Udai Pratap (Autonomous) College, Varanasi

E-learning Material

Module/Lecture	04
Subject	Zoology
Year/Semester	B.Sc. 5th Semester
Unit	II
Topic	Applied Zoology
Sub-topic	*Ascaris lubricoides*
Key-Words	Life Cycle, Pathogenecity and Control
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Ascaris lubricoides :

Classification :

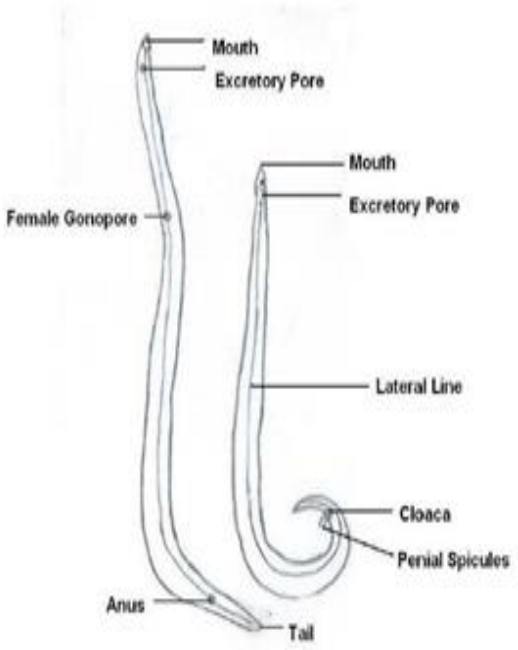
Phylum : Nematoda

Class : Chromadorea

Order : Ascaridida

Genus : *Ascaris*

Species : *lubricoides*



Geographical Distribution :

Ascariasis is the most common human helminthic infection found worldwide. Infection is highest in **tropical and subtropical regions**, especially in areas with inadequate sanitation. The number of infected persons is estimated to be more than 2 billion. The main epidemic region with prevalence rate of approx. 10-90% includes countries on South east Asia, Africa and Latin America including India. The infection is generally rare to absent in developed countries, but sporadic cases may occur in rural, impoverished regions of those countries. Some cases in these areas where human transmission is negligible have direct epidemiologic associations to pig farms.

Ascaris lumbricoides is an intestinal **endoparasite round worm**. It is the largest intestinal nematode to infect Human. The adult worm lives in small intestine and grow to a length of more than 30 cm. Human is only the natural host and reservoir of infection. This worm was observed and reported by many ancient people but details about its life cycle were known only after 1916.

Habit and Habitat of Ascaris :

The adult worm is an endoparasite found in the small intestine of man. The parasite, although normally an inhabitant of the **jejunum**, may wander up and down the intestinal tract and may even penetrate into other neighbouring channels. It is common among children.

Mode of infection:

Infection may take place either by swallowing fully developed Ascaris eggs encased in shells, **with raw vegetables or by drinking contaminated water**. It may also be conveyed directly into the mouth through dirty fingers. Incidence of Ascariasis is greater in children than in adults. In man it takes 60 to 75 days from the time of exposure of infection.

Shape and size :

Ascaris is an elongated endoparasite , its body is cylindrical , and gradually tapering at both ends, the anterior end being slender than the posterior. It is the largest size nematodes. **It shows sexual dimorphism. i.e., sexes are separate.** The female measures 20 to 40 cm in length and 4-6 mm in diameter with a straight tail. The male is smaller measures 15-31 cm in length and 2-4 mm in diameter with a **ventrally curved tail**. The whole body is covered by **cuticle** . The body surface bears a **minute transverse striation**, giving a worm's pseudosegmented appearance.

Adult:

The round worm is elongated animal and its body is tapering to both end. Freshly excreted worm is yellowish pink in colour, which gradually changes to white. ***Ascaris* have no eyes**. Its anterior end bearing a small terminal triradiate mouth aperture guarded by 3 broad

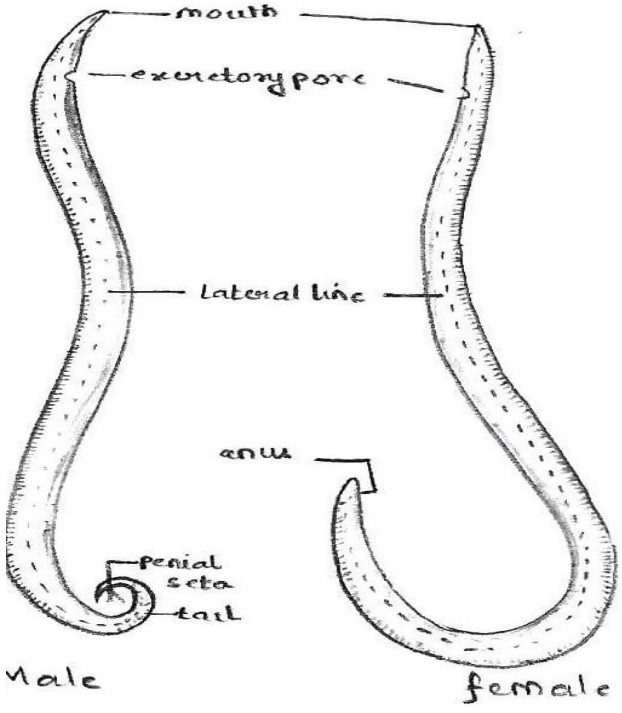
lips or labia. One lip is mid-dorsal and broadly elliptical, and 2 are sub-ventral or latero-ventral and oval. Of these, one is on the upper side, and the other two on the two sides of the mouth cavity.

