EARTWORM SPECIES

SPECIES OF EARTWORM SUITABLE FOR VERMICOMPOSTING

The earthworm species suitable for vermicomposting should have the following characteristics:

1. They should be easy to culture.
2. They should have high affinity for the substrate to be vermicomposted.
3. They should have high rate of vermicast output per worm and per unit digester volume.

SPECIES ADVOCATED FOR VERMICOMPOSTING

It is generally known that epigeic species have a greater potential as waste decomposers than anecics and endogeics. This is due to predominantly humus consuming surface dwelling nature of the epigeics. The commonly used epigeic species are *Eudrilus eugeniae*, *Eisenia fetida* and *Perionyx excavates*. All these three species are prolific feeders and can feed upon a wide variety of degradable organic wastes. They also exhibit high growth rate. But *Eisenia fetida* has a wider tolerance for temperature than the other two species, which allows this species to be cultivated in areas with high as well as low temperatures.

THREE TYPES OF EARTHWORM

Anecic (Greek for "out of the earth") – these are burrowing worms that come to the surface at night to drag food down into their permanent burrows deep within the mineral layers of the soil. Example: the Canadian Night crawler.

Endogeic (Greek for "within the earth") – these are also burrowing worms but their burrows are typically more shallow and they feed on the organic matter already in the soil, so they come to the surface only rarely.

Epigeic (Greek for "upon the earth") – these worms live in the surface litter and feed on decaying organic matter. They do not have permanent burrows. These "decomposers" are the type of worm used in vermicomposting.

SPECIES USED IN INDIA

About 4,600 species of earthworm are found all over the world. Out of these about 590 species are found in India. But only a few such species are used for vermicomposting in our country, mainly epigeic species like *Eudrilus eugeniae*, *Eisenia fetida*, *Perionyx excavates* and *P. sansibaricus*. Of these *P. excavates* and *P. sansibaricus* are endemic species. *E. fetida* is the best species suited for vermicomposting throughout the country. The Institute of Natural Organic Agriculture (INORA) in Pune advocates the use of surface worms (epigeic types) because they consume all types of garbage and multiply quickly.

The use of endogeics and anecics that are native to the local soil has been recommended by many agronomists. Though surface dwellers are capable of working hard on the litter layer and convert all the organic waste into manure, they are of no significant value in modifying the structure of the soil. The anecics, however, are capable of both organic waste consumption as well as modifying the structure of the soil. Earthworms comprising the epigeic and anecic varieties, for the combined process of litter and soil management have been recommended, although *P. excavates* and *Lampito mauritii* together take care of litter and other organic waste; *L. mauritii* being an anecic also helps in rejuvenating the soil by burrowing through it. The local endogeics recommended in the status report of The Council of Advancement of People's Action and Rural Technology (CAPART) for maintenance of soil fertility include *L. mauritii*, *Pontoscolex corethrurus*, *Pheretima posthuma*, *Octochaetona serrata*, etc.

Biology of *Eisenia fetida*

TAXONOMY:

Kingdom: Animalia

Phylum: Annelida

Class: Clitellata

Order: Opisthopora

Family: Lumbricidae

Genus: *Eisenia*

Species: *E. fetida*

Common name: Manure worm, Red wiggler worm, Red worm

EXTERNAL FEATURES (MORPHOLOGY):

The body of E. fetida is long, narrow, bilaterally symmetrical, cylindrical, soft and metamerically segmented. The mature worms measures about 10 – 13 cm in length and 3 – 6 cm in thickness. They have chemoreceptors and photoreceptors to sense the environment. The dorsal surface of their body is light pink to brown and the ventral surface is pale and brownish-yellow. The brown colour is due to the presence of a pigment called **porphyrin**.

