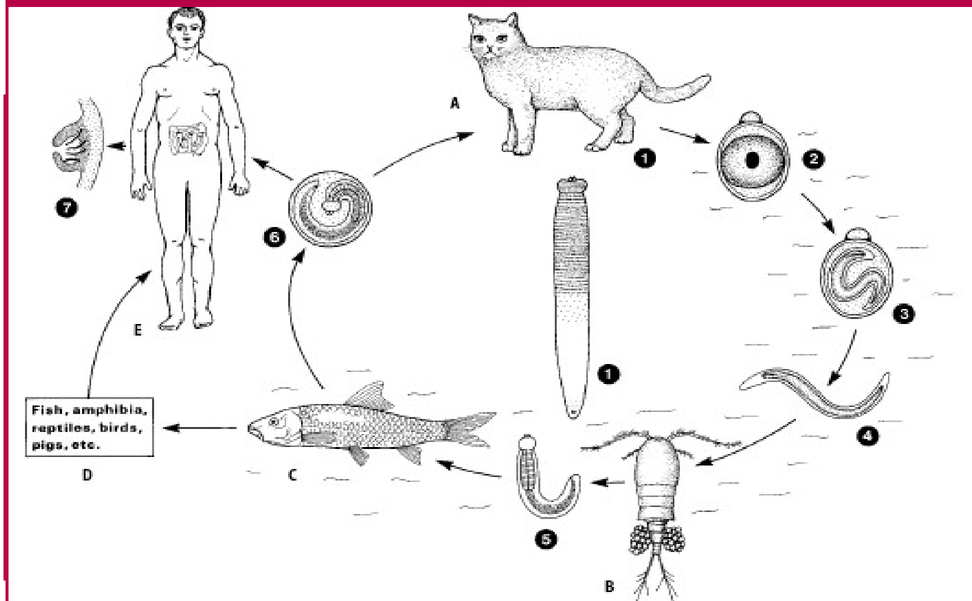
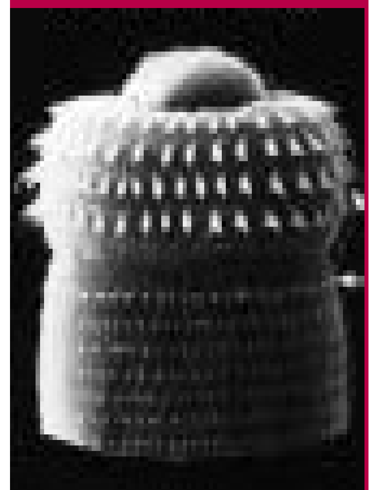
Chapter 6





Department of Parasitolgoy

Mode of Transmission of Parasites and Method of their Dissemination, Types of Development, Direct life cycle, Development of Parasites in the Host System

Compiled by

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The need of parasite transmission:

Though there are diversities in the life cycle of various parasites, yet one feature is common to all the parasite is that, they need to find a new and suitable host periodically. There are hazards and underlying difficulties in the process, but for a successful life, the parasite must overcome all these difficulties. The need to find a new host lies in the fact that:-

i) When the host becomes an intolerable environment due to development of resistance against the parasite.

ii) When the host dies.

iii) The parasite must prepare for the next generation before it has lived out its own life span.

Development of 'infective stage':

For entering into a new host, most parasites have developed a specialized stage called the 'infective stage' or 'infective form'. This form or stage does not develop further till it reaches a suitable environment or 'host'. Therefore, the infective stage may be defined as bridge between two environments, i.e., free living and parasitic and it is one of the basic adaptations to the parasitic way of life (Fig. 1).

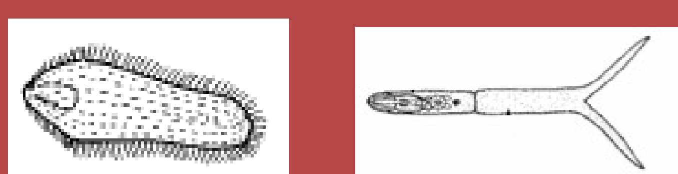

Fig.1. Drawing of a miracidium (left), the infective stage for snail intermediate host in the life cycle of trematode parasite; furcocercus cercaria (right) is the infective stage for final host in the life cycle of trematdoe species Schistosoma

The risks of transmission:

Most of the parasitic life cycle involves a free living stage away from the host; hence there remains an inherent risk of transmission. The positive and successful outcome is the arrival of the parasite in a suitable host. There are several other outcomes, wherein the parasite may be unsuccessful, for example,

i)When the parasite enters wrong species of host.

ii)The external environment is not suitable for the development and growth of the parasite.

iii)Death of the parasite before it reaches a suitable host.

iv) When the parasite reaches an immune host.

Factors that favors transmission of parasite:

Factors which favor transmission are:-

i)High reproductive potential.

ii) Longevity of the adult parasite.

iii)Multiple suitable host species.

iv) Lack of host reaction to the parasite.

v)Presence of a large population of suitable host (intermediate and definitive host).

vi)Lack of host reaction to the parasite.

vii)Effective dispersal mechanism of the parasite.

viii)Favorable climate.

ix)Forms resistant to changes in weather.

The process of parasite transmission:-

The process of transmission is thought of involving five distinct phases:-

i)Exit from the host

ii)Dispersal

iii)Development and survival away from the host

iv)Host finding

v)Entrance into a new host

Parasite which has a direct life cycle, the process takes place once during the life cycle; those having an indirect life cycle, the entire process are repeated for each occasion that the parasite changes hosts during the cycle. Different species of parasite solve the problems posed by this process in different ways; phylogenetically related parasites have similar or identical solutions.

1. Exit from the host

i) Passive exit:

Most parasite exit from the host by passive means. For example, eggs of parasite that passes out of the host along with faeces (Eggs of *Fasciola gigantica*, *Ancylostoma* species etc.), circulating gametocytes and microfilariae ingested by blood sucking arthropods (e.g, *Leucocytozoon* by *Simulium* flies, *Dirofilaria* by mosquitoes). Passive exit of eggs, oocyst or larvae is an uncomplicated event if the parasites are in the lumen of the gastrointestinal tract or in an organ that has access to the gastrointestinal tract e.g., bile duct or bronchus) or the urinary tract.

Parasites that oviposit in tunnels in the mucosa of the gastrointestinal tract, e.g., *Capillaria* sps., the parasite evokes an increased growth rate of epithelia, which makes more faster and certain sloughing of the epithelium containing the eggs into the lumen.