Dorsal and anterior extension of labial parenchyma bears minute **denticles.** The outer surface of each lip bears minute sensory papillae/ labial. **Labial papillae are hair-like structures used for tactile reception and are very sensitive to vibrations and touch**. The dorsal lip has 2 sensory papillae, one on each side. Each latero-ventral lip has 1 double sensory papilla in its ventral position. These four papillae form an outer labial circle, but nematodes have 6 papillae in the outer labial circle.The papillae of the inner labial circles are absent in *Ascaris*, but other nematodes have 6 papillae in its inner labial circle. The latero-ventral lip has lateral papilla, each in lateral and **cuticular excavation called amphid**. Amphids are reduced in parasitic nematodes. Just behind the latero-ventral, there is a pair of cervical papillae, one on each side close to the nerve ring. Papillae are **tangoreceptors (sensory)** while **amphids are olfactory chemoreceptors**.The lips bear a fine tooth.

The posterior end of the body shows clear **sexual dimorphism**. In females, the posterior extremity is conical and straight, the midventral transverse apertures, or anus, guarded by one pair of postanal papillae. Only the digestive tubes open to the outside through the anus. **In males, the tail end is curved ventrally in the form of a**

hook with a conical tip. In male anus is replaced by cloaca. It is the common aperture for the rectum and genital tubes. Two copulatory setae protrude from the aperture. They are called peneal setae or spicules. The setae serve to transfer-sperm into the female vagina during copulation. The male tail is characterized by numerous genital papillae ventrally, about 50 pairs of pre-anal papillae, and 5 pairs of postanal papillae. 2 anterior pairs of postanal papillae are double, while the rest are single. Genital papillae of male help in copulation.

Excretory pore lies mid-ventrally and near the anterior end. At about one-third of the entire length from the anterior end, the body is narrower in females, and this region is known as the **vulvar waist.** The female genital aperture called vulva or gonopore is situated on the ventral surface of the vulvar waist. But the genital pore on the male opens into the cloaca.



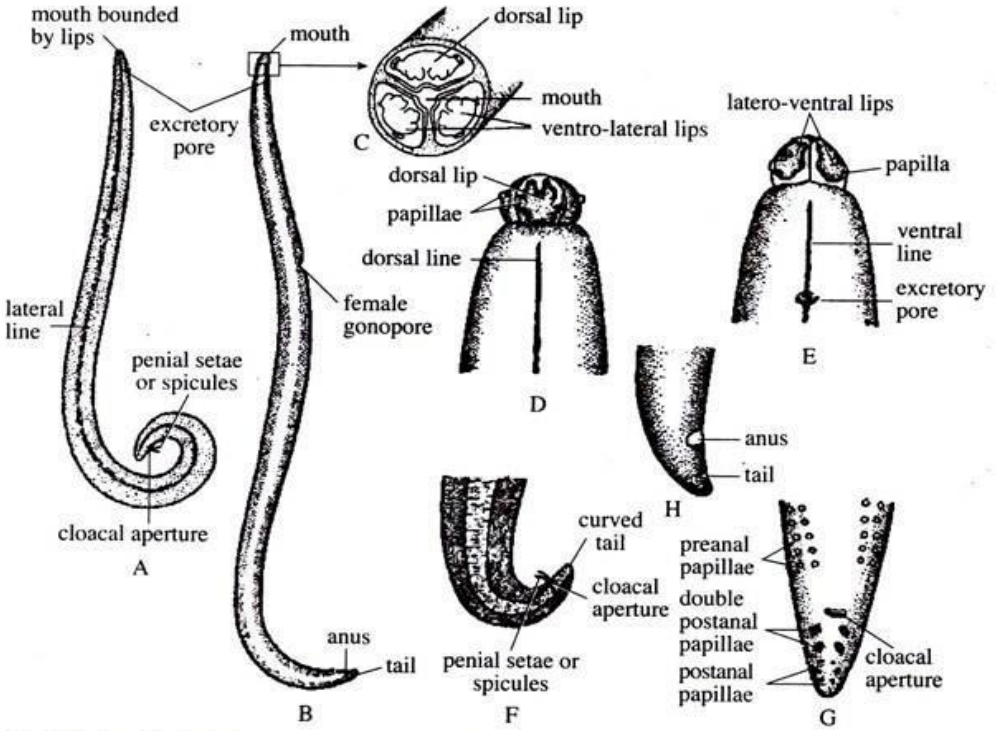


Fig. 1.64 : *Ascaris lumbricoides*. A. Adult male in lateral view. B. Adult female in lateral view, C. Enlarged view of head end, D. Anterior end in dorsal view, E. Anterior end in ventral view, F. Posterior end of male in side view, G. Posterior end of male in ventral view showing papillae, H. Posterior end of female in side view.

Body wall of *Ascaris lumbricoides* :

Ascaris's body wall is made up of 3 layers, i.e., **outer cuticle,** middle **sub cuticle or epidermis or hypodermis**, and inner **longitudinal muscle lining** of the body cavity.

The body is covered with a thick, tough, elastic transparent, and glossy layer **cuticle**. The cuticle is secreted by the underlying epidermis and continuous with the pharynx and rectum's cuticular lining. It is non-cellular and made of albuminous protein, resistant to host digestive juices but permeable to salt and water. The body wall of Ascaris is made up of an outer layer of cuticle which is thin, transparent, delicate and wrinkled transversely (Fig. 1.65). The cuticle of

Ascaris produces enzyme inhibitors that protect it from the host's digestive enzymes.In a young worm, the cuticle is shed off to permit growth.It is divisible into several layers with numerous vertical channels.The transverse wrinkles of the cuticle give the characteristic segmental appearance of the body.

The cuticle also lines the buccal cavity, esophagus, rectum, cloaca, vagina, and excretory pore. Under a light microscope, the cuticle can be identified into 4 layers, but in a recent study, the electron microscope has also revealed the fifth lipid layer. The lipid layer is about 1000 A° thick and in the form of a thin osmophilic membrane. Cortical or cortex layer which is made of keratin and resistant to the action of host digestive enzymes. It includes an outer cortical layer consisting of discontinuous strips or rings around the body and an inner cortical layer.