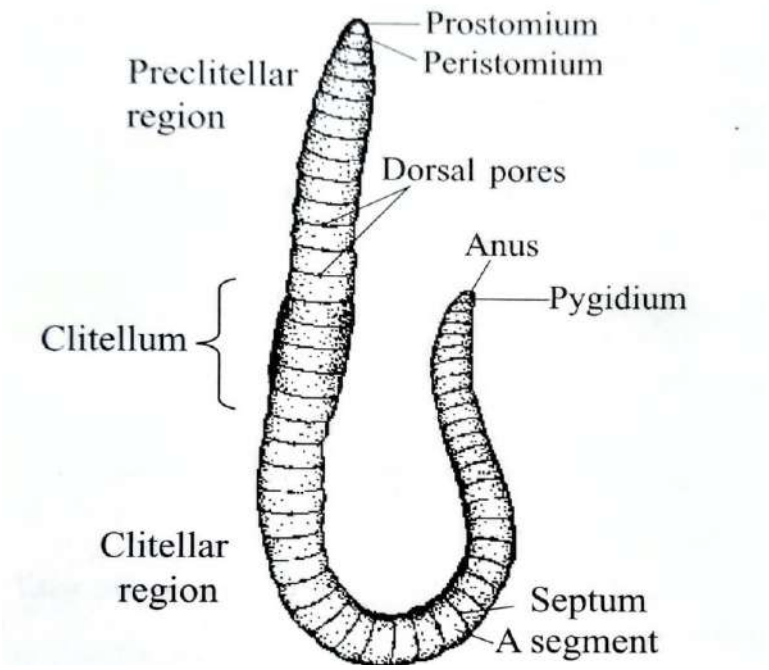

Fig. 1. Diagram showing external features of Eisenia fetida

The body consists of 100 – 120 similar segments called **metameres** which are covered by **cuticle**. The segments are separated by ring like grooves called **septa**. The first segment of the body is called the **peristomium**, which bears a crescent like **mouth** on the ventral side and the last segment is called **pygidium** which bears the **anus**. The peristomium prolongs forwards into a fleshy lobe called **prostomium,** which acts as a tactile and chemosensory probe. It overhangs the mouth on the dorsal side and seals the entrance of the mouth when the worm is at rest. **Clitellum** covers segments from 26 – 32. It is an elastic, glandular, thickened ring-like area of the body wall. The epidermis of clitellum contains three types of glands, viz. Mucus glands which secrete mucus, Cocoon secreting glands which secrete the wall of cocoon and Albumen glands which secrete albumen into the cocoon. There are chitinous bristles embedded in the skin, which are called **setae**. Each segment is provided with a ring of setae. Each seta is a S-shaped elongated structure with a swollen part at the centre. The swollen part is called **nodulus** while the

downward end is called **neck** and the upward end is called **base**. They help in locomotion and enable the earthworm to secure a hold on the surface.

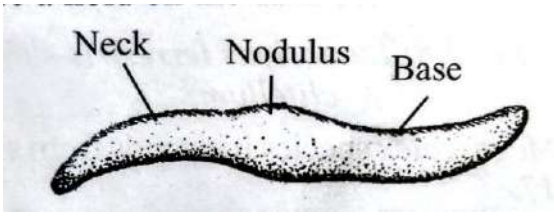

Fig.2. Structure of the seta

In addition to the mouth and anus the body contains a number of external apertures. **Dorsal pores** are serially arranged in the median dorsal line commencing from the segment 12 – 13. There is one pore in each groove except the last one. There are four pairs of **spermathecal openings** lying ventrally between segment 5 and 6, 6 and 7, 7 and 8 and 8 and 9. The **oviducal opening** is a median aperture located ventrally on the 14th segment. The **spermiducal apertures** are paired and they lie ventrally on the 18th segment. **Nephridial apertures** are scattered irregularly over the body behind the first two segments.

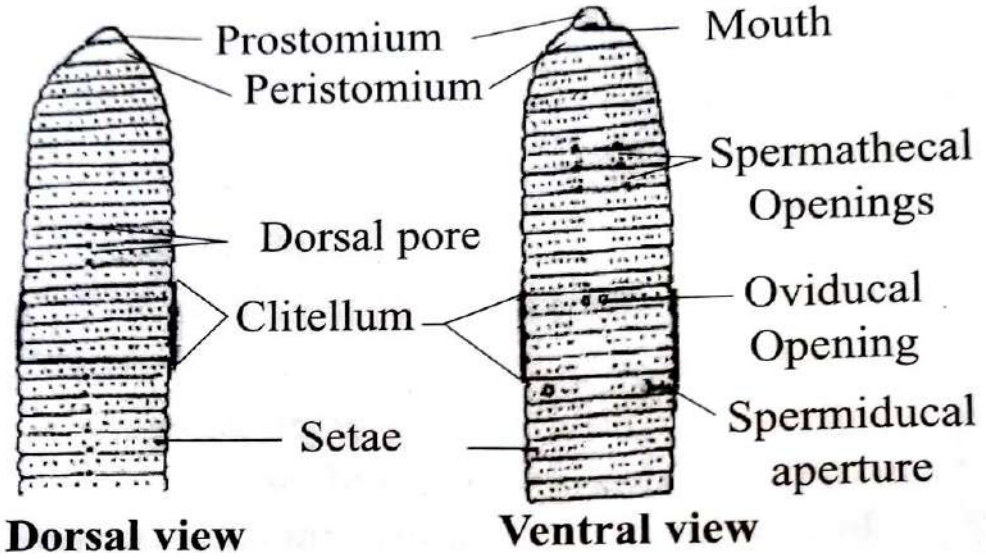

Fig.3. Positions of the external apertures

INTERNAL FEATURES (ANATOMY):

Body wall:- The body wall of red worm is **dermomuscular** as the muscle layers are thick and well developed in the skin. The body wall is **triploblastic** having the following layers- **cuticle**, **epidermis**, **circular muscle**, **longitudinal muscle** and **coelomic epithelium**. The cuticle is the outermost layer containing some pores. It is formed of collagen

