II. Outbreeding and Hybrid vigour

II. Outbreeding and Hybrid vigour

- Outbreeding is the opposite of inbreeding, it is the mating of animals less closely related than the average relationship within the breed.

- If two individuals do not have any ancestors in common for five or six generations back in their respective pedigrees, they are usually thought not being any more related than the average of the population

Consequences of outbreeding

1. Outbreeding increases the number of pairs of heterozygous genes in the individual

2. Outbreeding tends to decrease breeding purity

3. Outbreeding tends to cover up detrimental recessive genes.

4. Phenotypically, outbreeding usually improves traits related to physical fitness (hybrid vigour).

Hybrid vigour or heterosis

- **Heterosis, or hybrid vigour,** is the name given to the increased vigour of the offspring over that of the parents when unrelated individuals are mated.

- In 1914 Professor Shull proposed for the first time the word “heterosis ”

- The best known example for hybrid vigour in animals is **the mule** (male ass and mare)

- The reciprocal cross, called **the hinney or jennet**

Types of heterosis

- **There are three main types of heterosis**
  (Individual, Maternal, Paternal)

1) Individual (direct) heterosis

- It is the improvement in the performance of crossbred individual above the average of its parents.

- It is affected by Individual's gene that directly affects on its performance.

- All traits have what is called a direct or individual component of heterosis

- Examples
  (weaning weight, yearling weight and carcass traits)

2- Maternal Heterosis

- It is the improvement in the performance of the crossbred mother over the average of purebred mothers

Example:

I. Reproductive efficiency of the mother (age at puberty, calving rate)
II. Mothering ability (weaning weight, number weaned)
III. Longevity or lifetime productivity (greater longevity)

3- Paternal Heterosis

- It is the improvement in the performance of a crossbred sire over the average of purebred sires

- Examples:

age at puberty, sperm concentration, pregnancy rate and weaning rate / 100 cows

Trait with both direct and maternal component

1. Weaning weight.

- ✓ The direct component of weaning weight is a function of its inherent ability (its genes) for rate of growth
- ✓ The maternal component represented by the milk yield and mothering ability of its dam.

2. Dystocia

- ✓ The direct component is related to the size and shape of foetus.
- ✓ The maternal component is associated with the dam's pelvic size and conformation and other physiological and psychological factors.

3. Survivability

- ✓ The direct component is a function of those genes in young animals that affect physical soundness, immune response
- ✓ The maternal component relates to the dam's ability to nourish and protect its young.

Trait with both direct, maternal, paternal component

1. Conception rate

- ✓ The direct component of conception rate refers to the effects of genes in the embryo that influence its survival.
- ✓ The maternal component refers to the effects of genes in the dam that influence uterine environment and her ability to conceive.
- ✓ The paternal component refers to genes in sire affecting his ability to impregnate females.

2. Number weaned /100 cows

Factors affecting the amount of hybrid vigour

1. **The degree of non relationship.**
   species crossing > crossbreeding > outbreeding

2. **The heritability estimate**
   Traits with lower heritabilities tend to exhibit more heterosis than do traits with higher heritabilities.

✓ Fertility traits (lower h^2) so greatest benefits from heterosis

✓ Carcass quality traits (higher h^2) so affected by additive genes action so lowest benefit from heterosis

- Heterosis depends upon non–additive gene action and upon one parent being homozygous for one allele in which the other parent is homozygous for the other.

Individual, Maternal, and Paternal Hybrid Vigor

TABLE 18.2 Typical Individual (I), Maternal (M), and Paternal (P) Hybrid Vigor Estimates for a Number of Traits and Species

Species	Trait	$\%HV^I$	$\%HV^M$	$\%HV^P$
Cattle (beef)	Conception rate (trait of cow)	6.0	—	6.0
	Birth weight	3.0	1.5	—
	Weaning weight	5.0	8.0	—
	No. weaned/100 cows exposed	3.0	8.0	5.0
	Weaning weight/cow exposed	7.0	15.0	6.0
	Feed conversion (feed/gain)	−1.0	—	—
	Yearling weight	6.0	2.0	—
	Age at puberty	−5.5	—	—
Cattle (dairy)	Milk yield	6.0	—	—
	Fat yield	7.0	—	—
	Percent fat	—	−1.0	—
	Mature weight	5.0	—	—
	Interval from calving to first service	−1.0	—	—
	Services/conception	−13.0	—	—
	Interval from first service to conception	−17.5	—	—
	Percent calf survival	15.5	—	—

Hybrid Vigor (Heterosis)

Heterosis amount can be estimated by

a) The amount of heterosis in F1 generation

= Average of crossbred progeny – Average of parent breeds.

b)The amount of heterosis exhibited by an F2 generation is

commonly observed to be half of that manifested by the F1 hybrids.