The matrix layer is spongy in consistency and contains **Sulphur-rich protein Matricin**. This layer is elastic and contains several fine fibers. It consists of an outer fibrillar layer, a homogenous layer that shows several radial striations, and a boundary layer resembles the outer cortical layer. The fiber layer is the inner layer, but not the last layer of the cuticle ad consists of collagen fibers crossing each other and arranged in 3 strata. The basement membrane is a thin layer forming the inner limit of the cuticle. Beneath the cuticle is the ectoderm which forms a syncytial protoplasmic layer. The ectoderm is responsible for secreting the cuticle.

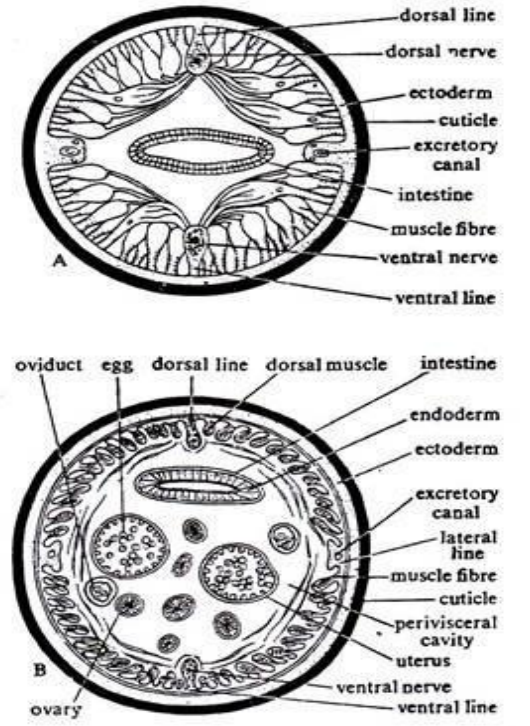


Fig. 1.65 : Transverse section of *Ascaris* passing through anterior third (A) and through middle region of female (B).

Epidermis or hypodermis :

The hypodermis or epidermis is a thin syncytial layer under the basal lamina. It contains many nuclei but no cell walls, the nuclei lie in the longitudinal epidermal chords only. This layer projects along the mid-dorsal, mid-ventral, and lateral lines and form epidermal chords. Lateral chords are more conspicuous and seen on the surface as yellow lines. Excretory canals and lateral nerves run along with the lateral chords. While dorsal and ventral chords contain dorsal and ventral nerve, respectively. The epidermis of free-living nematodes contains unicellular epidermal glands. In the epidermis fat and glycogen are reserved abundantly.

Below the ectoderm is a single layer of longitudinal muscle. The individual cells of the longitudinal muscles are spindle-shaped, straightened longitudinally and bears at the middle a bladder-like mass of protoplasm containing the nucleus which faces the side of the body (Fig. 1.66). This peculiar appearance of the longitudinal muscles is due to the differentiation of the cell into a contractile and a nuclear part.

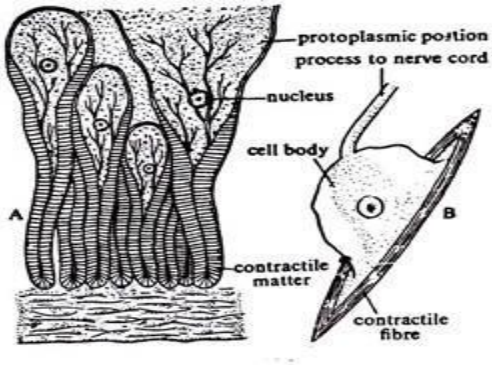
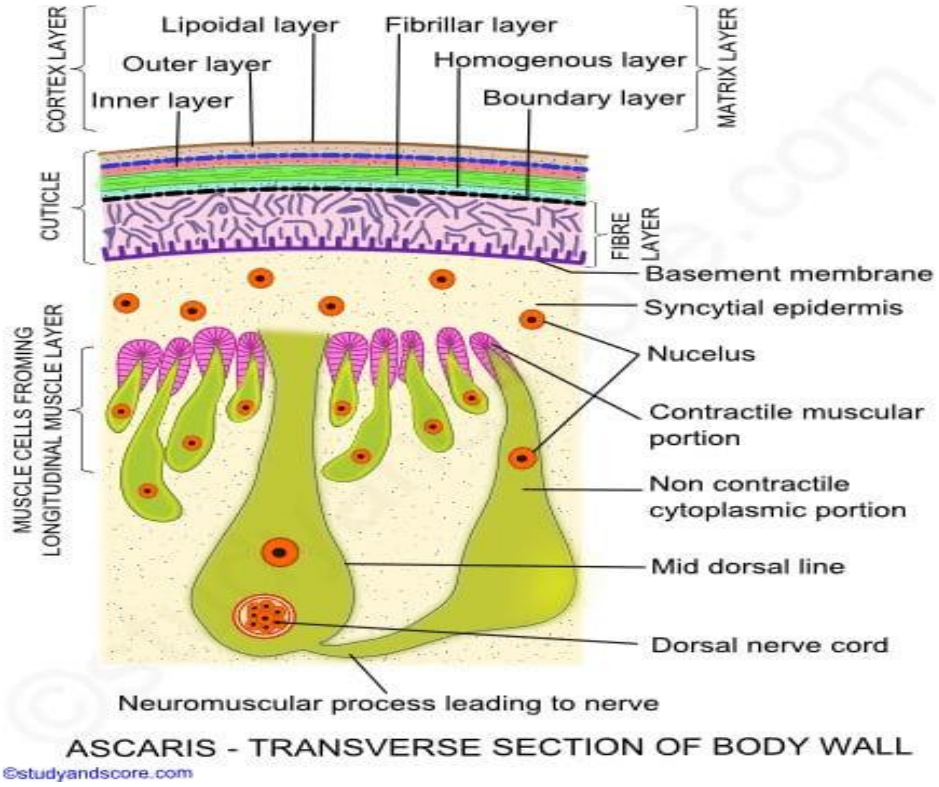


Fig. 1.66 : A. Showing the muscle cell in transverse section and B. An isolated muscle cell of *Ascaris*.