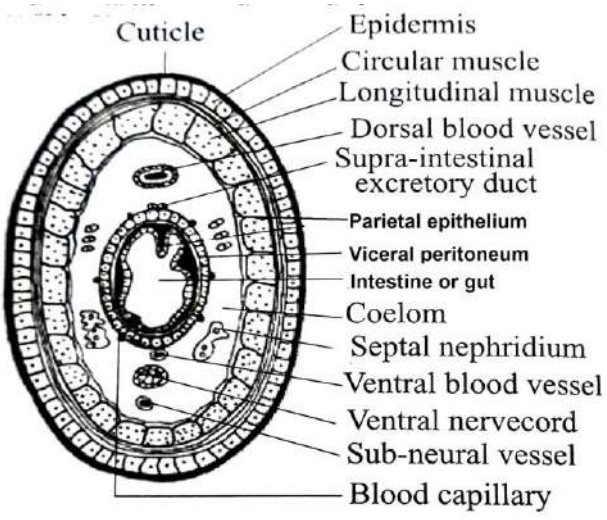

Fig. 4. T.S. of the body

fibres. The epidermis is composed of a single layer of varied cells, viz. **columnar cells**, **mucus cells**, **albumen cells**, **sensory cells** and **basal cells**. Below the epidermis the circular muscle layer is located. Underneath the circular muscle layer is the longitudinal muscle layer. In this layer the muscles are arranged in bundles separated by connective tissue **septa**. The longitudinal muscle is lined by a layer of coelomic epithelium called **parietal epithelium**.

Body cavity or coelom:- The coelom is the cavity lying between the body wall and the gut. It is lined by coelomic epithelium. The coelomic epithelium lining the body wall is called **parietal epithelium** while that of the gut wall is called **visceral peritoneum**.

The coelom is transversely divided into compartments by transverse partitions called **septa**. The coelom opens to the exterior through dorsal pores, coelomoducts, gonoducts and nephridia. The coelom is filled with a colourless alkaline fluid called **coelomic fluid**. It contains four different types of cells called **coelomic corpuscles** in addition to water, salt and proteins. The coelomic corpuscles are – **amoebocytes**, **mucocytes**, **leucocytes** and **chloragogen cells**.

PHYSIOLOGY:

DIGESTIVE SYSTEM

Structure of Alimentary canal:- Alimentary canal is a long straight tube extending from the first segment to the last segment of an earthworm's body. It represents a tube within a tube body plan. It begins with an anterior mouth or prostomium and ends in the posterior anus. Along with it, it includes buccal cavity, pharynx, oesophagus, gizzard, stomach and intestine.

Mouth:- It is a semicircular structure situated in the first segment called the peristomium just below the hood like prostomium. It is highly elastic in nature and can protrude out and in.

Buccal cavity:- It lies within the second and third segments.

Pharynx:- Following the buccal cavity, the pharynx lies in the 4th, 5th, and 6th segments. It is thick and highly muscular. The pharyngeal cavity is divided into two types - Dorsal chamber (ciliated) which possesses salivary glands in the outer region, that are formed by the chromophil cells (secrete saliva, i.e., mucus) and proteolytic enzymes for the digestion of the proteins. Ventral chamber (non-ciliated): It is non-glandular and is termed as conducting chamber.

Oesophagus:- It extends from 5th to 7th segments. They are quite thin, non-glandular and do not possess any muscular folds.

Gizzard:- It lies in the 8th and 9th segments. It acts as grinder hence termed as grinding machine, i.e. it aids in grinding of soil particles mixed with organic matter and other decayed materials. The wall of the gizzard is made up of an outer layer of the circular muscles, a single layer of epithelial cells and an innermost thick layer of cuticle that is secreted by epithelial layer. The contraction and relaxation of circular muscles cause the easy mastication of food and soil.

Stomach:- The gizzard leads to the stomach, that is present from second half of 9th segments upto 14th segments. It is a longer tube with short narrow cavity termed as glandular chamber. The wall of stomach consists of calciferous glands whose secretion causes the neutralization of acidity of soil.

Intestine:- It extends from 15th to the last segment. An internal long fold of dorsal wall is present after the 26th segment which is termed as typhlosole. Typhlosole is responsible for increasing the surface area of absorption. Intestine can be divided into three types on the basis of typhlosole - i) Pre-typhlosolar region:- It extends from 15th to the 25th segment and is highly glandular. A pair of short and conical intestinal caecae is present on the 26th segment. ii) Typhlosolar region:- It lies from 26th to 75-95last segment and is glandular and is highly absorptive. iii) Post-typhlosolar region:- It is the region after typhlosole. It lies in the last 23-25 segments (76-96 to 100-120). It is also termed as rectum and is absorptive in nature.

Anus:- It is present in the last segment. It is a vertical, slit-like, small terminal aperture. The defecation of worm-castings occurs through this aperture.

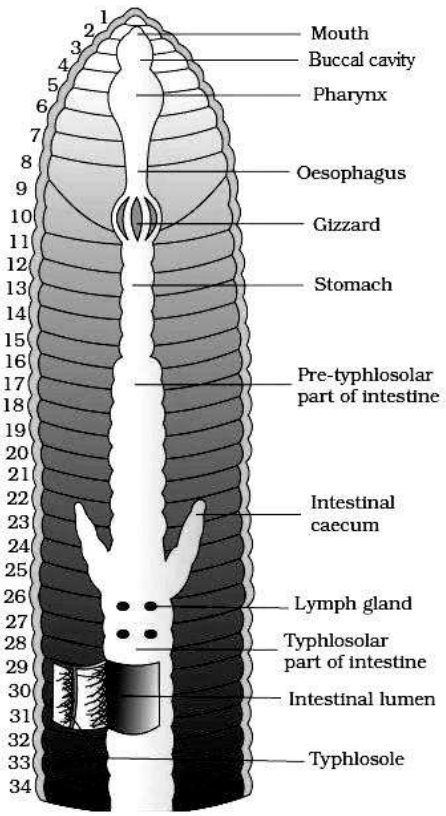

Fig. Alimentary canal

Physiology of digestion:- In pharynx the food is mixed with saliva secreted by glandular cells of pharyngeal bulbs. Saliva contains mucin and proteolytic enzymes. Within gizzard, food is grinded into fine powder. The main reason for ingesting soil is to produce friction during breakdown of food.

