Chapter 2

REVIEW OF LITERATURE
The life-cycle study of cestodes began with the Siebold's publication (1850) on the bladder worms, who treated bladder worms as the tape worms which had got into the wrong host. After that important contribution were made by a number of workers, notable among these was G. Friedrich (1852), who observed the true relationship between the bladder worms and taeniid tapeworms. Willemoes-Suhm's studied the life-cycle of Schistocephalus (1869); Donnedieu's studied the life cycle of Ligula (1877a, 1877b); Villot gave description of the bladder worm larvae of taeniid tapeworms (1883a, 1883b); Max Braun's Zur Entwicklungsgeschichte des breiten Bandwurms. Bothriocephalus latus (1883); Schauinsland described the embryonic development of Dibothriocephalus latus (1885); Grassi's studied the life cycle of Hymenolepis nana (1887); Grassi and Rovelli (1892) and a studied the life cycle of various cyclophyllidean tapeworms.

Wagner (1954) studied the Life History of a cestode - Proteocephalus tumidocollus Wagner, 1953 in Rainbow Trout and observed the effects of temperature on the development of the tapeworm larvae. Jarecka (1959) studied the life cycle of Bothriocephalus claviceps.

Calentine (1964) studied the life cycle of caryophyllaceid cestode - Archigetes iowensis in naturally and experimentally infected hosts. Adults were found to be the seasonal parasites of fish - Cyprinus carpio, while larvae occurred in the seminal vesicle of the oligochaete - Limnodrilus hoffmeisteri.

Calentine *et al.* (1970) studied the specificity of the species of a caryophyllaeid genus for their intermediate hosts. The major factor affecting specificity involved hatching of the cestode eggs. Other contributing factors were host cellular and chemical responses and physical size of the annelid species.

Yukhimenko (1970) studied the occurrence of *Bothriocephalus gowkongensis* Yeh, 1955 (Cestoda, Pseudophyllidea) in the young of Cyprinidae from the Amur River. Tandon and Singh (1972) observed that surface water temperature above 16°C but less than 20°C, high range of penetration of light and low total alkalinity favours the growth of cyclopoids.

Molnar and Murai (1973) carried out morphological studies on *Bothriocephalus gowkongensis* Yeh, 1955 and *B. Phoxini* Molnar, 1968 (Cestoda, Pseudophyllidea). Korting (1974) studied the life cycle of *Bothriocephalus* sp. (Cestoda: Pseudophyllidea) from carp.

Anderson (1974) examined the population of the cestode - *Caryophyllaeus laticeps* (Pallas, 1781) in the bream *Abramis brama* and the same author (1976) studied the seasonal variation in the population dynamics of *Caryophyllaeus laticeps*. Mc Daniel and Bailey (1975) studied the seasonal population dynamics of helminth parasites of centrachid fishes.
Korting (1975) carried out life cycle experiments with the tapeworm Bothriocephalus sp. from carp using Cyclops abyssorum Sars as the intermediate host. Procercoid development was found to be completed after 8–10 days. Comparing the results and descriptions of previous authors, it was suggested that the cestode belongs to Bothriocephalus acheilognathi Yamaguti, 1934 according to the priority of name.

Jones (1975) studied the morphology of Bothriocephalus scorpii (Muller) (Pseudophyllidea: Bothriocephalidae) from littoral fishes in Britain. Faina and Par (1977) described the use of rinsing of the digestive tract of live carps for the diagnosis of bothriocephalosis. Davydov (1978) studied the growth, development and fertility of Bothriocephalus gowkongensis (Jen, 1955), a parasite of Cyprinidae.

Moller (1978) studied the effects of salinity and temperature on the development and survival of fish parasites. The influence of salinity and temperature on nine species was examined. The greatest resistance was found in Anisakis larvae from herring - Clupea harengus, which survived for more than half a year. Parasites in the fish intestines appeared to be unaffected by changing water salinities, as the osmolarity in the intestines stays nearly constant. High temperature increased the effects of adverse salinities on parasites.

Scott and Grizzle (1979) described Bothriocephalus gowkongensis infection of Ctenopharyngodon idella, Pimephales promelas and Notemigonous crysoleucas. The histopathology was described in these species, and haematocrits and condition factors of infected and uninfected N. crysoleucas were compared.
Priemer (1980) worked on the life cycle of *Proteocephalus neglectus* (cestode) from *Salmo gairdneri*. The incidence of invasion was observed to be 65% and the main intensity was 2.8 with a maximum of 6 worms per fish. Copepods of the *Cyclops strenuus* group and *Cyclops furcifer* were used as experimental intermediate hosts. In this study it was shown that when infected copepods were eaten by definitive host, invasion took place after 21 days at 14-15°C. A transfer of the preadult worms from trout to trout was possible. Boomker *et al.* (1980) studied Bothriocephalosis in the carp in the Eastern Transvaal.

Andrews *et al.* (1981) studied the occurrence of *Bothriocephalus acheliognathi* Yamaguti, 1934 (*B. Gowkongensis*) (Cestoda: Pseudophyllidea) in the British Isles. Goedmakers (1981) studied the population dynamics of three species in French chalk stream and observed that in spring the population dynamics was highest.