Longitudinal muscle/ muscle layer :

A single layer of muscle cells remains attached to the hypodermis. In this layer, circular muscles are altogether absent.Longitudinal muscles form a single layer of spindle-shaped muscle cells beneath the epidermis and lining the body cavity.The muscle layer is divided into 4 longitudinal columns and strips 2 dorsolateral and 2 ventro-lateral. Each column contains about 150 muscle cells. For the identification of species in nematodes number and disposition of muscle cells play an important role. Each muscle cell contains two parts, a muscular part, which is contractile, lies towards the epidermis,

and a granular non-contractile protoplasmic part, a club-shaped, bladder-like mass of protoplasm with nucleus and network of supporting fibrils form a fibrous process or muscle tail. The muscular portion contains longitudinal contractile fibers arranged at intervals and also the fibers for attachment to the cuticle. The protoplasmic part remains inwards and connected with the neuromuscular process. Muscle cells of all the cells of 2 dorsolateral columns are ultimately connected with the dorsal nerve cord. While those of 2 ventro-lateral columns are connected with the ventral nerve cord. **Dobell (1965)** has emphasized that muscle tails are cellular extension, which forms synapsis on the motor nerves of the dorsal and ventral nerve cord.



Body Cavity of Ascaris :

The body cavity is not a true coelom as it is not lined by cell layers derived from the mesoderm. It, however, develops from blasto-coel (**i.e. between mesoderm and endoderm of embryo**) and is referred to as pseudocoel.

The body cavity is linked externally by fibrous processes of the longitudinal muscle cells and internally by cuticle encasing the intestine. There are five giant stellate **mesenchymal cells** in the pseudocoel of Ascaris, called **pseudo-coelomocytes**, occupying fixed positions. Pseudocoel is filled with an **odorous protein rich fluid**, known **as perienteric or pseudocoelomic fluid**.

Locomotion of Ascaris :

To counteract the peristaltic activity of the host's intestine, the dorsolateral and ventro-lateral muscles in the anterior end of Ascaris, contracts alternately to perform undulating movements. However, ability to perform change in body length is restricted due to absence of circular muscles in the body wall.

Digestive System of Ascaris:

The alimentary tract is a straight tube which runs along the entire length of the body (Fig. 1.67). Mouth is anterior and terminal in position and is guarded by three semicircular lips that are finely toothed. Behind the mouth is the buccal cavity, which leads into a

club-shaped pharynx. The pharynx is dilated and its wall is muscular, which helps it to draw food from the intestinal content of the host.

Pharynx then leads to the intestine, whose posterior part narrows down to form the rectum. The rectum opens to the outside through the anus, which lies about 2 mm from the tail end. The entire alimentary canal is made up of a single epithelial layer covered internally and externally by cuticle derived from the ectoderm. Digestive glands are totally absent as Ascaris feeds upon the digested food of the host.

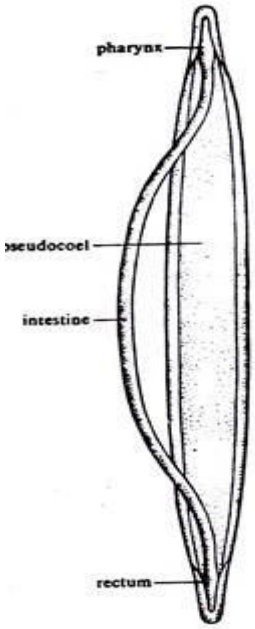


Fig. 1.67 : Alimentary system of *Ascaris*.

Respiratory System of Ascaris:

Like most other endoparasites, Ascaris respires anaerobically, as the oxygen content in the host's intestine is generally poor. According to Hyman, the small amount of haemoglobin present in the pseudocoelomic fluid and body wall, serves to transport oxygen.

Excretory System of Ascaris:

The excretory system of Ascaris consists of two longitudinal excretory canals, one through each lateral streaks (Fig. 1.68A). The two canals are connected anteriorly, below pharynx, by a transverse canalicular network. Extending from this is a short terminal excretory duct that opens to the outside through the single excretory pore situated on the ventral side.

Each longitudinal excretory canal extends posteriorly along the entire body length through a lateral epidermal chord and remains closed at its terminal end. Four to six big tufts of cells with ramifying protoplasmic processes remain in close contact with the canals.

It is believed that these cells collect, store and pass on the waste matter in dissolved state to the excretory canals. The whole system is neither a ciliated one nor there is any flame cells. It is presumed that the canal is an intracellular tubular extension of a single enormously elongated cell.

Nervous System of Ascaris:

The nervous system of Ascaris comprises of a nerve ring or circumenteric ring around the pharynx (Fig. 1.69). The ring is swollen at the ventral side and is ganglion like. The ring gives off six nerves each to the anterior and posterior sides.

Two of the posterior nerves are of considerable thickness and run along the dorsal and ventral lines up to the posterior end of the body. The dorsal and ventral longitudinal nerves are connected with each other by transverse commissures. The posterior tip of the ventral nerve cord is swollen and forms a ganglion just in front of the anus. The sense organs are the sensory papillae situated as small elevations on the lips.

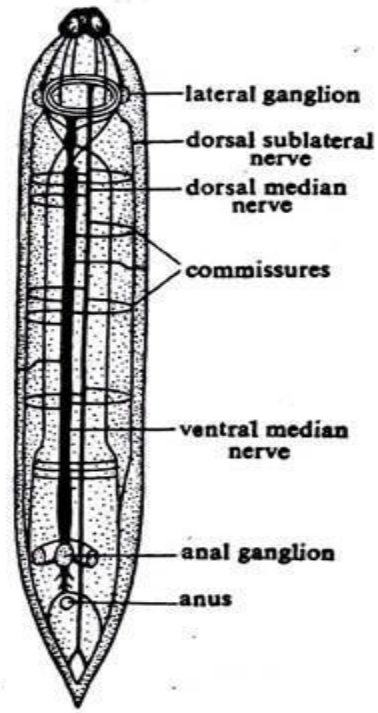


Fig. 1.69 : Nervous system of *Ascaris*.