From gizzard the food reaches into stomach. The gland cells of stomach secrete proteolytic enzymes, which convert proteins and small peptides into amino acids. In stomach, the neutralization of food by calcites ($CaCO_3$) and digestion of rest of the proteins takes place. In intestine complete digestion of proteins, polysaccharides, fat, chitin, and cellulose takes place. Proteins when acted by proteases break down to peptones and proteoses. Further, peptones and proteoses are acted upon by proteases to form amino acids. The amylase enzyme is responsible for breakdown of polysaccharides into disaccharides. The lipase enzyme converts fats or lipids into fatty acids. Cellulose is also converted to disaccharides by lipase. Chitin is converted to disaccharides by lipase. After completion of digestion, both the digested and undigested foods pass to typhlosolar region. Here, the digested substances are absorbed by typhlosole and are circulated throughout the blood vascular system. The portion of food and soil that remained, passes to post typhlosolar region for storage. Finally, such substances are removed from the anus in the form of castings.

Feeding (Alimentation):- Red worms are detritus feeders. They swallow large quantities of loose earth and utilize the decaying organic matter contained in it as food. They also directly feed on decaying plant residues like leaves, seeds, etc. they suck up the food through the muscular pharynx which can be protruded outside. Before swallowing the food is moistened with the juice formed by the pharyngeal glands. The pharyngeal mass secretes a digestive juice helping in the digestion of proteins.

EXCRETORY SYSTEM

The **nephridia** are the excretory organs of earthworm. They are ectodermal in origin. Nephridia are analogous to kidneys of vertebrates. Nephridia are present in all segments of the body except in first 3 segments and last segments. In earthworm, the nephridia functions for the removal of the excretory wastes both from blood and the coelomic fluid. There are 3 types of nephridia based on the structure and location:

1. **Septal nephridia** (Enteronephric nephridia):- Septal nephridia are the largest nephridia. They are located in both sides of septum in each segment, behind the 15th to 2nd last segment. Each inter-segmental septum possess two rows of septal nephridia numbering 80-100 on each septum. Each septal nephridium has 4 parts: Nephrostome (nephridiostome or ciliated funnel), neck, body of nephridium and terminal duct. Septal nephridium is distinguished from pharyngeal nephridia in having nephrostome. Septal nephridia are the only nephridia with nephrostome or funnel. The terminal duct opens into septal excretory canal. These canals in turn open into two supra-intestinal excretory canals, so called enteronephric nephridia.

2. **Integumentary nephridia**:- These are smallest nephridia. These are V-shaped in structure and are the most numerous types of nephridia. Integumentary nephridia are scattered in the body wall in all segments except in the first 7 segments and last segment. In each segment, there are about 200-250 integumentary nephridia. However, in the clitellar segments, the number is 10 times more than in ordinary segments. Hence, clitellar region is also termed as the forest of nephridia. As the terminal duct of integumentary nephridium is internally closed, each nephridium opens upon the body surface through nephridiophores. Hence, these nephridia are referred as exonephric nephridia. No nephridiopores are found in integumentary nephridia.

3. **Pharyngeal nephridia**:- Pharyngeal nephridia (3 pairs) occurs as paired tufts on either side of pharynx and oesophagus. One pair each is present in 4th, 5th, and 6th segments. Each of these tufts comprises of hundreds of pharyngeal nephridia as coiled tubes only. The terminal duct of nephridia of each tuft opens into a common pharyngeal nephridial duct or the common excretory duct. Thus, there are three pairs of common pharyngeal nephridial duct. They run upward parallel with ventral nerve cord and open into alimentary canal. Ducts from 4th and 5th segments open into the pharynx in 4th while those from 6th segment open into buccal cavity in 2nd. As these nephridia directly open into gut (buccal cavity and pharynx), they are of enteronephric type. Earthworms are mainly ureotelic as their chief excretory product is urea (urea-50% and ammonia-45% and other 5%). The chloragogen cells excrete silicates consumed along with the food.