Extraintestinal phases of some coccicidian parasites, e.g., *Toxoplasma gondii*, *Isospora* sps. may remain available for the predators long after oocysts have disappeared from the faeces

Cestode parasites of aquatic vertebrate hosts tend to lay eggs that produce swimming larvae, whereas cestodes of terrestrial vertebrate host store eggs in closed uteri and have immobile larvae.

ii)Active exit:

When the parasites actively go out from the host is termed as active exit, e.g., ectoparasites like flea, louse or flies jumps, crawl or fly away. In case of digenetic trematodes, the cercaria actively exit out from the snail intermediate host by making a lesion in the snail's integument. It is to be noted that, the emergence of the cercariae is governed by many factors such as light, temperature, humidity, pH, oxygen concentration, and population density of the snail host. In many species of flukes , the cercarial emergence coincides with the periodicity of the daily activity of the next host.

A special case is the **transplacental** exit of parasite. Several species of larval helminths and protozoa use transplacental exit *routinely*, e.g., nematodes like *Toxocara vitulorum*, *Toxocara canis Ancylostoma* and protozoa like *Toxoplasma gondii*. Some helminths use the transplacental exit *accidently*, e.g., *Fasciola*, *Taenia* sps. The most hazardous portions of the transmission process are the : survival outside the host and finding a new host. The transplacental mode of exit is very efficient, since it bypasses both of the above mentioned hazardous process of transmission. In case of poultry, *Toxoplasma gondii* has been recovered from the ovary, oviduct, and hence the eggs, disseminating the infection to the next generation of chicken.

Another case of efficient transmission of the parasite to the next generation of the host is the **Transmammary** exit or migration. In his process , the larvae accumulate in he stroma around the developing mammary acini during the latter stages of gestation. As lactation begins, the larvae penetrate into the acinar lumens and are ingested by the neonate as it nurses. This route is followed by the nematode parasite fro exit of parasite are the *Ancylostoma caninum*, *Strongyloides papillosus*, *Toxocara vitulorum*, *Toxocara canis* etc.

Factors that govern the egg /oocyst exit or output:

i. Crowding effect

The number of parasite eggs, larvae or cysts passing in the faces fluctuates rhythmically or otherwise does not correlate well with the parasite burden in the host. Generally, if the number of parasite is less in the host, the number of egg or oocyst output is high. On the other hand, if the parasite burden is high, the egg or oocyt output is less. This phenomena is called crowding effect. In *Fasciola hepatica* it was found that, the daily egg output per fluke varied from 4000 in heavy infection to 50,000 in light infections. Similarly, if an initial infection was given with 50 *Eimeria tenella* oocysts, the final output was equaled to about 80,000 oocysts for each infecting oocysts, but when 20,000 *E.tenella* oocysts were given, the oocyst yield fell to 1700 oocysts for each infecting oocysts.

ii. Host resistance

Resistant host plays a great role in the environmental contamination of eggs or larvae. Resistant animals use to trap egg or larvae in heir exudates or depress the fecundity of the parasites. These hosts often continue to shed low number of parasites sporadically. Dietary factors and genetics affect the resistance of the host to transmission of parasites.

iii. Post parturient rise, Spring rise, Autumn rise

The nematode egg output is greatly influenced by the phenomena known as post-parturient rise, spring rise or autumn rise. The phenomena are best known in sheep and horses also. These phenomena are separate and occur nearly simultaneously. The post-parturient rise occurs in ewes lambing either in spring or autumn. It is also associated with increased fecundity of inhibited, hypobiotic larvae. Factors responsible for the post-parturient rise are unknown, but lactation and breakdown in resistance are thought to contribute into it.

2) Dispersal

Environment plays a great role in the dispersal process of parasites. After the parasites have exited out from the host, they are subjected to the effects of environment. Many an environmental factors assists to spread the parasites from the place where they were deposited and thus spread the parasite over a larger area. This also helps to increase the chances of finding the new hosts. Parasite dispersal is a mechanical process except where the organisms are active by themselves, e.g. , dipteran flies (*Musca*, *Tabanus* etc.).

i)Wind

As the parasites are protected by vegetation, wind has little effect in their dispersal. However, strong wind can move pellets of sheep feces containing eggs or larvae of parasite to a certain distance having short grasses. Wind has great effect on the microclimate than on the dispersal of parasite.

ii)Water

Water is an important factor for the dissemination of parasites. Some parasites require an aquatic environment for development, e.g., *Dracunculus medinensis*, *Fasciola gigantica*, *Diphyllobothrium latum*, etc. Eggs of *Fasciola* are deposited on the ground, however, the need to be washed down to the water bodies during the rainfall, where they will develop. Once in water, fluke eggs develop at varying rate, so that miracidia (Fig. 1 & Fig.2) emerge over a period of time , enhancing chances of finding conditions suitable for dissemination and contact with snail intermediate host.

Fig. 2. Scanning electron micrgraph of a miracidium of *Fasciola hepatica* showing cilia at the anterior part. Cilia on the rest part of the body are lost

Larvae of *Dracunculus medinensis* are released into water in several batches(Fig. 3), enhancing contact with Cyclops , the intermediate host.

Water current can carry parasites and or/their aquatic hosts long distances downstream. Snails which serve as intermediate hosts for flukes, can be carried several kilometers in streams with velocity greater than 20cm/second. Release of cercariae from snails take place in water and occurs irregularly over an extended period, probably for the life of the snail in the case of *Fasciola*. This prolonged shedding assures that many cercariae will escape temporary adverse conditions. Cercariae swim in water and can be carried downstream by currents. Meacercariae frequently form at the surface of water, enabling them to float for long periods. Currents in water course can also carry parasites that have gained access to the water accidently, such as after flooding or heavy rainfall.

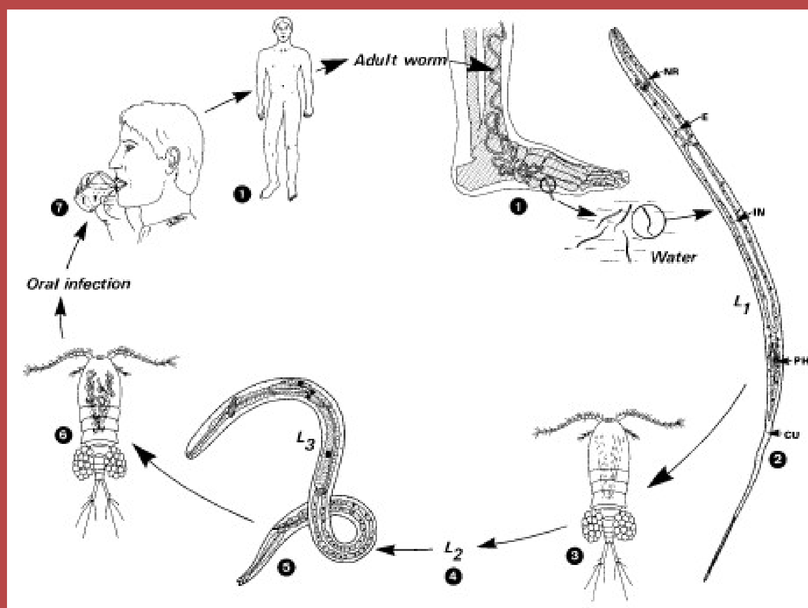

Fig.3. Life cycle of *Dracunculus medinensis*. 1. Larvae are released into the water; 2. Larvae; 3. Cyclop; 4. L2 Second larval stage; 5. L3 Third larval stage; 6. Larvae in flea; 7. Oral infection

