienced in horse breeding what a normal estrous cycle is.

☐ Discuss seasonal effects on the estrous cycle and length of estrus with an adult experienced in horse breeding.

☐ Study and outline in a written report the function(s) of each hormone involved in the estrous cycle, pregnancy, parturition, and lactation.

☐ Observe mares on a lighting management program at a breeding farm. Write a report on its advantages, the effect of the light on the mares, what horses need to be on the program, and what factors will terminate the effects of the program.

✔ Discuss, by demonstration or illustrated talk, the different physical changes that occur in the mare during the estrous cycle through pregnancy and parturition. Also relate the hormone(s) responsible for those changes.

☐ Visit a breeding farm and record the drugs used to control the estrous cycle, the procedure of administering the drug, why it was being used, and the effects of the drug. Give an oral report to a group or a knowledgeable horse breeder concerning the use of estrous-controlling drugs. Plan your involvement in Step 3 of this guide.

☐ Plan your own activity here.

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✔ *This symbol indicates that you must include this activity in your three activities to complete.*

Lesson 2. Stallion's Reproductive Anatomy, Sperm Production, and Evaluation

- ☐ Study and describe the function of the reproductive tissues, organs, and hormones of the stallion. Then, by giving an illustrated talk or demonstration, discuss the functions with a group or an experienced horse breeder. Plan your involvement in Step 3 of this guide.
- ✔ Observe a veterinarian doing a stallion breeding soundness exam and discuss with him or her the purpose and result of each evaluation.
- ✔ Visit a breeding farm and discuss with the breeding manager or a veterinarian what factors will affect daily sperm output of the stallion, how often they breed a stallion, and how they care for the stallion during breeding season. Write a report about what you learn.
- ☐ Plan your own activity here.

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Lesson 3. Breeding Procedures: Artificial Insemination (AI), Teasing, Sanitation, Handling, and Safety

- ☐ Discuss with a breeding farm manager the advantages and disadvantages of using artificial insemination (AI) on that farm.
- ✔ Describe to an adult experienced in horse breeding the equipment used in AI. Be able to assemble an artificial vagina and discuss what is being done and why.
- ☐ Design and discuss with an adult experienced in horse breeding your design for a breeding phantom.
- ☐ Videotape or write out the procedure for teaching a young stallion to mount a phantom. Discuss your report with an adult experienced in horse breeding.
- ☐ Assist in breeding a mare by artificial insemination and discuss the process in an illustrated talk or demonstration.
- ☐ Visit at least two breeding farms and study the teasing methods used. Discuss the methods with the manager as to their effectiveness and safety. Summarize in a report the advantages, disadvantages, and safety features of each method.
- ✔ Observe the daily behavior that a stallion and a mare show during teasing through at least one estrous cycle and after the mare is pregnant. Record the daily behavior and relate it to time of ovulation, being in or out of estrous, and being pregnant.

✔ *This symbol indicates that you must include this activity in your three activities to complete.*

- ☐ Predict the time you would recommend to breed each of three mares based on their teasing records. Discuss your predictions with an adult experienced in horse breeding.
- ☐ Observe mares being teased in foal heat. Why is their behavior different than mares without foals or mares bred at a later cycle? Discuss this with an adult experienced in horse breeding.
- ✔ Assist in preparing a mare and a stallion for breeding and summarize the procedures in a written report with emphasis on sanitation and safety.
- ☐ Observe and then assist in handling a mare or a stallion during the breeding act. Summarize the procedures in a written report with emphasis on safety.
- ☐ Study the criteria for successfully breeding a mare in foal heat. Look at a farm's breeding records or interview a breeding manager or veterinarian to determine if he/she supports the statement that foal heat mares bred under these criteria will settle and maintain the pregnancy as well as mares bred at a later estrus.
- ☐ Observe a veterinarian as he or she posts a horse. Have him or her point out the reproductive system.
- ☐ Study the palpation parameters used to determine if a mare is pregnant.
- ☐ Record a veterinarian's results as he or she palpates a mare and determine if the mare is pregnant.
- ☐ Discuss the use of ultrasound on the breeding farm. Write a brief report on its uses.
- ☐ Plan your own activity here.

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Lesson 4. Reproductive Cultures, Biopsies, and Breeding Problems

- ☐ Visit a breeding farm and identify common breeding problems. Write a summary of how these problems are handled.
- ✔ Observe a breeding soundness exam on a mare. Give a demonstration or illustrated talk on how mares are cultured, biopsies, and treated. Plan your involvement in Step 3 of this guide.

✔ *This symbol indicates that you must include this activity in your three activities to complete.*

- ☐ Observe at least 10 mares and rate their vulva formation as good, fair, or poor.
- ☐ Plan your own activity here.

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Lesson 5. Breeding Contracts

Only one activity is required in this Interest Area.

- ✔ Write a stallion breeding contract.
- ☐ Plan your own activity here.

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Mare and Foal Management

Lesson 1. Foaling Management

- ✔ Survey at least two farms to study their methods of mare and foal management, starting 30 days before foaling and until the foal is three days old. Write a report on the procedures used.
- ☐ Develop, either manually or with a computer, a vaccination and deworming schedule for a mare through gestation.
- ☐ Study and identify pre-parturition signs of a mare then discuss them with an adult experienced in horse breeding

✔ *This symbol indicates that you must include this activity in your three activities to complete.*

- ✔ Photograph or videotape the birth of a foal. Give a demonstration or illustrated talk about the foaling process using the photographs or the videotape. Discuss what occurs at each stage and what should be a normal delivery of a foal. Plan your involvement in Step 3 of this guide.
- ☐ Plan your own activity here.

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Lesson 2. Post-Foaling Management

- ✔ Observe a mare and a foal. Based on the criteria given for creep feeding, decide the appropriate age of the foal to begin creep feeding, what nutrients and what levels are required in creep feed, and how to design a creep feeder. Give an illustrated talk or written report on your findings. Plan your involvement in Step 3 of this guide.
- ✔ Plan and implement a weaning program for a foal. Record the behavior of the foal and mare for the first 10 days after weaning.
- ✔ Observe or treat a foal for constipation and summarize in writing your observations and treatment.
- ☐ Visit a breeding farm to study post-foaling problems, diseases, and deformities. Write a case report of the afflictions and treatments.
- ☐ Chart the growth of and photograph a foal each month from birth to one year by measuring its weight or height. Give a demonstration or illustrated talk on your results and how they compare to the expected growth. Plan your involvement in Step 3 of this guide.
- ☐ Write a report on milk production in the mare. What causes milk production and release, and how does one stop lactation after weaning?
- ☐ Plan your own activity here.

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✔ *This symbol indicates that you must include this activity in your three activities to complete.*

Genetics

You may wish to attend a breeding seminar or workshop at The Ohio State University Agricultural Technical Institute (ATI), the All-American Quarter Horse Congress, or other professional event. Plan your involvement in Step 3 of this guide.

Lesson 1. Qualitative and Quantitative Inheritance

- ✔ Explain to an adult experienced in horse breeding how the genes of a chromosome react to produce traits seen in a foal.
- ☐ Determine the percentage of each genetic type of foal that would result by crossing a stallion that is Hh or HH with a mare that is recessive hh for the trait of umbilical hernia.
- ☐ Use the heritability estimate to predict wither height of a foal of two parents of different heights.
- ☐ Plan your own activity here.

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Lesson 2. Breeding Systems, Records, Pedigrees

- ☐ Discuss with an adult experienced in horse breeding the factors that affect genetic process.
- ✔ Decide what breeding system(s) you would use to achieve your purpose as a horse breeder and write a summary stating that purpose and how this system will give the desired result.
- ☐ Attend a breed futurity show and write a report on what crosses of stallions and mares win most of the prizes.
- ☐ Calculate a full pedigree interpretation on a horse, including the percent inheritance for the most common ancestor, inbreeding coefficient, relationship coefficient, and the relationship of sire to dam.

✔ *This symbol indicates that you must include this activity in your three activities to complete.*

- ☐ Plan your own activity here.

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Lesson 3. Coat Color Inheritance.

- ☐ Determine the genotype of the parents that would produce your preferred coat color of a horse.
- ☐ Write a brief report on color genes. Under what situations may they be lethal or produce other abnormalities in a horse? Give an illustrated talk on this to your club. Plan your involvement in Step 3 of this guide.
- ✔ Study and write a report on color inheritance, then give an illustrated talk to your club. Plan your involvement in Step 3 of this guide.
- ☐ Plan your own activity here.

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✔ *This symbol indicates that you must include this activity in your three activities to complete.*

Step 3. Learning Experiences

Select three *Sample Learning Experiences* listed here and plan your involvement in the *Report of Learning Experiences* chart on the next page. Before starting your project, write your three choices in the section labeled *Plan to Take Part In.* Once you have taken part in a activity, record what you did and when. Learning experiences may be added or changed at any time.

Sample Learning Experiences

Breed or Futurity Show

Horse Bowl

Breeding Horse Farm

Illustrated Talk

Sale

Judging Team

Clinics

Newspaper Article

Demonstration

Project Meetings

Exhibit

Radio/TV Presentation

Farm Tour

Speech

Hippology Contest

Report of Learning Experiences

Plan to Take Part In	What You Did	Date Completed
(Example) Demonstration	I gave a demonstration to my club on how to interpret pedigrees.	5/20

Step 4: Leadership/Citizenship Activities

Check the activities you wish to do or plan your own in the space provided. Plan to do at least three. Keep track of your progress by dating (month and year) what you complete. Leadership / Citizenship activities may be added or changed at any time.

Date Completed (Mo./Yr.)	Plan To Do	Leadership/Citizenship Activities
___________	☐	Arrange for your club to tour a horse-breeding farm.
___________	☐	Encourage someone to join your 4-H club.
___________	☐	Arrange for a manager of a horse-breeding farm to speak to your club about the horse-breeding business.
___________	☐	Demonstrate something about equine reproduction to your club.
___________	☐	Help organize or work at a 4-H horse show.
___________	☐	Help coach, assist, or organize a horse bowl, horse judging team, or hippology contest.
___________	☐	Help someone identify horses that qualify as breeding stock.
___________	☐	Write a newspaper article about your 4-H Club.
___________	☐	Serve as safety officer for your 4-H horse club.
___________	☐	Arrange for a veterinarian to demonstrate or explain horse breeding procedures.
___________	☐	Conduct a presentation using photos or videotapes of the foaling process.

_____ ☐ Help someone select a horse project.

_____ ☐ Help someone with his or her horse project.

Or plan additional activities here.

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Equine Reproduction

The horse has the reputation of having the lowest fertility level of our domesticated farm animals. Actually this is not true. The national foaling percentage of all mares bred is only 50%. The cause for this low percentage is not the horse's fault; the cause stems from man's poor management.

Horse farms that use good breeding management procedures have had conception rates of 80 to 90% and foaling rates of 70+%, which compares favorably with other farm animals. To gain these kinds of results, however, a thorough understanding of the reproductive processes involved in both the mare and the stallion is essential.

The Mare

The Estrous Cycle

The normal estrous cycle of the mare is usually 21 to 22 days in length and can be divided into two parts — estrus (commonly called "heat" which is a period when the mare is showing signs of desiring copulation with a stallion) and diestrus (when she is not showing signs of sexual receptivity). Although the estrous cycle begins at puberty (at about nine to 12 months of age), it is not recommended to breed the filly until she is at least three years of age. This recommendation is based on allowing the filly to reach sufficient maturity to carry a foal to term. Although some fillies bred as two-year-olds have been able to carry a foal to term, 20 to 30 percent of two-year-olds have conceived and later aborted due to insufficient development of the uterus. The abortion rate in fillies bred as yearlings is 50 percent.

The mare is a seasonally polyestrous animal. This means that she will cycle many times in a year but she has a season (winter) in which she fails to cycle. Failure to cycle is called anestrus and in the mare is related to the length of daylight. As daylight length increases, as in spring, the mare begins to cycle, and in the late fall as daylight length decreases, she ceases to cycle. In addition, prolonged temperatures below 0ºF may contribute to keeping the mare in anestrus. With a January 1 universal birth date for horses, the pressure is on breeders to produce foals that are born early in the year. This means that breeders are trying to breed many mares early in the year when they are just starting to come out of the winter anestrus.

Hormones

To understand how to deal with all the complications of breeding mares, it is first best to understand the normal estrous cycle and its hormonal control. Hormones primarily regulating reproduction in the mare come from the anterior pituitary, the posterior pituitary, the ovaries (from the follicle and the corpus luteum), the uterus, the fetus, and the placenta. A listing of the hormones and their primary function by source follows.

Anterior Pituitary

FSH (Follicle Stimulating Hormone) — This hormone acts on the approximate 100,000 oocytes in the ovary that the mare was born with to cause about 10 of them each cycle to start to develop into a follicle. A follicle is a fluid-filled membrane containing the ova (egg) and other specialized tissues. (See Figure 1.)

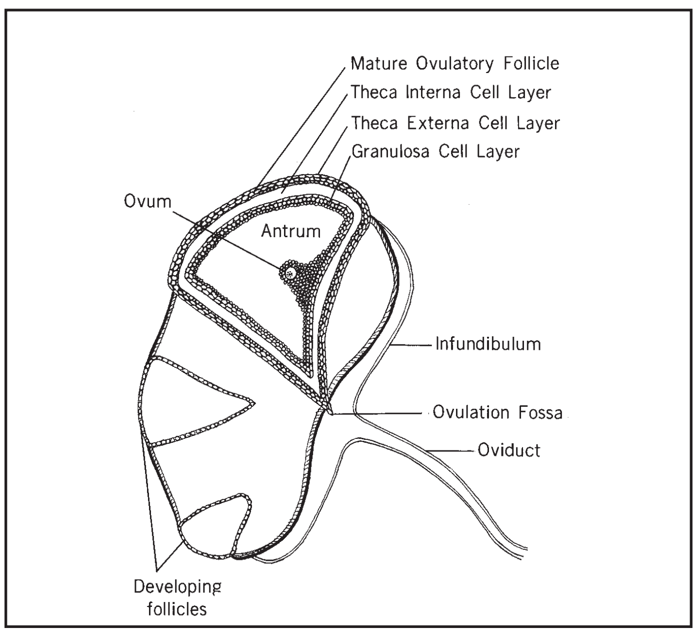

Figure 1. Ovary and related structures.

LH (Luteinizing Hormone) — This hormone acts on the growing follicles started by FSH to mature them and then cause at least one to ovulate — the release of the egg from the ovary into the oviduct. After ovulation, LH is responsible for the formation of the corpus hemorrhagicum (named such because of its bloody appearance) which will change in a few days to a corpus luteum (also called a yellow body due to its color).

Prolactin — This hormone is important in maintaining milk synthesis in the lactating mare. Its continual release is determined by milk removal from the udder.

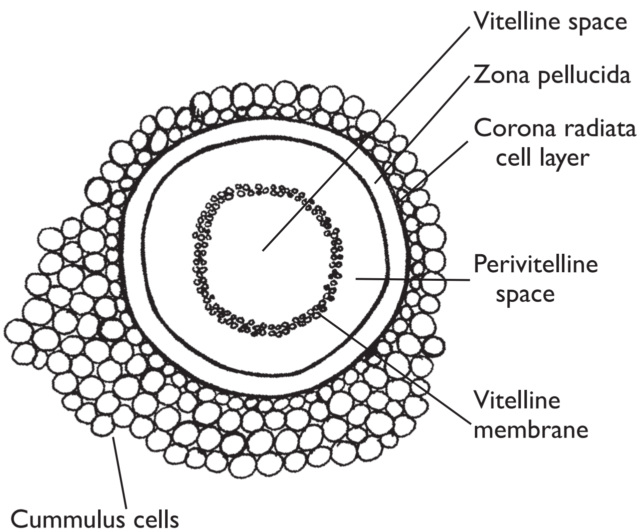

Figure 2. Released ovum.

Posterior Pituitary

Oxytocin — This hormone is actually produced in specialized areas of the hypothalamus and is stored and then released from the posterior pituitary. It acts on the uterus during estrus to cause contractions of the uterus to aid the transport of sperm up the oviduct to the site of fertilization. It also acts on the uterus at the time of foaling to contract the uterine muscles to expel the foal.

A third function of oxytocin is to cause contraction of the muscle tissue in the udder to push milk down toward the teat for the nursing foal. Oxytocin is released as a result of the foal rubbing the udder or attempting to nurse. That is why an older foal will often shove and push against the udder prior to wanting to nurse and then wait a short time (it takes about one to three minutes from stimulation until the hormone can cause maximum milk letdown) before actively trying to suckle.

A fourth function of oxytocin is maternal instinct. As the foal nurses, the hormone increases the mare's maternal instinct. For the first few days of the foal's life, the mare's instinct — as evidenced by her level of protection of the foal — increases. There is actually less and shorter separation anxiety if a foal is weaned at one day then if weaned at one month of age.

Ovarian

Estrogen — The theca interna cells of the developing follicle produce estrogen. The functions of ovarian estrogen are:

- The development of secondary sex characteristics.
- The desire for copulation.
- The thickening of the vaginal wall to withstand the stresses of copulation.
- The production of mucous to protect against infectious organisms introduced at the time of breeding.
- The growth of uterine tissues.
- The growth and muscular activity of the oviducts.
- The sensitization of tissues to the effect of other hormones.

Inhibin — Produced by the developing follicles and is thought to act as a signal to stop further FSH release.

Progesterone — Produced by the granulosa cells of the follicle, which will form much of the corpus luteum (CL) which will continue progesterone production until the CL lyses (shrinks to a nonfunctional state). The progesterone of the follicle causes a weakening of the connective tissue of the follicle, allowing it to erupt at the ovulation fossa and release the ova into the oviduct.

CL progesterone:

- Causes closing of the cervix.
- Causes secretions that aid in the nourishment of the embryo.
- Promotes placental growth.
- Decreases the rate and amplitude of uterine contractions.
- Prevents LH release.

Uterine Hormones

The uterus releases prostaglandins if no embryo is present in the uterus. It acts on the CL to cause it to regress to a nonfunctional state. This will allow a new cycle to begin since progesterone is no longer preventing LH release.

Fetal Hormones

The embryo migrates through the uterus from about day six after ovulation (the embryo spends four to six days coming down the oviduct after fertilization until it reaches the uterus) until day 16, while the migrating embryo secretes a substance to prevent prostaglandin release so that the CL can continue to function. Research shows that if the embryo is not allowed to migrate, the CL is lysed, the embryo lost, and a new cycle begins.

During gestation the ovary (fillies) and the testes (stallions) secrete hormones to aid in growth and development of the fetus.

Placental Hormones

Estrogens — These are produced in large amounts in the pregnant mare and are important in the growth of the fetus and the development of the mare's mammary duct system. They are also involved in preparing the uterus for giving birth.

Progesterone — Placental progesterone replaces CL progesterone by day 120 of gestation. Experiments have been done to remove ovaries of mares 180 days pregnant and the placental hormones maintained pregnancy. Functions of placental progesterone are:

- To continue to keep uterine contractions to a low level.
- To develop the secretory tissue of the mare's udder.
- To prevent milk synthesis.
- To prevent LH release.
- To aid the growth of the placenta and the fetus.

Equine Chorionic Gonadotropin (ECG) — This hormone is produced by the endometrial cups, which are made by the placenta starting about day 26 of gestation. ECG production starts by day 40 and lasts until about day 120. The cups are then sloughed away. The function of ECG is to cause the development of accessory follicles, which may or may not ovulate but will form accessory corpa lutea. It was thought that this was to increase progesterone production and aid in maintaining pregnancy, but research has not substantiated this theory. This hormone has been used in other species to cause multiple ovulations, but it does not have that effect on mares.

Relaxin — This hormone is released by the placenta and causes the relaxation of the pelvic ligaments and other structures around the birth canal. The effect of Relaxin begins about 30 days prior to birth and is responsible for the sunken tail heads, elongation of the vulva, and flabby appearance of the rear quarters.

The Reproductive Cycle

An **open cycle** (one in which the mare does not conceive) would have the following interaction of hormones: FSH is released and causes the formation of follicles. As they develop, they release Inhibin which decreases FSH release. These partially developed follicles then come under the influence of LH (it is available now due to low progesterone levels), which will mature the follicle. The growing follicle produces estrogen, which causes estrus (heat) and protects the lining of the reproductive tract against injury or disease.

The mature follicle can then release the ova due to progesterone-activated enzymes that weaken the follicle wall until it opens at the ovulation fossa. LH is then responsible for formation of the CL, and it begins to produce progesterone which in turn stops LH release, which stops any more follicles from being matured, decreases uterine contractions which were prevalent during heat, closes the cervix, and causes the uterus to produce uterine milk.

Because no embryo is present in the uterus by days nine to 16, prostaglandin is produced by the uterus and lyses the CL. After the CL is lysed and it stops progesterone production, the pituitary can again release LH to mature new follicles.

A **pregnant cycle** would have the same sequence of events, but with an embryo present in the uterus during days six to 16, no prostaglandin would be released due to secretions from the embryo being released while it migrates through the uterus. By day 16 to 17, the embryo ceases to migrate and usually will begin to attach to the uterus at the base of either horn.

By day 26 to 34, the developing placenta of the embryo starts forming endometrial cups, which are visible by day 40 and produce ECG, which will cause accessory corpra lutei to form and produce progesterone. ECG production is highest days 40 to 90, decreases greatly by day 100, and the endometrial cups are completely gone by day 160. By days 120 to 180, the placenta has taken over the production of progesterone and the CL of pregnancy disappears.