Hybrid Vigor (Heterosis)

Heterosis percent can be estimated by

$$H.v \text{ or } H\ \% = \frac{(Average of\ crossbred\ progeny) - (Average of\ parent\ breeds)}{(Average of\ parent\ breeds)} \text{ X 100}$$

$$= \frac{\overline{X}F_1 - \frac{1}{2}(\overline{X}p_1 + \overline{X}p_2)}{\frac{1}{2}(\overline{X}p_1 + \overline{X}p_2)} X\ 100$$

where :

H.V. or H % is hybrid vigor or heterosis percentage

XF1 is actual average of crossbred progeny.

XP1 is mean of first parent breed.

XP2 is mean of the other parent breed.

Genetic explanation of heterosis

- Heterosis occurred due to dominance, over dominance and epistasis

- In dominance and over dominance, the heterotic effect is due to the interaction of genes that are alleles.

- In epistasis, the interaction is between pairs of genes that are not alleles.

- It is difficult, if not impossible, to practically fix heterosis effect

- The most practical procedure of making use of heterosis seems to be:

➢ Formation of distinct lines or breeds, then, crossing these lines to find those which give the greatest hybrid vigour.

The different types of outbreeding

The outbreeding can be **classified into:**

1. Crossing species.
2. Crossbreeding.
3. Crossing strains or lines.
4. Crossing inbred lines.
5. Outcrossing.
6. Backcrossing.
7. Topcrossing and grading up
8. Mating likes.
9. Mating unlikes.

1. Crossing species

- Cross-species has not been widely used in animal production **because** different numbers of chromosomes to cross.

- The sperm may fertilize the egg but generally embryo survival is low.

- If the species cross survives to sexual maturity then it is usually sterile.

- Many species crosses are mainly of **zoological interest**

Lion X Tiger = Liger.
Ass X Zebra = Asbra (Africa).
Horse X Gravy's zebra = Zebroid (U.S.A.)
Horse X Ass = Mule
Cattle X Buffalo = Beefalo (Canada and U.S.A.)
(3/8 American buffalo+ 3/8 Charolais+ 2/8 Herford)
goats X sheep = geep

2- Outcrossing

- Outcrossing is the mating of unrelated animals within a breed.
- A breeder makes an outcross by bringing new genetic variation (new blood) into his flock by buying a new sire.
- **Mild outcross** occurred by buying a sire from another breeder with a similar breeding programe (same breed)
- **Severe outcross** occurred by buying a sire from a vastly different source (same breed)
- Outcrossing look like a crash program of improvement depending on how mild or severe the outcross is.

3- Crossing strains or lines

3. Crossing strains or lines:

- Strains or lines or families are crossed within or between populations.

4. Crossing inbred lines:

- The inbred lines are crossed within a population.

Backcrossing, Topcrossing and Grading up

5. Backcrossing:

- The crossbred offspring is bred back to one of its parents, which are usually purebreds.

6. Topcrossing and Grading up:

- A topcross is made when a breeder goes back to the original genetic source of the breed for some new genetic material.
- An example would be Angus breeders from Argentine or Australia returning to Scotland to buy a stud sire.

- **Grading up:**
- Referrers to successive matings of grade cattle to registered animals within the same breed.

- Grading up has been widely used where “native” stock were graded up by a number of crosses with registered sires of improved breeds (four generations)

Backcrossing

The basic first cross is **A x B** is give **C**:

Sire breed A x Dam breed B

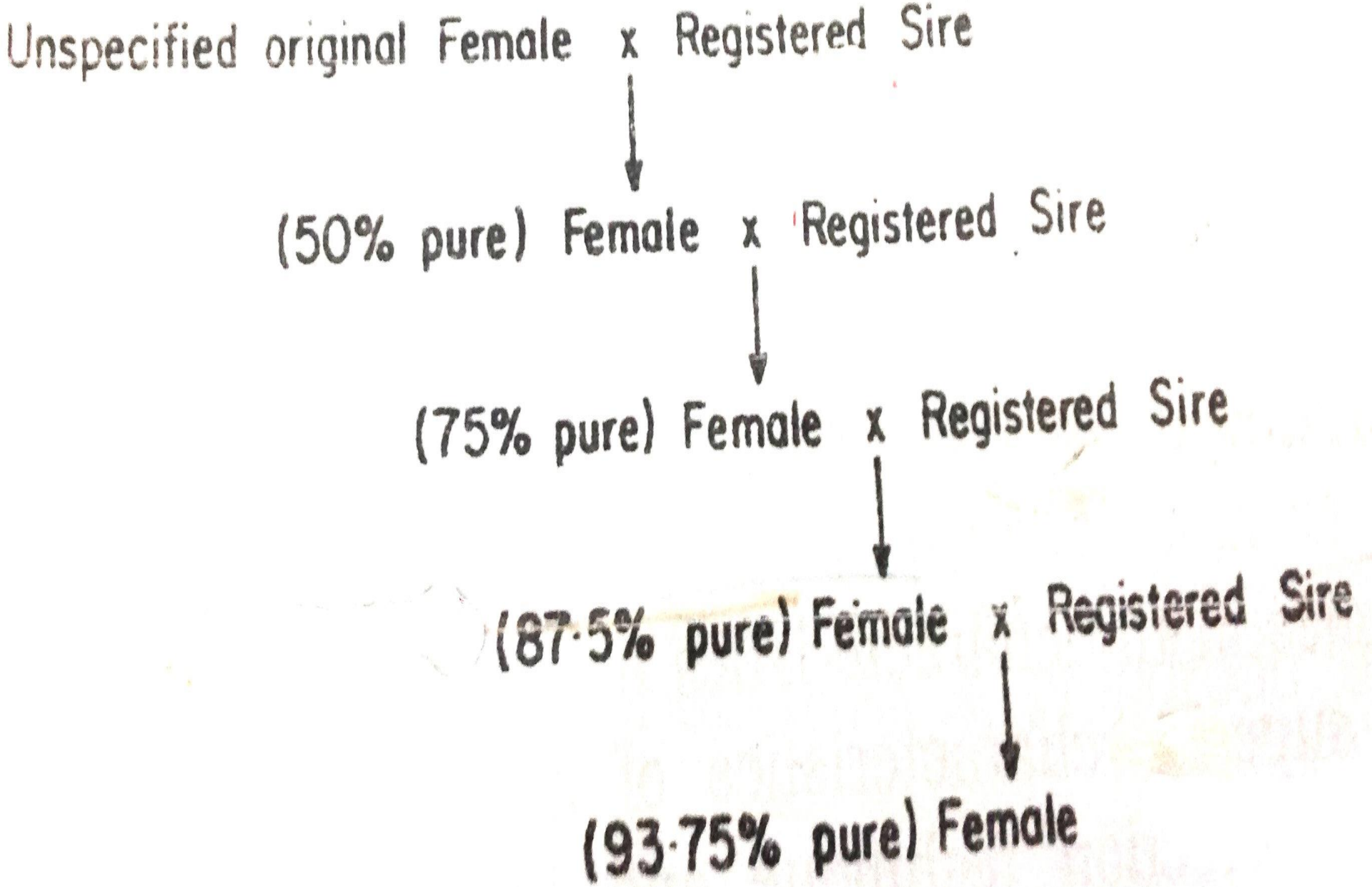
Offspring C

Alternative 1 (Backcrossing):

A x B

C x (Sire breed A or breed B).

Grading–up program



7- Matting likes

7. Matting likes (assortative mating)

- Mating likes means mating the best to best, worst to worst and average to average based on visual characteristics (phenotype of the animal).
- **Lush** warned against confusing between assortative mating with inbreeding.
- The former is mating animals that have similar looks, while the latter is mating animals that have similar genes (common ancestor).
- **Lush** also pointed out that mating likes was not efficient in altering gene frequency compared to other selection and mating methods.

8- Mating unlikes

8. Mating unlikes (negative assortative or compensatory)

- Here the deficiencies in the characteristics of one animal are balanced by the superior characteristics of another animal.
- It is a common correction technique for physical traits.
- Mating unlikes aims to improve the population

9- Crossbreeding

- **Crossbreeding** is the mating of animals of two or more different breeds.
- It is more extreme than outcrossing in its genotypic and phenotypic effects.

- **Purposes for crossbreeding**

a. Crossing of superior animals from two breeds to produce a new generation that is phenotypically superior on the average to either of the parent breeds because of hybrid vigour
- it provides an opportunity to make progress in one generation that would require several generations of selection to obtain.