Rainfall can cause spread parasites on ground surface. Larvae of nematodes may be moved short distances on pasture by rainfall. Rainfall tends to scatter faeces , thus disseminating larvae that will emerge later. Movement of water through soil has little or no influence on the migration of nematodes in soil, except that the presence of a film of moisture is necessary for nematodes to move.

iii)Animals

Animals use to disperse parasites mechanically, e.g., African trypanosomes by Tabanid flies, which feed quickly and move to another host within a few hours. This mechanism is responsible for the considerable extension of trypanosomiasis beyond the tsetse belt.

A symbiotic association known as Phoresy (discussed in detail in **Topic 1**) is also of importance for mechanical transmission of certain parasites,e.g., eggs of *Dermatobia hominis* are carried by mosquito on its body.

Various coprophilic flies and cockroaches have been incriminated in transport of protozoan cysts Earthworms, coprophagus beetles, and coprophilic flies have been reported to transport various nematode eggs and larvae. Flies have been found to transport tapeworm eggs. The transportation occurs via the integument or via the digestive tract. Many species of beetles are deleterious to parasites, either disrupting the faecal mass before larval development can occur or crushing the eggs while feeding on faeces. Occasional reports of lice attached to the phoretic hippoboscid flies are interesting but probably of minor importance for dissemination of lice.

Eggs of cyclophylidean tapeworms exit from the host still contained within the shed progllotid. The eggs (Fig. 4) are released from the progllotid and disseminated over a short trail while the motile progllotid crawls across the ground, the eggs being squeezed out of the end of the progllotid.

However, *Thysanosoma actinoides* varies this procedure. As the progllotid is dropping to the ground, it undergoes a violent spasmodic contraction, producing a fine spray of egg capsules for distances up to 20 cm. This disperses the eggs, making them available to intermediate hosts that are not associated with faeces.

Fig. 4. Egg packet of *Dipyllidium caninum*

iv) Plants

The inactive larvae of bovine lungworm *Dictyocaulus* (Fig.5) cannot leave the the faecal pat on their own power. The infective larvae migrate to the surface of the faecal pat about the same time that an abundant growth of sporangiophores of the fungus *Pilobolus* appears. The larvae crawl onto the sporangia, which then explode, sending the larvae as far as 3m. Fresh sporangiophores appear daily , and the fungus is present in about 95% of bovine fecal pats in great Britain. While the disatance may seem small , it suffices to place the larvae onto grass that cattle will graze.

Fig. 5 .A lung worm larva with typical tail appendage (arrow)

v) Action of man

The actions of man can a great role in the dispersal of parasites. The construction of dam can change the environment, creating opportunities for parasites to extend into new areas. The effect of construction of the Aswan High Dam in Egypt is one the best example in this regard. Schostosome infected snails moved upstream from the delta and the lakes behind the dam created conditions conducive to the introduction of the malaria vector, *Anopheles*. Construction of irrigation channels in Africa has extended the breeding sites of *Simulium* and the Turkey has led to the dissemination of *Fasciola*. The use sludge from municipal sewerage plants and from manure pits to fertilize pastures is another potential method of dissemination of parasite. Conventional sewage treatment is inadequate to destroy the eggs of *Taenia*, or nematode eggs and larvae. Temperatures of about 40^0C are needed to kill hardy eggs like *Taenia* and *Asaris*. Otherwise prolonged storage in ambient temperatures is necessary before the sludge can be considered reasonably safe for use on pastures. Under such conditions, *Taenia* eggs survive more than 6 months, trichostrongyle larvae up to 6 months and *Ascaris* eggs more than 12 months.

vi)Importation of animals

Parasites are frequently imported outside their natural range. Whether or not, the parasite survives in the new locality may depend more on the environment itself than on available hosts, but some parasites are remarkably adaptable. Parasites with simple life cycles , are more likely to adopt to the change in environment than are parasites with complex cycles. Because the double coincidence of suitable intermediate hosts and definitive hosts in the new area is somewhat remote. In rare instances, an imported parasite with an indirect life cycle may adept to a new intermediate host and becomes established .

Often *migratory hosts* may import parasites. A parasite *Ornithodoros moubata* has been seen in Africa to disseminate along the travel route of man. Probably, the parasites were dropped from the clothing of man and from their companion animals during travel.

Migratory birds could serve as a vehicle for the introduction of subtropical ticks into the temperate areas.

The *introduction of intermediate hosts* to a new area may be responsible for the introduction of a parasite.

The rigid control measures taken against introduction of infectious diseases like FMD, Newcastle Disease, are not observed against most parasitic diseases. This coupled with increasing intercontinental commerce , allows for greater possibilities for the importation and introduction of exotic parasites. Fewer parasites gain a foothold in a new area (introduced) than are brought into a new area (imported), because all conditions may not be suitable for survival and transmission in the new locality.

3.Survival and Development away from host

After a parasite has exited out from the host, it must successfully survive a period of time in the external environment in order to complete the transmission to the next host., be it an intermediate host or a definitive host. Climates that are uniformly ideal throughout the year foster continual transmission , and infections are curtailed only by the host’s response. Climates that are not uniform throughout the year produce an annual rhythm of transmission , with little or no transmission during the benevolent seasons.

i)Effect of weather

Components of weather which are most important for the survival and development of parasites in environment are temperature and moisture. Temperature moisture data collected from a standard weather shelters may have little relationship to actual conditions in the micro-environment of the parasite on the ground in the herbage. The type of habitats may influence how much discrepancy there may be. Open habitats may have soil temperatures higher than those of the weather shelter , while grassy , wooded or otherwise protected micro-environment may have lower temperatures.