Reproductive System of Ascaris:

Sexes are separate and sexual dimorphism is well marked (Fig. 1.64). Gonads are typically long, coiled and tubular. They are attached at the genital pore in females and cloaca in males. The male reproductive organs consist of a single coiled, thread-like tubule (Fig.

1.68A) occupying some portion of the body cavity and about eight times the length of the body.

This structure is differentiated at the anterior region into the testis, the middle region as the vas deferens and the posterior region as the seminal vesicle. The demarcations of these parts are very poor. The seminal vesicle continues as the ejaculatory duct and opens into the anus.

At the opening of this structure there is a pair of chitinoid spicules called penial setae, each of which is provided with a muscular penial sac. In case of male Ascaris, the anus is used for the elimination of faeces as well as of sperms and therefore, is called cloaca.

The sperms of Ascaris (Fig. 1.68C) are very peculiar as they show amoeboid movement inside the body of the female. A matured sperm is cone-shaped, having a broad base and an apex. The apex contains the acrosome and the broad base contains the nucleus and mitochondria. The sperms remain non-motile in the male gonoduct.

The female genital organs are a much coiled structure (Fig. 1.68B) present in the middle and posterior third of the body and its length is several times more than the entire length of the worm. If comprises of a pair of much coiled thread-like ovaries which pass into an uterus.

The two uteri unite to form a single, conical and muscular vagina, which opens to the outside by the female genital aperture situated on the ventral surface at about one-third the body length from the head. The fertilized and unfertilized eggs vary in character (Fig. 1.68D).

The fertilized egg is round or oval in shape, measuring 60 to 70 µm in length and 40 to 50 µm in breadth. It is always bile-stained and brownish in colour. It contains a very large conspicuous, un-segmented ovum, the nucleus of which is concealed by a large amount of coarse yolk granules. It is surrounded by a thick smooth translucent shell with an outer albuminous coat having a rippling surface.

The unfertilized egg on the other hand is narrower, longer and more elliptical in shape. It has a thinner shell with an irregular coating of albumen and contains an atrophied ovum. The eggs of Ascaris are highly resistant to desiccation and disinfectants and may remain viable in soil for 10 years.

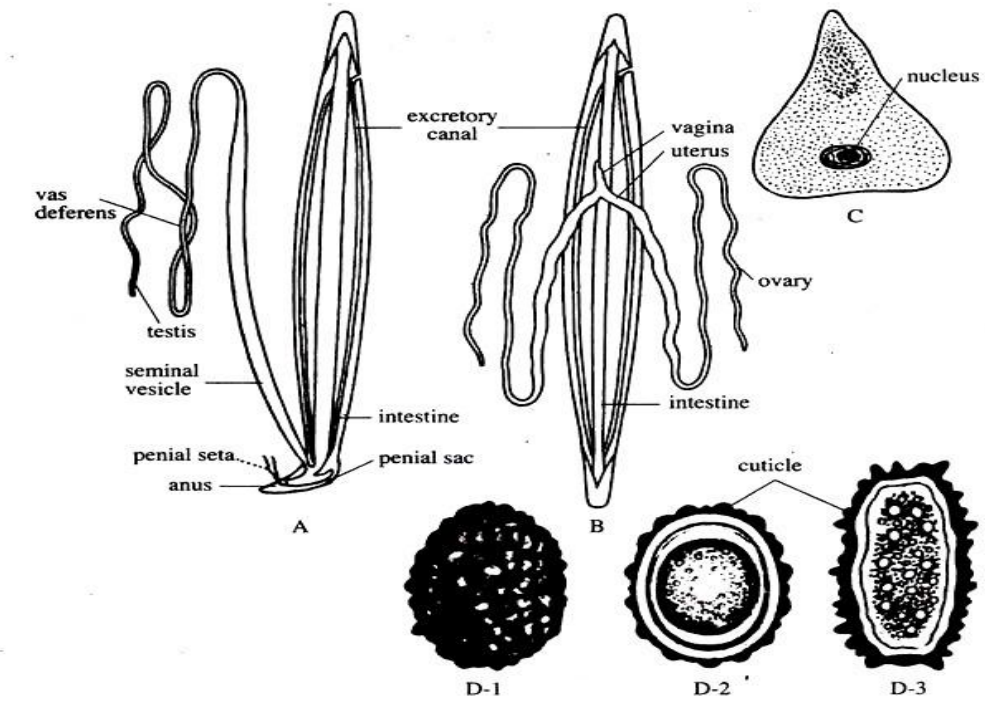


Fig. 1.68 : A. Showing the excretory system and male reproductive system of *Ascaris*. B. Female reproductive system of *Ascaris*. C. Spermatozoon of *Ascaris*. D. Egg of *Ascaris* (D-1. Surface view of fertilized egg. D-2. Median focus of fertilized egg. D-3. Unfertilized egg.)