Zhongzhang (1982) examined the developmental studies on *Polyonchobothrium ophiocephalina* (Tseng, 1933) a *Bothriocephalus opsariichthydis* Yamaguti, 1934. Mckinnon and Featherston (1982) studied the location and means of attachment of *Bothriocephalus scorpii* (Muller) (Cestoda: Pseudophyllidea) in red cod, *Pseudophycis bacchus* (Forster in Bloch et Schneider), from New Zealand waters.

Granath *et al.* (1983) studied the immature, mature and gravid specimens of *Bothriocephalus acheliognathi* from mosquitofish (*Gambusia affinis*) by using scanning (SEM) and transmission electron microscopy (TEM). Font (1983) examined a seasonal population dynamics of five species of intestinal helminths of brook stickle back, *Culaea inconstans*. 
Granath and Esch (1983a) described the temperature and other factors that regulate the composition and infrapopulation densities of *Bothriocephalus acheilognathi* (Cestoda) in *Gambusia affinis* (Pisces). Granath and Esch (1983b) studied the seasonal dynamics of *Bothriocephalus acheilognathi* in ambient and thermally altered areas of a North Carolina cooling reservoir.

Hoffinan (1983) studied the Asian tapeworm - *Bothriocephalus opsarichthydis*, its prevention and control. Pool (1984) studied the stages in the life cycle of *Bothriocephalus acheilognathi* with the help of scanning electron microscopy. It was observed that the emergence of the coracidium occurred after 3-5 days at 20°C. After consumption by the copepod intermediate host, the coracidium developed into a procercoid. Upon development of a cercomer the procercoid was found to infect the fish definitive host.


Dupont and Gabrion (1986) did experimental work on 5 species of fishes to evaluate their value of paratenic hosts, in the life cycle of *Bothriocephalus claviceps*, a parasite of the eel - *Anguilla anguilla*. Hanzelova and Zitnan (1987) studied the embryogenesis and development of *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda) in the intermediate host under experimental conditions. Firdous (1986) studied the seasonal influence of helminth infection in relation to sex of the hosts - *Channa punctatus* Bloach. Agarwal (1986) studied the dynamics
and regulation of endohelminth population in fish hosts - *Clarian batrachus*, *C. punctatus* and *Colisa latia*. Eiras *et al.* (1986) described the histopathology in *Paulicea lutkeni* naturally infected with *Megathylocus brooksi* and *Jaulia glandicephalus*. *Megathylocus brooksi* attaches to the epithelium of the anterior intestine by means of suckers, resulting in damage to the epithelium of the anterior intestine by means of suckers.

Dupont and Gabrion (1987) worked experimentally on parasite specificity in the copepod-procercoid system of *Bothriocephalus claviceps*. Two criteria were used to characterize five potential host species - *Macrocyclops albidus*, *Macrocyclops fuscus*, *Eucyclops serrulatus*, *Acanthocyclops robustus* and *Macrocyclops viridus*. First criterion involved susceptibility of the copepods to infection and the second criterion involved the growth and development of the procercoid. The two most susceptible hosts were *M. albidus* and *A. robustus*.

Riggs and Esch (1987) studied the abundance, dispersion, and prevalence of the pseudophyllidean cestode - *Bothriocephalus acheilognathi*, in 3 species of fish (*Gambusia affinis*, *Notropis lutrensis*, and *Pimephales promelas*). The study was conducted in 3 ecologically distinct areas of a North Carolina cooling pond.

Riggs *et al.* (1987) investigated the differences in growth, maturation, biomass and fecundity of *Bothriocephalus acheilognathi* in three host species, conducted on metapopulations from three distinct communities in Belews Lake, North Carolina. The results demonstrate that the host suitability is determined by morphological, physiological and behavioural differences in the host species which affect transmission dynamics and the quality and stability of the entire environment.
Heckmann et al. (1987) gave new host records for the Asian fish tapeworm - *Bothriocephalus acheilognathi*, in endangered fish species from the Virgin River, Utah, Nevada, and Arizona. Pool (1987) gave a note on the synonomy of *Bothriocephalus acheilognathi* Yamaguti, 1934, *B. aegyptiacus* Rysavy and Moravec, 1975, and *B. kivuensis* Baer and Fain, 1958. Chubb et al. (1987) described the methods for the collection, fixation, preservation and examination of the cestodes parasitic in British freshwater fishes. An illustrated key to the species was provided, with the exception of members of the genus *Proteocephalus*, for which the information was tabulated.

Hanzelova and zitan (1987) examined the effect of season on embryogenesis of *Bothriocephalus acheilognathi* Yamaguti, 1934 (Cestoda). Robert et al. (1988) studied the importance of paratenic host in the biology of *Bothriocephalus gregarious* (Cestoda, Pseudophyllidea), that is a parasite of turbot.