a) Temperature

Parasites generally do not develop below 10^0C or above 40^0C. There are zones above and below this developments zone where the parasites merely survive and temperatures beyond these latter zones are lethal. Generally, temperatures above 40 -45^0 C are rapidly lethal , and most parasites can withstand freezing for at least short durations. Different geographic strains of a parasite may vary in tolerance to the effects of temperature. Within limits, the rate of development of most parasites outside the host is increases with the increasing temperatures, but the length of survival decreases with increasing temperatures. Therefore , parasite development progresses slowly in each year in spring and autumn, , when temperatures are somewhat cool. Many nematode parasites for example, trichostrongyles in ruminants may undergo only two or three generations per year.

b) Overwintering

Most helminth parasites has the overwintering capability in many climates. Parasites can overwinter in host also. Parasites overwintering both inside and outside the host contribute to the resumption of transmission in the spring. Generally, nematode larvae that have hatched from the eggs are more resistant to freezing tem[rapture than are the undeveloped eggs of the same species. In some species , the larval development is completed within the eggs, and the infective larva remains within the egg shell . Such eggs are characterized by thick, protective shells are resistant to effects of weather, and remain infective for long periods. Similar protection is offered by the stout metacercarial cyst of *Fasciola* and the thick empbryophore of *Taenia*.

c) Moisture

Soil moisture and relative humidity are also very important determinant for parasite survival . Desiccation is the most important determinant of survival in nature of taeniid eggs. , bovine lungworm larvae, equine strongyle larvae, and ascarid eggs, while trichostronglye larvae can withstand a greater degree of desiccation. Desiccation may enhance survival o trichostrongyle larvae. Metaceracriae of *Fasciola* die within minutes after the cyst wall becomes dry. Hard ticks are typically sensitive to desiccation , so they prefer rough , protected terrain where the microclimate is stabilized at about 80% relative humidity. These ticks loose much water via transpiration at relative humidities lower than 70%. Soft ticks , on the other hand are well adapted to hot, arid climates, surviving well in microclimates as dry as 20% relative humidity. For oocysts of coccidia, adequate environmental moisture is necessary for survival. It has long been noticed that moist litter conditions in poultry houses foster oocysts development and survival, leading to severe outbreaks of coccidiosis.

d) Sunlight

Sunlight has a lesser effect on parasites , but it has been very difficult to separate this effect from that of heat. Some parasites that have larvae remaining within the eggs have pigmented eggshells, which may offer the larvae some protection from the effects of sunlight. However, the brown eggs of *Asaris* offer very little protection against sunlight, so the degree of protection offered by pigmentation of the shell is open to further examination. Much more protection is offered by herbage and slope of the land. Shade from grass cover is considered to be very protective factor, not only from sunshine but also as a stabilizing factor for all components of the microenvironment.

4. Host finding

i. Passive host finding

Various active and passive schemes are used to locate another suitable host once the parasite has developed to an infective stage. For protozoan and helminth parasites with direct life cycles, the typical scheme is passive, i.e., the infective parasite lies more or less in the same site in which it developed and awaits the arrival of the host. A typical example is the nematode egg or larva awaiting ingestion by a susceptible herbivore ranging and grazing the area. Many host that are otherwise totally susceptible to a parasite are not infected in nature because of feeding habits. Awaiting ingestion by a suitable host involves a large element of chance and parasites using this scheme are prolific and /or long lived to offset this. The ruminant hookworm *Bunostomum*, can find a new host only when the faeces in which it lies adhere to the host's skin, a process that requires the correct host as well as the correct consistency of faeces.

Some parasites have developed certain behavior patterns in order to increase their chances of being acquired by a host. Metacercariae of *Fasciola hepatica* prefer to encyst on green parts of plants and on higher parts of the plant, thus increasing their chances of ingestion by a host. Larvae of *Thelazia callipaeda* , which live in the conjunctival sac, float in the lachrymal pool so that, they become more accessible to muscoid vectors.

Another phenomena that can be considered as passive behavior is the appearance of microfilariae at certain times of the day in the blood is generally known as ***periodicity***. The phenomenon coincides with the feeding habits of the vector. In those microfilariae that are transmitted by blood sucking arthropods, a nocturnal periodicity (i.e., complete or partial absence in daytime, large numbers in nighttime) is seen for example, *Dirofilaria immitis*. Some species of microfilariae instead of circulating in the blood, accumulate in various parts of skin. These accumulation site corresponds to the sites of the vector. For example, *Simulium* (black flies) feeds 80% of the time feeding near the umbilicus of cattle., where 90% of the microfilariae of *Onchocerca cervicalis* accumulate . Many arthropod ectoparasites spend part of their cycle away from the host. If the host is available only intermittently, the parasite may wait the nest and synchronize its life cycle with that of the host. Some Hippoboscid flies of migratory birds lay larvae that pupate rapidly while the bird is nesting , but abandoned pupae undergo diapauses and await the seasonal return of the host.

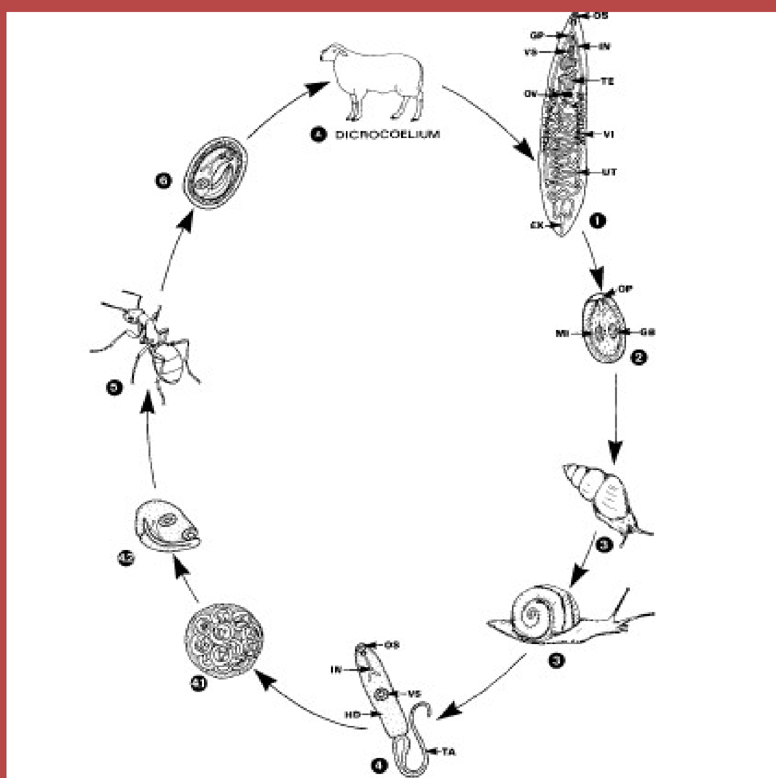

Fig. 6. Life cycle of *Dicrocoelium dendriticum*, a liver fluke of sheep. 1. Adult fluke; 2. Egg ; 3. Land snail; 4. Cercaria ; 4a and 4b. Slime ball ; 5. Ant *Formica* sps. ; 6. Metacercaria; 7. Final host sheep