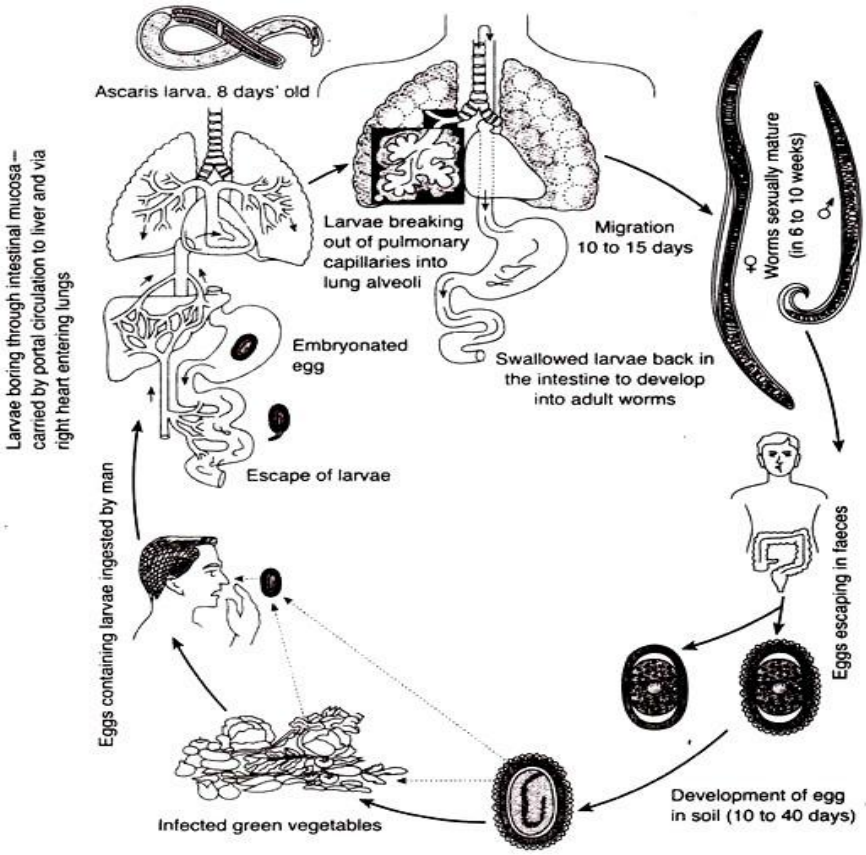


Fig. 1.70 : Life cycle of *Ascaris lumbricoides*.

The egg in this condition is passed to the outside along with the stool of the host. At this stage they are not infective to man. The development of the zygote to larva takes place outside the body of human host and it takes a fairly long time (about 10-40 days), depending upon the atmospheric temperature and humidity.

The egg containing the coiled-up embryo is infective to man. The embryo does not hatch in the open but remains quiescent within the egg shell until it reaches a new host.

Infection to the new host is direct. Infection results when contaminated food or drinks are ingested by man. The coiled-up embryonated eggs pass down to the duodenum where the digestive juices weaken the egg shell and stimulate the enclosed larvae into activity.

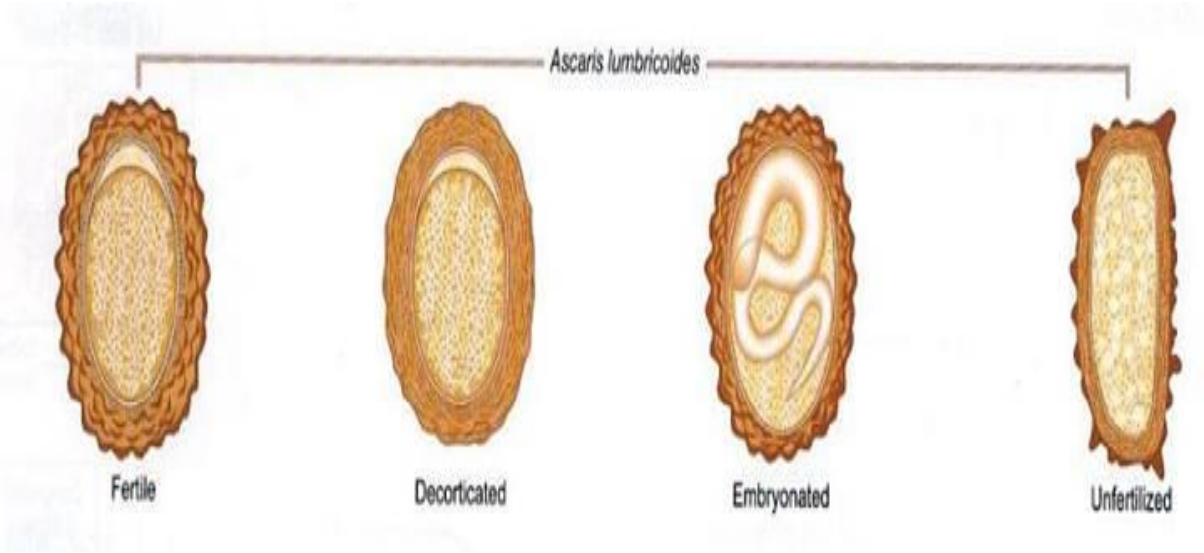
The larvae emerge through a rent in the egg shell produced as a result of splitting and not by digestion of the eggshell. It takes about two hours to hatch. These larvae measure about 0.2 to 0.3 mm in length and 13 to 15 µm in breadth.