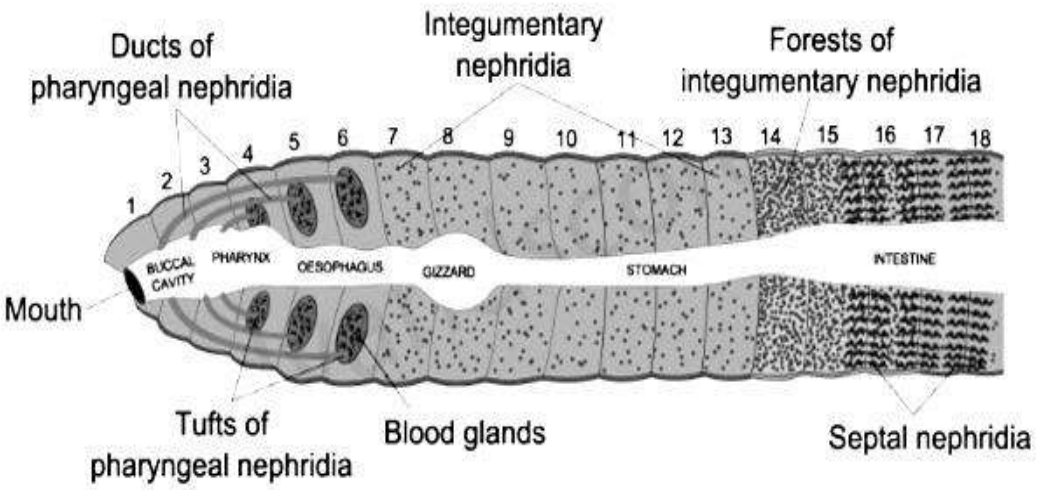

Fig. Excretory system

REPRODUCTIVE SYSTEM

Earthworm are **monoecious** or **hermaphrodite** or **bisexual**. However, self-fertilization doesn't occur because of relative location of male and female reproductive organs as well as it is **protandrous**. Protandrous refers the condition where male reproductive organs mature earlier than the female ones. Thus, cross fertilization occurs in earthworm. It comprises of male reproductive organs and female reproductive organs.

Male Reproductive Organs of Earthworm:- The male reproductive organs comprises of **testes**, **testis sacs**, **seminal vesicles**, **spermiducal funnel**, **vasa deferentia**, **prostate glands** and **accessory glands**. The male reproductive organs include:

Structure	Number	Location
Testis	2 pairs	10th and 11th segment
Testis sacs	1 pair	10th and 11th segment
Seminal vesicles	2 pairs	11th and 12th segment
Spermiducal funnels	2 pairs	10th and 11th segment
Vasa differentia	2 pairs	10/11th to 18th segment
Prostate glands	1 pair	16/17th to 20/21th segment
Accessory glands	2 pairs	17th and 19th segment
Common prosatic ducts	1 pair	18th segment
Male genital aperture	1 pair	18th segment

i) **Testes**:- Testes are very minute structures that are whitish in colour. There are two pairs of testes and they are lobed. One pair each is present in segment 10th and 11th that are found attached with the posterior surface of 9/10 and 10/11 inter-segmental septa. Each testis possess 4-8 finger like lobules that contains rounded cells in masses termed as spermatogonia. Testes are enclosed within testis sac. During the young stage of the earthworm, the testes are fully developed whereas they get degenerated in the adult stage.

ii) **Testis sacs**:- Testis sacs are whitish, wide bilobed sacs that encloses testis. They are thin-walled and fluid-filled sacs. On the ventrolateral sides of the ventral nerve cord, the two testis sacs are located in the 10th and 11th segments beneath the stomach. In the testis sac, a large spermatic funnel having folded and ciliated margins is

present behind each of the four testes. The testis sacs links with a pair of seminal vesicles. The spermatogonia are casted into the testis sacs then, they are passed into the seminal vesicles.

iii) **Seminal vesicles**:- These are large, whitish spherical structures. These are found in two pairs, each pair is located in 11th and 12th segment. The testis sacs open into seminal vesicles by a narrow duct. The posterior seminal vesicles are larger than the anterior ones. The seminal vesicles of the 11th segment are present enclosed in the posterior larger testis sac. The seminal vesicles of the 12th segment are exposed in the coelomic cavity. These are located ventro-laterally below the stomach. They are also termed as septal pouches, as they develop as septal outgrowths. The spermatogonia from testis sac are received by seminal vesicles. Seminal vesicles aids for nourishment to the sperm. Here, the spermatogonia matures and form spermatozoa.

iv) **Spermiducal funnel/ spermatic funnel**:- They are cup like curvature in structure and are present in two pairs. Each spermiduct funnel is internally ciliated. It is located below each testis in the segment 10th and 11th segment. It is found enclosed within the same testis sac. It helps in conduction of spermatozoa. After the maturation, sperms from seminal vesicles revert to testes sac and pass into vasa differentia via spermiducal funnel.

v) **Vasa deferentia**:- It is thin, long, narrow, thread like tubular structure. Posteriorly, each spermiducal funnel leads to vasa deferens. These are found in two pairs and each pair is located on the either side of the alimentary canal. Both the pair of vasa deferentia runs in close proximity and laterally to the nerve cord below the alimentary canal on the ventral body wall. It extends from 12th to 18th segment and meets prostatic duct in the 18th segment forming common prostatic and spermatic duct. The sperms from spermatic funnel are collected by the vasa deferentia and are supplied to prostate glands.

vi) **Prostate glands**:- Prostate glands are large, whitish, flat solid, irregularly shaped glands. These are found in pair and are located one on either side of the alimentary canal in the segments from 16th to 20th or 17th to 21st . Maximum portion of prostate glands are glandular region while a small part is non-glandular region. A thick curved prostatic duct arises from each prostate gland in 18th segment. The prostatic duct is connected to the two vasa deferntia of its own side and forms a common prostatic and spermatic duct. On the ventral side of 18th segment, prostatic duct opens via a male genital aperture. Hence, each genital aperture has three distinct apertures, two of the vasa deferentia and one of the prostatic gland. In earthworm the prostatic secretion is useful for the activation of sperms. It also aids in motility of sperms.