Predators seem to prefer to attack animals that exhibit an abnormal appearance or behaviour pattern . Parasites that occur in these victimized animals, may have caused such changes , thus increasing the chance o success of host finding. Many examples of this are known , and many more may exist. A classic example is that of the ant infected with metacercariae of *Dicrocoelium dendriticum* (Fig.6) spastically adhering to herbage , making the ants accessible to grazing sheep. Wild ruminants heavily infected with *Echinoccous* cysts usually become debilitated , making them easier prey for wolves, which harbor the adult *Echinococcus*. The snail vector for *Fasciola* is normally amphibious, but infected snails remain inactive in the water, thus aiding cercarial release. Grasshoppers infected with *Tetramers* larvae become sluggish, and flour beetles *Tribolium* infecte with *Raillietina* cysticercoids do not seek concealement. Disorientation an paralysis make sheep infected with *Multiceps multiceps* or mice and squirrels infected with *Bayilisascaris columnaris* larvae in the brain easy prey. Infections by *Macrocanthorhynchus* in the beetle intermediate host may stunt the growth of the beeltes. It is possible that stunted beetles are in some way easier prey for the swine host.

Many nematode parasite that rely on passive host finding undergo larval development in faeces. Because host animals are very reluctant to feed immediately adjacent to faeces, the larvae must emigrate from faeces to have a chance to be ingested. Emigration is accomplished by the infective larvae, earlier stages usually staying in the faeces. Horizontal migrations up to 1 m can occur, but most larvae remain well within the 30 cm of the fecal mass. A fecal mass serves as reservoir of emigrating larvae for up to several months, presumably due to varying rates of development of eggs at different depths of the faecal mass and to random migration routes taken by larvae within the faeces. The release of larvae from the faeces may be due to weathering of the faeces more than to active emigration. A film of moisture (dew or rainfall) is needed for the larvae to migrate in soil or on herbage. The migration from faeces to herbage may be random and not affected by a specific taxis or attractions. , whereas the traditional view is that, negative geotaxis accounts for vertical migration on to herbage. Since nematode larvae have no known photoreceptor, phototaxis probably is not involved in migration. However, the importance of vertical migration on to herbage is in question, only a small percentage of larvae climb herbage. When in soil , most larvae remain in top 5 cm and they move better and live longer in looser soils that can adequately oxygenated .When on herbage, almost all larvae remain on the lower parts , not more than 10 cm from the ground.

ii. Active host finding

Active host finding is practiced by most parasitic arthropods , by trematode miracidia and cercariae and by some nematode larvae. Most dipterans (mosquito, blowfly, tsetse etc.) have well developed sense organs and powers of flight so that, they can actively seek a host. Various stimuli that emanate from all warm blooded animals, e.g., warmth, water vapor, carbon dioxide fatty acids, amines are nonspecific exciters for dipterans and occur in a plume drifting downwind from the host. receptors on antennae and palps of insects, upon encountering the host stream cause the insects to respond to increasing gradients of these stimuli , bringing them closer to the host. Different insects may respond to certain components in the host stream in different ways. A component that is taxic for one insect may not be taxic for another. Ticks have a receptor known as Haller's organ on the dorsal surface of the tarsus I that is sensitive to 'humidity' and 'odor'. Ixodid ticks climb vegetation and await the arrival of a host. When the waiting tick encounters the host stream , it waves its legs , reaching out to grasp the nearing host.

Trematodes have two larval stages that may be involved with active host finding, the miracidium that hatched from eggs and the cercaria that emerged from snail.

Freshly hatched miracidia swim rapidly, while miracidia 2h old swim slowly and have lost the infectivity for the snail. Miracidia seeking bottom-feeding snails have positive geotaxis and those top feeding snails have negative geotaxis.

Cercairae emerging from the snail also undergo active host finding in many cases (Fig. 7). Different species of cercariae show varying combinations of phototaxis and geotaxis. Generally, cercariae infecting vertebrates are positively phototactic.

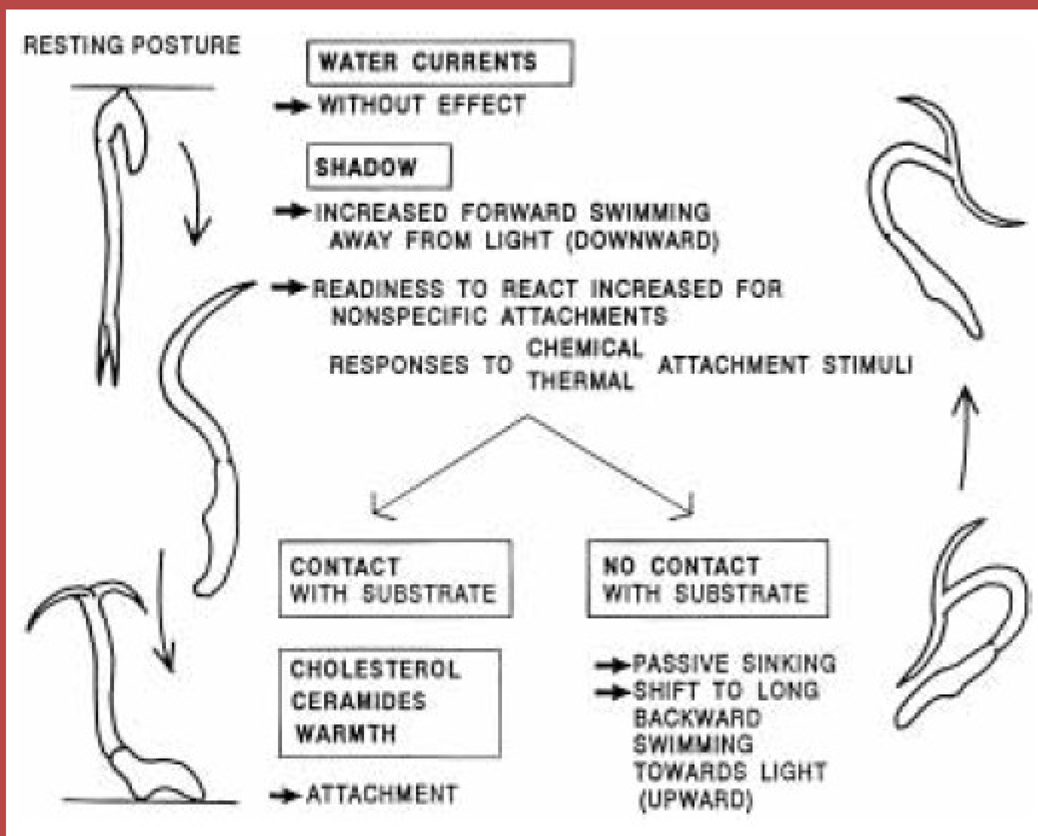

Fig. 7 Host-finding of a duck parasite Trichobilharzia ocellata . Function of the cercarial responses to external stimuli are shown in boxes

Nematode larvae that penetrate host's skin , e.g., hookworm, *Strongyloides*, show active host-finding responses similar to those in other groups of active hostseekers. The most important stimuli are heat and carbon dioxide. The infective larva is inactive until stimulated, at which time it becomes active for several minutes, and then again assumes the resting posture.