The placental progesterone keeps the uterus from contracting, develops the secretory tissue of the mare's mammary gland but inhibits milk production. The placenta also produces estrogens, which aid in nutrient transfer from mare to fetus, develop the duct system of the udder, and sensitize the uterus to oxytocin influence at time of parturition.

During the last month of pregnancy, the ratio of estrogen to progesterone changes as progesterone rises two to three days before parturition and drops just before parturition. The udder begins to enlarge; Relaxin relaxes the pelvic ligaments and softens tissues around the birth canal. At some point, oxytocin causes contraction of the uterus, and the foal is born followed shortly by the placenta. The exact cause of parturition is not definite, but has to do with estrogen and progesterone ratios, stretch factors of the uterus due to size of foal, prostaglandin release, oxytocin release, and probably many other hormones of fetal, placental, and mare origin.

Due to the mild form of placental attachment, only the surface epithelium is lost, and the mare's uterus can be ready to accept a new embryo and start a new pregnancy as short as 15 days after parturition if there were no complications with parturition. Also since the source of progesterone was discarded at birth (the placenta), LH can be released to mature follicles which cause estrus as soon as two to 11 days (average is nine) after parturition. This estrus is commonly called foal heat.

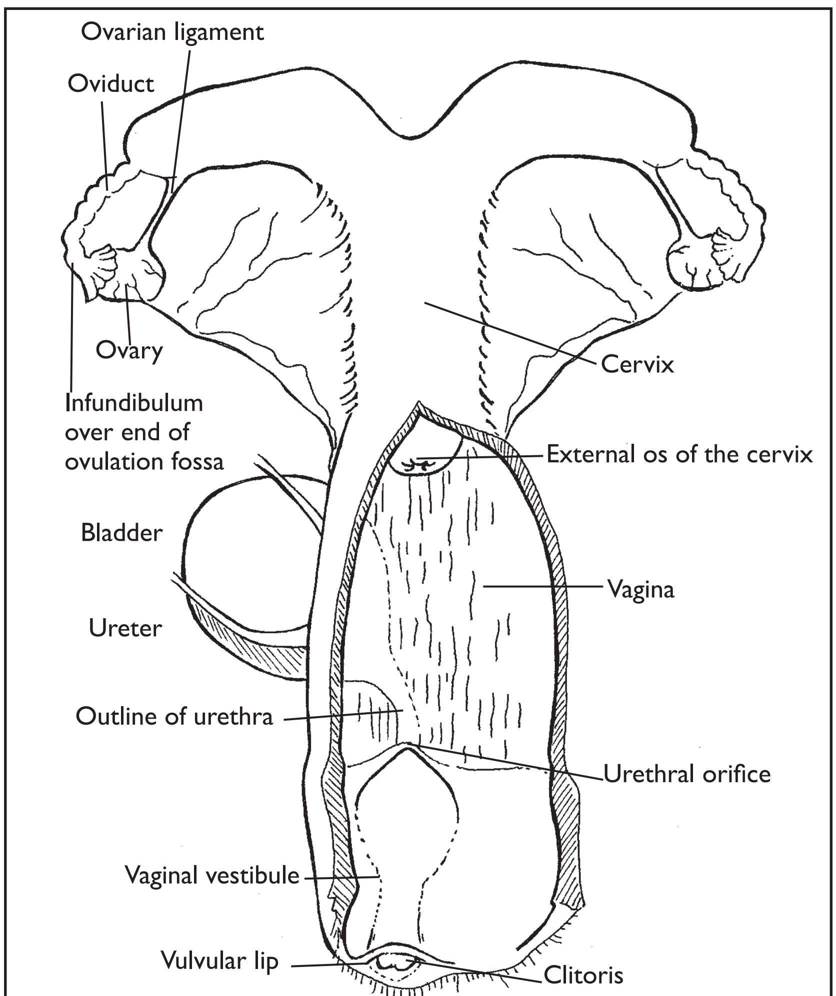

Figure 3. Reproductive organs of the mare.

Controlling the Estrous Cycle

Daylight Length

The greatest problem with the estrous cycle is to get the anestrus mare to cycle early in the year. Daylight length and to a lesser extent warmth and nutrition are the only practical ways to get a mare to come out of winter anestrus. For light to work on the mare, the following conditions must be meet:

1. The mare must have a period of decreasing light such as normally occurs in the fall before lengthening the daylight will work.
2. The mare must be put under a light program 60 days before the expected breeding date and must not be removed for any reason. (Seventy-two hours without the light program will set the mare back to day one of the program.)
3. The mare needs sufficient light for 16 hours each day. (It takes 12 or more foot candles of light at eye level. A 200-watt bulb, incandescent or fluorescent, will work for a 12′ by 12′ stall.) Because of the overcast weather in Ohio, it is recommended to have at least some of the artificial light in the morning to awake the mare's system. Instead of giving 16 hours of light, a new method that works as well is to turn the lights on for two hours between 1 a.m. and 4 a.m. and then turn them off. Whichever method you use, be sure to not give 24 hours of light each day because that is the same as not giving any light. The mare needs a light and a dark period for a lighting program to work.
4. Prolonged weather below 0ºF will override the light effect, so it may be necessary to stable mares in warmer quarters if the weather is very cold for several days.
5. Mares need to be adequately fed and in good health for breeding.
6. If a pregnant mare foals early and you want to rebreed early, she should be under lights the same as the open mare you want to breed early.
7. After a mare that is under lights is bred, continue the lighting program through March. If a mare bred early and taken off lights has an early embryonic death, she may go into anestrus and not cycle again until summer.

Hormonal Control of the Estrous Cycle

Progesterone — A major problem in breeding mares early is to establish a normal cycle as the mare comes out of winter anestrous. Obtaining an ovulation during the first cycle seems to be difficult for most mares. As a result, many mares are in estrus for as long as 14 to 30 days. They are usually producing multiple follicles, but they are unable to ovulate one and form a corpus luteum. Once they do accomplish the first ovulation, they usually fall into a more normal cycle of 21 days with an estrus of five to seven days, with ovulation occurring 24 to 48 hours before the end of estrus.

It has been found that if a mare has multiple follicles of 20 mm or larger that progesterone treatment for 12 to 14 days will stop the mare from showing heat, and after stopping the treatment, the mare will come into a normal heat in three to eight days and ovulate. The synthetic progesterone that works best is Altrenogest (Regumate), given orally each day at the rate of 0.044 mg/kg body weight.

Altrenogest at the same dosage rate has been used to keep a show mare out of heat to avoid the poor disposition of some mares when they are in heat. The treatment for this has been maintained as long as 90 days with no noticeable side effects.

Regumate has also been used to synchronize estrus in a group of mares so they can all be bred in a short time and all foal at about the same time. Normally cycling mares should be put on Regumate for 14 days and upon withdraw should all be in heat within three to eight days.

Regumate has also been used to prolong time from parturition to first ovulation. Starting 12 hours after parturition, the mare is placed on Regumate and kept on it for five to 10 days. When removed, the mare matures and ovulates a follicle usually within seven days. If the mare is on longer than 10 days, there is a decrease in conception rate, or if she conceives, a higher abortion rate.

Prostaglandin — This hormone is used to lyse a corpus luteum, as long as the CL is at least five days old. Prostaglandin has no effect on the newly developing CL.

There are three cases where it is advantageous to eliminate a CL. The first is to short cycle a mare that we either missed breeding before she ovulated, or one that was not physically ready to be bred, as in the case of a foal-heat mare whose uterus was not ready for a new pregnancy at ovulation time. The sixth day or later after ovulation, the mare can be given 8 ug of PGF2a/kg body weight intramuscularly to lyse the CL. She will be back in heat in three to five days and will ovulate in seven to nine days.

PGF2a at the same dosage is used to synchronize estrus in mares. Two treatments are usually required because at the first treatment some mares are probably in that time period between ovulation and the sixth day. Therefore, two treatments are given 15 days apart, and all mares will normally come in heat two to eight days after the second treatment.

The third case for prostaglandin treatment is the pseudopregnant mare. Occasionally a mare will conceive but lose the embryo early in gestation and, if the placenta has produced endometrial cups, they will persist after the death of the embryo and prevent the mare from recycling. Prostaglandin will lyse the CL of pregnancy and accessory CLs and bring the mare back into heat. It may take more than one shot to get this accomplished.

Human Chorionic Gonadotropin (HCG) — This hormone is used in the mare to cause ovulation. If a mare with a 30- to 35-mm follicle is given 2500 IU of HCG (2.5 cc of most commercial preparations), ovulation should occur in 24 to 48 hours after treatment. This treatment is useful to help time ovulation when mares are bred with shipped semen to prevent needing more than one insemination. It could also be used to ovulate a follicle on Friday when you breed her to ensure that she ovulates soon because you could not breed her again until Monday due to conflicting circumstances on Sunday.

HCG has also been used in the case of the mare in transitional anestrous to try to ovulate a persistent follicle. It has had some success with large persistent follicles.

Deslorelin, called Ovuplant, has also been found to be effective in causing ovulation of follicles 30 mm to 40 mm in diameter within 48 hours after injection of the implant. Results are equal to HCG in causing ovulation. However, if the mare does not conceive, the implant may prolong the mare's return to estrus, is more costly than HCG, and is not any more effective.

The Stallion

The Testicle

This organ in the unborn foal starts to develop in the area of the backbone and during development moves toward the inguinal ring and hopefully into the scrotum prior to birth. The testicle is quite large in the unborn foal until about 30 days prior to birth at which time it begins to shrink in size and then is able to be pulled through the inguinal ring into the scrotum.

Cryptorchid is the term used to describe failure of the testicle to descend into the scrotum. Cryptorchidism is thought to be caused by a dominant genetic fault resulting in incorrect development of the gubernacular cord so that the testes either does not get to the iguinal ring, or the epididymus does not expand the inguinal ring sufficiently to allow the testes to enter the scrotum. The testicles should be in the foal's scrotum by two weeks of age. Some testicles are in the inguinal canal and may not descend for up to one year of age. All males should have both testicles descended by the time they are a year old.

A testicle in the abdomen will produce testosterone, the male hormone, but cannot produce sperm. Most of these horses are as aggressive as stallions, sterile if both testicles are retained, and of lower fertility if one testicle is retained. Cryptorchids should not be used for breeding animals since it is a genetic fault.

The stallion reaches puberty (when sperm production begins) at about 12 months of age. For this reason, yearling stallions should not be kept with females that you do not want bred. Although sperm production may begin as early as 12 months, several stallions (about 35%) are still not producing enough sperm to settle a mare at two years of age. In order to determine if a stallion is fertile, a breeding soundness exam ought to be done at least 60 days prior to starting to breed mares. The breeding soundness exam may also give you an idea of how many mares you can expect to breed to any one stallion.

Three types of cells in the testicle are directly involved with reproduction. The testicle is a mass of tubules with connective tissue between the tubules. Within the tubules (see Figure 5), spermatogonia cells divide to produce the sperm cells. Also present are Sertoli cells that nourish sperm cells and produce inhibin. Inhibin acts on the hypothalamus to regulate FSH release, which determines the level of sperm production.

The third type of cell is the Leydig cell, which is in the connective tissue between the tubules. These cells produce the testosterone which causes the secondary sex characteristics, maintains the function of the accessory sex glands, and is important for normal sperm production. The Leydig cells are under the hormonal control of ICSH (interstitial cell stimulating hormone — the equivalent of LH in the mare) from the anterior pituitary, which is controlled by the hypothalamus.

About 55 days pass from the time a spermatogonia begins to divide until it is released and passes through the tubule and into the epididymis.

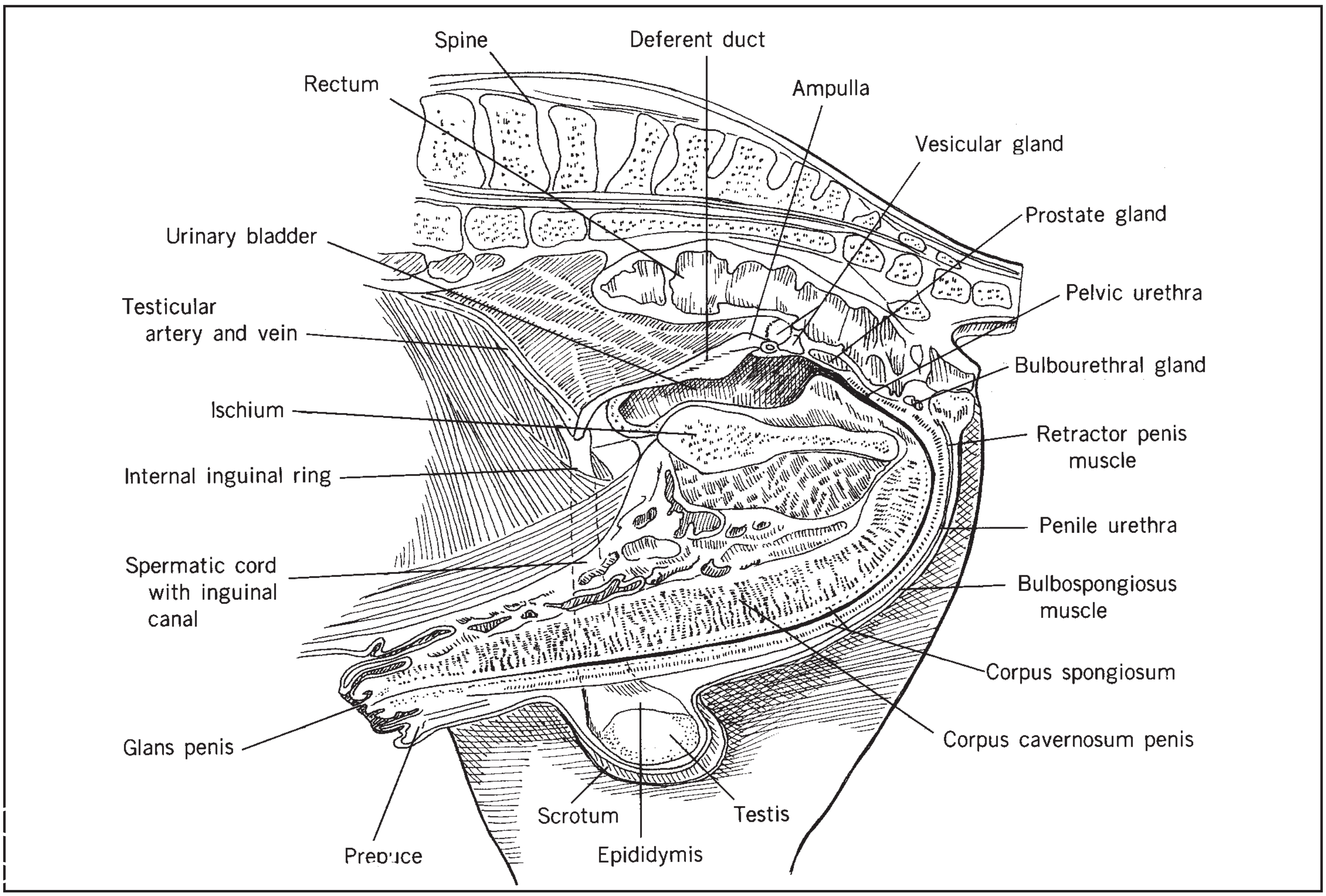

Figure 4. Reproductive tract of the stallion as seen in a left lateral dissection. From Pickett *et al.*

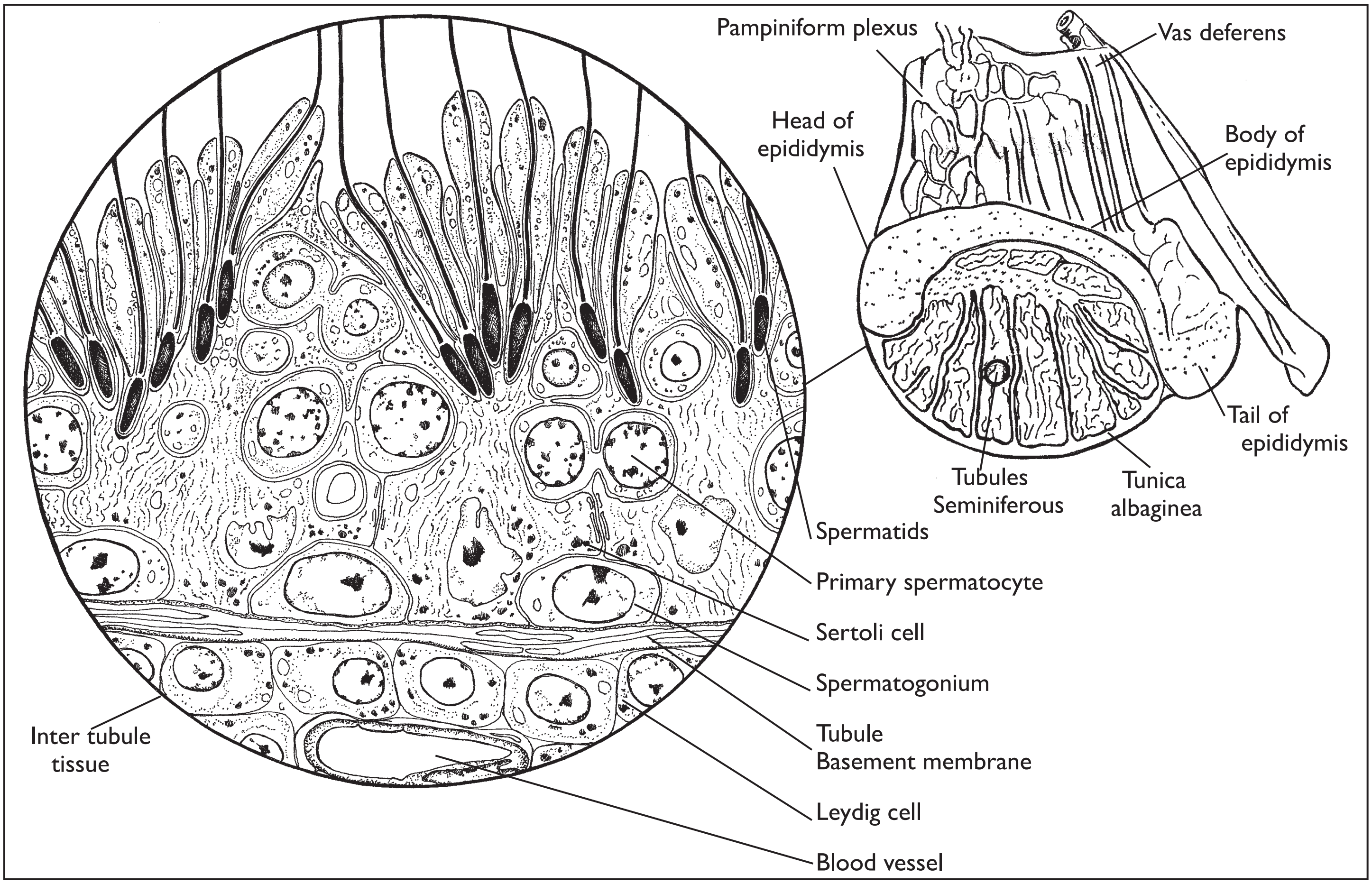

Figure 5. Equine testicle and cross section of a seminiferous tubule.

The Epididymis

After leaving the testes, the sperm are pushed into the epididymis. This organ removes some of the fluid and concentrates the sperm. It also secretes materials to mature and nourish the sperm as they migrate from the head to the tail of the epididymis. Sperm are stored in the tail of the epididymis until ejaculated or pushed out due to more sperm being pushed down through the epididymis. Two epididymis tails can store 54 billion sperm in a normal mature stallion.

Regardless of ejaculation frequency, it takes about five days for sperm to pass from the head to the tail of the epididymis. Sperm may be stored in the tail for several weeks if not ejaculated or pushed on down the tract. Sperm can remain viable for up to 60 days in the tract of the stallion.

Sperm not used in breeding are pushed down the tract and excreted with the urine, reabsorbed along the tract, and/or excreted by masturbation.

Vas deferens and the Accessory Sex Glands

After the epididymis, the sperm are pushed into the vas deferens, which can store an additional 36 billion sperm. Accessory sex glands are located along the vas deferens. During the ejaculation process, fluids are passed in three fractions. The first is fluid from the prostate and cowper's glands, which flushes and cleanses the ejaculatory duct. The second fraction contains sperm from the vas deferens and/or tail of the epididymis and secretions from the ampullar region of the vas deferens. The third fraction is gel like and comes from the seminal vesicles. It pushes most of the sperm from the ejaculatory duct and has some bactericidal properties.

Castration

Males of less than excellent quality are usually castrated in order to produce good reliable animals that are more docile. The time to castrate is up to the owner. Castration can occur safely at any time in the male's life. Many breeders castrate colts as yearlings so they can be keep with fillies of the same age. Some feel a colt should be at least two years old in order to develop a more massive forehand. The author has not seen any proof that waiting until two years of age will help make a narrow horse more massive because after castration, the horse will loose most of those massive characteristics seen in a stallion. Castration can even be done to the old stallion that is no longer fertile or needed so that he can be more easily kept on the farm or sold for a docile riding horse.

After castration, the horse may still be able to settle a mare due to sperm being stored in the vas deferens above where the testicle was cut off. Theoretically, the horse could be fertile for up to 60 days; practically, he is probably no longer fertile after 30 days.