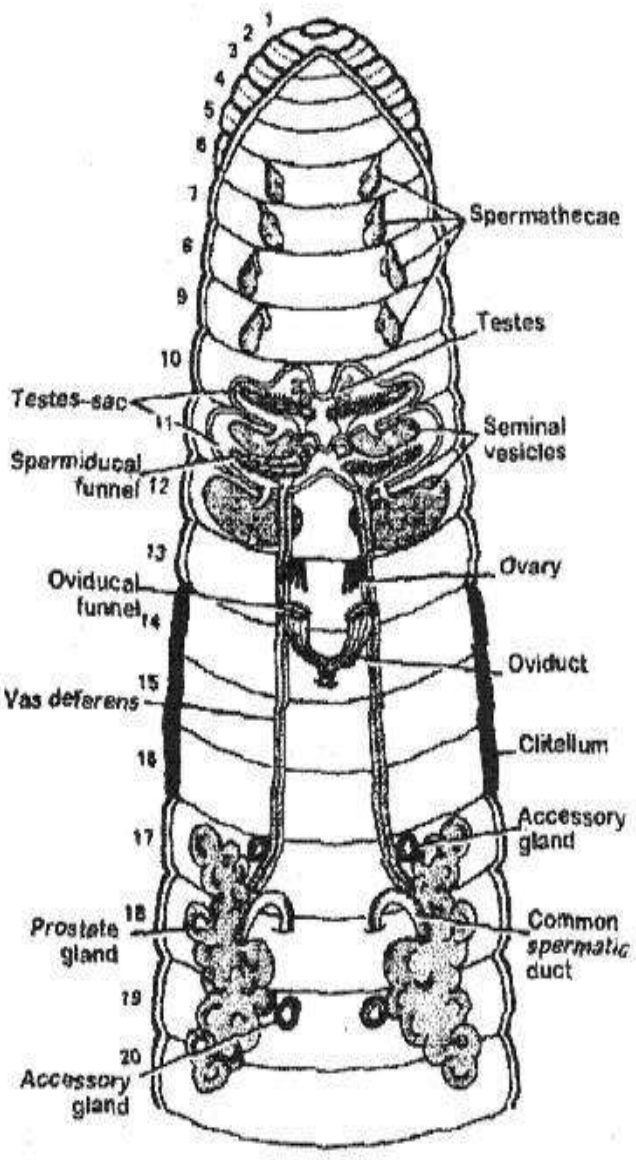

Fig. Reproductive system

vii) **Accessory Glands**:- Accessory glands are rounded structures and are found in two pairs. Each pair is located in the segments 17th and 18th on the ventral body wall at the lateral sides of the nerve cord. These glands are exposed to outside by a collection of small ductless glands. On the two pairs of genital papillae positioned externally on either

side of the mid-ventral line, these glands open in the 17th and 19th segments. The secretion of these glands is thought to hold the two worms together during the copulation process. After the completion of spermatogenesis, tailed spermatozoa are formed. These spermatozoa again enter the testis sacs and reach the vasa deferentia via the spermatic funnels. Then they are discharged through the male genital apertures along with the prostate glands' secretion. Male genital pores are found in pairs and is located in 18th segment.

Female Reproductive Organs of Earthworm:- Female reproductive organs consist of the **ovaries**, **oviducal funnel**, o**viducts** and **spermathecae**. Female reproductive organ includes:

Structure	**Number**	**Location**
Ovaries	1 pair	13th segment
Oviducal funnels	1 pair	13th segment
Oviducts	1 pair	13th and 14th segment
Female genital aperture	single	14th segment
Spermathecae	4 pairs	6th, 7th, 8th, and 9th segments ventrolaterally

i) **Ovaries**:- Ovaries are white, small, lobulated structures that are found in a pair. In the 13th segment, ovaries are located one on either side of the ventral nerve cord. It is attached with the posterior region of the inter-segmental septum of 12/13 segments. Each ovary consists of various finger like projections where developing ova are found in a row, giving the beaded appearance. In each ovarian lobe, the ova exhibits several stages of its development where mature ones lie in the distal part and the immature ones are found in the proximal part.

ii) **Oviducts**:- A small, ciliated ovarian funnel with folded margins are present below each ovary in 13th segment. Each ovarian funnel opens into a short and conical oviduct. Oviducts are ciliated. The oviducts of both the sides unite below the nerve cord. Here, it open by a single median female genital pore ventrally in the 14th segment. The ova after maturation are released from the ovaries and are received by the ovarian funnel. Then, it passes through the oviduct and that is discharged out via the female genital pore.

iii) **Spermathecae**:- Spermathecae are four pairs and each pair is located ventro-laterally in the 6th, 7th, 8th, and 9th segments. Each spermatheca is flask shaped structure. Each spermathecum is made of ampulla and neck (upper short tubular part). The main body is the ampulla. At the junction of the ampulla and neck, a small sac is found. This sac is termed as diverticulum. Spermathecae are also termed as seminal receptacles as they are designed for receiving sperms from another worm during copulation and temporary storage of sperms. The diverticulum of spermathecae stores sperms, which reach here after copulation. Spermathecal duct opens outside by small pores situated in the grooves of 5/6, 6/7, 7/8, and 8/9 segments.

iv) **Female genital pore**:- It is single pore and is located in the 14th segment.