5. Entrance into the next host

The successful endpoint of transmission is entrance into a susceptible host. What determines the suitability or susceptibility of host has not been fully answered , but anatomical , genetic , biochemical and immubnological characteristics play a role.

i. Passive entrance

In the case of most parasites, entrance into the host is the result of being ingested or being inoculated into the host by a vector.

ii. Active entrance

Some parasite enter the host by active penetration of the skin. Miracidia typically penetrate into the snail host , and some cercariae , e.g., schistosomes and some nematode larvae, e.g., hook worm, *Strongyloides* penetrate into the vertebrate host. Penetration by the miracidia tends to occur around the tentacles or the foot but may occur at any convenient exposed site. Penetration is believed to be mediated by histolytic secretions from glands in the miracidia with muscular actions aiding the penetration. The penetration is very irritating to the snail and heavy infections may kill the snail within a few days as a result of visceral tissue damage. Cercarial penetration of the vertebrate host follows considerable exploration of the skin , searching for a suitable wrinkle , hair follicle or break in the stratum corneum. It is believed that muscular action aided by histolytic enzymes effects penetration. Infective nematode larvae that penetrate the host's skin turned to orient themselves perpendicularly to the skin surface. Entry is possible any on the host's body, but the larvae search hair follicles, wrinkles, or microlesions for penetration. Penetration of the keratin layer is complete within 5 minutes and appears to be entirely mechanical. The larva moves parallel to the skin surface during penetration. After entrance in the epidermis , further penetration into and through the dermis is either enzymatic or mechanical .

A special case of host entrance is the autoinfection, which is immediate and direct reinfection of the same host animal by infective stages from its own parasites. In this case ,the same benefits that are enjoyed by the parasite in tranplacental transmission are present. Several parasites have been reported to produce autoinfection , some of which are *Hymenolepis nana*, *Filaroides hirtih*i, *Enterobius vermicularis*, *Strongyloides stercoralis* etc.

Types of Development:

Different parasites have different types of development in their life cycle. The different types may be direct or indirect life cycle.

i. Life cycle pattern of Digenetic trematodes:-

All the digenetic trematodes have indirect life cycles. This means that, they require an intermediate host. Generally, if the trematode has an intermediate host, it usually use to be a snail (either land or aquatic). But when two or more intermediate hosts are required , the second intermediate host may be an ant, grasshopper , dragon fly (larva) , a snail , frog or some crustaceans.

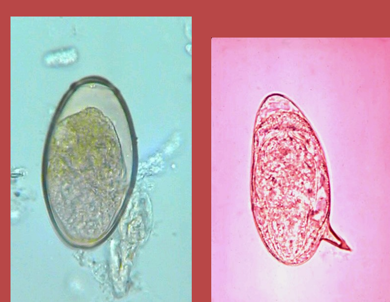

Fig. 8. An egg of *Fasciola gigantica* (left) , **operculum** is shown as thin rim at the upper pole of the egg; an egg of *Schistosoma* species (right) showing a **spine** at one side of the egg with a miracidia inside

Trematodes usually lay operculated eggs(Fig.8). An operculum is a hatch like structure at one pole of the egg.

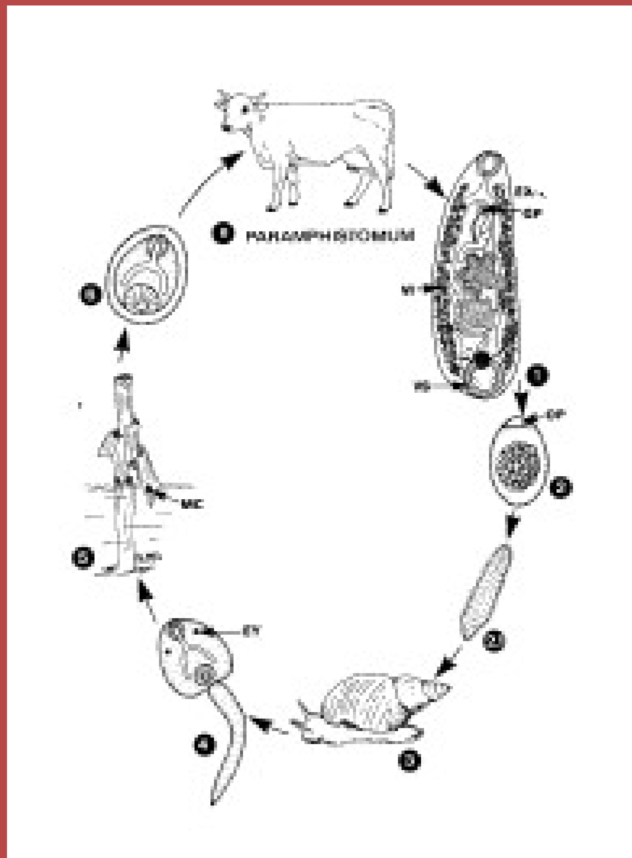

Fig. 9. Life cycle of *Paramphistomum* speices. 1. Adult parasite in rumen of cattle;
2. Operculated egg; 3. Miracidium; 4. Snail intermediate host;
5. Cercariae from snail; Metacercariae in aquatic herbage;
6. Metacercaria; infection in final host cattle

Upon proper conditions, this hatch-like structure is opened and the developing embryo is escaped. However, in case of the parasites under the Family Schistosomatidae, instead of operculum, there is one spine at one pole of the egg. When laid trematode, each egg is embryonated and under proper environmental conditions the embryo develops to a structure, known as '**miracidium'**. Hence, for embryonic development of trematdoe egg requires some time. For Schistosomatidae, the eggs (Fi.8) already contain a developed miracidium when it is laid. **There are five larval stages in the development of digenetic trematodes**. They are **miracidium**,

sporocyst, **redia**, **cercaria** and **metacercaria**. In most of the flukes, the eggs hatch and release the miracidium in or near the water. These enter into the snail intermediate host and then develops into sprocysts. Each sprocyst on the other hand grow and gives rise to a number of rediae, which in turn produces a number of cercariae. Hence, one egg is capable of producing a number of cercariae. The cercariae are encysted either in aquatic vegetation or inside the body of a second intermediate host to be metacercariae. Final hosts are infected by ingestion of metacercariae along with infected vegetation or ingestion of part or whole of the body of the infected second intermediate host containing the encysted metacerariae (Fig.9).