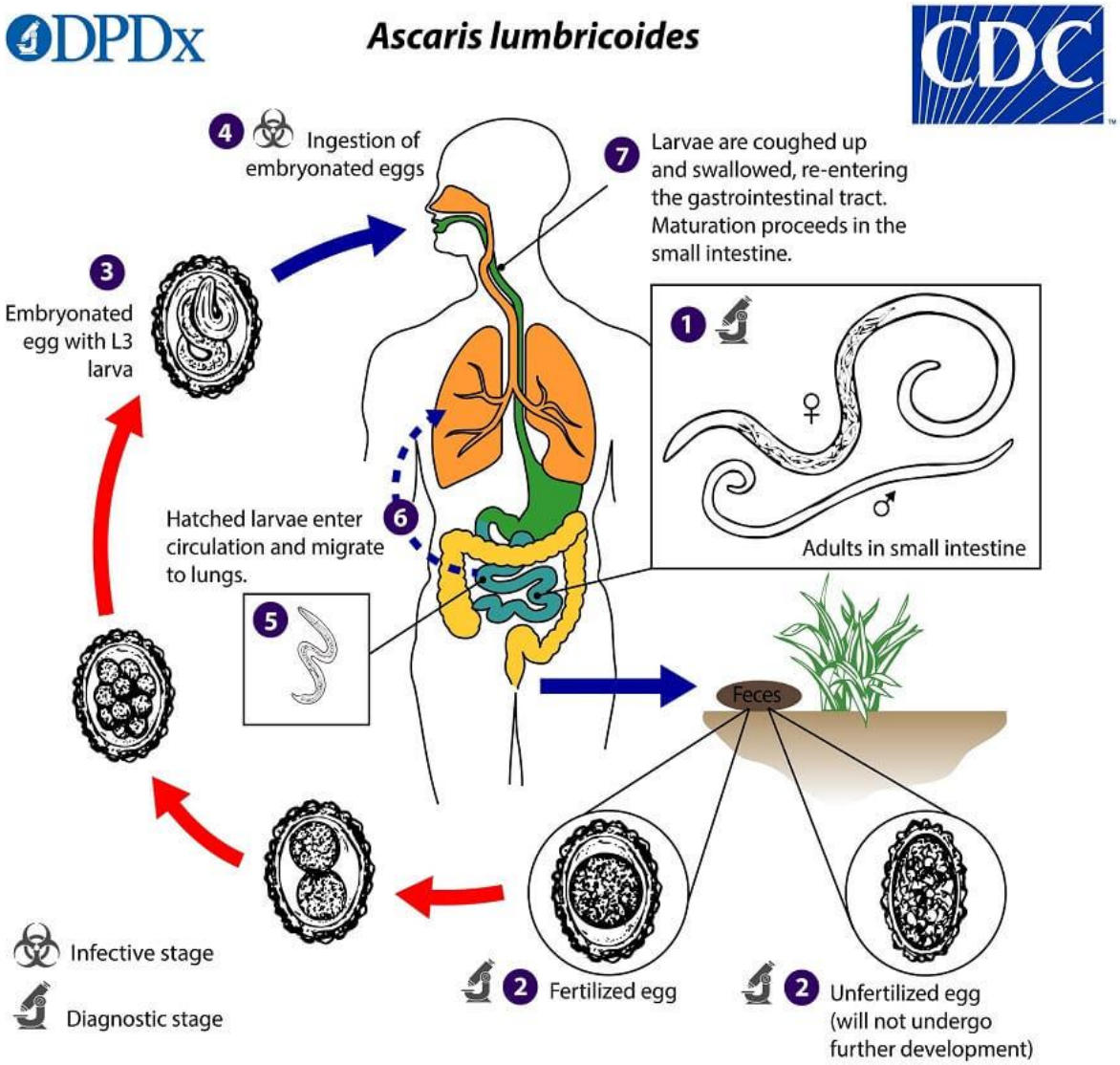
The larvae undergo moulting before hatching. The newly hatched larvae burrow their Way through the mucous membrane of the small intestine and enter the lymphatic ducts or veinules. From the lymphatic ducts it is carried to the mesenteries, lymph nodes and then to the portal vein from where the larva comes to the liver. Here, they live for a period of 3 to 4 days.

Then, after passing through interlobular veins, central veins, sub-lobular veins and hepatic veins, are drained into the inferior vena cava which opens into the right atrium of the heart. From here they are carried to the lungs, where the larvae moult twice and grow much bigger in length (from 0.2 mm to 2.0 mm). Breaking through the capillary wall they reach the lung alveoli and crawl up the bronchi and trachea.They are then propelled into the larynx and then to the pharynx where they are once more swallowed. It takes about 10 to 15 days for such migration from the lungs to the pharynx. The larvae, then pass down the oesophagus to the stomach and upper intestine, where the fourth moulting takes place. They while staying in the lungs acquire a resistance to the gastric juice.

The larvae having returned to their normal abode become much bigger, about 10 times their original size and measuring about 2 to 3 mm in length. In about 6 to 10 weeks-time, they become sexually mature. The worm starts producing eggs within two months from the time of infection. The life-span of the adult worm in the human host is rather short, average being less than a year.

At the time of massive infection, the larvae may reach the general circulation and are carried to the various organs and tissues. They may then happen to lodge in such aberrant sites as kidney, brain, spinal cord and other organs. They are unable to grow to maturity and most of them are destroyed. They may even be secreted in the urine at the time of heavy infection.


Ascaris lumbricoides
Fertile
Decorticated
Embryonated
Unfertilized


DPDx
Ascaris lumbricoides
CDC
4 Ingestion of embryonated eggs
7 Larvae are coughed up and swallowed, re-entering the gastrointestinal tract. Maturation proceeds in the small intestine.
3 Embryonated egg with L3 larva
1
♀
♂
Adults in small intestine
Hatched larvae enter circulation and migrate to lungs.
6
5
Feces
Infective stage
Diagnostic stage
2 Fertilized egg
2 Unfertilized egg (will not undergo further development)

Pathogenicity of Ascaris:

The adult worm produces the following pathogenic effects:

(i) Spoliative action:

By robbing the host of its nutrition.

(ii) Toxic action:

The body fluid of Ascaris is toxic and causes anaphylactic reaction.

(iii) Mechanical effect:

By causing obstruction of the tubular passages, such as appendix, bile duct, pancreatic duct, bronchus and perforating through ulcers in the alimentary canal.

Clinical Manifestation of Ascaris lumbricoides :

Disease caused by *Ascaris* is commonly called **Ascariasis.** There is a greater incidence of Ascariasis in children than adults. Most of the infections caused by them are asymptomatic. the symptomatic Ascariasis are of two types. **i.e. intestinal ascariasis and pulmonary ascariasis.**