LIFE CYCLE

Like other earthworms red worms are also sexually reproducing organism. They are hermaphrodite with all individuals bearing both male and female sex organs. Although hermaphrodite they exhibit cross fertilization only as they are protandrous, a condition wherein the male gametes mature earlier than the female gametes. The life cycle of red worms can be discussed involving the following events:

Copulation: - Copulation is the sexual union of two mature worms for the exchange of sperms. It commonly takes place in the rainy season during the months of July to October, in the morning hours before sunrise. During copulation, two earthworms lie opposite to each other in such a way that their ventral surfaces remain in touch and male genital openings of one comes just opposite to the spermathecal openings of the other and vice versa. The area of genital aperture is raised into a male genital papilla. It is inserted into a spermothecal opening. Both the earthworms receive sperms and prostatic secretion in all of their spermathecae by a protuberance that arises from the male genital opening. Copulation lasts for about an hour. Sperms are stored in the spermathecae. After the exchange of sperms, the worms separate and go into their burrows.

Cocoon formation:- Fertilization occurs only in the cocoon or ootheca and is always external. After maturation of ovaries, cocoon or ootheca formation starts about 4 days after copulation. Three varieties of glands are present in the epidermis of clitellar segments, i.e., 14th, 15th and 16th segments. They are mucous glands that secrete mucus for copulation, cocoon-secreting glands that produces the wall of the cocoon and albumen glands that secrete albumen in which eggs are deposited in the cocoon. A cocoon of earthworm contains many fertilized eggs. However,

only one develops into embryo, while other fertilized eggs serve nutritive/ nurse cells. Cocoon-secreting glands of the clitellum secrete a membranous girdle. This girdle after hardening, the deposition of albumin between the girdle and the body wall takes place. The worm begins to withdraw itself backwards from the girdle. As the girdle moves over the female genital pore, it receives eggs, and when it passes over the spermathecae, sperms are emitted into it through spermathecal pores. Finally, the girdle is removed off from the anterior end of the worm. In a short time, the elasticity of its wall closes up its two ends forming a cocoon or ootheca. Several cocoons are formed after each copulation as the spermatozoa present in the spermatheca do not move out all at one time. The cocoons are oval in structure, light yellow in colour and are about 2 to 2.4 mm in length and 1.5 to 2 mm in breadth.

Fertilization and Incubation:- Fertilization occurs inside the cocoon. The eggs are fertilized by spermatozoa leading to the formation of 2-4 zygotes in a cocoon. Cocoon is found in moist and cool places and young one hatch out after 18-26 days. The period from fertilization to hatching is called **incubation period**. Albumen cells provide nutrition to the developing embryos.

Development & hatching:- Development is direct without any larval stage. Development of the zygotes begins within the cocoon. The zygote undergoes cleavage which is holoblastic and spiral, leading to the formation of an embryonic stage called blastula. The blastula develops to form gastrula which finally elongates to become a young worm. The young worms, 2-4 in number per cocoon, are released by the rupture of cocoons. It is called **hatching** and the young worms are called **hatchlings**. The hatchlings grow into mature worms in 40 – 60 days when they develop clitellum. Once clitellum is developed, they are ready for copulation, thus completing the life cycle. So, the duration of life cycle in red worm is 60 – 90 days. A mature worm can produce on an average one cocoon every three days. Under laboratory condition a mature worm continue to produce cocoons upto 500 days with a life span of about 600 days.