Castrated males may maintain their stallion-like behavior. Length of time they do this depends somewhat on their age at the time of castration. If the horse is under two years of age, behavior will probably change within 30 days. Older horses, particularly if used to breed, may still want to mount mares and be stud-like longer. Most of these will change after going through a winter season, but a few may still act somewhat stud-like forever, however, at a much lower level of aggression. Sometimes a few of these may be controlled by using Regumate and decreasing it over time.

Factors Affecting Sperm Output

Many factors have an effect on sperm production. Some of the more important are as follows:

1. Age and Testicle Size.

The testicle will grow in size until at least five years of age and often even longer. Although maximum efficiency in sperm production may occur at two to four years of age, maximum production occurs at five to 10 years of age due to the larger size of testis.

In a stallion-breeding exam, the total scrotal width is determined to evaluate the stallion's sperm-producing ability. During the breeding season, a normal stallion should measure 96 mm plus or minus 7.5 mm for a two- to three-year-old, 100 mm plus or minus 7.5 mm for a four- to six-year-old, and 109 mm plus or minus 7.5 mm for stallions seven or more years of age.

Because sperm production is seasonal in the stallion, expect a 33% decrease in total scrotal width during the winter months. Some use testicle longitudinal circumference, not including the epididymis, to evaluate sperm-producing ability instead of scrotal width. Normal circumference values for light horse stallions are 27 cm or greater.

Daily sperm production in normal stallions, two to 16 years of age, should be four to five billion and of these three to four billion are available for ejaculation. The difference between daily sperm production and daily sperm output is probably due to some reabsorption along the tract, but this is probably more due to excretion in urine and the collector's inability to get a complete ejaculate.

2. Seasonal Effects

Sperm production in the stallion is like the normal cycling pattern of the mare. As daylight lengthens, sperm production increases. Stallions can be made to increase sperm production earlier in the year by using the same lighting programs used to make mares cycle early. If you have a lot of mares to breed early in the year, a lighting program could be beneficial; otherwise, do not do it. Lights will cause stallion sperm production to peek early, but production will also drop early, and you will have fewer sperm in May when most stallions have the most mares to breed.

3. Frequency of Ejaculation

The more often a stallion ejaculates, the fewer the number of sperm that will be obtained per ejaculate. Stallions should not be bred more than once per day for maximum output over a period of time. However, a stallion can be ejaculated more often each day and still be fertile — how fertile depends on the individual's ability to produce sperm and how often he is used. Most normal mature stallions could breed three times a day for a few days, but never use a two-year-old more than once per day. If this frequency is needed often, artificial collection and insemination should be used instead.

When breeding a stallion with three hours rest between ejaculates, the second ejaculate will contain about half the number of sperm of the first ejaculate. A third ejaculate taken after another three hours, it will have half the number of sperm of the second. To go further will probably produce ejaculates that do not contain sufficient sperm to settle a mare, and the third ejaculate would have been inadequate in some stallions.

4. **Hormone Treatments — Testosterone Injections**

Anabolic steroids have been given to horses to increase size and muscle mass. These are effective for what they are designed to do, but they have the side effect of producing stallions with small testis that are lowly fertile. After withdrawal of the hormones, the stallion will be able to develop toward normality and probably will be fertile within six months. It is questioned by many, if the stallion that is under anabolic steroids for extended periods of time when young, will ever develop sexually to the level he would have without anabolic steroids. Mares on anabolic hormones are often infertile for six to 18 months after withdrawal. Testosterone had also been given to stallions to increase their sex drive. There is no evidence that this has any affect on sex drive (libido).

The synthetic hormone Altrenogest (Regumate) has been used to decrease male sex behavior. Regumate given at 0.088 mg/kg body weight has been shown to suppress male sex behavior, decrease sperm production, and increase sperm abnormalities in stallions. Withdrawal after 60 days in normal mature stallions allowed them to return to normal sperm production.

HCG (Human Chorionic Gonadotrophin) has been used in the stallion to increase libido (sex drive) for stallions that have lost interest in breeding. The hormone stimulates the Leydig cells to produce testosterone which then increases libido. There are long-term side effects if this hormone is used often. This hormone can also be used in a gelding that acts like a stallion to eliminate the possibility that a testicle is retained in the supposed gelding's abdomen. By taking a blood sample and checking testosterone levels before and after giving HCG, a diagnosis can be made. If a testicle were present, testosterone levels would rise.

5. **Masturbation**

Some stallions will ejaculate themselves, thereby wasting sperm. Masturbation is accomplished by rubbing the erect penis on the abdomen until ejaculation occurs. For a normal stallion with high sperm production, some masturbation will probably have little effect. However, if the habit is carried to extreme or the stallion is a low sperm producer, it can have a very severe effect on settling mares. Masturbation probably has an even greater effect on libido, because stallions that masturbate a lot often do not display any interest in a mare in heat.

One way to stop masturbation is to use stallion rings, which fit on the end of the penis and prevent its enlarging. Various baskets or brushes designed to prevent the stallion from getting an erection also can be used. Stallions housed next to mares in heat or those that have mares constantly going by their stalls are more likely to masturbate than stallions housed away from mares.

6. **Disease**

Many diseases can cause infertility, including pseudomonas, viral arteritis, coital exanthema, and fevers. Any disease that causes a fever of more than 105ºF for four hours or more can kill sperm. Because it takes about 60 days from the time sperm start to develop from the spermatogonia until available for ejaculation, the fever may cause a temporary sterility for as long as 60 days. Horses being transported long distances occasionally have also become temporarily sterile for some unknown reason, so it is best to move stallions to their place of stud at least 60 days prior to the breeding season. If the stallion must be moved during the breeding season, the semen should be checked to determine if the sperm are alive. This problem has been more common in draft horses than in light horses.

7. Sexual Preparation

The term sexual preparation refers to the time a stallion wants to breed a mare until you allow him to mount and breed. In other livestock, particularly bulls, it was found that restraint and mounting without allowing ejaculation increased sperm output when the male was finally allowed to breed.

Extra teasing does not increase total sperm output per ejaculate from the stallion. Extra teasing will, however, increase the production of gel-like semen, which is undesirable if using artificial insemination since it plugs the insemination rod, and it will decrease the number of times a stallion will false mount before mounting and ejaculating. This last trait is important with artificial insemination because the fewer times a stallion enters an artificial vagina (AV) to ejaculate, the less dirt and bacteria are deposited in the semen.

Breeding Recommendations

Sperm live for 48 to 72 hours in the reproductive tract of the mare. Therefore, only one breeding every other day is necessary.

In general, it is recommended to not breed more than 20 mares in a breeding season to a two-year-old stallion if using hand breeding. Hand breeding is taking the stallion to the mare in heat and separating them after copulation. Also, a two-year-old stallion should not be allowed to pasture breed by turning him out with the mares for the season.

An older mature stallion can be hand bred to a maximum of 50 mares in a season if they are spread out evenly over the season, or pasture bred to a maximum of 30 mares each year. With artificial insemination (AI), these numbers can be greatly increased. Some mature stallions have been bred to as many as 400 mares in one season using artificial insemination.

The Stallion Breeding Soundness Exam

To determine if a stallion is a sound breeder, it is recommended that he be examined at least 60 days before the breeding season. This allows time to treat minor problems or to get another stallion in case this one is not fertile. The exam evaluates the stallion for general physical condition and semen quantity and quality.

Physical characteristics to be evaluated include anything that would prevent normal mounting and ejaculation, size and condition of the reproductive organs, and the horse's desire to breed (libido). It is not hard to understand why horses that are in physical pain will not breed, but figuring out the psychological reason a horse has no libido is often very difficult to discover and correct.

Measurements taken on semen quantity and quality are for volume, morphology, sperm concentration, percent live sperm, livability of sperm, reproduction tract culture, and other factors such as presence of white or red blood cells. The volume of semen is variable among horses with a common range of 20 to 450 cc. Average is 120 cc, but the number of sperm is more important than the volume.

Sperm motility is the most important point of seminal evaluation. Not only do sperm need to be moving, but they need to exhibit fast linear motion across the microscopic field being evaluated. Ideally at least 70 percent of the sperm should be motile and show rapid linear motion across the microscopic field as they are evaluated. Samples with motility of less than 30 percent and with poor linear motion are considered poor.

Sperm morphology is an evaluation of structure of the sperm. In general, defects are broken into primary and secondary defects. Primary defects are those caused by them being formed incorrectly in the testes. Secondary defects are caused by sperm being stored in the stallion's reproductive tract so long that they degenerate. Primary defects are the most serious. Less than 10% primary defects is very good and more than 30% is poor. Secondary defects should be less than 10% to be very good and more than 50% is poor.

A sperm concentration of more than 120 million sperm per cc is very good; a concentration of less than 30 million per cc is poor. As a mare should be bred with 500 million live sperm, the sperm concentration and total volume need to be adequate to supply at least this amount.

Percent of live sperm is determined by using a live-dead stain that stains dead cells red and leaves the cells that were alive at staining time clear. Seventy percent or higher live sperm is considered very good and less than 30% is poor.

The culture of the reproductive tract identifies pathological organisms that make the stallion infertile. More than five white blood cells per high-power microscopic field are an indication of possible infection. The presence of red blood cells indicates blood in the semen, and blood is spermatocidal.

Livability of sperm in a collection bottle maintained at body temperature is considered good if 50% are alive after one hour. (Normally, 70% are alive at collection, and you expect to have 30% of these die in one hour, leaving about 50% alive in the ejaculate.) If semen is diluted with a media to prolong life and is refrigerated, sperm survival and fertility can be maintained much longer — 48 to 72 hours.

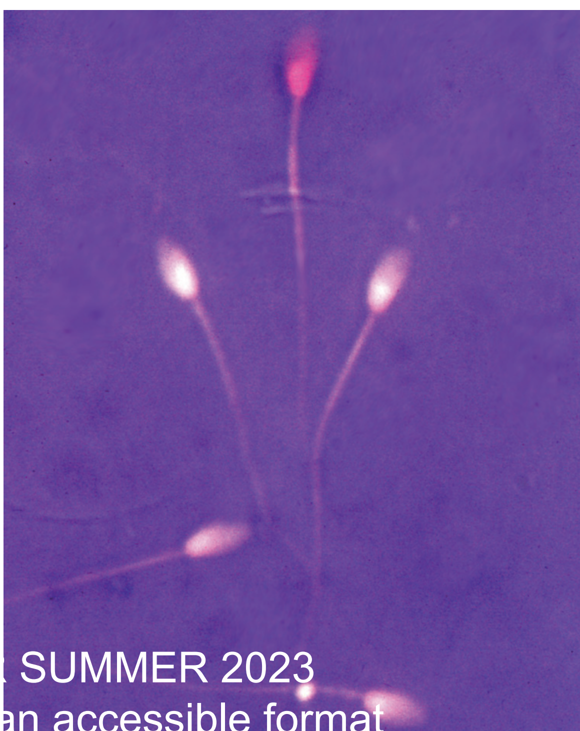

Figure 6. Sperm treated with live/dead stain.

Artificial Insemination

This method of breeding has become more popular in recent years for the following reasons:

1. It is safer for the mare, the stallion, and the handler if using a phantom mare.
2. It allows monitoring of the quality of the semen in each ejaculate.
3. It allows better disease control because antibiotics can be added to the semen and only sterile pipettes invade the mare's vagina instead of the penis.
4. Many more mares can be bred to one stallion, increasing the revenue from that stallion and helping to eliminate the maintenance of mediocre or poor stallions.
5. It decreases the number of times needed to collect the semen from the stallion. You can collect semen three times a week to breed instead of every day or multiple times a day.
6. It really expands the income potential from a stallion, with most breeds now allowing the use of shipped or frozen semen.

Figure 7 depicts an artificial vagina (AV). Basically an artificial vagina is a cylinder that is lined with a hot water jacket into which the stallion will ejaculate. The ejaculated semen is collected into a container attached to the AV.

Figure 7. Artificial vagina.

Figure 8. Colorado Model, Artificial Vagina.

For the AV to work, it must apply pressure to the penis. This is done with the quantity of hot water put into the water jacket. The AV must also supply enough heat to the penis — about 110ºF to 120ºF — to stimulate ejaculation. The liner is lubricated with a sterile, non-spermatacidal lubricant so that the stallion's penis can enter and slide as the stallion thrusts during breeding.

After the semen is collected, the AV is taken apart and thoroughly washed with hot water. Soap is not used because soap residues are hard to remove from the rubber by rinsing and will kill sperm. After it is washed, the AV is hung in a dust free, dark area (light deteriorates rubber) to air dry. The same liner is used only for one stallion for the entire breeding season to decrease the chance of spreading any infection. Disposable liners can be placed inside the regular liner if desired for ease of cleaning.

Figures 8 and 9 show two styles of artificial vaginas, the Colorado and the Missouri models. Either will work, and each has its advantages and disadvantages. The Colorado Model is excellent for maintaining temperature for long periods of time. This is advantageous for stallions that are slow to breed or for use in cold weather. Its disadvantages are that it is heavier and much more expensive.

The Missouri Model is much cheaper and lighter to use. One disadvantage is that the water fill hole on the AV is a air valve as you would find on an car tube. To make it easy to fill, you can get a replacement air hose for a little hand air pump and the necessary fittings to attach it to a hose that will fit your faucet.

Figure 9. Missouri Model, Artificial Vagina.

Although artificial insemination (AI) offers many advantages, it also has some important disadvantages. The most important disadvantage is that AI requires that the semen handler knows how to collect and maintain a viable ejaculate. Sperm must be protected from rapid temperature change and exposure to much light. If a collection is being made in cold weather, the semen in the collection bottle must be protected.

Figure 9 shows an insulated bag that can be placed over the end of the AV for such purposes. At body temperature, the ejaculate will lose about 30% of its viable sperm within one hour. **Therefore, it is important to have the mares ready to breed as soon after collecting the stallion as possible.**

Semen can be maintained longer by adding a diluent, which was warmed to semen temperature, to the collected semen immediately after it is collected. The semen can be maintained even longer if the diluted semen is properly cooled.

A semen diluent is a combination of substances that nourish and protect the sperm. Generally, a diluent contains sugar, skim milk or egg yolk, and antibiotics. The sugar (usually glucose) provides energy for the sperm. The skim milk or egg yolk protects the sperm against cold shock (damage done by rapid temperature change), buffers the toxic products of sperm metabolism, and maintains proper osmotic balance (to prevent damage from withdrawing or excess uptake of water from the sperm cell). The antibiotics destroy any bacteria present in the ejaculate.

Several commercially developed diluents are available for purchase. Individual stallions may have a better sperm survival rate with one diluent when compared to others, so you may want to try several to find which one works best for your stallion.

A second disadvantage of AI is that it does require more equipment. In addition to the normal supplies for breeding, an AV, a microscope, a water bath and/or incubator to keep equipment and semen warm, an area to wash and clean equipment and a clean storage space for the equipment are needed. A phantom mare is also recommended over a live mare because collections can be made more safely.

Getting a horse to breed an AV if you also allow him to breed naturally is another disadvantage of AI. If you plan to use AI, always collect the stallion in an AV during the breeding season. Some stallions will breed either way, but many will not. In general, if you plan to breed 30 or fewer mares to a stallion in a breeding season, you should be able to get by without using AI unless you have a stallion with low fertility or a disease problem. However, if you breed at least 30 mares a year, AI will probably be the most economical way to breed your stallion.

Using Cooled or Frozen Semen

Today many breeds allow the use of cooled shipped semen, and some also allow the use of frozen semen. Freezing semen allows the most efficient means of providing semen for breeding because the sperm can be collected and stored for long periods of time, thereby making coordination of collection and shipping less of a problem. However, at present there are considerable problems with freezing semen and getting good conception and foaling rates. For best success, semen must be inseminated within 12 hours of ovulation because the thawed sperm cells do not survive much past 12 hours.

The use of cooled semen allows semen to be collected, properly diluted, and then shipped to a mare thousands of miles away. The semen is usually good for at least 48 hours and up to 72 hours for some stallions. Each breed organization has its rules for use of cooled or frozen semen, and the breeder needs to follow the rules if the foal is to be registered.

The biggest problem with cooled semen is the coordination of ovulation in the mare with collection and shipping of the semen. The first part of the problem is to identify the mare in heat without a stallion present. This will require someone that can do rectal palpation and ideally someone who has the ultrasound equipment to measure the size of follicles. In general, when a follicle reaches 35 mm in size, you would expect ovulation within 48 hours. However, different mares ovulate different size follicles. When follicles reach 30 to 35 mm (or ovulation is expected within 48 hours), semen is ordered. HCG or Ovuplant are often used to help ensure ovulation.

The next problem is obtaining properly prepared semen. When preparing the stallion that will produce the semen for shipping, special attention needs to be taken when washing the stallion's penis. Be sure to clean the pocket around the urethra in the glans penis. This is often overlooked, and the end result is a semen collection with a lot of dirt in it. Also you want to ideally collect the stallion with only one attempt. If the stallion enters the AV several times before ejaculating, that will also increase dirt in the semen. The filter that is used in the AV is to only keep the gel portion out of the sperm-rich fraction and it does not filter out dirt well.

After collection the semen needs to be protected from any rapid temperature change. The semen should be diluted with an appropriate diluent (that is warmed to 100ºF) within 15 minutes of collection. Semen should be diluted to at least three parts diluent to each part semen. The concentration of sperm after dilution should be no more than 100 million per cc for good survival rate. You need to send at least one billion live motile cells to breed a mare in hopes that there are still 500 million motile cells left after shipping to inseminate the mare.

Some stallion semen does not survive well when its own seminal plasma is left in the diluted semen. Therefore, removing most of the seminal plasma by low-speed centrifugation is often used for those stallions. Also not all diluents give the same survival results for any one stallion. Therefore, the semen shipper may want to experiment with the different commercial diluents that are on the market for shipping cooled semen to find which gives the best results.

The cooling rate for semen after dilution to 64ºF can be quite rapid. Cooling on down to 39º should occur at 0.09 degrees F/min. Usually the semen is collected, diluted, and then set in a refrigerator (set at 39ºF) or placed into a shipping semen unit such as the Equitainer. The semen is then sent to the nearest airport for shipping. For shipping, the semen is either placed in sterile semen collection bags with all air expelled and banded shut with a rubber band or placed into all plastic syringes. (If a syringe has rubber on the plunger, it will kill sperm with prolonged contact.)

Upon receiving cooled semen, the breeder will take the semen and inseminate the mare. The semen does not need to be heated before use. A few drops should be heated to about 100ºF and evaluated under a microscope, if possible, to determine the survival rate of the sperm. Motility needs to be at least 50% for good fertility rates.

Semen lives longer in the mare than in the shipping container or refrigerator, so all semen should be put in the mare when the semen arrives. Keeping half of the insemination dose and administering it 24 hours later is probably of no benefit. Conception rates using shipped cooled semen are about the same as using fresh semen. However, foaling rates have been slightly lower using cooled shipped semen.

Training the Stallion to Breed the Phantom

A phantom mare is a mounting dummy built strong enough for a stallion to mount and be artificially collected. Figure 10 shows a home-made phantom that consists of old telephone poles strapped together with steel straps and butted against a wall to prevent the stallion from pushing it down. A 6-inch layer of high density foam (bought from a mattress company) is strapped to the top pole and covered with a nylon reinforced rubberized tarpaulin made by a local canvas company.

Some factory-made dummies use steel beams instead of the telephone pole, and the rest is of similar materials. The factory phantom usually has the advantage of height adjustability for different-sized stallions.

Figure 10. A home-made phantom mare or mounting dummy.

In general, the phantom's height should be about 4 inches less than the stallion. If it is too low, the stallion tends to crawl too far up on the phantom and may bump his stifles on the end. If the phantom is too tall, he may have trouble staying on during ejaculation.

The width of the phantom needs to be the width of a mare (about 18 inches). If it is too wide, the stallion will have a hard time mounting it. A phantom is sold into which the artificial vagina can be inserted, eliminating the need for someone to hold it during the breeding process. The problem with this is that extreme stress is placed on the penis if the stallion falls off the side of the phantom during breeding.

Training the stallion to mount a phantom usually goes much easier than people expect. It is also easier for a horse that has never bred a mare. Start by putting the stallion in an area with the phantom and a mare in heat. Be sure distractions such as other horses are out of sight.

Begin by teasing the mare until the stallion has an erection and wants to mount the mare. Then pull the stallion over to the phantom and let him press his chest against the end of the phantom. This will be enough to get some stallions to mount. If not, take your hand and push against the end of the erect penis with the stallion's chest against the phantom and he may mount. If this does not work, the next step is to put the mare directly beside the phantom. When the stallion tries to mount the mare, pull him over onto the phantom instead.

Most stallions learn very quickly. Just be sure that the training procedure is a pleasant one for the stallion. After the first time, the stallion will probably become easier to collect. If you had to start with the mare beside the phantom, move her further away with each subsequent collection. Eventually the mare may be eliminated for many stallions, but some will still need to tease an estrus mare to get the initial erection and then go to the phantom for collection. Some will always need an estrus mare close to the phantom during semen collection.

Teasing

Teasing occurs when the stallion smells, touches, talks to, bites, and/or licks the mare to determine if she will allow him to mount and breed her. Teasing is still one of the best management tools available to determine estrus (time of sexual receptivity) in mares.

Each mare has her own type of response when she is in estrus. Signs of estrus are frequent urination followed by excessive winking (everting of the clitoris), squatting for mounting as she urinates, desire for coitus, swelling of the vulva and reddening of the membranes of the vagina, and mucous excretion from the vulva. A mare, however, may exhibit only some of these and to varying degrees.