Chuvhan (1988) studied the seasonal cycle, survival and poly parasitic infection of cestodes in hill stream fishes. Courtney and Christensen (1988) conducted experiments to assess the relationship between annelid age and susceptibility of the annelid as an intermediate host for a caryophyllaacid, as well as the effect of a mixed-species infection on the rate of metacestode development and parasite mortality.

Rusinek (1989) repeated under experimental conditions the life cycle of *Proteocephalus thymalli* (Cestoda: Proteocephalidae), a parasite of Siberian glanie (*Thymallus arcticus*). The intermediate hosts, the copepods - *Epischura baicalensis*, *Cyclops kolensis* and *C. vicinus*, were determined. The development
time of *P. thymalli* in the first intermediate host was determined and the morphology of the larval and adult phases was described.

Marcogliese and Esh (1989a) studied the seasonal population dynamics of *Bothriocephalus acheilognathi* in the mosquitofish, *Gambusia affinis*, in Belews Lake, North Carolina cooling reservoir over a two year period. Peaks in prevalence and abundance were observed during early summer and autumn. Marcogliese and Esh (1989b) studied the experimental and natural infection of planktonic and benthic copepods by the Asian tapeworm - *Bothriocephalus acheilognathi*.

Pronin *et al.* (1989) estimated the dynamics of egg production of the tapeworm - *Diphyllobothrium dendriticum* experimentally in nestlings of the herring gull - *Larus argentatus* per day and per reproductive period. It was proposed to estimate coefficient of reproduction intensity as the ratio of egg output per unit of time and maximum egg number in a mature strobile.

Robert *et al.* (1990) investigated the relationship between sympatric populations of four species of Cestoda belonging to the genus *Bothriocephalus* (*B. barbarus, B. gregarius, B. funiculus and B. scorpii*) and populations of their respective hosts - *Scophthalmus rhombus, Pserra maxima, Ciliata mustela* and *Myxocephalus scorpius*. Rkhami and Gabrion (1990) described the fine structure and differentiation of the embryonic envelops before and after hatching in two bothriocephalid species of teleostean fish. Scanning electron microscopic observation of the egg surface confirmed the specific ornamentation of the capsule. Comparison of the composition of the embryonic envelops of pseudophyllideans with those of other tapeworm orders and trematodes revealed ontogenetic, structural and functional similarities between the embyotrophic layers. Hanzelova
et al. (1990) observed that the temperature affected the numerical size of the helminth metapopulation in definitive host.

Scholz (1991a) studied the development of the tapeworm - *Khawia sinensis* parasitizing carp (*Cyprinus carpio* L.) from the release of cestode eggs into water to the formation of infective procercoid in the intermediate host under laboratory conditions. Scholz (1991b) studied the development of the tape worm - *Khawia sinensis* up to the stage of sexually mature parasites releasing eggs in an experimentally infected definitive host (*Cyprinus carpio*) at 15-16°C.

Scholz (1991c) studied a part of the life cycle of *Proteocephalus neglectus* LaRue, 1911, a parasite of trout, starting from the release of eggs from mature parasites into water, to the early phase of development in the definitive host, under experimental conditions. Special regard has been paid to development in the intermediate host - *Cyclops strenuous*. The percentage of infected copepods depended on the length of their contact with parasite eggs.

Scholz (1993) studied the development of the tapeworm *Proteocephalus torulosus* in the intermediate host under experimental conditions. Of 8 copepods used in these experiments, complete development of larvae was observed only in *Cyclops strenuous*. The infectivity of larvae from *C. strenuous* for the definitive host, cyprinid fish was very low and only one chub of 26 fish used for feeding experiment became infected.

Scholz et al. (1996) described the cestode *Bothriocephalus pearsei* n. sp. (Cestoda: Pseudophyllidea) from the intestine of the cichlid - *Cichlosoma urophthalmus* (Gunther). The new species differed from congeners mainly by the
morphology of the scolex, which was clavate, with the maximum width in its middle part, had a distinct but weakly muscular apical disc; 2 short and wide bothria and 2 elongated grooves.

Scholz (1997) studied the life cycle of the tape worm *Bothriocephalus claviceps* (Goeze, 1782) (Cestoda: Pseudophyllidea) under experimental conditions. It was demonstrated that the parasite completed its development within four months at the temperature range of 22-24°C. The rate of development of the coracidia was seen to be controlled by temperature, with delayed formation of coracidia at lower temperature.

Scholz (1999) reviewed on the basis of literary data and personal experimental observations, the life cycle of *Proteocephalus* Weinland, 1858 (Cestoda: Proteocephalidea) parasitizing fishes in the Palearctic Region. Special attention was given to the development within the intermediate and definitive host.

Scholz et al. (2001) studied the Caryophyllidean cestodes (Platyhelminthes: Eucestoda) from freshwater fishes in Japan.

