Lethal and Sub-lethal characters

Lethal Factors

- Lethal genes are those that have a drastic effect and cause death of the young during pregnancy or at birth.

Sub-lethal/ Semi-lethal Factors

- Lethal genes cause the death of the the young after birth or some time later in life.

Non-lethal or Detrimental genes

- Non-lethal or detrimental genes do not cause death but definitely reduce the viability or vigour.

- Lethal factors produce their lethal effects only in the homozygous condition.
- Lethal factors which produce a visible effect in the heterozygous condition are called as semi-dominant lethal factors eg. Creeper fowl and Dexter cattle.

- Lehtal factors which do not show visible effect in heterozygous state are hard to distinguish.
- Can be identified using a testcross.
- Lethal factors were first noticed in Cambridge in the yellow mice by Cuenot.
- When two yellow mice are crossed they produce yellow and non yellow progeny in the ratio of 2:1 respectively.

- Although this ratio did not yield the typical 3:1 ratio, indicated that the yellow mice are heterozygous.
- All the progeny with YY genotype would not survive.
- When a yellow mice was crossed with non-yellow, the offspring were yellow and non-yellow in the 1:1 ratio, which resembled a test cross.

Dominant lethal killing

- The test cross also confirmed the dominance of yellow over non-yellow.
- The homozygous yellow mice die.
- The factor for yellow coat colour was therefore assume to be a lethal factor.
- The hybrid (heterozygous) yellow individuals carried both the factors for lethality and normality.

Cross

Parents	Yellow (Yy)	X	Yellow (Yy)	
Gametes	Y y		Y y	
Progeny	YY Yellow	Yy Yellow	Yy Yellow	yy Non-yellow
	(Dies)			

Test Cross

	Yellow	X	Non-yellow	
Genotype	Yy	X	yy	
Gamets	Y y		y	
Progeny	Yy		yy	
Phenotype	Yellow		Non Yellow	
Ratio	1	:	1	

Sex Linked Lethal Genes

- Sex linkage refers to the association of a hereditary trait with sex.
- Genes located on X and Y chromosome are called as Sex Linked Genes.
- Sex linked lethal genes alters the sex ratio in the progenies.
- Males (XY) can never be heterozygous for the lethal factor.

- All the males who inherit the lethal factor will die.
- The lethal genes could therefore be transmitted by heterozygous female (XX).

L= Normality l = lethality

Males
lY= die
LY= normal

Females
ll= die
Ll= normal (carrier)

LY X Ll

Gamets L Y L l

Progenies LL Ll LY lY
Normal Normal Normal Lethal
Female Female Male Male
(Carrier)

- Half of the males of above cross will die and the sex ratio gets disturbed.
- Indicates a sex linked recessive factor is operating.
- In birds (poultry) the situation will be revesrs since males are homogametic (ZZ) and females are heterogametic (ZW).

Lethal Genes in Farm Animals

- Reported in Cattle, Horses, Sheep, Swine and Poultry.
  - 1. Amputated
    - Observed in Swedish Holstein Friesian cattle.
    - Claves born dead.
    - Affected calves have no appendages or may have appendages developed only to the elbows and hocks.
    - Have atrophied upper jaw in the form of a beak (parrot jaw) and the lower jaw is almost completely absent.
    - Cleft palate is also observed.

- The condition is caused by a single recessive gene.
- Amputated character inherits in simple mendelian fashion
- Observed when heterozygous bull is mated to heterozygous cow.

Aa X Aa

A a A a

AA Aa Aa aa

(Normal) (Amputated)

Hypotrichesis Congenita

- Found in the Swedish Holsteins and in Jerseys in the United States.
- The hair is present only on the muzzle, eyelids, ears, pasterns and end of the tail.
- The body is without the initial covering of hair.

Achondroplasis-1 :

- In Britain the ‘Dexter’ show an interesting lethal condition. The Dexters are derived from another breed called ‘Kerry’.
- The Kerry breed is a normal breed and the Dexters resembles the Kerry in most respects but is rather short limbed.
- When two Dexters are crossed a bull dog calf results.

Kk x Kk

Gametes K k K k

KK Kk Kk kk

(Kerry) (Dexter) (Bull Dog)

Bull Dog calves

- The affected calves have short vertebral columns, rounded and bulging forehead, cleft palates and very short legs.
- The bull dog calves are aborted after their death in the 6^{th} to 8^{th} month of pregnancy, following a pronounced accumulation of amniotic fluid.
- This is a semi-dominant lethal factor since the heterozygote's show a visible effect viz. the short limbed Dexter cattle.