For teasing to be most useful, it should be done by the same stallion handler every day. The handler should learn to recognize the signs of a mare coming into estrus, one ready to breed, or one going out of estrus by the amount of interest she shows in the stallion.

Teasing can have detrimental effects on the stallion. If a stallion is teased every day but never ejaculates, he often becomes aggressive and may savage the mare. The mares quit showing to him out of fear, and teasing is useless. A solution is to breed or artificially collect the stallion occasionally to maintain a good attitude. Stallions that bite a lot may need to be muzzled while teasing.

When teasing you may find that some mares react differently to different stallions. Many mares in foal heat will not show heat as well as they may in subsequent cycles due to a strong psychological desire to protect the newborn. Some mares will not show heat at all, and other methods are necessary to determine when to breed her. Also some mares are slower to show heat. It may take as long as five minutes or more for mares to absorb enough stimuli from the stallion's presence before showing. If teasing is done in a group of mares, the more docile may not show because the dominant mares will chase them away.

Safety during teasing is critical for all involved. During teasing, the stallion may bite, strike with the front feet, or kick with the rear feet, and the mare can do likewise. Therefore, the handler must be alert at all times and stay out of the way of flying feet. Ideally a solid wall four- to five-feet tall is used with one horse on each side. Other riskier methods are teasing across gaits and through partially opened stall doors.

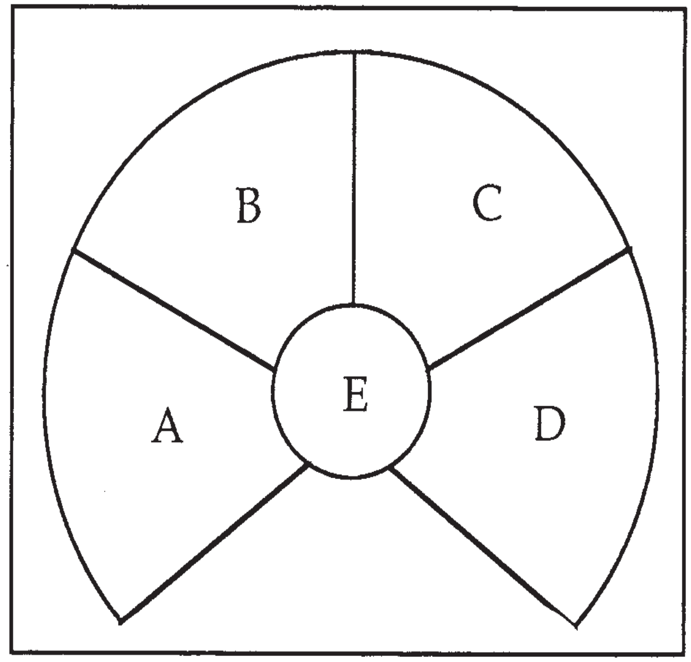

Figure 12. Teasing with the stallion in a pen surrounded by pens or pastures of mares.

Figure 12 shows a teasing system where the stallion is placed into a pen surrounded by pens or pastures of mares. The stallion is left there for several hours, and mares that come to his pen are recorded and checked for stage of estrus.

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Figure 11. Teasing with a fence between the stallion and the mare.

For teasing to be beneficial, a daily record must be kept on each mare. A sample of a record form is on page 38. This form includes a set of symbols to put in the daily record for various things that would be done to a mare. The back of the form provides space for palpation and ultrasound results and to further explain the treatment given to a mare. If you would rather have the record on an 8-1/2-x-11-inch page, use it as it appears on page 38.

Teasing Record

Mare's Name______________________________ Stallion______________________________

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan																															
Feb																															
March																															
April																															
May																															
June																															
July																															
Aug																															
Sept																															
Oct																															
Nov																															
Dec																															

-	Mare out of heat	b	Breed mare	d	Cultured mare
-+	Mare coming into heat	B	Bred mare	T	Treated mare
+	Mare in heat	F	Mare foaled		
+-	Mare going out of heat	c	Culture mare		

Owner's Name____________________________________

(Front of 5x8 Card)

Date	RO	LO	Uterus	Treatment and/or Recommendation

(Back of Card)

Preparation for Breeding and Breeding Procedures

Sanitation is the first consideration in preparing the mare and the stallion for breeding. The mare should be washed to remove filth from any place on the hindquarters that the penis may touch when breeding. This includes the anal and vulvular area and the crease between the hindquarters all the way down to the udder.

Wash with a mild soap, rinse thoroughly to remove all soap, and wipe dry. Use a disposable material such as cotton or heavy duty soft paper towels, which are disposed of after washing each mare. Do not use a sponge or a cloth that could carry disease from mare to mare.

The mare's tail should be wrapped to prevent the dirt in the tail from getting into the vagina. Another reason is to prevent a stallion from cutting his penis on a tail hair that might be lying across the vulva as he mounts the mare. A good tail wrap that is cheap, easy to wash, and reuse after each mare is an old bicycle inner tube that is cut and then split long ways. A string can be placed in one end to tie it when it is wrapped on the tail.

Before breeding, the stallion's penis should be washed with a mild soap, rinsed thoroughly, and wiped dry using a disposable material that will not be used on another horse.

Research has shown that washing is good, but excessive washing with powerful disinfecting soaps can be harmful. Stallions washed with these soaps had more infections and were more likely to spread infection than those washed with plain water. This is because the stronger soaps kill the nonpathological bacteria that prevent dangerous bacteria from growing. Therefore, it is recommended to wash stallions with only mild soap to break up the filth and then rinse with lots of water because any soap residue will kill sperm.

Restraint during natural breeding may be needed for the safety of handlers and horses. Breeding hobbles to prevent the mare from kicking the stallion are sometimes used. These consist of a leather strap around the neck with a rope going to leather straps on each of the mare's hocks. The only danger is that a stallion could fall off the mare and get tangled in the hobbles. For safety a quick release should be at the front near the handler.

Some use a twitch as restraint for a mare that may kick. Most mares in heat will stand if the stallion is not savage while breeding and if she has been teased some before being mounted. The only truly safe way to breed a nasty mare is to use AI.

Stallions need to be trained to be gentlemen during the breeding act. When a stallion learns to breed for the first time, the handler may need to accept some bad manners to avoid damaging the stallion's desire to breed. Soon, however, a handler should require better behavior of the stallion. A stallion should not mount until permitted. He should have an erection prior to mounting and should be willing to tease the mare until the handler lets him mount. Also, the stallion should not be allowed to charge or savage the mare during mounting.

Figures 13 and 14 show two ways a chain lead may be used for restraint. A whip or breeding bridles are additional means of restraint.

Figure 13. Using a chain lead to restrain the breeding stallion.

Figure 14. Another way to use the chain lead.

When to breed the mare during estrus (heat) depends on the time of ovulation. The mare ovulates about 48 hours before the end of heat. Unless you use palpation, you cannot be sure when the end of heat will occur. The general recommendation is to breed a mare every other day she is in heat starting the second day. A normal estrus lasts five to seven days in a mare, but early in the year (January to March) estrus may last 30 or more days due to the transitional estrus.

Do not breed a mare more than three times per estrus because of the greater chance of infecting her. If the estrus is a transitional, ovulation will probably not occur anyway. If you use teasing records and also have the mare palpated to determine the presence of follicles that will ovulate, the number of breedings often can be reduced to one or two per cycle.

Foal Heat Breeding

The mare is unique because she rebreeds sooner after birth than any other type of livestock. This is because the placenta has a very mild form of attachment to the uterus, and the uterus can heal and be ready for a new pregnancy quickly. Research shows that the fastest the uterus can be ready to accept a new embryo is 15 days after foaling. Foal heat occurs about nine days after foaling — normal range is two to 11 days. Also fertilization of the ova occurs in the oviduct, and it takes four to six days for the fertilized ova to travel to the uterus. If breeding on foal heat is to be successful, the following criteria must be met:

1. The mare must have had a normal birth with no excessive trauma.
2. The placenta must have passed within three hours of foaling time. Retained placentas increase the bacterial infection of the uterus, slowing recovery.
3. Rectal palpation must show that the uterus has involuted adequately. The horn that was pregnant should not be more than 5 inches in diameter; the other horn should be less than 3 inches in diameter.
4. Ovulation must occur no earlier than the ninth day after foaling. Embryos from foal-heat breedings that arrive in a healthy uterus day 15 or later have as good a chance of survival as embryos from breedings in later cycles.

Miscellaneous Mare Breeding Problems

Maiden mares may have a hymen, a thin membrane across the vagina, which may tear and bleed during coitus. Significant bleeding may decrease the chances of settling the mare because blood kills sperm. You can avoid this by entering the mare’s vagina wearing a sterile sleeve and using sterile lubricant and tearing the hymen several days before breeding.

Older mares that fail to conceive and maintain a fetus may become impossible to get in foal in subsequent years. After age 14 a mare’s uterus deteriorates very quickly if she is not in foal. Therefore, keep old mares pregnant if you wish to keep raising foals. Giving her a year off may be a mistake.

Uterine infections are a problem for all mares. Maiden mares and those that foal normally and are bred using good sanitation procedures rarely have infections. If a mare does not settle after breeding for two cycles, she needs to be evaluated by a veterinarian. Usually he or she will take a culture; if the mare is old or has had a poor reproductive history, he or she will probably also do a biopsy.

A culture is done by passing a sterile rod through the cervix and swabbing the uterine wall. In the past a culture was taken during estrus, but today it is done anytime during the cycle. If you culture a pregnant mare, however, she would lose the embryo.

The swab is smeared on a culture media to allow any bacteria or fungus present to grow. Later the organisms are identified to determine if they are pathological. If they are, sensitivity tests are done to determine what treatment will kill the organism most effectively.

Next the vet infuses the desired treatment into the mare's uterus. Uterine infections are usually treated by infusion of medication into the uterus. Systemic treatment such as antibiotic shots may be used with uterine infusions if the infection has progressed deep into the uterine tissue. After treating the mare, the vet will wait two weeks and then reculture to determine if the treatment was successful.

The biopsy goes one step further by taking a small bite of tissue out of the uterine wall. This tissue is cultured and evaluated under the microscope for presence of scar tissue and other indications of uterine deterioration. A Grade 1 uterus is normal.

A Grade 2 has abnormalities, some of which are correctable by treatment. The mare has a 50 to 70% chance of maintaining a pregnancy. A Grade 2 is often referred to as 2a or 2b. The 2a is indicative of an infection being present and only small amounts of scar tissue. If the infection is cured, maintaining a pregnancy is closer to 70%. A grade 2b has more scar tissue and infection and if the infection is cured, the chance of maintaining a pregnancy is lower because of scar tissue present.

A Grade 3 uterus has irreversible conditions and only has about a 4 to 10% chance of carrying a foal to term.

Much has been learned in the last 10 years about treating uterine infections, but early treatment is most important. The longer the infection exists, the more damage is done and the deeper into the uterine tissue it will go, making successful treatment difficult. Mares should be checked for pregnancy in the fall of the year they were bred to be sure they are still pregnant. Clearing up infection in the fall will prepare the mare for breeding in the spring and prevent losing valuable breeding time.

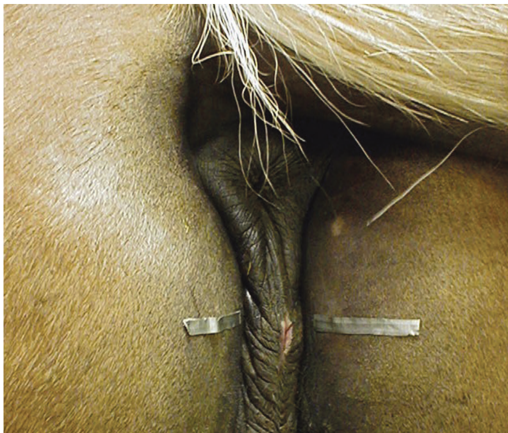
Another breeding problem is trying to breed a large stallion to a small mare. Fortunately, the horse does not usually have problems with a mare having a foal by a much larger stallion. However, at breeding time, a stallion with a long penis may tear the vagina of a small mare. To prevent this, breeders use a breeding roll often made from a wooden handle about two feet long and wrapped with material to make a roll 6 to 8 inches in diameter. When the stallion mounts, the roll is simply inserted between the stallion's belly and the mare's buttocks so he cannot enter the mare with the full length of the penis.

Vulvular conformation can be a problem for a mare. Figure 15 shows three conformations. Ideally the opening of the vulva lies below the level of the pelvis. This level can be determined by using the fingers to press up and down the sides of the vulva until feeling the underlying pelvis. A vulva that is tilted forward and opens above the pelvic bone is likely to become infected from fecal material falling across it. A caslick operation prevents infection from poor conformation. If a mare has a caslick, it must be opened before foaling or the vulva will be torn badly. The vulva should be reclosed as soon as possible after foaling, leaving enough room to breed.

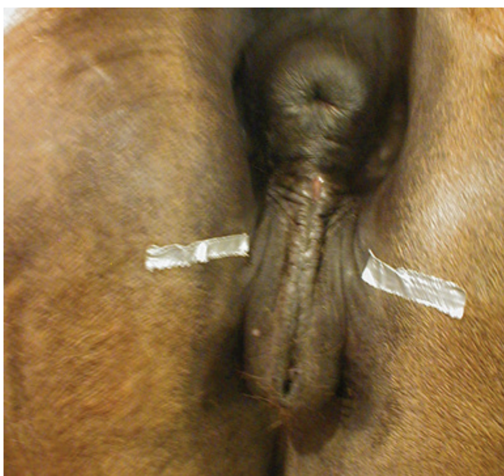
The caslick operation trims the skin on the edge of both vulvular lips. The lips are then stitched together so the lips grow together, sealing off the upper portion of the vulva. This prevents manure from getting into the mare's vagina and causing infections.

The conformation of the vulva worsens with age. After several foals and/or with a sway backed condition, the vulva is pulled more forward and becomes more tilted. During pregnancy, the conformation may become worse, because the weight of the fetus in the uterus tends to pull the vulva forward.

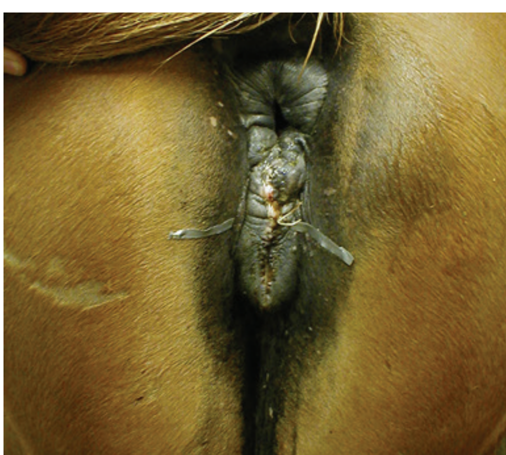
Figure 15. Vulvular conformation can be a problem for a mare. The level of the pelvis is indicated by strips on each side of vulva.



Good: All of opening of vulvular lips below level of pelvis, lips closed tightly, vulva perpendicular.



Fair: About half of opening of vulva above pelvis level, lips closed tightly, vulvular lips slightly tilted.



Poor: Almost entire opening of the vulva above pelvis level, lips without normal straight closure, vulva tilts extremely forward. Mare has had a caslick to close the vulva within about 2 inches of the bottom.

Early embryonic death is common in the mare. If a mare is going to lose a pregnancy, it will usually occur within the first 60 days. Causes may be hormonal failure, infection of the uterus at time of breeding, or genetic lethals. A mare should be checked several times during the first 60 days of pregnancy. Typical times to check are at days 18 to 21, 35 to 40, and 55 to 60.

Mares that abort after the second check often do not come into heat for several months and will be missed by teasing. This psuedopregnancy occurs because endometrial cups are often formed and functioning even if the embryo has died. Psuedopregnancy is usually maintained for four to six months, but it could be terminated with one or a few shots of prostaglandin.

Techniques and Instruments Used in the Breeding Industry

Rectal palpation is the procedure of placing the hand and the arm into the mare's rectum and feeling the mare's ovaries, uterus, and cervix through the rectal wall. Palpation of the ovaries determines the number and the size of follicles. The corpus luteum may be felt for the first 24 to 48 hours. Research shows that ovulation occurs in follicles that are at least 1 inch (2.5 cm) in diameter and that a follicle may get to be as large as 5 inches (10.6 cm) and still be normal. Most follicles that are about to ovulate are 1.5 to 2.5 inches (4 to 7 cm).

Palpation can be used to evaluate the size and the tone of the uterus. A maiden mare should have uterine horns of 3/4 to 1 inch (2 to 2.5 cm) in diameter. A mare at least 45 days past foaling will have slightly larger horns than a maiden mare. A foal-heat mare may have uterine horns more than 5 inches (10.6 cm) in diameter. During estrus the uterine horns lose tone and will increase slightly in diameter. Uterine tone is rated as excellent if the horns have a definite tubular structure that resists flattening as it is palpated. Excellent uterine tone is only present in the horns about three to five days after foaling and during early pregnancy (days 18 to 40).

Uterine tone is good if the horns have a tubular structure and spring back to the original shape after flattening. This tone is most common during the diestrus portion of the cycle. Horns with tubular structure that do not readily return to shape after flattening are fair tone. Fair tone is usually a transitional phase between good and poor tone. Poor tone is a horn that feels like an empty intestine. It is flabby and flattened. It is found in some mares during estrus and often during anestrus.

In addition to tone, a palpater that is using ultrasound can see fluid in the horns. This is common in the estrus mare that is producing a lot of mucous secretions. An abnormally enlarged and/or doughy-feeling uterus or a uterus containing fluid when the mare is not in heat may indicate infection.

Palpation can evaluate the condition of the cervix. During estrus, the cervix should become completely relaxed at the time of ovulation and begin to close afterwards. The closed cervix during diestrus should be 1 inch (2 cm) wide and 2-1/2 inches (6 to 7 cm) long. During estrus, it relaxes until it can no longer be felt. From day 18 to day 90 of gestation, it is narrow, 1/2 to 3/4 inches (1 to 1.5 cm), and elongated to about 4 inches (8 to 9 cm). During anestrus the cervix is usually completely relaxed.

Palpation can diagnosis pregnancy. If a mare as early as 18 days past ovulation has all of the criteria listed here, she is pregnant: Follicles no larger than 1 inch (2.5cm), excellent uterine tone, and a narrow, elongated cervix. Also, by day 24 of gestation, a bulge (the conceptus) may also be felt in the pregnant horn. However, only a trained palpater can diagnose the bulge this early. By day 30 the bulge is readily palpatable and by day 45, no palpater should miss the bulge.

Palpation can be done most safely in a palpation chute (Figure 16). Only people properly trained in palpation should attempt to so.

Ultrasound has probably been the most useful instrument technology for equine breeding. Although these units are very expensive and require professional use, they have solved many problems. Ultrasound can safely determine pregnancy as early as 16 days past breeding (Figure 17). With palpation pregnancy determination has been questioned until 24 days past breeding, and most vets were not sure until 30 to 45 days.

Figure 16. Palpation chute for checking mares.

The most valuable use of ultrasound is in the determination of twin pregnancies. Twin pregnancies are a serious economic problem in the horse. Most are either aborted in the last half of gestation, or if born, are often under developed. About 20% of all ovulations are multiple.

The mare has some inherent ways to selectively reabsorb one of the twin embryos and does so in many cases. However, for the mare that does not, we can use ultrasound as early as 16 days to identify the twins and by rectal palpation separate and crush one of the embryos. By crushing one early, before day 28, the chances of the mare retaining the other embryo are very good. Crushing an embryo much later will often cause enough irritation to the uterus to reject the remaining embryo.

If, when checking the mare at day 16, the two embryos are beside each other, the vet will wait and recheck before day 28. In 85% of the embryos that are beside each other, one will destroy the other without intervention.

Figure 17. Ultrasound exam showing a 28-day pregnancy. Dark circle with white circle in center on the screen is embyronic vesicle and the white in the center is the embryo.

Figure 18. An ultrasound picture of the ovary showing three follicles, two small, one large.

Ultrasound has been used in mares earlier than 16 days, but research at The Ohio State University has shown a significant loss of embryos if they are subjected to ultrasound examination at younger than 16 days.

Stallion Breeding Contracts

Before taking a mare to be bred to any stallion, the owners of both the stallion and the mare should have a written contract to prevent future disagreements. Breeding contracts vary, depending on each owner's risks and personal desires. All contracts should include the following items:

1. Identification of the mare and the stallion should include name, registration number, and other information needed when filling out breeding report forms.
2. Costs should be listed, including the stallion's service fee, board costs, and vet expenses. When these must be paid should also be defined.
3. Most breeding farms require the mare to be healthy and in sound breeding condition. A negative Coggin's test is usually required. Some contracts include a requirement for the mare to be on a vaccination program for rhinopneumonitis during pregnancy. If she is not, the owner will not have to honor any live foal guarantee. Negative uterine cultures are required by some contracts, but this is occurring less often. Most farms would just as soon examine the mare upon arrival and have their vet do the cultures required.
4. Most contracts require the mare to be halter broke and reserve the right not to breed a mare if she is unacceptable to the stallion's owner.
5. The contract usually states that the stallion owner will diligently try to settle the mare but is not responsible if she fails to settle.
6. Most contracts make a live foal guarantee. If the mare fails to produce a live foal, the stallion owner will rebreed the mare the following breeding season for no additional stallion service fee. A live foal is defined in many ways. The most popular is a foal that can get up under its own power and nurse.
7. The method of handling the mare and her foal, if she has one with her, should be defined. Usually the mare owner can decide how the mare should be boarded, and it should become part of the contract.