Conradt and Schmidt (1992) worked on the double surface membrane in plerocercoids of *Ligula intestinalis* (Cestoda: Pseudophyllidea). They suggested that the plerocercoids are covered by two closely apposed lipid bilayers. Adult *Ligula intestinalis* removed from the gut of the final host *Anas platyrhynchos* or obtained by *invitro* transformation exhibited a single surface membrane. Tierney and Crompton (1992) examined the aspects of the infectivity of the plerocercoid stage and fecundity of the adult stage *Schistocephalus solidus*, using the chicken, *Gallus gallus* as the experimental host. Amin (1992) studied the ecology and
intraspécific relationships of Bothriocephalid cestodes in Walleys, Stizostedion vitreum.

Nie and Kennedy (1992) examined the populations of *Bothriocephalus claviceps* (Goeze) (Cestoda) in the European eel, *Anguilla anguilla* (L.), in three localities in southwest England. Nie and Kennedy (1993) studied experimentally the infection dynamics of *Cyclops vicinus* by the larvae of *Bothriocephalus claviceps*. The mean number of procercoids/copepod increased as the density of eggs increased, whilst the number of copepods surviving decreased correspondingly. The mean number of parasites/copepod and the mortality of copepods were found to increase with the increase in time of exposure to eggs, even when the egg density was constant. These two parameters were also found to differ between gravid female copepods and unsexed young copepods.

Sysoev *et al.* (1994) studied the morphology of procercoids of four *Proteocephalus* species from copepods by scanning electron microscopy. In some species, a host-dependent variability in dimension indices and microthrix density was observed. Castaneda *et al.* (1995) studied the ultrastructure of the pseudophyllidean cestode - *Bothriocephalus acheilognathi*, parasite of freshwater fish of commercial importance.

Dezfuli and Scholz (1995) studied the occurrence of the tapeworm *Cyathocephalus trunacatus* (Pallas, 1781) (Cestoda: Spathebothridea) in its intermediate host, the amphipod - *Echinogammarus stammeri*, in the River Brenta. Tapeworms were localized in the anterior portion of each amphipod's hemocoel.
Morley and Hoole (1995) studied the Ultrastructural studies of the host-parasite interface between *Khavia sinensis* and *Cyprinus carpio*. Pathology induced in the gut included loss of microvilli, compression of enterocytes and shedding of host material into the gut lumen. An interface layer occurred between the gut wall and the neck and posterior scolex of the parasite. A cellular response, which was evoked either by the worm or the damage induced, comprised eosinophils, macrophages and lymphocytes.

Varriale *et al.* (1996) studied the influence of temperature and light on the development of the eggs of three species of *Bothriocephalus* (Cestoda: Pseudophyllidea). Dove *et al.* (1997) studied in the Australian freshwater fishes, the Asian fish tapeworm - *Bothriocephalus acheilognathi*.

Wedekind (1997) studied experimentally the infectivity, growth and virulence of *Schistocephalus solidus* in their first intermediate host, copepods of the species *Macrocyclops albidus*. Eleven or 14 days post-infection, the presence and growth of the cestode larvae relative to survival, growth and reproduction of their host were determined. Wedekind *et al.* (1998) gave the evidence for strategic egg production in a hermaphroditic cestode. It was tested whether egg production differs between *Schistocephalus solidus* that reproduce alone and those that are allowed to reproduce in pairs. Egg production in an in vitro system was found to depend on the cestodes social situation. When kept alone, larger cestodes produced larger eggs. This was not so when kept in pairs – the difference between these two reproductive modes was found to be highly significant in this respect. Further experiments revealed that these hermaphrodites produced a larger total egg mass when kept alone than when kept in pairs.
Shimazu (1999) redescribed and studied the life cycle of *Gangesia parasiluri* Yamaguti, 1934 (Cestoda: Proteocephalidae). Its life cycle was studied in the field as in laboratory. Procercoids were formed in haemocoel of *Mesocyclops leuckarti* (Claus) (Copepod: Cyclopidae) 7 days post infection at 21-25°C. They developed into plerocercoids in the intestine of pseudorasbora - *Pumila pumila* Miyadi (Teleostei: Cyprinidae), *R. Brunneus* and *S. Asotus*. Plerocercoids were fed to sasotus, from which immature worms were recovered.

Dorucu (1999) studied the seasonal variation in natural levels of infection with procercoids of pseudophyllidean cestodes - *Diphyllobothrium spp.* and the abundance of *Cyclops strenuus abyssorum* (copepod) in Loch Lomod, Scotland. The prevalence of infected copepods was found to increase with the temperature of water, a peak occurring in June, while relatively low levels were recorded between December and March. The population density of *C. strenuus abyssorum* also exhibited seasonal variation.

Zadarska and Nebesarova (1999) studied the structural differences of microtriches and distal cytoplasm of the tegument in the apical and lateral suckers, scolex proper and neck of *Proleocephalus macrocephalus* (Eucestoda: Proteocephalidae) collected from the European eel - *Anguilla anguilla* in the Czech Republic. Variations were observed in the shape of microtriches covering the different parts of the scolex and neck.