- **Example**
- Targhee ewes (low twining) X Finnish Landrace sheep (high twining)
- Border Leicester ewe (low growth) X Cheviot (high growth)

9- Crossbreeding

b. Breed complementation or complementarity.

- Crossing breeds of widely different characteristics and adaptability to produce a new breed with many of the best characteristics of each of the parent breeds

- The purpose is to make use of additive genetic variation in the parent breeds and any heterosis that results is of secondary importance

In Beef cattle:

Shorthorn X Brahman ---------- **Santa Gertrudis.**

Brahman X Angus ---------- **Brangus cattle.**

In sheep

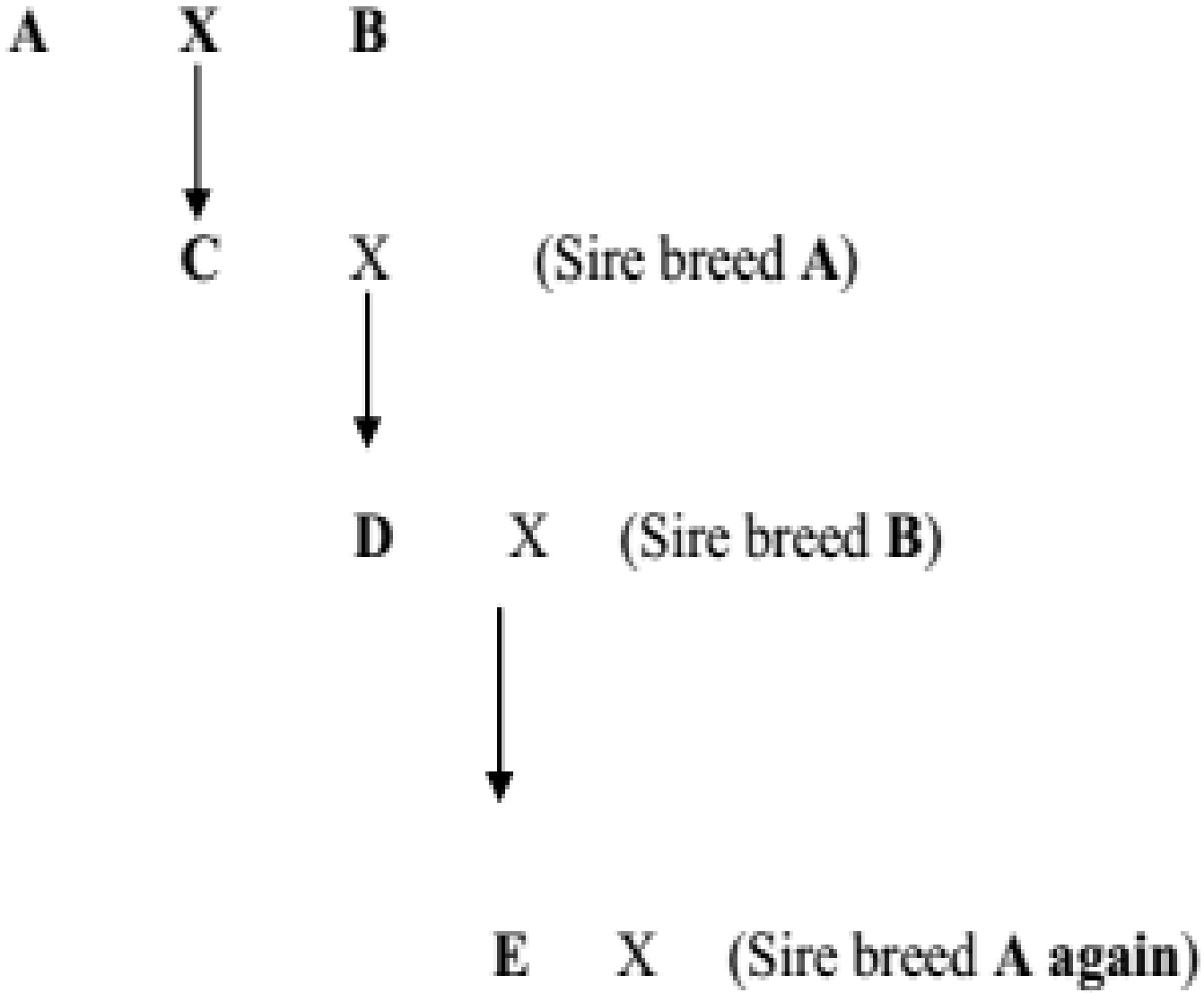
Rambouillet X Lincoln ---------- **Columbia**.