The breeding farm manager also should have a statement that says he/she is not responsible for injury or death of the mare and/or foal if cared for according to the contract.

8. The contract should contain an agreement of when a breeder's certificate will be given to the mare owner.
9. The names, addresses, phone numbers, date, and signatures of both parties should be given on the contract.
10. Most contracts will allow acceptable substitute mares to be used if a mare dies or becomes infertile before she settles. If the stallion dies or becomes infertile, you may lose your money, get a refund, or be able to breed to another stallion owned by the stallion owner.

Many other contractual arrangements are being used in the horse industry. Syndicates owning a stallion, those owning a mare, and lease agreements for mares or stallions are but a few. A suitable contract should accompany any action to prevent misunderstandings and law suits.

Mare and Foal Management

Brood Mare Management Prior to Foaling

The normal gestation length in the mare is 335 to 342 days. Rarely do mares foal before 320 days and only occasionally do they go 365 days. The mare does not develop much fetal mass until the seventh month of pregnancy. Therefore, she can be worked the same as a nonpregnant mare until that time. From the seventh through the ninth month, she should do only light work. Free exercise or only very light work should be done during the last months.

For nutritional care of the mare, refer to Ohio State University Extension Bulletin 762, *Horse Nutrition*.

The mare should be in good flesh with enough fat to cover the ribs. Ideally, the mare should be a little fat (body condition score of 6 or 7) at foaling time. The drain of lactation often requires more energy than the mare is getting fed. Excess energy stored as fat helps maintain her condition and enables her to rebreed more readily. Fat in mares does not appear to hinder mares during foaling as it does in cattle.

The pregnant mare needs to be on a good vaccination program. The foal receives antibodies through colostrum to protect it against disease. A mare should be vaccinated 30 to 60 days before foaling so that the maximum level of antibodies are transferred to the foal. Do not vaccinate mares closer than 30 days because some medications may have a negative effect on the mare and/or foal at this time.

Vaccinations should at least include tetanus, rhinopneumonitis, EE, WE, and WNV (Eastern and Western, and Encephalomyelitis West Nile Virus vaccines), and flu. In some parts of the country, Botulism, Rotavirus, Rabies, and others may be recommended by the local veterinarian. The Rhinopneumonitis vaccination is to prevent abortion as well as to prevent the flu-like symptoms that it can cause in a foal. The recommended vaccine, Pneumobort K, is given in the third, fifth, seventh, and ninth month of pregnancy. Some recommend that it also be given to the mare between foaling and rebreeding.

Deworming is recommended one to three days prior to foaling to decrease the number of parasite eggs in the mare's manure. This is important because the first solids a foal will eat will be his mother's manure. Deworming decreases the parasite load the foal will ingest.

During late gestation, a mare may be colicky because the foal lies against some part of her digestive system. Most colics correct themselves as the mare moves around. However, colics should to be watched carefully and help should be obtained if the mare is in a lot of pain or is showing more distress.

Before the mare foals, put her in a clean stall or on a pasture where she can get away from other horses. Foaling in a group of horses is hazardous, particularly if the mare has not foaled before or is low on the dominance order in the group. If chased from her foal by dominant mares, the mare will not claim her foal.

Foaling mares should be clean, particularly around the hindquarters and udder. They should also be in quiet comfortable surroundings. Bedding should not be sawdust or shavings because it harbors the Klebsiella bacteria that may infect the foal through the navel cord or the mare's uterus.

Signs of Pregnancy and Parturition

Early signs of pregnancy can best be determined by palpation and ultrasound. However, some observations made during gestation can indicate pregnancy. The most obvious is that the mare ceases to cycle. Also a mare often has a change in disposition, usually for the better. Pregnancy seems to calm a mare and make her more careful. By seven months the rear flank should also be deeper than on a non-pregnant mare, but this is greatly affected by degree of fatness.

Within the last 30 days, the mare's belly will hang very low and often have a V shape to the underline. The hindquarters become flabby, the vulva elongates, and the croup sinks around the tail head as Relaxin takes its effect. The udder usually begins to fill about 30 days before parturition, but this is highly variable among mares.

Waxing is often the first sign of foaling. Waxing occurs when colostrum leaks from the teats and then the last drop dries on the end of the teat. The first wax that forms is often serum colored, but then becomes white as more leaking occurs. Parturition should occur within 24 to 72 hours after the mare waxes. However, many mares do not wax before foaling.

There are foaling tests that can help predict time of foaling. They are based on the amount of calcium that is present in the mare's milk. Before foaling if some milk is stripped from the udder and tested, we know that the mare is probably going to foal within 12 hours (95% of times) when the calcium level reaches 180 to 280 ppm. The greatest value for the test may be that it tells us when the mare is not going to foal, so we do not need to watch her as closely.

The Three Stages of Foaling

First Stage

Uterine contractions begin, and the cervix relaxes as the feet and head push against it, but there are no outward signs. The mare is restless and, if in a group, will leave the group to find a place to foal alone. This stage takes about one to four hours, but the mare may prolong it due to disturbances in her environment. The first stage ends with her "breaking her water." The placenta tears open over the cervix as the foal pushes its way into the birth canal, expelling the fluid between the allantoic layer of the placenta and the amniotic layer (Figure 20).

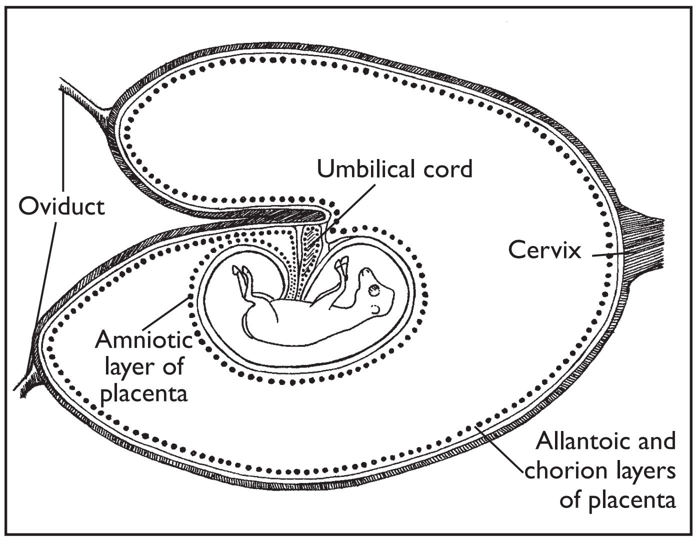


Figure 19. Uterus with fetus and its placenta.

Second Stage

During this stage, the mare has strong uterine contractions, will break out in a sweat around the neck and shoulders, and usually lies down to deliver the foal. She may get up and down several times during delivery, which may be due to her needing to reposition the foal (Figure 19). Normal delivery (Figure 20) is for the front feet to come first, soles down, and with one foot slightly ahead of the other. This helps to pass the shoulders through the opening in the pelvis, which is the most difficult part of the birth. If both feet are even, the shoulders may lockup on the pelvis and delay or prevent birth.

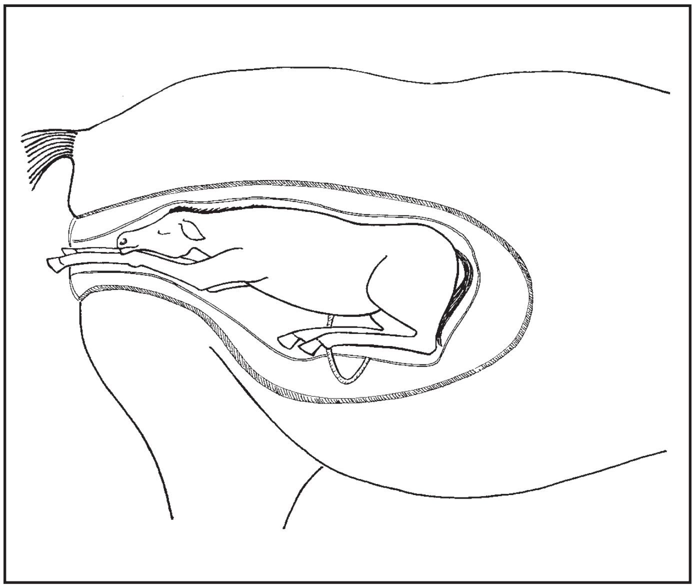


Figure 20. Foal position for a normal delivery.

Next, the nose should follow near to the foal's knees; it will be covered with the amnion. As the foal is pushed out of the mare, the amnion often breaks, and the foal begins to breathe. If the foal does not break the amnion, an attendant should do so immediately after the shoulders have been delivered. After the hips are delivered, the mare will probably relax with the rear legs still partially in the birth canal until the foal struggles or the mare gets up. There is no hurry for the mare to get up; let her rest.

The umbilical cord usually tears when the foal struggles or the mare gets up. How soon the cord breaks is of no importance, but it must be severed after being stretched. Stretching causes the muscles in the cord to close the blood vessels, which prevents blood loss from the foal when the cord breaks. Reports that say the foal can get substantial amounts of blood from the placenta after being born and before the cord breaks are false.

If the cord must be severed, first stretch the cord by holding it where it enters the foal's body and about four inches away from the belly with your other hand. Stretch the cord between your hands. If it does not break during stretching, it can then be cut about one inch from the belly.

Usually the second stage takes 10 to 60 minutes to complete, with an average of 20 minutes. If 70 minutes pass, the foal will be dead. This is because the foal's placenta begins to separate from the uterus during this stage. When separation prevents an adequate supply of oxygen to the foal, it will die. Therefore, the foaling manager must recognize problems early and provide assistance quickly. A dead foal may need to be delivered by fetotomy (removal by cutting in sections and then removing).

If a mare needs help during foaling, assistance must be given with care. If you do not know what you are doing, get qualified help. If you need to place your arm into the birth canal, it must be clean and lubricated. An arm wedged between the pelvis and the foal could be broken during a contraction. If you pull on the foal's legs to assist birth, pull with the mare's contractions and apply no more force than two adults pulling. Usually the direction of pull should be downward toward the mare's hocks. Sometimes you need to push the foal back in some, move the one leg ahead of the other some, or rotate the foal slightly to unlock it from the pelvis.

Figure 21. Mare in second stage of foaling. Amniotic sac is protruding and covers the front feet and nose of the foal. Attendant is checking that position of delivery is correct; note one fore leg is ahead of the other, soles are down, and the nose is at mid cannon.

A condition during parturition called Red Bagging occurs when the placenta separates prematurely and you see red placental tissue instead of, or in addition to, the amnion when the mare breaks her water. The foal must be delivered as soon as possible so the attendant needs to help get the foal out quickly or it will be dead.

Third Stage

During this stage, the mare passes the placenta. Ideally, the placenta is delivered within three hours of foaling. If it is not passed within three hours, oxytocin should be administered. If the placenta is still not expelled by 24 hours, the vet may need to use antibiotic or antiseptic infusions to remove it. A final attempt to remove it would be the vet going in and manually trying to remove it, and you need to expect infections and uterine damage if this is done.

Post Foaling Mare Problems

Placentas that are retained for more than 24 hours commonly cause founder in the mare and lengthen the time until she can rebreed due to infection. After the placenta is delivered, it should be checked to ensure that all has been passed (Figure 24). There should be only one hole. Missing patches (most common at the tip of the horns) may indicate retained parts that can cause infection and founder.

The placenta should never be pulled out because parts of it may remain in the uterus. Let it be expelled by its own weight and with the mare's contractions. Mares that are slow to expel the placenta are often helped by administering 20 IU of Oxytocin every 15 minutes (repeated a maximum of four times) if treated within first three to eight hours.

Foaling colic occurs in many mares after foaling (Figure 25). This colic is caused by the uterus continuing to contract painfully after the foal is delivered. The mare may lay down and roll which could endanger the foal if she rolls violently. This colic occurs usually within the first 30 minutes after foaling and usually corrects itself.

Figure 22. Foal has broken through the amnion, and mare and foal are resting as the second stage is completed.

Figure 23. Mare has gotten up and broken the umbilical cord. The placenta is still in the mare but should be expelled within three hours. Note second mare with foal and placenta on the right.

Figure 24. Expelled equine placenta. The large part at the bottom of the picture is the allantoic chorion. Above is the amniotic layer. The end of the umbilical cord can be seen in the top center of the amniotic layer.

Figure 25. Mare showing typical foal colic.

Excessive internal hemorrhage may occur in a mare when blood vessels break during foaling. Mares over age 14 are more likely to suffer from this problem due to the brittleness of blood vessels. Often the hemorrhage is so severe that the mare dies almost immediately. Moderate bleeding causes colic symptoms about eight to 12 hours after foaling along with pale membranes and a rapid heart rate. Horsemen expecting this problem may give the mare blood coagulants at foaling to try to prevent loss from death, but if a major artery breaks, these are probably of little value. Today with embryo transfer, embryos from valuable old mares could be raised in young mares and eliminate the chance of death during foaling.

Turn out of the mare and the foal is critical. Exercise strengthens the foals legs and helps return the mare's uterus to normal. During the first week some dark exudate may be excreted from the vagina. However, by the second week this should stop.

Common sense dictates when to turn out after foaling. If the weather is warm and the turn out area is clean and grassy, the mare and the foal could go out the first day. If they will be turned out with other mares, waiting one or two days until the foal is strong may be a good idea. Do not turn out weak or sickly foals, particularly if the weather is cold or wet. Also, turning foals out in muddy lots in cold weather is an excellent way to cause foal diarrheas.

Mares with foals by their side may not show heat when teased because of their maternal instinct to protect the foal. Use palpation and/or ultrasound to determine when to rebreed these mares.

Post Foaling Foal Problems

The Navel

Umbilical cord care after foaling has been a controversial subject over the years. Should you put iodine on the navel stump? Treating the navel is an attempt to prevent bacteria from getting into the foal's circulation by means of the navel and traveling throughout the body and causing joint ill which is a life-threatening infection. If you use iodine, use a mild (1 to 2%) iodine. Or better yet use a 0.5% Chlorhexidine solution. The antiseptic used should not cauterize and seal off the umbilical stump because that would lock bacteria already in the navel, making it more likely that joint ill will occur.

The cord by nature seeps a little for the first 24 hours which is nature's way of removing harmful bacteria from the cord. A mild antiseptic would kill surface bacteria and allow the cord to seep. The only time a strong cauterizing iodine should be recommended would be if the cord was treated immediately upon breakage and before it touched anything in the environment. Many horsemen do not put anything on the navel and if the foal is in a clean environment until the naval dries up, they rarely have any infected navel problems.

Putting iodine on a foal's feet at birth has no value, as there is no opening for bacteria to enter the body.

Leakage of Urine

Another umbilical problem that sometimes occurs is the leakage of urine from the navel during urination. Before birth the foal excreted urine by the navel, but the tract should have closed at birth. This problem is easy to diagnose. Either you will see the naval leak during urination or you can smell your fingers after touching the cord. This problem is treated by cauterizing the cord to seal off the tract.

Nursing

Nursing should occur 15 minutes to two hours after birth. When born, the foal needs colostrum (the first milk which is high in antibodies, protein, and energy) to gain protection against disease. The foal's gut normally absorbs these antibodies only for about the first 24 hours of life. Most foals have a natural instinct to suck, seen when the mare starts to lick the foal for the first time. A human can get the same response from the foal by rubbing the foal dry after birth.

The next problem is to get the foal to a teat. Most mares, particularly mares that have had a foal before, will help the foal find the teat. Be sure the foal gets the teat in the mouth and that milk comes out of the teat. Some foals will suck on the side of the udder and sound like they are getting milk. In truth they are getting nothing.

Some mares have a lot of edema, and the udder and the belly are very sore to the touch. First-time foaling mares with a lot of edema may not allow a foal to nurse unless you twitch or restrain her in some way. A few nursings will remove the pressure and decrease the soreness. Older experienced mares with edema usually allow nursing even though it is obviously painful for them.

Some mares will foal with no visible functional udder. Most of these will develop milk almost immediately after foaling, or the vet can treat them to start producing milk if he does it within the first 24 hours. If the mare dies or does not produce milk, check Extension Bulletin 762, *Horse Nutrition*, for how to feed and care for the orphan foal.

Foal Constipation

Foal constipation is a common problem in the newborn. During gestation, the foal has produced manure, called meconium, in the colon. This meconium is dark colored and often hard to expel. Shortly after being born and usually after nursing, the foal will try to pass the meconium. If the foal is constipated as evidenced by a lot of straining, an enema is in order. Probably the simplest enema is to expel about 50 cc of mineral oil gently into the rectum. Watch the foal closely to be sure one enema was sufficient. Within 24 to 36 hours, the foal should start to produce yellow manure, which comes from the milk. If the manure is yellow, the meconium has all passed.

Jaundiced Foal

Jaundiced foal (neonatal isoerythrolysis, hemolytic icterus) is a disease that occurs if the mare produces antibodies against the foal's blood type. The foal is born healthy, but after drinking the colostrum and absorbing the antibodies, the foal's red blood cells are destroyed, and it suddenly becomes anemic. If treatment is not immediate, death will follow in a few days.

Treatment consists of getting the foal off the mare's milk for the first 36 hours and giving a transfusion of blood from a compatible donor (the best donor is a gelding that is negative for the Aa and Qq blood antigens). There are blood tests, if done in the last six weeks of gestation, that can determine if a problem is likely to exist.

If there is a problem, do not let the foal nurse for the first 36 hours. Provide colostrums from a mare that does not react to his blood type for this time. By making the foal wear a muzzle he can stay with the mare. Each time you feed him, milk out the mare as well. (If you do not milk her, she will stop lactating.) She quits making colostrum after 36 hours, and the foal quits absorbing it in about 24 hours. After the 36 hours, the muzzle can be removed, and the foal can be allowed to nurse its dam.

Combined Immuno Deficiency

Combined immuno deficiency is an inherited inability of a foal to produce antibodies against disease. This genetic recessive trait has been identified in the Arab breed. The foal is born healthy and remains healthy for about two weeks, because the antibodies from colostrum protect him from disease. Antibiotics will be used but cannot maintain the foal and it eventually will die. If the foal is affected, both parents carry the gene. Only by avoiding the use of known carriers in a breeding program can the gene be eliminated.

Leg Deformities

Leg deformities are a common problem of the newborn foal. Fortunately most are minor and correct themselves within one to four weeks. The only deformities that require immediate attention at birth are those that prevent the foal from placing its foot flat on the ground. Casts and braces are used for these cases. If the foal can place its foot flat on the ground and after 30 days still has a major deformity, action is necessary. Because the ankles stop growing by day 90 and the radius stops growing by 12 months, treatment needs to be early.

Figure 26. Foal born buck kneed but self corrected by 30 days of age.

Not all things can be corrected. Bench knees cannot be changed. However, the body will deposit more bone on the inside of the cannon and over time, the degree of bench kneedness will look to be less. Also the splay-footed horse whose whole leg turns out will improve with age, and the leg will be turned inward as the body develops. If articular surfaces are damaged, the animal may be breeding sound but not for work. (If the cause of the damage is structural incorrectness, which may be caused genetically, the horse should not be used for breeding purposes.)

Use this schedule to evaluate deformities for correction:

Day 1	Look for any malformations and square off any pointed toes.
Weekly	Monitor effects of exercise, degree of change, and square off toes.
Month 1	Moderate or noncorrecting ankles require a decision as to whether ankle surgery is required. Check knees and trim feet in balance.
Month 2	This is the last chance for correcting ankles. Trim feet in balance.
Month 3	Ankles must be straight. This is decision month for knees. Corrective trimming should be started if needed.
Month 4	Final month for knee corrections.

Corrective trimming continues until age two.

Neonatal Maladjustment Syndrome (Dummy Foal)

Neonatal Maladjustment Syndrome (Dummy Foal) occurs in a foal that did not have an adequate oxygen supply during parturition. This usually occurs due to a separation of the placenta from the uterus before the foal is born and is able to breathe on its own. The foal is called a dummy foal because it does not have the normal suckling desire and wanders about the stall. Some make a barking sound and are called barker foals. The severity of the oxygen deficiency determines the chances for the foal's survival. Mildly affected foals will often survive if they get milk, which may involve hand feeding for several days. If the deficiency is severe enough that sufficient brain tissue decay occurs, the foal will die.

Hernias

Inguinal and umbilical hernias may be found in the newborn foal. The inguinal hernia, the least common, occurs when some of the foal's intestines fall through the inguinal ring into the scrotum. This hernia requires immediate surgical correction. While the cause is unknown, excessive pressure on the foal's abdomen during birth could be a contributor.

The most common hernia is the umbilical hernia. Part of the intestine falls through the umbilical hole in the abdominal wall, making a pouch. This problem occurs in varying degrees and is rated in accordance to the size hole that exists. Small hernias, no larger than one finger diameter in size, may close on their own by the time the foal is a yearling. Larger hernias may require clamping or surgery. A foal with a hernia requires close management until the hernia is closed. At any time a loop of intestine could become strangled in the umbilical ring and die, causing severe colic and possible death.

Clamping has become a much-used way of closing a hernia even on those two and three fingers in diameter. Clamping a hernia requires much care to ensure a loop of intestine is not also clamped. Put the foal to sleep and roll the foal over on its back to be sure that all of the intestine is back inside the opening. Place a clamp around the excess skin as tight against the belly as possible; then tighten. Each day the clamp may need additional tightening. In about 10 to 14 days, the clamp drops off with the dead skin held within the clamp. The hernia closes due to the inflammation and scar tissue formed in the umbilical area.