Dezfuli et al. (2000) studied the species associations among larval helminths in an amphipod intermediate host. The results showed that the associations among helminth species in intermediate hosts are not random, and are instead the product of selection favouring certain pathways of transmission. Heckmann (2000) studied the Asian tapeworm - *Bothriocephalus acheilognathi* (Yamaguti, 1934), its control methods and effect on endangered fish populations.

Okaka (2000) worked on the maturity of the procercoid of *Cyathocephalus trunatus* (Eucestoda: Spathebothriidae) in *Gammarus pulex* (Crustacea: Amphipoda). The procercoids harboured in the body cavity of *Gammarus pulex* for over one year of infection were seen structurally matured and produced viable eggs. The eggs were found to develop to infective onchospheres in 24 days when cultured at 25°C. Young specimens of *G. pulex* were infected with the onchospheres and the early procercoids of the infection also develop to mature one in three months thus establishing the life cycle of tapeworm using only *G. pulex* as the host.

Nie et al. (2000) studied the occurrence of *Bothriocephalus acheilognathi* in cyprinid fish from three lakes in the flood plain of the Yangtze River, China. Jones (2000) described the ultrastructure of the tegument of scolex, bothridial pits (ciliated pits) and rhyncheal system of *Otobothrium mugilis* (Cestoda) from plerocerci collected from the teleosts - *Arius graeffei* and *Mugil cephalus*. Scanning electron microscopy revealed that filamentous microtriches were abundant across the entire surface of the tegument. Palmate microtriches were dominant on the bothridia and their margins.
Saksvik (2001) worked on the life cycle of *Eubothrium* sp. (Cestoda: Pseudophyllidea), from Atlantic salmon (*Salmo salar* L.). The life cycle was completed in one year and included only one intermediate host (*Acartia tonsa* Dana) (Copepoda: Calanoida). The larvae developed in the haemocoel of the copepod after 15 days post infection at 16°C. The total prevalence of *Eubothrium* sp. in the salmon after infection was 95.3% with mean intensity of 15.0 (1-87). The infected Salmon were kept in the laboratory where the growth of the cestodes was studied for eleven months. Growth and maturation of the cestodes were dependent on the number of worms present in the intestine.

Cohen *et al.* (2001) studied the surface topography and ultra structure of the tegument of *Paranaella luquei* Kohn, Baptista-Farias & Cohen, 2000, a microcotylid monogenean parasite from the gills of *Hypostomus regani* (Ihering, 1905) (Loricariidae), by scanning (SEM) and transmission electron microscopy (TEM). Kurovskaya (2001) described the influence of the cestode *Bothriocephalus acheilognathi* on morphological and physiological characteristics of carps reared in warm water.

Franz and Kurtz (2002) studied the altered host behaviour in tapeworm-infected copepods. According to their study parasites are able to influence intermediate hosts in a way that optimizes their growth and transmission to the next host. *Macrocyclops albidus* (Copepoda) suffer from a reduced escaping ability and an increased level of general activity, when infected with *Schistocephalus solidus* (cestode). This facilitates predation by the subsequent host, the three spined sticklebacks. Their study suggests that behavioural changes in infected copepods are mediated by a mechanism different from energy depletion or a re-allocation of
resources between muscles and lipids. They rather proposed that the tapeworms directly manipulate copepod behaviour.

Xiang-Hua (2002) studied the population of Bothriocephalus acheilognathi, a parasite in juvenile grass carp. The tapeworm population in age 0 and overwintering age of grass carp followed an annual cycle from its establishment to its decline, whereas age of commercial sized fish was not affected. A high level of prevalence in winter led to a peak in early spring and a high level of mean intensity in the following months.

Van der Veen and Kurtz (2002) studied the outcome of infection of the (intermediate) host, the copepod - Macrocyclops albidus, with the cestode - Schistocephalus solidus. According to their study during the establishment phase of the parasite, the host may firstly avoid ingesting the parasite and, secondly, may prevent the parasite from entering the body cavity, and, thirdly during the growth phase of the parasite, the host’s immune system may eliminate the parasite from the body cavity. They were able to study the growth phase separately from the establishment phase.

Heins (2002) demonstrated the occurrence of the crowding effect in plerocercoids of the cestode - Schistocephalus solidus infecting three spine stickleback - Gasterosteus aculeatus from Walby and Scout lakes, Alaska. There were significant differences in infection between the two lakes, including different distributions of parasite intensities among hosts and different expressions of the crowding effect.
Salgado and Lopez (2003) studied the geographical distribution of the *Bothriocephalus acheilognathi* the fresh water fish of Mexico, highlighting infections in autochthonous and endemic species it compiles the existing information and presents original data.

Falavigna *et al.* (2003) reported the occurrence, prevalence and infection intensity of proteocephalidean larvae in naturally infected intermediate hosts of the Upper Paran River floodplain. Eight cyclopid copepods - two copepodids, one male and five females - comprising 0.3% of the cyclopid copepods examined, were naturally infected.