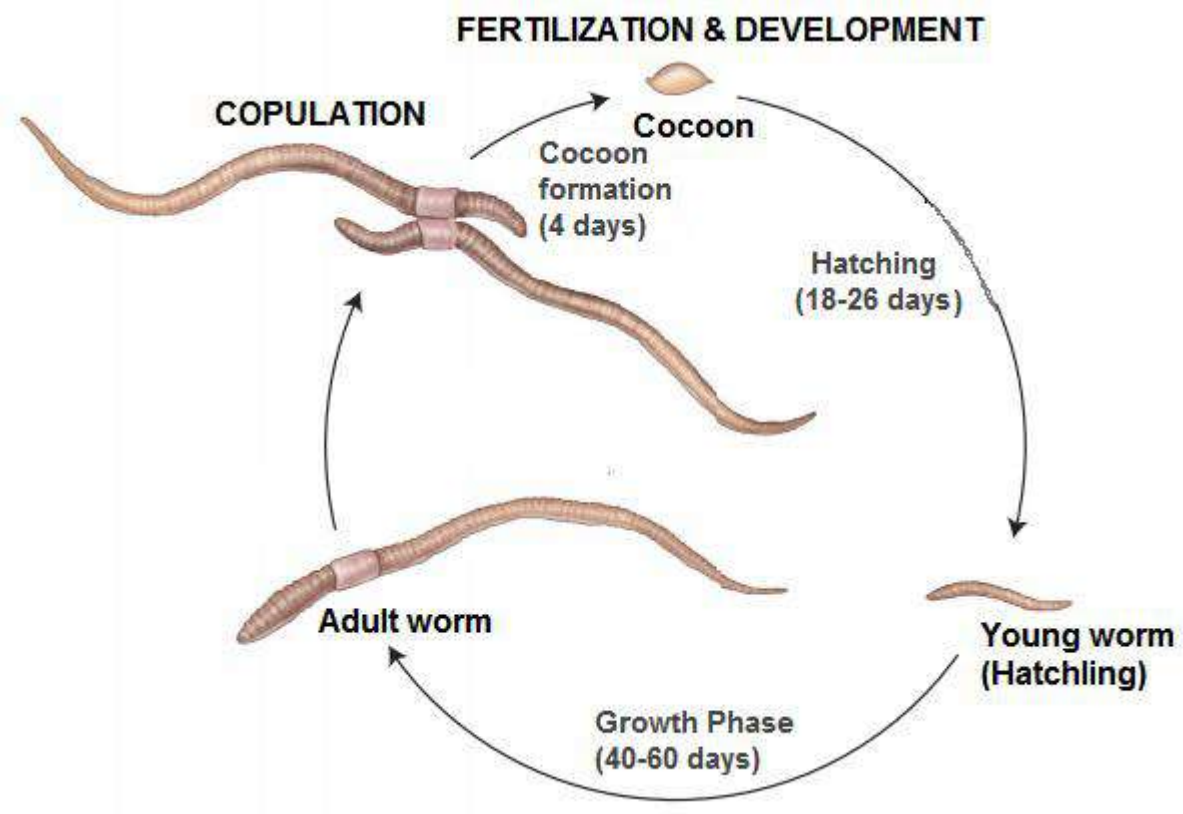

Fig. Life cycle of Eisenia fetida

FACTORS AFFECTING THE EARTHWORM POPULATION

There are many factors affecting earthworm population dynamics positively and negatively. Soil organic matter (SOM), total soil nitrogen, available potassium, available phosphorous, soil texture and pH level are frequently regulated by the earthworm population. Disturbances in a natural system alter the habitat of soil biota and in some cases make the habitat unfavorable for them. The increased use of chemical fertilizers and chemical pesticides creates a threat to soil organisms. Soil cultivation may cause mechanical damage to earthworms or expose them to predation. In some cases, the machinery may create adverse conditions for earthworm growth, development, and fecundity. Some of the environmental and soil factors are responsible for the death of earthworms. The earthworms are present in the soil for thousands of years and making the soil productive and fertile. It is important to understand the effects of these factors on earthworms for sustainable management of the soil for the best growth and development of soil organisms for optimum output and sustained production. So, sufficient kinds of literature were reviewed for understanding the roles of earthworms in soil fertility and factors affecting their population dynamics.

Earthworms eat organic residue that needs to be present in sufficient quantity. The quality of residue is also important. Residue with a high carbon to nitrogen ratio is not very palatable for earthworms. Manure can help make it more palatable. Packed manure is an excellent food source for earthworms. In some cases, the residue has to undergo some weathering before earthworms can digest it. Topsoil dwellers need smaller particles than subsoil dwellers, which can use large leaves, for example. The placement of food becomes a critical issue for some earthworm species. Topsoil dwellers prefer small organic residue particles incorporated into the soil, but subsurface dwellers need residue at the surface of the soil.

Environmental Factors:

Soil organic matter content, soil moisture content, soil type, soil pH, soil temperature are the most serious factors that frequently regulate the earthworm population. Biotic factors and climatic conditions strongly affect the abundance and distribution of earthworms.

Soil type – The soil environment in which earthworms live affect their abundance and distribution. Soil texture affects earthworm populations since it influences other soil properties like nutrients and moisture. Higher numbers of earthworms are found in medium and light loam soil compared to heavy clay, sandy and alluvial soils.

Temperature– They doesn't tolerate temperatures below freezing level, nor do they tolerate high temperatures. Prolonged exposure to temperatures above 35°C kills them. They can move down into the soil to escape these adverse temperatures. Optimum temperatures are between 10 to 16°C. Temperature greatly affects the metabolism, growth, activity, reproduction, and respiration of earthworms. Higher temperatures above the critical limit for survival can kill earthworms. Moist and cold conditions can be better tolerated by earthworms than dry and hot conditions.

pH – They thrive best at neutral pH value but can tolerate a pH from 5 to 8.

Soil texture – They choose soils with loamy texture. Coarse sand can be a negative factor either because these soils dry out more easily, or because the abrasive action of sand grains damages their skin. In some studies, clay soils had fewer earthworms compared to lighter-textured soils. The reason for this phenomenon is not clear.

Moisture – They commonly require adequate moisture for their proper growth and development. Water constitutes about 75 to 90% body weight of earthworms. They respire through moist skin and the blood capillaries on the surface should get enough moisture to perform the respiratory activity. Earthworm activity is determined by adequately available soil moisture.