The umbilical hernia is most often caused by a recessive inherited trait. If a foal is born with a hernia, it means both parents are carrying the recessive gene. A hernia can be a result of excessive abdominal pressure during birth, blows to the umbilical area, or forceful separation of the umbilical cord. However, if a mare or a stallion commonly produces foals with umbilical hernias, genetics should be expected.

Foal-Heat Diarrhea

Foal-heat diarrhea is a common problem in foals. A foal often gets diarrhea at the same time the mare comes into her first estrus after foaling. The diarrhea lasts for about a week, may cause some soreness and hair loss around the buttocks, but is not often debilitating. Research has been done on mare's milk composition and possible parasite infections, but no one has found a solution.

Some feel that diarrhea is due to the foal starting to eat roughages. Because the foal's digestive tract is not used to roughage, the tract is irritated. After the foal has a normal microbial population to handle the roughage, the diarrhea subsides. Some companies sell products that claim to provide the microbial population (usually lactobacillus) and decrease the instance of diarrhea. These are probably not necessary except for unusual problems.

If the diarrhea is persistent, treating the foal with 60 cc of Kaopectate (for a 100- to 150-lb. foal) twice a day for three days will often cure the problem. Stop sooner if the diarrhea stops. If the foal has a fever or is depressed, the problem may be more severe, and a vet needs to be consulted before any treatment.

Rotavirus

Rotavirus is another much more severe diarrhea that can be life threatening. This virus can survive nine months on a farm and several hours on the hands of humans. It attacks the foal at two days to six months of age. Symptoms include diarrhea of any color, but not bloody; the foal is depressed, stops nursing, may or may not have fever, and dehydrates rapidly.

Treatment involves IV fluid therapy, use of bismuth subsalicylate, probiotics, and often anti-ulcer medication. Protection against the disease can be gained from vaccinating the mare in late gestation with a vaccine for rotavirus. The mare then passes protection to the foal by antibodies in the colostrum. The vaccine is not cleared for use in foals.

Epitheliogenesis Imperfecta

Epitheliogenesis Imperfecta is a genetic defect that produces foals with patches of skin missing. The skin is most often missing from the knees and hocks to the hoof. It is a recessive trait, and the foal will die. Some draft breeds and American Saddlebreds are more likely to have this problem.

Figure 27. Mare nursing her foal.

Lactation in the Mare

Mare's milk has the following composition: 10.9% solids, 1.8% fat, 2.5% protein, 6.1% lactose (sugar), and 0.4% ash (mineral). The first milk, colostrum, is higher in all of these values and also contains the antibodies needed by the foal to fight disease. Colostrum is produced to some degree for the first three days before decreasing to the values given above. Milk production in the mare is maintained by its removal from the udder. Milk letdown into the duct system is a response to massaging of the udder prior to nursing. The amount of milk produced each day is in direct relation to the frequency and amount of milk removed.

Milk production peaks four to eight weeks after foaling. Production remains at a high level for the first three months, starts to decrease during the fourth month, and drops quickly thereafter. Milk production quantities vary greatly from mare to mare. According to one study, average production for mares weighing 1,000 to 1,200 lbs. was as follows: First month = 30.6 lbs., Second month = 32.2 lbs., Third month = 37.2 lbs., Fourth month = 33.2 lbs., Fifth month = 24.0 lbs., and Sixth month = 16.5 lbs.

This data helps to explain why foals usually do not eat much creep feed for the first two months of life and really start to eat a lot of feed by four months of age. If a mare is a good milker, she can provide most of the nutrition needed for the foal for the first two months. However, the foal's size and growth needs soon surpass milk production capabilities. The foal has to look for more feed to supplement its milk diet. Feeding a lot of grain to mares to produce milk for foals is uneconomical, particularly after four months of lactation. It is better to wean the foal and grain feed it, and to turn the mare out to pasture to fatten up for next year's foal.

Lactation stops as withdrawal of milk stops and as intramammary pressure breaks down the secretory cells. In mares this is done most simply by removing the foal and turning the mare out to pasture or placing her on hay. Udder disease such as mastitis is uncommon in mares, and total stoppage of milk removal works well. The udder remains tight and tender for one to two weeks after weaning and usually regresses to prelactation size in 30 to 45 days.

Avoid turning weaned mares out with foals, but if it is necessary, be sure the udder is completely regressed. Otherwise a foal may nurse and lactation will be reestablished. Some feel that it is inhumane to not milk out the mare due to the tenderness associated with a tight udder. They milk the mare out on a schedule that decreases the number of milkings over several weeks. This method works but requires much more labor and time.

Many methods used to wean foals work. Some general guidelines are as follows: Wean foals in pairs or more; leave the foal in familiar surroundings and remove the mare; and be sure that the fences are adequate and safe enough to keep a fretful foal and mare apart. Watch feed consumption of foals closely as they may not eat for a few days and then overeat, resulting in colics and ruptured stomachs.

Total separation is the most common way to wean foals on large breeding farms. The mares are removed far enough away so they cannot see or hear their foals.

A second method, called limited separation, is used when separation out of sight and sound cannot be done. It works well for the owner of a few foals on small acreage. It has also been shown to produce less stress than total separation. This method separates the mare and foal physically but lets them have sight and sound contact, and whatever touching can occur through a fence, but no nursing is allowed.

To do this a sturdy separation must be between the mare and the foal. After a few days the mare and the foal will begin to pay less attention to each other. After one week of separation, the mares can be taken further away if desired with little fuss and no detectable stress.

Weaning age is based on several conditions. First is the mare's use in your program. If she is a valuable show horse, it may be more beneficial to wean the foal as early as a week of age. Use the method outlined in Ohio State University Extension Bulletin 762, *Horse Nutrition,* for the feeding of orphan foals. You may also want to wean early so a foal does not need to be sent to a breeding farm with the mare. Your reason could be to decrease board costs or to prevent the foal from getting diseases common to the breeding farm.

The second condition is the health or lactation ability of the mare. The third condition is labor, as it is usually labor-wise to wean all foals on a farm at one time.

In general, most foals in Ohio are weaned at four to six months of age. Most mares remain on pasture with their foals until fall. They are then weaned so they can gain flesh for next year and because milk production is poor. Studies have shown that foals weaned at three days, two months, four months, and six months appeared equal in growth and weight. When weaning foals at any age, it is important that you use feeds formulated to meet the needs of the foal. The foal should also have been on that feed for at least three weeks prior to weaning. (The obvious exception is the foal that is an orphan or is weaned at three days, which would be on milk).

Foal Growth and Miscellaneous Care

Foals of 1,000 to 1,200 lbs. mares weigh 100 to 120 lbs. at birth and will double their weight during the first month of life. Fastest growth occurs from birth to three months of age. Growth slows slightly from four to six months, and slows more from seven to 12 months of age. By six months of age, a foal weighs 36 percent of its mature weight; and by one year of age, it weighs 53 percent of its mature weight. Also, by six months of age, a foal is 84 percent of its mature height, and by 12 months, 90 percent of its mature height. By two years of age, a horse is 99 percent of its mature height. Additional growth is primarily a result of muscle development raising the thoracic cavity between the shoulder blades. This growth may continue until five years of age.

Sex and season also affect the size of the foal at birth. Males are heavier than fillies and are born three to five days later. Foals born in January to March are lighter than April-to-June foals. However, it takes late foals 18 months to catch up in size to early foals.

Many breeders select for size and early development in foals. In general, if you want a fast-growing large foal to show in a weanling futurity, use parents that produce large fast-growing foals. Nutrition can only help a foal reach genetic optimum size — it cannot make a giant out of a small frame. A rule of thumb for determining the size a foal will reach is that for every four-inch difference in size between the mare and the stallion, the foal will be an inch taller than the shorter parent. The mare has a greater effect on foal size; therefore, it is wise to use big mares to get big foals.

Additional observations estimating a foal's future appearance are as follows: The face is proportionally shorter than mature length and the cranium is proportionally larger. The croup is higher than the withers due to the lack of forehand muscle development. The horse may be two or older before it shows definite withers and evens up in height from hip to withers. Looking at the parents may help you decide if the foal will even up when mature. Wait until the foal is at least 10 days old before evaluating in order to allow the foal's legs time to straighten out some and the body to fill out a little. Knowing how other foals in the same family of horses developed will help you evaluate how this foal will develop.

Tail chewing is a common problem with a pen of foals, particularly when the foals are in a dry lot and do not have access to pasture. Tail chewing is a habit caused by boredom. Here are suggestions for stopping the habit:

1. Saturate the tail with Apinol, a cheap liquid antiseptic that tastes awful and is harmless.
2. Use cribox paste to wipe into the tail. It lasts for about two weeks.
3. Turn the foals out on pasture. Just doing this will often stop the behavior.

Wood chewing is a problem attributed to teething in foals or boredom. Nearly every foal will chew wood to some degree. The best solution is to prevent boredom and to use either hardwoods for stalls and fences or to cover chewable edges with steel. Preparations are available to stop wood chewing; they have variable effectiveness.

Bugs in foal's and adult horse's ears are a problem in some areas. The bugs suck blood from the ears, making them sore. Trimming the hair out of the ears and using a repellent works best. A light coating of Vaseline can be rubbed in the ears and works very well for several days to stop the bugs. Some add citronella in Vaseline, which can also be used around the eyes to repel flies. Commercial fly repellents also are available.

Figure 28. Good pastures are valuable for nutrition and health of both foal and mare.

Genetics

What any animal becomes is a result of two factors — genetics and environment. Environment includes such things as health care, training, nutrition, and all of the other factors that man and nature impose on the horse. Genetics, on the other hand, includes traits passed from parents to offspring that determine how an animal can respond to environment.

In general, the mare and the stallion contribute equally to a foal from a genetic standpoint. However, the mare has more influence (called maternal effects) on the foal's final makeup environmentally for the following reasons:

First, the mare nourishes the foal in her uterus. This has a profound effect on foal size since the mare will limit the foal's size so that she can give birth to it. An experiment was done that crossed Shetland ponies with Shire draft horses to determine the effect of mare size on both foal and mature size. The foals of Shetland mares by Shire stallions were smaller at birth and when mature than foals of Shire mares by Shetland stallions.

Second, the mare provides nourishment for the foal after birth. Foals of mares that do not milk well are slower to grow, and if not supplemented with feed, these foals may be stunted to some degree.

Third, the mare has more influence on disposition because she raises the foal. Most foals take a rank in dominance in a herd similar to their mother's.

How Genetics Works

The nucleus of all cells in the body contains chromosomes on which genes (the basic unit of inheritance) reside. A horse has 32 pairs of chromosomes and an undetermined number of genes. In the normal body cell, the chromosomes are lined up as pairs, and the chromosomes of each pair are of similar shape and contain similar locations (called loci) for the same gene or a variation of the same gene. The exception to this is the sex chromosomes in the male. The male is usually denoted as XY (XX in the female), because the Y chromosome is smaller in size and contains few genes.

In the sex cell (ova of female and sperm of male), the chromosome pairs are separated so that each has 32 unpaired chromosomes. At fertilization the chromosomes of the ova and the sperm unite to again form 32 pairs. The genes at the same loci of the chromosomes react to produce the traits seen in the foal.

Terms

Homozygosity — Genes at a locus on each of the paired chromosomes are identical.

Heterozygosity — Genes at a locus on each of the paired chromosomes are different.

Dominance — A gene's ability at a locus to override the effect of the gene at the same locus on its paired chromosome. As a result, the dominant gene is expressed, and the recessive gene is present but not expressed for that trait in the animal.

An example of this is the Gray gene for coat color. If an animal is heterozygous having a "G" (notation for dominance is a capital letter) and a "g" (small letter denotes recessive), the foal will be Gray. (A later discussion on parrot mouth shows the possible combinations resulting from crossing parents with a dominant and a recessive gene.)

No dominance or incomplete dominance — Occurs when a gene is not totally dominant or recessive, and a cross between two variations of the gene produces a trait that looks like a blend of both genes. Or in the case of Hyperkalemic Periodic Paralysis (HYPP), the trait is only shown under certain circumstances. Horses homozygous for the disease rarely live to two years of age unless they are maintained by medication. Heterozygotes usually show symptoms under stressful circumstances.

Allele — The name given for each possible variation of a gene that occurs at the same locus on the chromosome. For example, the allele for the (E) gene is the (e) gene. Sometimes, however, there are more than just two possibilities for a locus. An example for this is the (A) gene in horses. There are four possible variations of the (A) gene — A^t, A, a^t, a. In this case, they are also dominant in the order as given.

Epistasis — Occurs when a gene at one locus has an effect on a gene at another locus. The (A) gene is also an example of this because it causes the (E) gene to fade out the black gene to a bay, a brown, or to let it be black.

Linked traits — Traits that are inherited as a group. When sex cells reproduce themselves, the chromosomes will intertwine and then pull apart and in so doing will often exchange parts of their strands. This exchange of parts is called crossing over and can occur at any place along the length of the chromosome strand. However, it is found that if genes are located close to each other, it is less likely to separate them during crossing over than genes that are located far apart. Therefore, since they are rarely separated, they are called linked genes.

Sex-linked traits — Sex-linked traits are those traits that are related to the sex of the foal. The trait is carried on the sex chromosome. The X chromosome does contain many genes (some estimate 5% of all the genes), but the Y chromosome only contains a few. This means that technically a male foal is genetically more like the mare, since the genes on his X chromosome came from the mare and those genes are expressed due to not having an allele to interact with them on the Y from the sire.

Sex-limited traits — Those that are expressed only in a certain sex. For example, a mare carries the gene for cryptorchidism, but does not show it since she has no testicles, or a stallion contains genes for milk production but does not produce milk.

Qualitative Traits

Qualitative traits are controlled by only one or a few genes and have different phenotypes. Phenotype is what the horse looks like as opposed to genotype, or the genetic makeup. Table 1 lists some of these traits and how they are inherited.

Because qualitative traits are controlled by one or a few pairs of genes, it is possible to determine the probability of getting a certain phenotype. In some cases, the genotype can be determined as well. For example, the genetic makeup of a parrot-mouthed horse is PP or Pp. If this horse was mated to a normal mare who had pp, the chances of getting a parrot-mouthed foal would be as shown on the next page.

Table 1. Equine Qualitative Traits.

Trait	Mode of Inheritance
Parrot Mouth	Dominant
Cryptorchid	Dominant (may be two genes involved)
Umbilical Hernia	Recessive
Combined Immunodeficiency	Recessive
Congenital Contracted Heels	Recessive (in either of two genes)
Congenital Night Blindness	Recessive
Epitheliogenesis Imperfecta	Recessive
Hyperkalemic Periodic Paralysis	Incomplete dominant
Hereditary Equine Regimal Dermal Asthenia (HERDA)	Recessive
Coat Colors	(See section on Coat Color Inheritance.)

PP male x pp mare = Pp — all heterozygous and parrot mouthed.

	P	P
p	Pp	Pp
p	Pp	Pp

Pp male x pp mare = 1/2 parrot mouth and 1/2 normal foals

	P	p
p	Pp	pp
p	Pp	pp

If the heterozygous foals were mated, the result would be 3/4 parrot mouthed foals (one homozygous, two heterozygous) and 1/4 normal foals.

	P	p
P	PP	Pp
p	Pp	pp

Most detrimental traits in horses are thought to be recessive. Therefore, test matings are necessary to determine if an individual is carrying that gene. For example, a stallion of excellent quality has a dam that produced a foal with umbilical hernia in the past. Before promoting and using this stallion extensively, how can you be sure he will not pass on a gene for hernia?

First, if the dam had a hernia, she was homozygous recessive and passed the recessive gene to the stallion. The stallion has the recessive gene and will pass it to at least half of his offspring. If the mare did not have a hernia, but produced hernias in her foals, she is a heterozygote and half of her foals will at least carry the recessive gene. A progeny test on the stallion could determine the probability that he is free of the recessive gene. Table 2 gives the matings required to produce a high probability that the stallion is free of the trait. The results of these matings never prove that a stallion is free of a gene but give an indication that he probably is.

Table 2. Numbers and Kinds of Matings Required to Test a Male to Determine the Probability He Does Not Carry a Recessive Gene.

Kinds of Females	Probability Females Are Carriers (%)	Number of Matings Required at Odds of	
		95/100	99/100
Homozygous recessive	100	5	7
Known heterozygote	100	11	16
Look normal but sire and dam are known carriers	67	17	26
Look normal but one parent is a known carrier. Or test mate to own daughters.	50	24	35

Quantitative Traits

Unfortunately only a few of the known traits are qualitative. Most traits are quantitative, controlled by many pairs of genes interacting to produce indistinguishable gradations of phenotype. Researchers use a measurement called the heritability estimate to identify what percent of the variation in a trait is caused by genetics as opposed to what is caused by the environment. Table 3 lists heritability estimates for some traits. Even in the best possible controlled research, there are still some environmental effects. As a result, different researchers have found different values. Table 3 gives a range of values for some traits.

Table 3. Heritability Estimates for Some Quantitative Horse Traits.

Traits	Heritability Estimate
Speed	45-60
Weight	30-57
Wither Height	40-61
Muscling	40
Disposition	23
Pulling Power	26
Points for Movement	41
Length of Stride	68
Intelligence	53
Fertility	10

Heritability estimates are commonly divided to classify traits into traits that are highly heritable (greater than 40 percent), moderately heritable (from 20 to 40 percent), and lowly heritable (less than 20 percent). The heritability estimate is used for at least two calculations. The first is to determine the probability that a horse will be a good breeding prospect.

If a stallion is being considered for purchase as a race horse, his race record would be a good indication of whether he has genes for speed as the trait is highly heritable. On the other hand, if he is being selected for pulling power, you would want more information than his own record since this trait is only moderately heritable.

In all cases, look at all records available on a horse and his close ancestors to make a purchasing decision. Table 4 shows the value records have in selecting a horse. From the table you see that the higher the heritability, the more accurate the prediction of how a horse will produce. Also, the table shows how quickly ancestor records decrease in value the more distant the ancestor.

Table 4. Percent Accuracy of Predicting Genetic Value from Own and Ancestor Records.			
Records Used	**Heritability Level**		
	10	**25**	**50**
	%	%	%
Own	32	50	71
Own + one parent or one progeny	35	53	73
Only one parent or progeny	16	25	35
Own + 2 parents	38	57	76
Only two parents	23	35	50
Own + one grandparent	32	51	71
Only one grandparent	8	12	18
Own and 4 grandparents	35	53	73
Only 4 grandparents	16	25	35

A second use of the heritability estimate is predicting the value of the trait in the offspring. An example follows: A Standardbred stallion paces a mile in 1:55 and is bred to a mare that paces the mile in 2:00 The difference between the two is 5 seconds.

If speed is 50% heritable, the average of the offspring of this cross should pace a mile in 1:57.5 minutes (5 seconds x 0.50 = 2.5 seconds is due to genetics; therefore, the average pacing speed of offspring would be 2:00 – 2.5 seconds). This is only a rough estimate of value as heritability estimates are based on populations and one animal is hardly a population. If the animals in the example were from populations that had the same average speed as themselves, the answer would be more accurate.

Factors That Affect the Rate of Genetic Progress

Several factors affect the rate of genetic progress in a breeding program. First is the mode of inheritance. Selecting for a trait controlled by one gene instead of many would be much easier. If you want to introduce a trait into a herd quickly, it is easier to select for a dominant trait because it is visible. However, it will be hard to get the trait in the homozygous state because its recessive gene often will be present but not seen. On the other hand, it takes longer to introduce a recessive trait into a herd because the dominant gene covers it at first. However, when the desired recessive trait is seen, it is homozygous and will produce pure when bred to another homozygous recessive individual.

A second factor affecting the rate of genetic progress is the generation interval. This is the time from which a foal is born until it produces a foal. For horses the generation interval is usually six to eight years. This is because not only does the horse need to be old enough to reproduce, but most traits selected for will not be seen until the horse is trained and being shown. With advances in embryo transfer, the interval could be shortened by collecting embryos from a horse that is being shown and raising them in a surrogate mare.

A third factor is the number of traits selected for at the same time. If selecting for 10 traits, progress is much slower than if selecting for only one. The solution is to start with individuals of superior quality with only one or two faults to fix instead of starting with a critically inferior horse.

A fourth factor affecting genetic progress is selection pressure. Selection pressure is the percent of offspring that are kept to produce the next generation of foals. The higher the selection pressure, the fewer and only the best horses are kept as replacements. Keeping only the best will speed up the genetic progress. Also, with artificial insemination, it is now possible to breed one stallion to several hundred mares each year, so there is no good reason to keep any but the best stallions.

A fifth factor is the variation of genes in a population. A greater variation of genes available causes a decrease in progress simply because so many possibilities may result. Ideally, a population should contain only the best expressions of a gene.

A sixth factor is records. The more records on the breeding stock, the better you can estimate the quality of the offspring. Each breeder needs to develop a record system on which to base breeding decisions. An example of such a record is shown on page 62. This is an index selection type of document. Each trait of the horse is given a weighted value, and a total value is determined. The breeder culls the mares with the lowest total score. The index selection method allows for high scores in one area to make up for poor scores in other areas. Each breeder needs to determine the weight to place on each portion of the record. This should be based on the strengths and weaknesses of traits in the herd and their economic value to the breeder.

The production portion of the form allows the breeder to keep a record of the foals. This record will help in decisions on how to breed the mare, based on problems identified in previous breedings. Using records of the quality of foals produced from available stallions, the breeder may decide to cull the mare even if her own record is good. B, L, Q scores are those the foal receives using the criteria from the top of the form for Balance, Legs, and Quality.