Poddubnaya *et al.* (2003) studied the ultrastructure of *Archigetes sieboldi* (Cestoda: Caryophyllidea): relationship between progenesis, development and evolution. Their observations demonstrate that progenetic *Archigetes sieboldi* shares characteristics of both larval (progenetic) and adult stages. As a result of the progenetic development there has been a secondary reduction in the life cycle of *A. sieboldi*. It was postulated that a similar process of progenesis may have played a major role in the early evolution of the Caryophyllidea by first appearing in a plerocercoid stage of an ancestral strobilate cestode from fish.

Schjorring and Luscher (2003) tested the hypothesis that the cestode - *Schistocephalus solidus*, is capable of premature gamete exchange as a plerocercoid in the last intermediate stickleback host. They suggested an alternative hypothesis to explain the higher hatching rate of eggs produced by cestodes from doubly infected fish as compared to those from single infections.
Blend and Dronen (2003) described *Bothriocephalus gadellus* from the intestine of the beardless codling - *Gadella imberbis* from the southwestern Gulf of Mexico, with a review of *Bothriocephalus* Rudolphi, 1808.

Aydogdu *et al.* (2003) examined the seasonal variations and the effects of host size and age on parasite prevalence and abundance in a wild population of common carp (*Cyprinus carpio*) from Iznik Lake in Turkey. Twelve monthly samples were collected which revealed one species of monogenean - *Dactylogyrus extensus*, and two species of cestode - *Caryophyllaeus laticeps* and *Bothriocephalus achenognathi*.


Torres *et al.* (2004) studied the identification of the copepod intermediate host of the introduced broad fish tapeworm - *Diphyllobothrium latum*, in Southern Chile. In this lake, the highest levels of infection by this tapeworm occur in the introduced rainbow trout - *Oncorhynchus mykiss*. Of the 2 calanoid copepods found in Lake Panguipulli, *Diaptomus diabolicus* and *Boeckella gracilipes*, only *D. diabolicus* became infected on experimental exposure to coracidia.

Piasecki *et al.* (2004) presented the importance of Copepoda in Freshwater Aquaculture. Copepods play major roles in pond ecosystem, serving as, food for small fishes, micropredators of fish and other organisms, fish parasites, intermediate hosts of fish parasites, and hosts and vectors of human diseases.
Al-Bassel (2005) studied the *Phyllobothrium lactuca* (Cestoda: Phyllobothriidae) and *Philometra salgadoi* (Nematoda: Philometridae) parasitizing *Boops boops* from the Mediterranean Sea, Egypt. Both were identified using standard keys, and examined by Scanning Electron Microscopy (SEM). The two parasites represent new host record of *B. boops*.

Bertasso and Oldewage (2005) studied the aspects of the ecology of the Asian tapeworm - *Bothriocephalus acheilognathi* Yamaguti, 1934 in yellowfish in the Vaal Dam, South Africa. The cestodes were identified as either *Bothriocephalus acheilognathi* Yamaguti, 1934 or "other cestode spp.". The majority (99.8%) of the cestodes found in both yellowfish species were identified as *B. acheilognathi* (Asian tapeworm). The prevalence, mean intensity and abundance of *B. acheilognathi* in both yellowfish species were calculated.

Ibrahim and Mackiewicz (2006) with the help of light and electron microscopy, studied the development and morphology of the scolex and mode of attachment of *Wenyonia virilis* Woodland, 1923, a caryophyllid cestode from the silurid Nile fish *Synodontis schall* (Bloch et Schneider, 1801). Scolex and genital primordial changes through four stages of juvenile development were described.

Selver and Aydogdu (2006) studied the occurrence of helminths during spring and autumn months on rudd (*Scardinus erythrophthalmus* L. 1758) from Kocadere stream. A total of 87 rudd fish were investigated. Of these, 66 were infected with four species: *Dactylogyrus difformis* (Monogenea), *Diplodistomum spathaceum* metacercaria with *Asymphodora markewitschi* (Digenea), and *Hysterothylacium* sp. (Nematoda).
Rocka (2006) studied the helminths of Antarctic fishes, their Life cycle biology, specificity and geographical distribution. Dejen et al. (2006) studied the effects of diet, season and habitat occupation on the prevalence of plerocercoid larvae of the tapeworm - *Ligula intestinalis* in two closely related small barbs and the effects of the parasites on the barbs life histories in Lake Tana during one year. In all effected barbs, *L. intestinalis* caused retardation in gonad development, maturation at reduced size, and lower absolute fecundity.

Poddubnaya et al. (2007) studied the ultrastructure of the proglottid tegument (neodermis) of the cestode *Echinophallus wageneri* (Pseudophyllidea: Echinophallidae), a parasite of the bathypelagic fish *Centrolophus niger*. Ba et al. (2007) studied the ultrastructure of the spermatozoon of *Bothriocephalus claviceps* (Cestoda: Pseudophyllidea), a parasite of *Anguilla anguilla*.

Kuchta et al. (2007) carried out a comparative study of the scolex hook morphology of five species of tapeworms of the genus *Trienophorus* Rudolphi, 1793 (Cestoda: Pseudophyllidea), parasites of pikes (*Esox lucius* L. and *E. reichertii* Dybowski) in the Palaearctic Region. Measurements of scolex hooks of 81 plerocercoids and 492 adults from different hosts and regions were compared using basic statistics and forward stepwise linear discriminant analysis. The shape of the scolex and that of tridental hooks were found to be suitable only for differentiation of the taxa with a similar shape of hooks.