Merino X Lincoln X Leicester ---------- **Corriedale.**

Rambouillet X Lincoln X Corriedale ---------- **Targhee.**

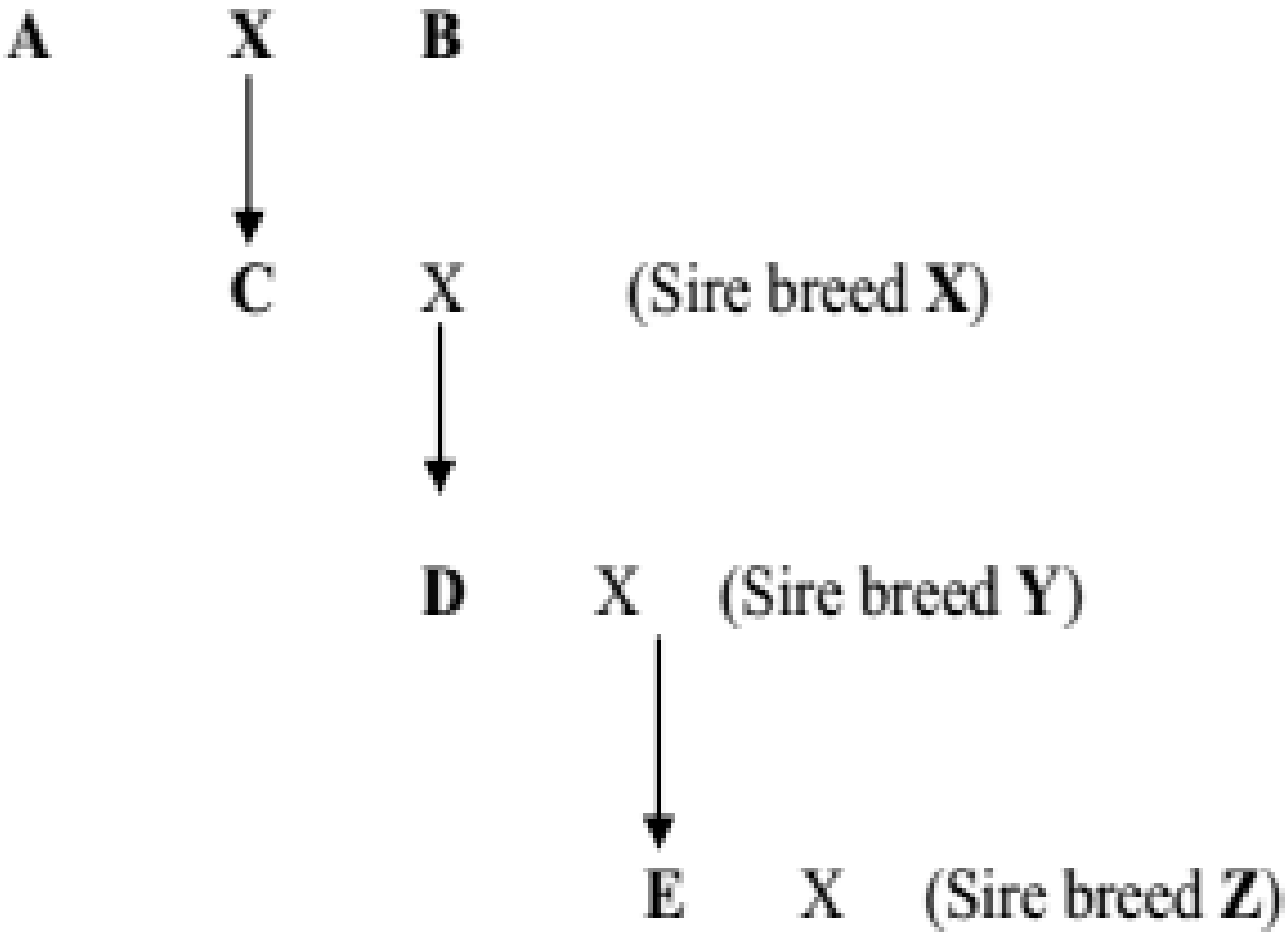
Two–breed rotational cross program or

Alternative 2: (Two–breed rotational cross program or Crisscrossing)