In case of Schistosomes or blood flukes, there is no metacercarial stage. The cercariae are known as furcocercus cercariae(Fig.1). They penetrate through skin of the final host to develop into adult stage (Fig. 10).

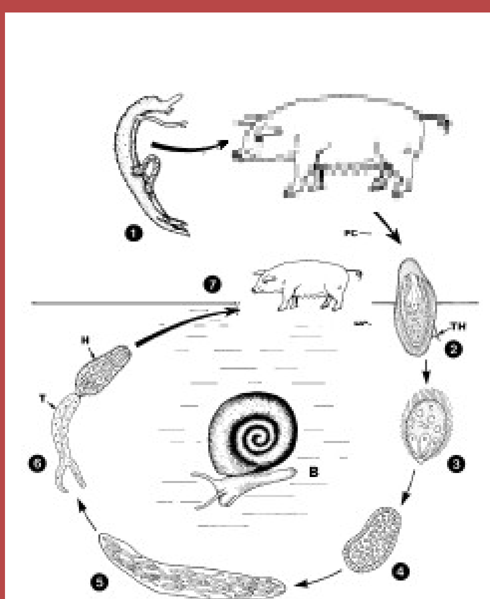

Fig. 10. Life cycle of *Schistosoma incognitum*.

1. Adult schstosome in pig; 2. Egg with miracidium; 3. Miracidium; 4. Sporocyst in snail; 5. Cercariae; 6. Furcocercus cercariae; 7. Cercariae enters pig through skin penetration

ii. Life cycle pattern of Cestodes :-

All the tapeworms have indirect life cycle, except the species *Hymenolepis nana*, in which both the direct and indirect lifecycles occur. The eggs may be embryonated or unembryonated when passed out from the host. A fully develop egg *contain* an *onchospher*e , *which* is *bilatera*lly *symmetr*ical , spherical, or oval and is armed with three pairs of hooks. Usually embryonated eggs are ingested by intermediate hosts, for example, oribatid mites, gastropod mollusks, ants, beetles, earthworms, houseflies, fleas, louse, or stable flies etc. and develop to a cystic stage known as Cysticercoid. Cysticercoid is a microscopic cystic structure, which does not contain any fluid, the scolex is invaginated inside and develops in the invertebrate intermediate hosts(Fig.11).

Fig. 11. Cysticercoids with invaginated

In Taeniid tapeworms, different vertebrates act as intermediate host , e.g., cattle, buffalo, sheep, goat and other ruminants, pigs, rabbits, hare, rats, ungulates and sometimes man in which the metacestodes or larval stages develop. One such metcestode is known as *Cysticercus*, which is a macroscopic, fluid filled cystic structure with invaginated scolex found in vertebrate host, e.g., *Cycticercus cellulosae* in pig. Other metacestodes are ***Coenurus*** (*Coenurus cerebralis*), **hydatid** cysts (Fig. 12), **Stobilocercus**, etc. The infection of the definitive host occurs either by ingestion of the whole invertebrate intermediate host or by eating raw or undercooked or not properly cooked meat of vertebrate intermediate host containing the infective metacestode or larval stage.

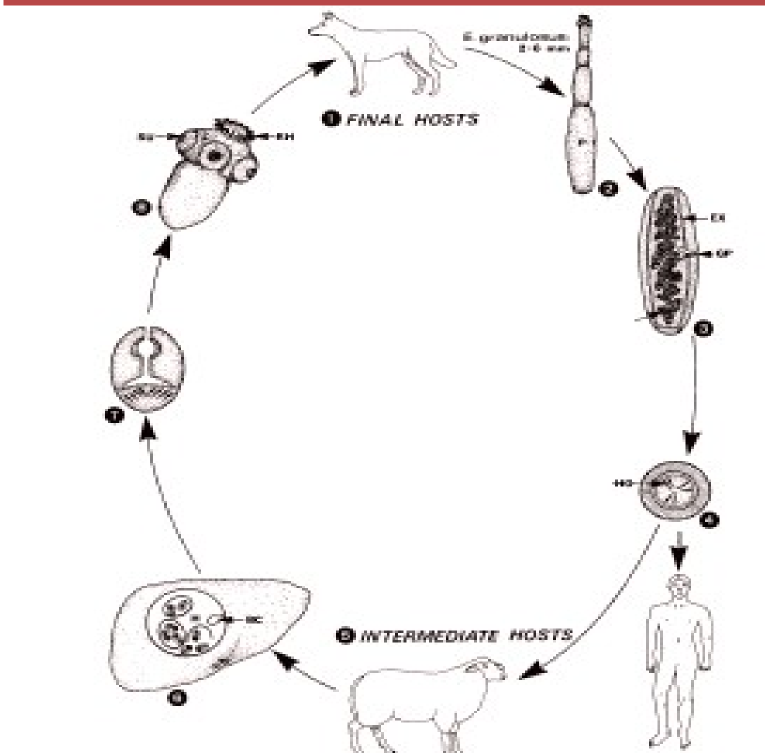

Fig.12. Life cycle of *Echinococcus granulosus*. 1. Final host; 2. Adult *E.granulosus*; 3. Gravid segment; 4.Egg with onchosphere; 5,6.Eggs ingested by intermediate host, animal or man; 6. Hydatid cyst in liver of intermediate host; 7. Brood capsule; 8. Protoscolices

Some cestodes, for example, the Class Cotyloda, require two intermediate hosts to complete the life cycle. The first intermediate host is copepod (an aquatic invertebrate belongs to crustacea) and the metacestode or larval stage is called **Procercoid.** When the infected first intermediate host is ingested by second intermediate host (mostly fishes), the second larval or metacesode stage is developed. This stage is known **Plerocercoid**. Final hosts are infected by ingestion of uncooked, or not properly cooked fish infected with plerocercoids.

iii. Life cycle pattern of nematdoes :

Nematdoes have six developmental stages . The first five stages are larval stages, known as First larval stage (L_1), Second larval stage (L_2),Third larval stage (L_3),Fourth larval stage (L_4) and Fifth larval stage (L_5). The last stage is the adult stage. Growth and moulting occurs in between two stages. In the ***Secernetian*** (for detail description of Secernetia, refer the Chapter no. 5) ***parasites*, *the infective stage is usually the L_3*** (Fig**.** 13). Nematodes which are found in the gastrointestinal tract, their eggs (and larvae) passes out along with faeces. Those in lungs and kidneys, the eggs are found in sputum and urine and develops outside the host up to the infective stage in those nematdoes which have direct life cycle; while the same larval development takes place inside the intermediate host. or an insect vector when life cycle is indirect.