Xiang-Hua, (2007) studied the Diversity of the Asiatic tapeworm - *Bothriocephalus acheilognathi* parasitizing common carp and grass carp in China. Distinct diversities were noticed. The hatching period of eggs at 27°C–28°C was 1.69 ± 0.2 d in grass carp tapeworms and 3.98 ± 0.3 d in worms in common carp.
Hansen et al. (2007) examined the role that predation of infected conspecific fish and postcyclic transmission might play in the life cycle of the Asian fish tapeworm - *Bothriocephalus acheilognathi*. This study provided evidence that postcyclic transfer of *B. acheilognathi* could occur. Postcyclic transmission might be an important life history trait of *B. acheilognathi* that merits consideration when studying the impact and distribution of this invasive and potentially pathogenic tapeworm.

Jarkovsky et al. (2007) studied for the first time the seasonal cycle of the cestode - *Proteocephaltis sagittus* (Cestoda: Proteocephalidae) in the stone loach - *Barbatula barbatula* from the Hana River, Czech Republic. The parasite occurred in loaches throughout the year but infection parameters differed significantly among seasons, with the highest values of prevalence and abundance from the late winter to the early summer.

Hammerschmidt and Kurtz (2007) studied the establishment process of *Schistocephalus solidus* tapeworms in their second intermediate host, the three-spined stickleback, from oral uptake after experimental exposure, to passage through the gastro-intestinal tract and arrival in the fish body cavity.

Kuchta et al. (2008) worked on the suppression of the tapeworms of order Pseudophyllidea and proposed two new orders, Bothriocephalidea and Diphyllobothriidea.

While reviewing the work done on the fish cestode parasites of Kashmir, it becomes evident that the study started in 1927 when Faust rediscovered the metacercaria of *Neodiplostomum kashmiriensis* and *Strigea annandales* from fish.
obtained by the survey party of the Zoological Survey of India from Kashmir. Thereafter, Kaw (1941-1951) gave a detailed contribution of helminth fauna of Kashmir. After Kaw, major studies on the helminth fauna of Kashmir were carried out by Fotedar. Fotedar (1958) reported *Adenoscolex oreini*, gen. et. sp. nov., a Caryophyllaeid Cestode from the intestine of *Orienus sinuatus*, a freshwater fish from Kashmir. The same author did lot of work on the helminth fauna (1958, 59, 69, 70, 71a, & 71b). After Fotedar further contribution in the field of helminth fauna Raina and Dhar (1972); Raina, Chishti and Khan (1973); Fotedar & Qadri (1974); Raina, Chishti and Koul (1975); Fotedar & Dhar (1974a, 1974b, 1974c & 1977).

Yousuf and Qadri (1975) studied the cladocera of Malpur Sars and observed that the species composition of the cladocera of this lake was very limited. The same authors (1981a) reported on the seasonal distribution of family Chydoridae in Manasbal Lake. In another study (1981b) they found that *Diaphanosoma brachyurum* Lieven (Cladocera: Crustacea) remain confined to the deeper strata. As per their data, the species prefer water having a temperature above 20°C and pH greater than 8.0 with low quantities of CO$_2$ and bicarbonates. Yousuf et al. (1983) discussed the Crustacean communities of seven water bodies of Kashmir and attributed the relatively higher population density of cladocera and copepod in the Malla Bagh pond and Kushal Sar Lake to the higher concentration of nutrients in these waters. Yousuf et al. (1984) studied the summer and winter cladoceran communities of Anchar Lake and classified them into warm stenothermal and cold stenothermal. Yousuf and Quadri (1985) studied the seasonal fluctuation of zooplankton on Manasbal Lake and observed that more than half of the total population was represented by copepoda. During stratification zooplankton was reported to have a well marked preference for thermocline zone. Yousuf et al.
related seasonal changes in dissolved oxygen, carbon dioxide, nutrient concentration and sparseness of zooplankton association to large fluctuations in volume of water. Yousuf (1988) studied the copepod plankton of Lake Manasbal and reported that Mesocyclops leuckarti, Cyclops vicinus and Acanthodiaptomus denticornis Wierz constitute the true planktonic forms.

Raina and Koul (1977, 1984); Raina and Narain (1992). Balkhi (1983) studied the zooplankton communities of Nilnag. Balkhi et al. (1987) examined the hydrobiology of Anchar Lake (Kashmir) and observed the water to be alkaline mainly due to presence of bicarbonates of calcium and Magnesium. They recorded a bimodal pattern of zooplankton with the primary peak in summer.