Three-breed rotational cross program

Alternative 3 (Three-breed rotational cross program:

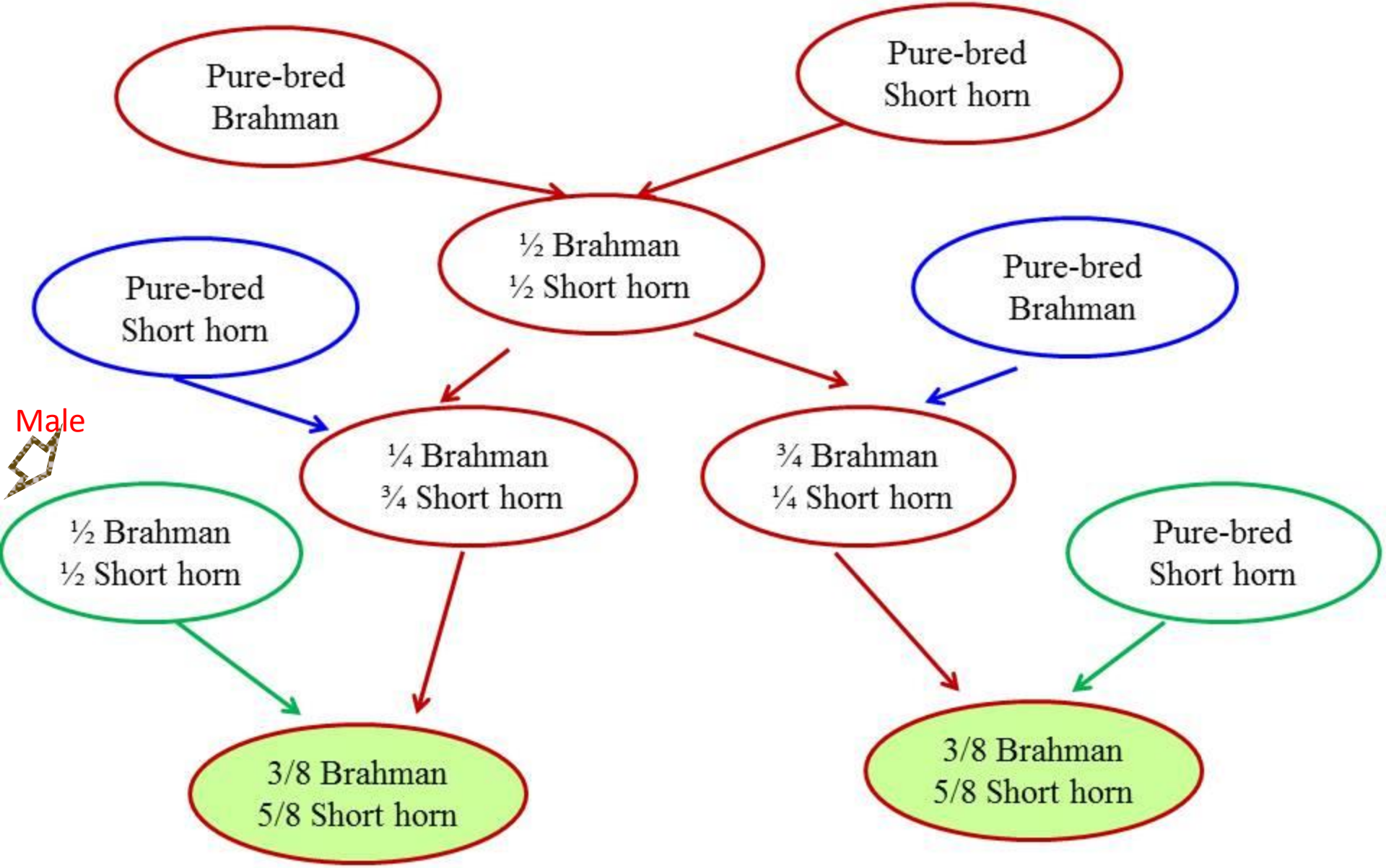


Interbreeding

- Interbreeding where the F1 crossbred C.
- Here the population is closed and selection of male and female parents is made within it.
- A modification of this technique is to carry on interbreeding using F1 sire all time.

- **Example**
- Santa Gertrudis cattle crosses Shorthorn and Brahman cattle.
- Brangus cattle by crossing Brahman and Angus breeds.

Santa Gertrudis



Brangus cattle