Achondroplasis-2:

- In Norway in a cattle breed called ‘Tele-mark’ has been noticed a lethal factor called the ‘Bull dog’.
- The affected calf has a face shortened like that of a bull dog and the limbs are short and bow legged.
- Affected calves are carried to full term and are born dead.
- This gene is inherited as a Mendelian recessive.
- Traced back to a grand sire called Nicolas in whom probably the mutation of the gene took place.
- Any two descendents of Nicolas when bred, produced the bull dog calf.

Short – spine :

- Noticed in the Oplandske of Scandinavian hill cattle.
- In the affected claves, the head and limbs are normal, but the spine is faulty.
- The centra are very small and the neural arches missing.
- The calves die in few hours after birth. Inherited as a Mendelian recessive.

Other abnormalities in cattle due to lethal genes

- Cerebral hernia,
- Congenital spasm,
- Curved limbs,
- Harelip,
- Umblical hernia,
- White heifer disease etc.

Sheep and Swine

- Sheep
  - Amputated,
  - Dwarfism,
  - Muscle contracture etc.
- Swine
  - Atresia ani,
  - Hair whorls,
  - Hydrocephalus
  - Paralysis etc.

Semi-dominant lethal factor in poultry

- There is a breed of chicken known as “Creeper” in which the wings and legs are very shortened giving the birds a squatty appearance.
- All long bones of the limbs are shortened. The tibia appears more affected than others. Some birds have their toes permanently curled.

The Inheritance.

1. Creeper x Normal

   Creeper : Normal

2. Creeper x Creeper

   Creeper : Normal

   2 1

3. Normal x Normal

   Normal

- Two normal parents never produce creeper offspring and two creeper parents frequently produce some normal offspring
- Therefore creeper can not be due to a recessive gene.
- It id due to a dominant gene since creeper is inherited directly from one generation to the next ie. Creeper bird always have at least one creeper parent.
- If creeper is due to a dominant gene, however, creeper birds must always be heterozygous, since creeper crossed with normal always give a 1:1 test cross ratio.
- Further, creeper never 'breed true' when crossed among themselves since they do produce some normal offspring.
- Hence, creepers are always heterozygous.
- ¼ of the embryo die in the shell around the 4^{th} day of incubation.

Inheritance of Creeper in poultry

C - Lethal c - Normal

Cc X Cc

Creeper Creeper

Sperms

		C	c
Eggs	C	CC Dies	Cc Creeper
	c	Cc creeper	cc normal

Let ‘C’ to represent the gene for creeper and ‘c’ its normal allele the cross may be diagrammed as follows :

Creeper x Creeper

Cc Cc

Gametes C c C c

	C	c
C	CC dies	Cc creeper
c	Cc Creeper	cc normal

All the birds having the genotype CC would die and the resultant phenotypes of the progeny would be creeper and normal birds in the ratio of 2:1 .

Lethal gene in humans

- Several genes are suspected to be intermediate lethal.
- Brachyphalangy - persons with short fingers.
  - These persons will have only two joints instead of three joints in their fingers.
  - X-rays studies indicate that this conditions is due to the facts that the middle bone (phalanx) of the fingers is greatly shortened and often fused with one of the other bones of the fingers.
  - In one such marriage of two persons with this same gene produced one child without any finger or toes and was unable to survive.
  - Two other children showed the characteristic short fingers and one was normal.
  - This is the exact 1:2:1 ratio which would be expected from parents heterozygous for an intermediate lethal.

Genes lethal under certain conditions:

- Certain genes becomes lethal under certain environments.
  - Erythroblastosis foetalis.
    - The gene for Rh factor is not lethal.
    - When an Rh negative woman bears an Rh positive child she may become sensitized to the Rh factor and generate antibodies in her system which react with Rh antigen.
    - The inheritance of the child influences the nature of the parent.
    - When such a sensitized woman bears another Rh positive child, this same reaction will occur in the body of the child causing abnormalities.
    - Such babies are born dead or die shortly after the birth.
    - Thus in the uterus of sensitized woman the dominant gene for the Rh factor may be a lethal.

Genes lethal under certain conditions:

- Albinism in humans is not lethal under protected environment.
  - Intense sunlight - skin would become so badly burned that death would occur.
- Frizzled feathers in chicken.
  - This gene causes the feathers to break off easily and results in birds which are almost naked.
  - If such birds are kept in warm environment they manage to survive but if they are exposed to cold weather, without the insulation of normal covering of feathers death occurs.
  - Hence the gene is lethal under one environmental condition and not lethal under other condition.

Elimination of lethal genes:

- Identifying the carriers (heterozygotes) and prevent them from further breeding.
- Intermediate lethal genes are much easier to detect, because all individuals carrying intermediate lethals will exhibit some phenotypic expression of the gene.
- As a result it is much easier to eliminate them.
- Prevent reproduction of the easily recognizable heterozygous individuals.