Dhar and Peerzada (1989) examined the seasonal variations in helminth parasites infecting snow trout *Shizothorax niger*. They observed the peak of *Adenoscolex oreini* in winter. The same authors (1992) studied the seasonal occurrence and maturation of the cestode *Adenothorax oreini* in fishes of Wular Lake. The recruitment was observed to occur in autumn. Fayaz and Chishti (1994, 1996, 1997 & 1998); Peerzada and Fayaz (1998) studied the seasonal influence on the helminth fauna in some hill stream fishes of Kashmir valley. Ara et al. (2000) reported for the first time Pseudophyllidean cestode *Bothriocephalus* (Rudolphi; 1808) from the fishes of Kashmir. Khan et al. (2004) studied the seasonal occurrence of helminth parasites in *Schizothorax* in Dal Lake Kashmir.

The above review reveals that attempts have been made at global and national levels to study the life cycle of the cestodes, but from this region of the globe there are scanty references available and the studies are mainly of taxonomic nature. The literature survey reveals that no effort has been put in to study the cestode life cycles and the endeavour was aimed at bridging the gap.

(1986)
Review of Literature

The important contributions by different authors in the above review can be overviewed under three main heads as follows:

**Life cycle studies:** Friedrich (1852); Willemoes-Suhm (1869); Donnedieu (1877a, 1877b); Schauinsland (1885); Grassi (1887); Grassi and Rovelli (1892); Wagner (1954); Calentine (1964); Calentine et al. (1970); Korting (1974, 1975); Davydov (1978); Moller (1978); Priemer (1980); Zhongzhang (1982); Pool (1984); Conn (1985); Dupont and Gabrion (1986); Hanelova and Zitnan (1987); Dupont and Gabrion (1987); Riggs et al. (1987); Hanelova and zitnan (1987); Robert et al. (1988); Chavhan (1988); Courtney and Christensen (1988); Rusinek (1989); Pronin et al. (1989); Scholz (1991a, 1991b, 1991c); Scholz (1993); Scholz (1997); Scholz (1999); Tierney and Crompton (1992); Nie and Kennedy (1993); Morand et al. (1995); Dezfuli and Scholz (1995); Varriale et al. (1996); Wedekind (1997); Wedekind et al. (1998); Shimazu (1999); Dezfuli et al. (2000); Okaka (2000); Saksvik (2001); Franz and Kurtz (2002); Van der veen and Kurtz (2002); Schjorring and Luscher (2003); Blend and Dronen (2003); Torres et al. (2004); Rocka (2006); Hansen et al. (2007); Hammerschmidt and Kurtz (2007).

**Morphology**

*Light microscopy:* Villot (1883a, 1883b); Molnar and Murai (1973); Jones (1975); Pool (1987); Chubb et al. (1987); Robert et al. (1990); Scholz et al. (1996); Scholz et al. (2001); Conradt and Schmidt (1992); Swiderski and Mackiewicz (2004); Ibrahim and Mackiewicz (2006); Kuchta et al. (2007); Kuchta et al. (2008).

*Scanning Electron Microscopy:* Granath et al. (1983); Pool and chubb (1985); Rkhami and Gabrion (1990); Sysoev et al. (1994); Castaneda et al. (1995); Morley and Hoole (1995); Zdarska and Nebesara (1997); Zdarska and Nebesara (1999); Jones (2000); Cohen et al. (2001); Poddubnaya et al. (2003); Al-Bassel (2005); Ibrahim and Mackiewicz (2006); Poddubnaya et al. (2007); Ba et al. (2007).
**Seasonal observations and General studies:**

**Outside Valley**

Max Braun (1883); Davey and Peachey (1968); Yukhimenko (1970); Tandon and Singh (1972); Anderson (1974, 1976); Mc Daniel and Bailey (1975); Faina and Par (1977); Scott and Grizzle (1979); Boomker et al. (1980); Hoffman (1980); Andrews et al. (1981); Goedmakers (1981); Mckinnon and Featherston (1982); Font (1983); Granath and Esch (1983a, 1983b); Hoffman (1983); Firdous (1986); Agarwal (1986); Eiras et al. (1986); Riggs and Esch (1987); Heckmann et al. (1987); Marcogliese and Esh (1989a, 1989b); Hanzelova et al. (1990); Amin (1992); Nie and Kennedy (1992); Heckmann et al. (1993); Dove et al. (1997); Dorucu (1999); Dove and Fletcher (2000); Heckmann (2000); Nie et al. (2000); Kurovskaya (2001); Xiang-Hua (2002); Heins (2002); Salgado and Lopez (2003); Falavigna et al. (2003); Aydogdu et al. (2003); Piasecki et al. (2004); Bertasso and Oldewage (2005); Selver and Aydogdu (2006); Dejen et al. (2006); Xiang-Hua, (2007); Jarkovsky et al. (2007).

**From Kashmir Valley**

Fisheries

Raina and Dhar (1972); Yousuf and Qadri (1975, 1981a, 1981b); Yousuf et al. (1983); Yousuf et al. (1984); Yousuf and Quadri (1985); Yousuf et al. (1986); Yousuf (1988); Balkhi (1983); Balkhi et al. (1987); Raina and Kouli (1977, 1984); Raina and Narain (1992).

Fish Parasitology