A second type of selection system is a minimum culling level. All selected traits have a required level to attain. If the horse fails in any of the traits, it is culled no matter how well it may do in the other traits. This system is used for the person doing inbreeding to set a type for his herd. When inbreeding, traits become homozygous, so if a defect is seen, the horse is likely homozygous for it. To continue breeding the horse will just increase the incidence of the defect in the herd.

A third selection system is called the tandem method. This system is little used because it selects for only one trait at a time. When that trait is established, selecting begins on another trait. The method produces results too slowly. If you introduced a simple dominant gene into the herd, it would take about five generations for it to be established. Five horse generations are about 30 years, or about the working lifetime of a man. A man could not live long enough to see his product if he selected for two or three traits using this selection system.

Breeding Systems

The breeder can chose from four basic breeding systems — grading up, crossbreeding, outcrossing, and inbreeding.

Grading up, the least used, is the crossing of an individual of unknown ancestry to a registered animal of some breed. The advantage of this system is that it usually produces a horse of superior quality over the scrub parent. However, starting with a scrub animal and with the goal of producing a superior animal takes too long. Also, today's horse market is for the registered animal, and horses produced in this system are usually not registerable.

Crossbreeding is the mating of horses registered in different breeds. The major advantage to this system is hybrid vigor. If animals of very different gene pools are crossed, the offspring often exceed the value of either parent. They usually are of better health, are more fertile, grow taller and more muscular, and are superior athletes compared to inbred animals.

Although the heterozygote has the aforementioned benefits, it has one major disadvantage for the horse breeder. These superior looking and performing animals do not breed true and usually are unsuccessful as parents of the next generation. Ideally, a good breeding animal will stamp its characteristics on its offspring (commonly called prepotency).

FOR SUMMER 2023

Horse Production Record		
Horse's Name:____________________________	**Score**	**Weakness**
Balance		
1. Symmetry (10)		
2. Head and neck (15)		
3. Shoulder, withers, heart (15)		
4. Back, hip (15)		
Legs		
1. Front (20)		
2. Rear (20)		
Quality		
1. Sex type, refinement (10)		
2. Muscling (15)		
Disposition (20)		
Way of Going (20)		
Mature Height (10)		
Pedigree (30)		
TOTAL		

Production Record					
Year	**Sex**	**Sire**	**BLQ-6 Mos.**	**BLQ-1 Yr.**	**Weakness**

Because the crossbred is a heterozygote, it produces offspring more like the average of the populations from which it came, and the foals have great variation in type. Also, some breeds will not allow crossbreeding, and those that do, put special registration restrictions on such animals.

Outcrossing is the third breeding system and the one most often used by purebred breeders. Outcrossing is the mating of animals from different families within the same breed. Because offspring are of the same breed, registration is not a problem. Animals also gain a degree of hybrid vigor because they are from different families.

Usually a breeder will have a family of horses he or she wants to improve. To do this, the breeder needs to go to another family to get some good traits to replace his family's defects. But be careful — if you go to several different families to get different traits, you greatly increase the possible gene variations. You may end up with an animal that contains so many gene variations that it lacks prepotency.

Inbreeding is the mating of individuals more closely related than the average of the population from which they came. **Linebreeding** is a form of inbreeding in which a high degree of relationship to an outstanding ancestor in the pedigree is maintained. Inbreeding increases the number of genes that are in a homozygous state. This creates a prepotent animal because it decreases the gene variation an animal can produce. Offspring tend to look like the inbred parent. The problem with inbreeding is that the undesirable as well as the good genes are in a homozygous state. Breeders that inbreed should probably use a minimum culling level system and eliminate all animals with an economical genetic defect, no matter how good everything else may be.

A second problem with inbreeding is that animals with genes in a homozygous state lack vigor. Geneticists say that the level of inbreeding that produces this loss of vigor is 25%. Most horse breeders stop when the inbreeding coefficient reaches 12%. Table 5 lists the kinds of matings to produce different levels of inbreeding.

Table 5. Inbreeding Coefficients

Relationship of Parents	Inbreeding Coefficient
Sire to Daughter	25%
Dam to Son	25%
Full Brother to Full Sister	25%
Half Brother to Half Sister	12.5%
Grandsire to Granddaughter	12.5%
Granddam to Grandson	12.5%
Uncle to Niece	12.5%
Aunt to Nephew	12.5%
One Common Grandparent	3.1%
First Cousins	6.3%
One Common Great Grandparent	1.6%
Two Common Great Grandparents	3.1%
Three Common Great Grandparents	4.7%

How to Be a Successful Breeder

A person who breeds horses must have a purpose, and that purpose will determine the breeding system to use. If a person wants to produce an outstanding performance animal, and if crossbreeding is allowed in his/her breed registry, he/she should choose to crossbreed. (If cross-breeding is not allowed, then outcrossing between families within a breed should be done.) However, to crossbreed, a person still needs to pick outstanding horses from the different breeds that have many of the traits he/she would find in his/her ideal horse. For example, if a person wants to produce a great cutting horse, you may use a King-bred mare (known for cutting ability) of the Quarter Horse breed and cross on a Thoroughbred stallion that could cut cattle as good as a King-bred animal.

However, if a breeder wants an outstanding horse that will be a great producing stallion or mare, a different method should be used. He/she should start with a few of the best mares of a breed that comes close to his/her ideal. (It is far better to start with a few excellent related mares than 100 mediocre ones.) From these, the breeder would outcross to other families only to get one or two needed traits. When these needed traits are obtained, the breeder then begins to inbreed to create a high-quality family. Families are important in breeding because a horse always produces offspring that are close to the average of the population from which the horse comes. Therefore, excellent families ensure excellent offspring.

By the time you have outcrossed and done some inbreeding, you will probably die of old age, and, hopefully, some of your children will continue the family of horses you began. As the family of horses is inbred, outcrossing or crossbreeding (if the breed allows it) will need to be done occasionally to maintain vigor. To accomplish this, the breeder should find a stallion that is as close to his/her ideal as possible but is unrelated. Crossing him on his/her mares will decrease the inbreeding level and produce horses less likely to produce as they look. However, by crossing the crossbred daughters back to stallions of the original family, the type and prepotency can be regained quickly.

Interpreting Pedigrees

A pedigree is the written ancestry of a horse. Figure 29 is an example of a four-generation pedigree that will be used in this discussion. For simplicity, letters and numbers have been substituted for names.

To start, each horse has a sire side of the pedigree (the upper portion, which gives the ancestors of the sire) and the dam side (the lower portion containing the dam's ancestry). By convention the sire of an individual is listed above the dam. In the example, S, 1, 2, and 7 are males and D, 3, 4, 5, 6, and 8 are females.

For practical purposes, no more than a five-generation pedigree is used due to the insignificant amount an ancestor farther away contributes.

The first thing a pedigree provides is the percent of an individual's genes that come from another individual in the pedigree. Usually you want to know the relationship of the product (X in the example) to any outstanding ancestors in the pedigree. This tells the probable proportion of genes X has from that ancestor.

Every individual obtains half its genes from each parent. Therefore, for each generation an individual is separated from another, the genetic effect is halved. Parents contribute one half each, grandparents one fourth, great-grandparents one eighth, and so on. To calculate the relationship, add all of the pathways from X to ancestor 1 in the example:

$X - S - 1 \quad = (1/2)^2 \quad = \quad 0.2500$

$X - S - 4 - 1 \quad = (1/2)^3 \quad = \quad 0.1250$

$X - D - 1 \quad = (1/2)^2 \quad = \quad 0.2500$

$0.6250 =$

Probable portion of X's genes that came from 1.

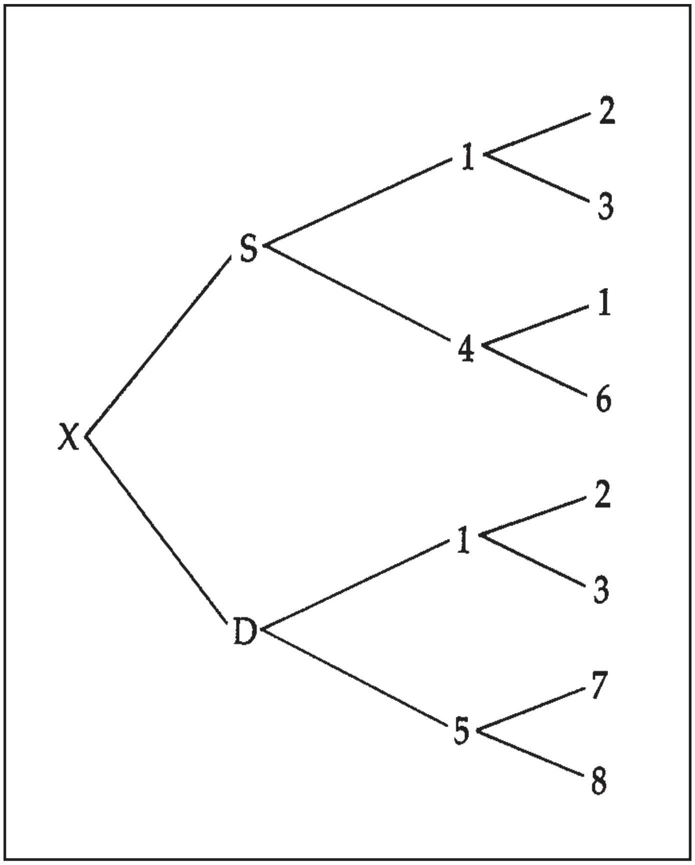


Figure 29. Sample pedigree (a four-generation pedigree).

A pedigree also can tell the inbreeding coefficient of a horse. The inbreeding coefficient is the percent of genes an individual has in a homozygous state above that of the average population. All horses within a population (breed) have some genes in a homozygous condition because they come from a common ancestor. These homozygous genes make a horse look like others of the breed. The inbreeding coefficient tells whether an animal will be prepotent. It also tells you if the inbreeding level is too high and will cause decreased vigor and low fertility in the offspring.

To determine if an animal is inbred, look for the first common ancestor that appears on both sides of the horse's pedigree. A horse can have more than one common ancestor. In the example, the common ancestor of X is 1. Individuals 2 and 3 are also on both sides of the pedigree but are accounted for because they are the parents of 1 in every case. Therefore, they do not count in determining common ancestors.

To determine the inbreeding coefficient, connect all the possible paths from the sire to the common ancestor and back to the dam, and add these. Additional rules for making pathways are that no ancestor can occur more than once in a pathway, and any pathway is acceptable as long as it has at least one different ancestor in the pathway. Using the example, the following would be the inbreeding coefficient of X:

S – 1 – D	$= (1/2)^2$	=	0.2500
S – 4 – 1 – D	$= (1/2)^3$	=	0.1250
Pathway sum		=	0.3750

Next the pathways are put into a formula that determines the inbreeding coefficient.

$$Fx = ½ \Sigma ((1/2)^n (1 + F_a))$$

Fx = the inbreeding coefficient of X

Σ = sum of all of the pathways to common ancestor(s)

^{n} = the number of generations from sire to common ancestor and back to the dam.

F_a = the inbreeding coefficient of the common ancestor. If the common ancestor is not inbred, the $(1 + F_a)$ part of the formula is eliminated. In the example, there is no evidence that 1 is inbred, so assume he is not.

$$Fx = \tfrac{1}{2}\,\Sigma\,(\,(1/2)^n\,)$$

$Fx = \tfrac{1}{2}\,(0.3750)$ from the sum of pathways

$Fx = 0.1875 = 18.75\%$ more of X's genes are in a homozygous condition than the average of the population.

Computer programs are available that are designed to calculate the inbreeding coefficient.

A third calculation that can be made from a pedigree is the relationship of any two individuals. This tells the percent of duplicate genes they have because they are related by a common ancestor. The formula for this is as follows:

$$R_{sd} = \frac{\Sigma\,(1/2^n\,(1 + F_a))}{(\sqrt{1 + F_s})\;(\sqrt{1 + F_d})}$$

R_{sd} = relationship of S to D

Σ = sum of pathways

F_a = inbreeding coefficient of common ancestor. (In this example, A is not inbred.)

F_s = inbreeding coefficient of S = 0.25 or 25 percent is found by using formula for determining inbreeding coefficient.

F_d = inbreeding coefficient of D that is not inbred in this example.

Determine pathways from S to D through the common ancestor.

$S - 4 - 1 - D = (1/2)^3 = 0.1250$

$S - 1 - D = (1/2)^2 = 0.2500$

0.3750

$$Rsd = \frac{0.3750}{(\sqrt{(1 + 0.25)})\;(\sqrt{(1 + 0)})}$$

$$Rsd = \frac{0.3750}{(\sqrt{1.25}} = \frac{0.3750}{1.118}$$

= 0.3354 or 33.54 % of S and D's genes are identical because they have 1 as a common ancestor.

Figure 30. Chesnut mare and foal. Chesnut to chesnut always produces a chesnut.

Figure 31. Palomino mare with sorrel foal. Palominos produce the yellow body color only half the time.

Coat Color Inheritance

Color inheritance is a complicated topic, and at times it is hard to explain some of the colors that occur. However, this section will cover the basics of color inheritance.

The pigmentation of skin and hair is determined by granules called melanin which are produced by specialized cells called melanocytes. In the horse, two types of melanin are produced—eumelanin, which is a brown/black pigment, and phaeomelanin, a yellow/red pigment.

Except for the dominant white horse that lacks melanocytes, all horses have these cells in the hair follicle of the skin. The size, shape, and quantity of the melanin granules and their arrangement in the hair affect color. Several genes affect these characteristics of the granules.

For a more in-depth study of this topic, *Horse Color* by D. Phillip Sponenberg and Bonnie Beaver is a good reference.

The Color Genes

The B Gene

The dominant B gene represents the eumelanin pigment, which produces a black coat and skin color. Its homozygous recessive (bb) produces a chocolate or liver coat color with a brownish pink skin color. Both coat colors fade when exposed to the sun unless the horse has another gene that prevents fading. Most black horses are born mousey gray or black.

It is thought that only a few breeds, the Quarter Horse and the Morgan, have the recessive expression (b) of the gene.

The A Gene

The (A) gene has four possible alleles. (An allele is one member of a pair or series of genes that occupy a specific position on a specific chromosome.) Given in order of dominance, the alleles are A^t, A, a^t, a. The A^t causes the coloration that is seen in Przewalski's horse, but this is not found in our domesticated horse.

The A gene causes the bay color pattern. It restricts most of the eumelanin granules to the mane, tail, and lower legs (called points of the horse). Eumelanin left in the body hair in relation to amount of phaeomelanin determines the shade of bay. The A gene does not create a bay pattern in sorrels because another gene has already restricted the eumelanin. The A gene may have an effect on the phaeomelanin, however, and be responsible for the lighter shades of sorrel.

The a^t gene is recessive to the A gene, and when a^ta^t or a^ta is present, the black horse is faded to a seal brown. If a bb gene combination is present, it will fade the liver to a light seal brown.

The homozygous aa gene has no effect on the shade or distribution of color in the coat.

The E Gene

This gene extends or restricts the presence of both eumelanin and phaeomelanin. When one is extended, the other is restricted. Given in order of dominance, there are three different expressions of this gene — E^D, E, and e.

The E^D gene allows full extension of black or liver throughout the hair coat. These colors will be non-fading if this gene is present. (The horse born with this gene is coal black if BB or Bb or very dark liver if bb.) The E^D gene is epistatic (one gene prevents the expression of another) to the A locus, and the genes A, a^t will not be expressed even if present.

The E gene allows normal expression of black and liver pigment, and the A locus will affect this expression. The homozygous ee will restrict the eumelanin granules (black and liver) to the eyes and skin, allowing only the phaeomelanin granules (red and yellow) to remain in the hair coat. This produces the sorrel or chestnut. Lighter sorrels are thought to have an A gene, and darker sorrels are probably homozygous aa. Although the term chestnut is often used to denote a dark sorrel, in this discussion of color inheritance sorrel and chestnut are considered the same.

The F Gene

This gene affects the color of the points of the horse and modifies phaeomelanin if eumelanin is not allowed in the points by the E gene. (It must be ee with ff to work.) The homozygous recessive ff makes a flaxen mane and tail. An FF or Ff makes a red mane and tail.

The Z Gene

This dominant gene causes the silver dapple commonly seen in Shetlands. This gene affects eumelanin to make a flaxen mane and tail. The EE or Ee must be present if the Z gene is to be expressed.

The Sty Gene

This gene causes a smutty or sooty effect on coat colors. This gene is not well documented but is thought to be dominant. The hair coat will have dark hairs mixed with the light hair or will have eumelanin placed in the tip of the light hairs, both of which make a smutty or sooty effect. In its homozygous recessive state, the clear or pure body colors are expressed.

The G Gene

The gray gene in its dominant form GG or Gg causes a horse to become gray with age no matter what color the horse may be when born. As the foal begins to shed its foal hair, gray hairs are present. The horse grays further with each shedding until, after several years he appears white. He is gray, not white, because the skin is dark. White horses have pink skin.

In gray horses pigment granules are gradually restricted to the skin and are not able to enter the hair shaft. Gray horses must have at least one gray parent. Those over 15 years of age are more susceptible to melanomas, which are pigment tumors.

Some grays do develop a sprinkling of color throughout the hair coat (called flea-bitten). The genetics of this is unknown.

The R Gene

The R gene causes the roan effect on the basic colors of horses. The typical roan is the horse with a roan body, but the head, neck, mane, tail, and lower legs are of solid color. Roans are classified by the base body color: Blacks are blue roans, bays are red roans, and sorrels or chestnuts are strawberry roans.

The roan gene is dominant; a horse must have at least one roan parent to be roan. All roans are heterozygous Rr, and the homozygous dominant RR is a lethal causing death to the embryo. The homozygous rr is in all non-roan horses.

The dominant roan gene will cause all other colors to roan except dominant white and gray. To tell a roan from a gray: roans are born roans and grays are born a solid color and gray more with each shedding of the hair coat. Both roan and gray genes are possible in one horse. This horse is born looking like a roan, but becomes gray all over with age.

Rb Gene

The Rabicano (squaw tail) pattern is caused by this gene. White hairs appear at the base of the horse's tail and in the rear flank area. Depending on the extent of the expression of this gene, these horses may be confused with roans.

P Gene

The Pangare gene is dominant and causes lightening of the hairs containing phaeomelanin on the muzzle, around the eyes, in the rear flank, the inside of the rear legs, and the mid line of the belly. It is the gene that makes the blond sorrels commonly seen in the Belgian breed.

The W Gene

The white gene W is found in the horse that is born white, has pink skin, and colored eyes. White horses are heterozygotes Ww because this gene in the homozygous dominant form WW is lethal to the embryo. The homozygous ww gene allows all other color genes to be expressed. The W gene is dominant to all other color genes.

White horses can result from Sabino (another color pattern that produces a horse that has a lot of white) to Sabino matings, and there is no known lethal associated with that gene. White horses occur sometimes from Appaloosa matings and even at times from the mating of two solid-colored horses. The genetics of these are not understood at present. Mating of Overo paints can also produce white or almost white foals, but this is a lethal homozygous allele of the gene. Overo paints can be DNA tested to determine if they carry this lethal gene.

The C Gene

The C gene is thought to have three expressions— C, C^{cr}, c. The c gene in a homozygous state is thought to not exist in the horse, as it would cause a horse to be a true albino. The C gene is necessary for the expression of the eumelanin and phaeomelanin. The c^{cr} gene causes the dilution of the red pigment (phaeomelanin). Therefore, if a c^{cr} gene is present, it will dilute the body color of a sorrel (chestnut), bay, and the lighter areas of a seal brown to yellow. The c^{cr} gene has no effect on black, liver, and the dark areas of seal brown because it does not affect the eumelanin pigment.

When the genes are heterozygous C c^{cr} the result is a palomino. When the gene is homozygous c^{cr} c^{cr}, it will dilute sorrels to cremello (almost white) and bays to perlino (nearly white body with points being dark to light rusty colored).

When the gene combination C c^{cr} acts on a bay or maybe some seal browns, a buckskin may result. Because the body hair is a combination of black and red hairs and the c^{cr} gene only fades the red color, the body color may be a clear yellow or a sooty yellow buckskin if the Sty gene is present. The definition of buckskin for this discussion is a yellow body with black points and no dorsal stripes or zebra striping on the legs or over the withers. Dorsal and zebra stripes are seen in relation with the D gene, which causes the dun colors.

The D Gene

This locus is like the C locus in that it controls the amount of pigment in the hair shaft, but unlike the C locus, it dilutes both eumelanin (black) and phaeomelanin (red). The gene in the dominant form D, either in homozygous or heterozygous state, will dilute color. The homozygous dd is recessive and allows normal expression of color. The D gene does not affect point color or black hair caused by the Sty gene.

The D gene is thought to be closely linked to the a^t gene which is thought to cause a dorsal stripe and zebra stripes on the legs and a stripe over the withers. Therefore, all of the following colors produced by the D gene will usually include these markings:

Red Dun or Clay Bank Dun: The D gene dilutes chestnut to a yellow body with red points. If this horse had a gene for flaxen mane and tail, it would be called Isabella. A homozygous DD isabella would be a palomino that would breed true if bred to another isabella.

Grulla: The D gene dilutes eumelanin of the black or seal brown to a uniform smoky gray with black points. The gene's effect on liver color probably produces the brown grulla, which is a smoky light brown color with darker points.

Dun (also called buckskin by some): The D gene effect on a bay is to dilute the body to yellow and leave the black points black.