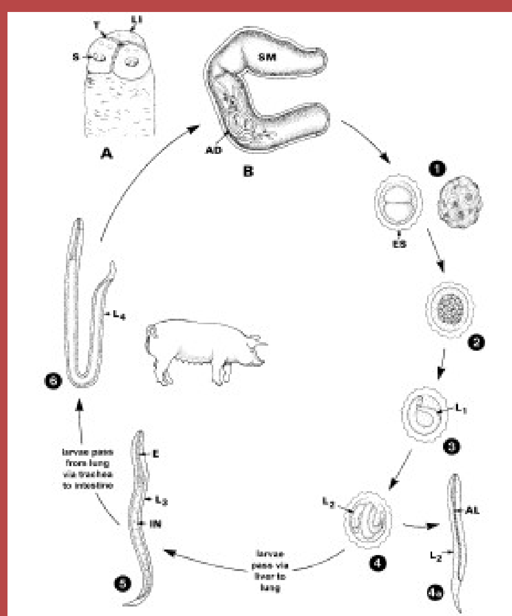

Fig.13. Life cycle of *Acaris suum*. A. Lip structure of *Ascaris* . B. Part small intestine impacted with *A. suum*; 1, 2.Developing egg; 3.Egg developing an L_1; 4 & 4a. L_1 is moulted into L_2 inside the egg. This is the infective stage for *Ascaris* sps. In other Secernetia, L_3 is the infective stage; 5. When egg containing L_2 is eaten by the final host pig, the egg is hatched and L_2 is moulted into L_3; 6.L_4 inside the final host, pig. Thereafter L_5 and adult stage will develop.

Filarid worms found in blood or tissue fluids are transmitted by blood sucking insects which act as vector or intermediate host. Beetle, houseflies, stable flies, cockroach, grasshopper, mosquitoes, tabanid flies earthworms, snails, slugs, etc. act as intermediate host and vector of nematode parasites. Various types of life cycles are found among nematode parasites depending to some extent on the degree of adoption to a parasitic existence, that has been reached. The more complete this adaptation, the more unsuited is the parasite to lead a free living existence. The most specialized forms have no period of free existence at all.

iv. Life cycle pattern of Protozoa :

The reproduction of protozoa is either asexual (binary fission,budding, mutipl fission, or schizogony, or merogony)or followed by sexual stage (gametogony, or conjugation and sporogony). Protozoa have both direct and indirect life cycle.

a. Direct life cycle :

In this type no vector is involved. The infective stages are transamitted from one animal to another through ingestion of contaminated food or water or sexual transfer. Such types of life cycle are seen in the parasites *Eimeria*, *Balantidium*, *Hexamita*, *Trichomonas* etc.

b. Indirect life cycle :

In this type of life cycle , vector species is required. Such type of life cycles are seen in *Trypanosoma*, *Sarcocystis*, *Babesia*, *Plasmodium*, *Theileria* etc. Filarid worms found in blood or tissue fluids are transmitted by blood sucking insects which act as vector or intermediate host. Beetle, houseflies, stable flies, cockroach, grasshopper, mosquitoes, tabanid flies earthworms, snails, slugs, etc. act as intermediate host and vector of nematode parasites. Various types of life cycles are found among nematode parasites depending to some extent on the degree of adoption to a parasitic existence, that has been reached. The more complete this adaptation, the more unsuited is the parasite to lead a free living existence. The most specialized forms have no period of free existence at all.

v. Life cycle pattern of Arthropods:

There are variations in the life cycle pattern of arthropods.

a. Life cycle pattern of insects:

In insects, the sexes are separate. After feritilization, either **eggs** or **larvae** are produced. Development often involves three or more larval stages followed by the formation of a **pupa** and a marked transformation or metamorphosis to the adult stage as in all the diptera (flies) and siphonaptera (flea) . This type of development is known as **holometabolous** life cycle (Fig.14). When the development occurs from egg through several nymphal stages, which resemble the adult, the life cycle pattern in known as **hemimetabolous** life cycle (Fig. 15). Different stages I the life cycle are known as instars.

Egg → **Larva** (3 larval stages) → **Pupa** → **Adult**

Fig. 14 . Stages in Holometabolous life cycle

Egg → Nymph (5 nymphal stage) → Adult

Fig. 15. Stages in Hemimetabolous life cycle

b. Life cycle pattern of arachnida:

In case of arachnida the life cycle consists of development from egg through the larva to nymph to adult (Fig. 16). Usually there is only one larval instar.

Egg → Larva → Nymph → Adult

Fig. 16. Stages in arachnida life cycle

Route of entry of parasites :

Different parasite enters into the host through different routes. The common routes of entry of parasites are :-

i. Oral :- *Fasciola*, *Taenia*, *Ascaris*, *Eimeria* etc.

ii. Skin:- Schistosomes, *Ancylostoma*, *Strongyloides* etc**.**

iii. Blood:- *Babesia*, *Theileria*, Trypanosomes etc.

iv.Sexual contact:- *Trictrichomonas foetus* , *Trypanosoma equiperdum* etc.

v. Transplacental :- *Toxocara vitulorum*, *Toxocara canis* etc.

vi. Transmammary :- *Toxocara vitulorum, Toxocara canis, Ancylostoma caninum* etc.

Development of Parasites in the Host System:-

After entry of the infective stages into a suitable host, they may encounter different forms of resistance from the host. If the parasite can successfully establish their infection, the infective stage further transforms into sexual maturity or adulthood. Every parasite species has their own preferred site of development, known as **predilection site**. For example, *Fasciola hepatica* develops in liver , *Eurytrema pancreaticum* develops in pancreas etc. Some parasite undertake an elaborate migratory route (*Ascaris*, *Fasciola* etc.) inside the host and then settle in their predilection site, while others simply go to their destination (Strongyles). The adult males and females unite and fertilize the eggs. These eggs are laid to exit out of the host and thus the life cycle is completed.

The clinical manifestations of parasitic infections may be acute or chronic. In most of the parasitic diseases, the symptoms develops slowly and are chronic in nature while compared to bacterial or viral diseases.

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