1. Intestinal ascariasis :

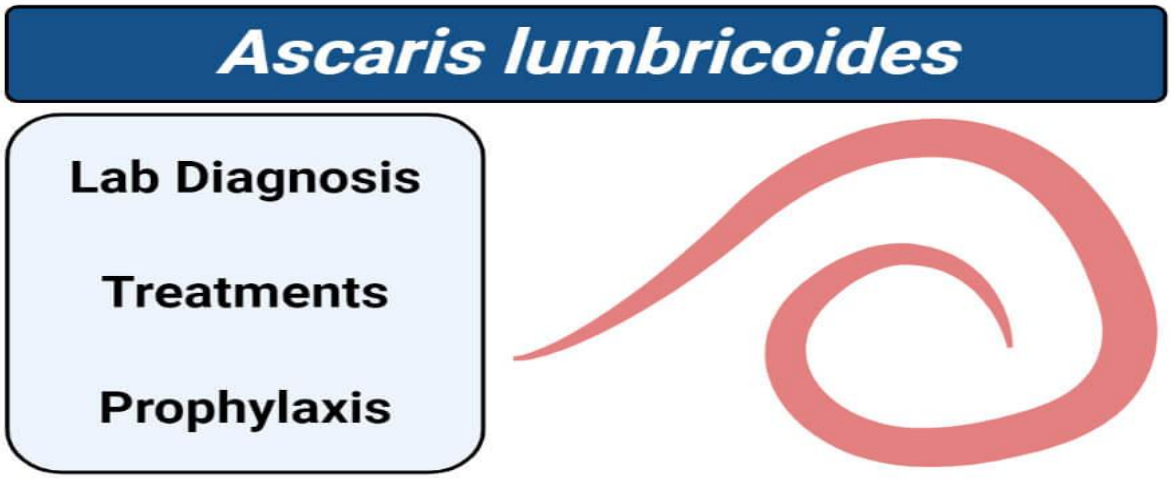
- Nausea
- Vomiting
- Irregular stool or diarrhea

- Colicky abdominal pain
- Abdominal distention
- Loss of appetite
- Weight loss
- Intestinal blockage, which causes severe pain and vomiting.
- Malabsorption of nutrition
- Growth retardation
- visible worms in the stool
- Growth impairment in children due to malabsorption
- Heavy worm in children leads to intussusception and total obstruction
- Complications: Appendicitis, Biliary colic, and perforation of the bile duct, Hepatomegaly
- Some people may have other symptoms like fatigue and fever with a large infestation.

2. Pulmonary ascariasis :

- Transient eosinophilic pneumonitis (Loeffler's disease); elevated IgE
- Bronchospasm
- Dyspnea
- Coughing and gagging
- Wheezing or shortness of breath
- Aspiration pneumonia (rarely).
- Blood in mucus

- Chest discomfort
- Fever



a. Detection of Parasite :

Adult Worm :

- In the case of heavy infection, the adult worm is possible to find in stool or sputum of the patient by the naked eye.
- Barium meal may reveal the presence of an adult worm in the small intestine.
- A plain abdominal film may reveal masses of worms in gas-filled loops of bowel in patients with intestinal obstruction.
- Pancreaticobiliary worms can be detected by ultrasound (more than 50% sensitive) and endoscopic retrograde cholangiopancreatography (ERCP; 90% sensitive.

Larvae :

In the early stages of infection, when migrating larvae cause

Loeffler's syndrome, the diagnosis may be made by demonstrating the larvae in **sputum**, or more often in **gastric washings.**

- **Eosinophilia** may be present, especially during the larval migration through the lungs which supports the diagnosis. At this stage, no eggs are seen in feces.
- **Chest X-ray** may show patchy pulmonary infiltrates.

b. Microscopy :

Specimen: stool, bile

The **saline emulsion of stool** is examined **microscopically** for the presence of eggs. Both fertilized and unfertilized eggs are usually present.

- If very few eggs are present the diagnosis may be easily missed so the concentration technique will increase the yield of diagnosis through microscopy.
- Eggs may be demonstrative in the **bile** obtained by **duodenal aspirates.**

c. Blood examination :

- A complete blood count may show eosinophilia in the early stage of invasion.

d. Serological Tests :

- *Ascaris* antibody can be detected by **Indirect hemagglutination (IHA)**, **Immunofluorescence antibody (IFA)**, **Enzyme-linked immunosorbent assay (ELISA** is a plate-based assay technique

designed for detecting and quantifying soluble substances such as peptides, proteins, antibodies, and hormones. Other names, such as enzyme immunoassay (EIA), are also used to describe the same technology.

- **Serodiagnosis** is helpful in extraintestinal ascariasis like **Loeffler**) **syndrome** - It is a rare, transient, self-limiting, and benign pulmonary eosinophilia lasting less than one month (usually 6-12 days). The **syndrome** is characterised by pulmonary infiltrates on X-ray, elevated blood eosinophils and an acute onset of potential symptoms of mainly cough, dyspnoea and wheeze)

Lab diagnosis:

1. **X-ray**
2. **Ultrasonography**
3. **CT scan**
4. **Other test:** blood count shown peripheral eosinophilia

Therapeutic Treatment of Ascaris:

For a long time **Santonin** was the classical remedy of ascariasis but recently **oil of chenopodium** and hexylresorcinol have been widely used. Seeds of **Butea** and dried fruits of **Embelia** have also been used by grinding it into a paste and mixing it with sugar and water.

Treatment of Ascariasis :

- Anti-parasite medications are the first line of treatment against ascariasis. The most common are:
- **Albendazole** (500mg single dose),
- **Ivermectin** (150–200 mg/kg once).
- **Mebendazole** (100 g twice daily for 3 days or 500 mg once).
- **Pyrantel pamoate** single dose of 10 mg/kg weight.
- **Piperazine citrate**
- These medications, taken for one to three days, kill the adult worms. Side effects include mild abdominal pain or diarrhea.
- Pregnant women may take **pyrantel palmoate**(**11 mg**/kg once; maximum **1 g**).
- Partial intestinal obstruction should be managed with nasogastric suction, intravenous fluid administration, and the installation of piperazine through the nasogastric tube.
- Complete obstruction requires immediate **surgical intervention.**

Prophylaxis of Ascariasis :

- Ascariasis can be eliminated by preventing fecal contamination of soil. The *Ascaris* egg is highly resistant. Therefore, the use of night soil as manure will lead to the spreading of the infection, unless the destruction of the eggs is ensured by proper composting.
- Treatment of vegetables and other garden crops with water containing iodine 200 ppm for 15 minutes kills the eggs and larvae of *Ascaris* and other helminths.

- Avoid eating raw vegetables.
- Improvement of personal hygiene.
- Treatment of infected persons especially the children.

References :

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