If the D gene is present with the c^{cr} gene, you do not get a double dilution but you would expect paler than normal colors.

Genes Controlling Markings and Patterns

White face markings were thought to be dominant genes — Star (St), Stripe (Sr), Snip (Sn). White leg markings and chin spot (white on the lower lip) were considered a recessive. All of this is now being questioned. It is thought that there are other modifier genes that control the amount of white that is expressed, or perhaps these traits are controlled by many genes that interact to produce the markings to determine how much white is produced. We do know that if horses are selected for white markings, we do have success in getting more white.

Distal spots (dark color spots) on the coronary band of the white leg marking are presently thought to be caused by a dominant gene.

One point of interest with markings is that identical twins produced by splitting the embryo will have similar markings but to different extents. This may indicate an effect from something different than genes on the markings.

Tobiano is a color pattern of paints and pintos where the white crosses the top line, the head is colored, and all legs are white. The gene for tobiano is dominant T. It is either TT or Tt in spotted horses and tt in solid-colored horses. Since the Tobiano gene is linked with a blood factor that we can identify genetically, it can be determined if the horse is homozygous for this gene.

Overo is a color pattern of paints and pintos where the white rises from the belly and rarely crosses the top line and the legs are usually colored except for white markings. This pattern is thought to be a dominant gene, O, because sometimes when overos are crossed, they will produce solid colored offspring. It is thought that other modifier genes may also be involved to allow the expression of the overo pattern. Homozygous oo produces solid-colored horses. There is a third allele, o^e, and if it is in the homozygous state, it will cause a nearly white foal with the lethal defect *atresi coli* (absence of part of the large colon). It is felt that the nearly white paint or pinto is more likely to carry this gene, o^e, and horses having glass eyes (white in the iris) may carry this expression of the gene. Therefore, it is not recommended to mate two horses that have a large amount of white or that have glass eyes.

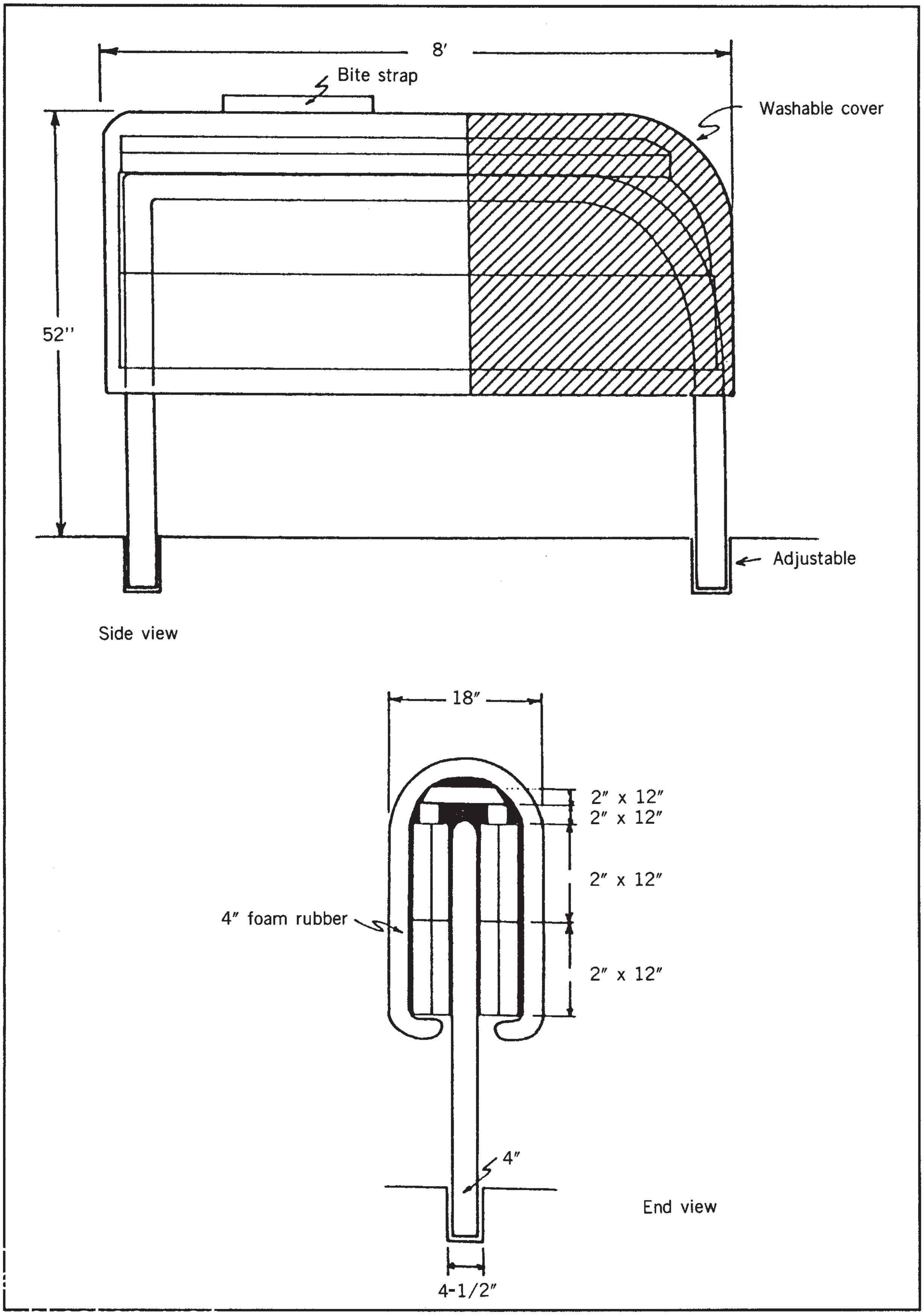
Sabino is another color pattern that produces a horse that has a lot of white and is considered a dominant gene. Minimum expression is high white stockings and a lot of facial white. It is thought that the heterozygote, Sb sb, has less white and the homozygous dominant, Sb Sb has extreme white, producing what is called a medicine-hat pattern with lots of white on the body. This gene is common in the Clydesdale, Spanish mustang, Dutch Warmbloods, and in some paints and pintos.

Appaloosa color patterns are caused by several genes, and their mode of inheritance is not clearly understood. In general, Appaloosas bred to solid horses often produce one of the Appaloosa patterns, which would lead one to think they are dominant traits. However, sometimes two solid horses will produce an Appaloosa pattern, so there must be complicating factors.

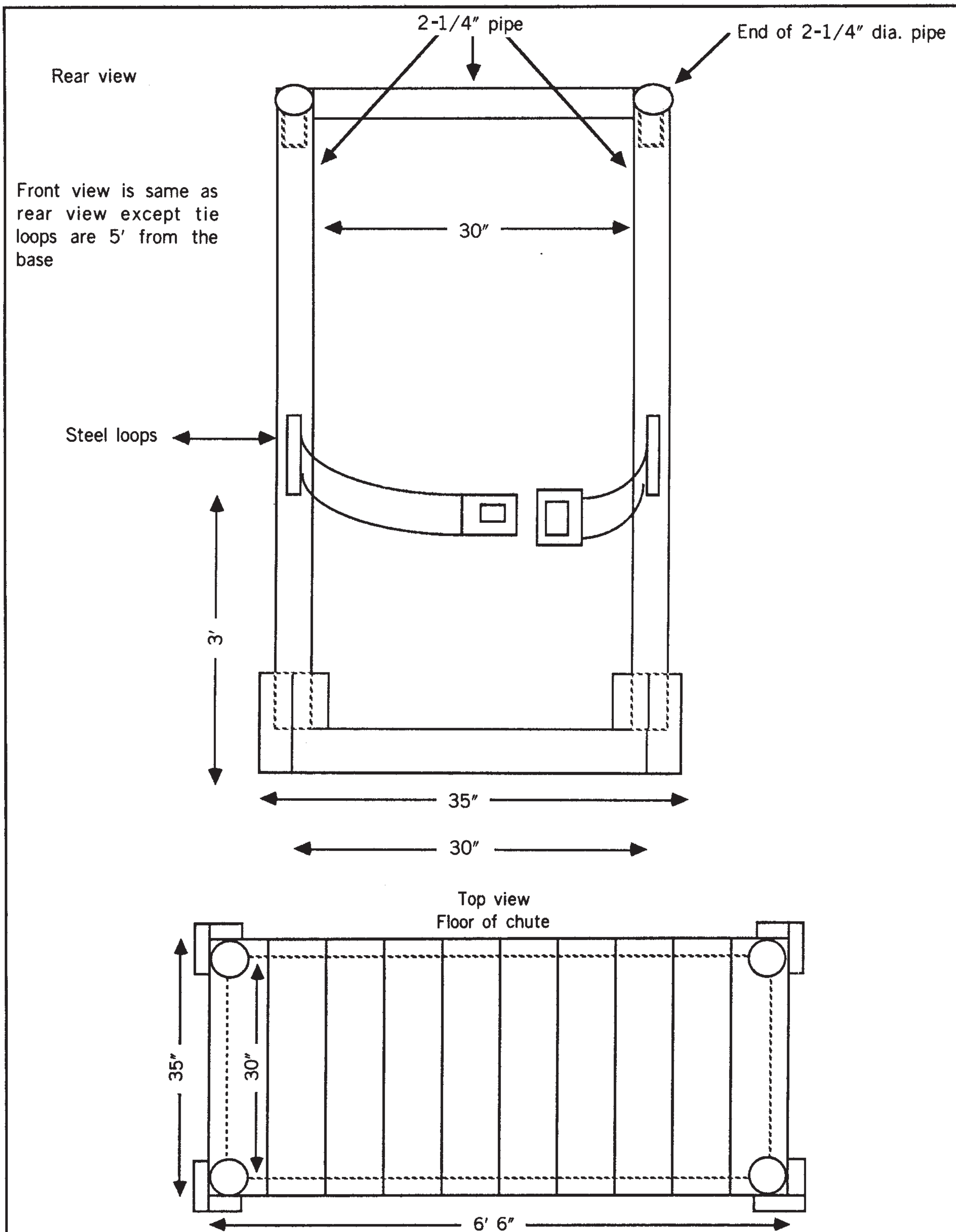
Some think that the Blanket pattern and Leopard pattern are extremes of the same gene.

Figure 32. A palomino overo foal.

Appendix A: Dimensions for the Breeding Phantom



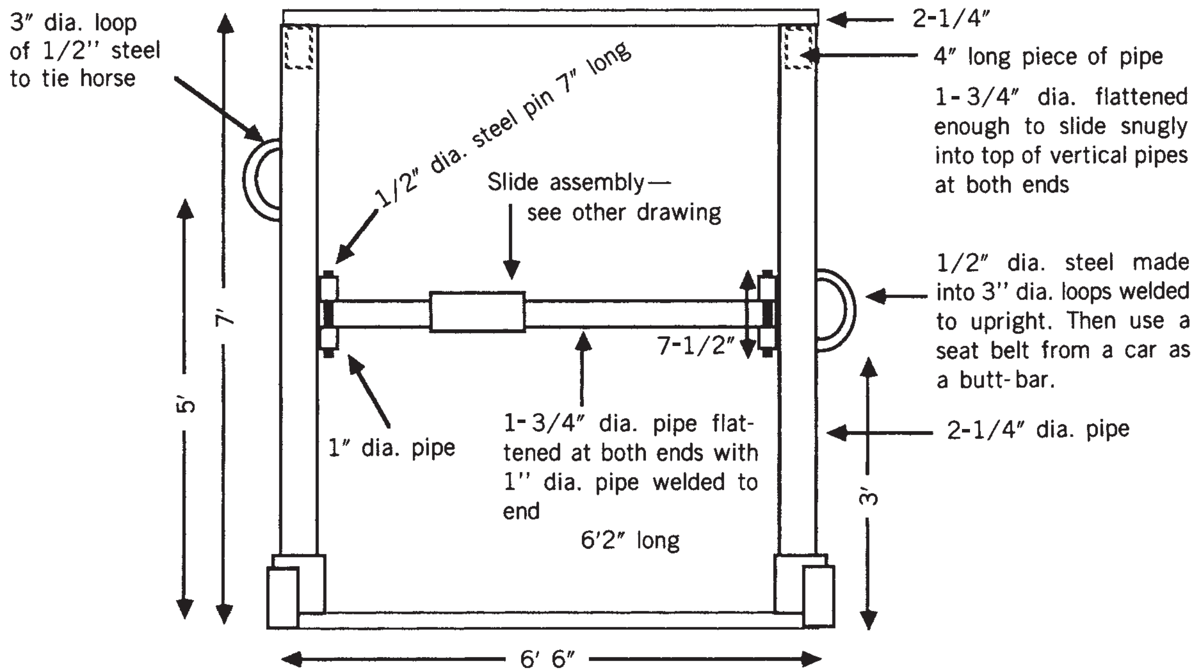
Appendix B: Plans for a Portable Palpation Chute



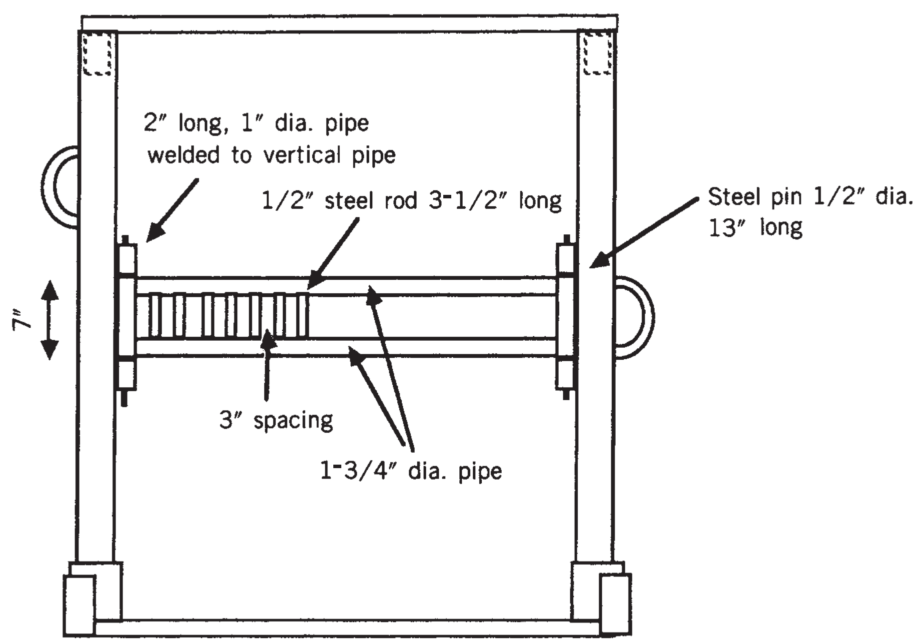
Floor has a frame made from 2'' angle iron with 2'' oak planks. Circles are 3'' dia. (outside) pieces of pipe 8'' long which are welded to the top of the angle iron of the base using 10'' long pieces of 2'' angle connecting pipe to itself and then to the angle iron of the base.

All pipe diameters in drawing are outside diameter.

Palpation Chute (continued)



Left side



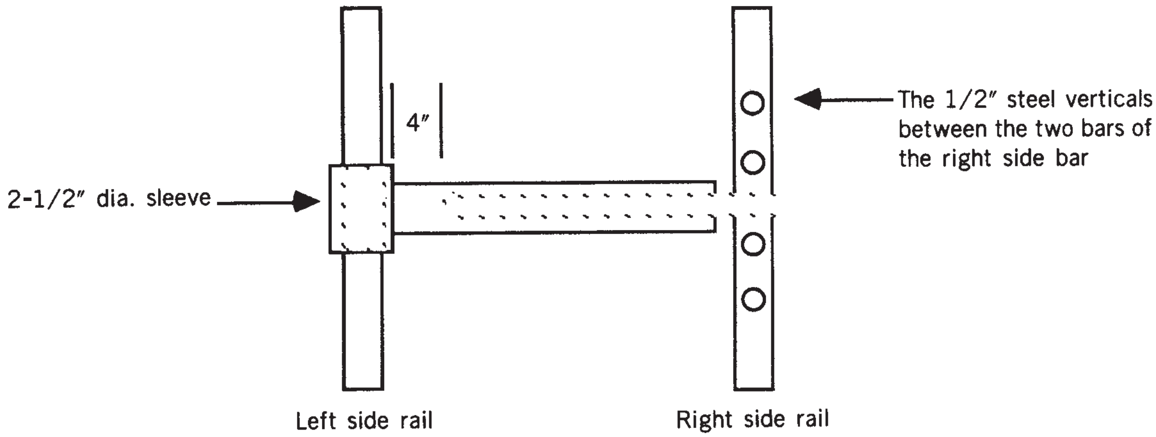
Right side

Measurements same as left side except for side bar.

Palpation Chute (continued)

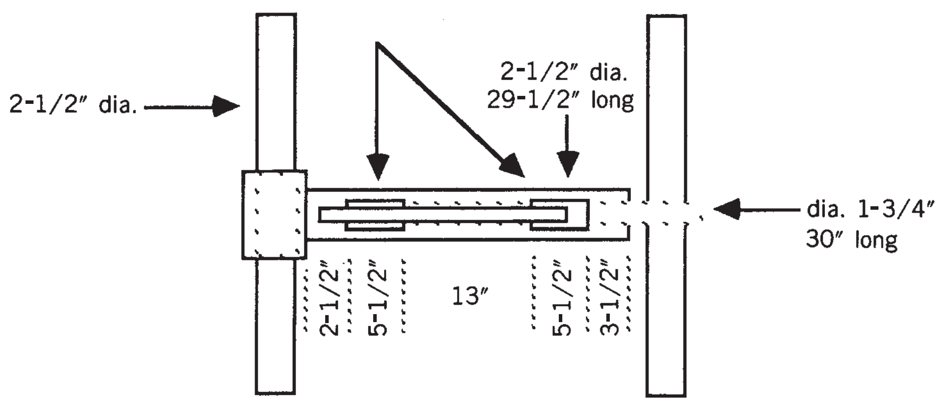
Slide mechanism

Allows for adjustment of length of chute and a way of quick release if horse jumps over the front bar.

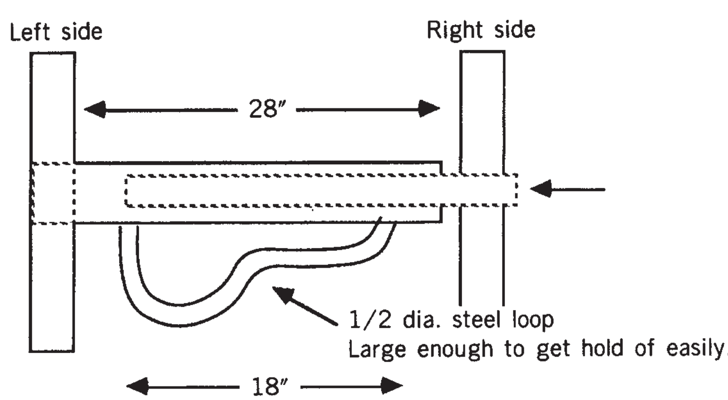


Top view

Slots cut in outside pipe 3/4″ wide so handle can move slide mechanism



Bottom view



Rear view shows slide mechanism at front of chute.

Appendix C: Some Equine Reproduction Equipment Suppliers

NASCO
901 Janesville Ave.
Fort Atkinson, WI 53538-0901
1-800-558-9595 or 920-563-8296
E-mail: Custserv@eNASCO.com
http://www.nascofa.com
Equine breeding supplies, artificial vaginas, Whirl Pak Bags.

American Reproductive Systems
14395 Ramona Ave.
Chino, CA 91710
1-800 300-5143 or 909-597-3043
E-mail: sals@arssales.com
www. Arssales.com
Densimeter, Semen Diluents, etc.

Butler Company
2763 Westbelt Dr.
Columbus, OH 43228
1-614-771-1010
Sterile non-spermicidal lube, insemination rods, Lubrivet non-sterile lube, sterile plastic sleeves, non-sterile sleeves.

Equine Breeders Services
1102 South St.
Penrose, CO 81240
1-719-372-6722
Phantom and AI equipment.

Exodus Breeders Supply
5470 Mount Pisgah Rd.
York, PA 17406
1-717-252-0721
E-mail: exodus@exodusbreeders.com
http://www.exodusbreeders.com
Hemacytometer Counting Chamber, Equine Express Semen Shippers, stallion equipment, Equine Express Semen Extenders, sterile and non-sterile lubricants, Colorado AV supplies, insemination pipettes, rectal sleeves.

Hamilton Thorne Research
Equine Division
P. O. Box 2099
South Hamilton, MA 01982
1-800-367-0266
Equitainer, semen extender.

Midwest Scientific Instruments
Dieter Hahn
1920 Stockwell Drive
Columbus, OH 43235-7372
1-614-451-2110
Microscopes — sales and service.

Reproduction Resources
P.O. Box 354
10015 Green St.
Hebron, IL 60034
815-648-2431
AI supplies.

Cole Palmer Instrument Co.
625 E. Bunker Ct.
Vernon Hills, IL 60061
1-800-323-4340
Scientific instruments, microscope, slide warmers, Henacytometer.

Other Sources

http://www.vetwarehouse.com
Click on Equine Supplies

http://www.equine-reproduction.com/index.html
Click on Links page

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FOR SUMMER 2023

The 4-H Pledge

I pledge
my head to clearer thinking
my heart to greater loyalty
my hands to larger service, and
my health to better living
for my club, my community, my country,
and my world.

FOR SUMMER 2023
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