Chapter 1

Introduction
Strategically located Jammu and Kashmir State constitutes the northern most extremity of India situated between 32°.17' and 36°.58' north altitude and 37°.26' and 80°.30' east longitude, the total area of the state is 2,22,236 square kilometers including 78,114 square kilometers under Pakistan occupied Kashmir and 42,685 square kilometers under China. Jammu & Kashmir is bounded on the North by China, East by Tibet, South by Himachal Pradesh, Punjab and West by Pakistan. The temperature of the states varies from extreme temperate to tropical i.e. from Kashmir to Jammu – plains. Another region of the state is Ladakh, with semi-arctic cold and sometimes reaches to a temperature of -25°C. The state ranks 6th in area and 17th in population among the States and Union Territories of India. The state consists of 14 districts, 59 tehsils, 119 blocks, 3 municipalities, 75 towns, and notified area committee, and 6,652 villages. Out of which 6,41 are inhabited and 235 are un-inhabited villages. The total population of the state is 1,01,43,700, Males: 53,60,926, Females: 47,82,774; Sex ratio: 900 (females per 1000 males), Literacy rate: 54.46% (males-65.75%, females-41.82%). Decadal growth of population (1991-2001): 29.04%, the population density is 99 (persons per sq. km) and urbanization ratio: 24.88.9 (J & K census, 2001). The feeding habits of the people of valley vary and are now adapted according to the climate, taste and the availability. Beef and mutton are highly being consumed. As the majority of the population of Kashmir is Muslim and due to complete absence of swines, T. solium is almost absent. However, there remains an apprehension of human to human infection due to T. solium as large number of pilgrims (non-Muslims) from other states, if infected, can transmit infection to humans inhabiting in Kashmir. But Taenia saginata taeniasis is endemic in Kashmir. There is increased morbidity, rather than mortality due to this infection in the valley.

The cestodes or tapeworms belong to the class cestoda. The adult, inhabit the intestinal tract of vertebrates, and the larvac inhabit the tissues of vertebrates and invertebrates. All the cestodes are hermaphrodite, elongated, generally flattened dorso ventrally and without a body cavity or alimentary canal. They may
be a few millimeters to several meters in length. Their body consists of head which is modified into an organ of attachment, the Scolex, armed with suckers and often with hooks. This is usually followed by a short un-segmented portion called the neck, and in general, the remainder of the body strobila consists of a number of segments or proglottids, which are separated by transverse constriction and vary considerably in shape and size. The excretory system is nephridial system with flame cells and efferent canals. The central part of the nervous system is situated in the scolex and generally consists of a rostellar nerve ring and two lateral nervous ganglia from which six cords run posterior. In addition there is a pair of dorsal and ventral nerve ring. They have one or two sets of reproductive organs in such proglottids; in mature or gravid proglottids, the reproductive organs are fully mature. Gravid proglottids detached and passed out of the host singly or occasionally, in chains and the eggs released by disintegration of gravid proglottids.

*He was as fitted in to survive in this modern world as a tape worm in an intestine* – William Golging (free fall).

With the exception of *Hymenolepis nana*, for which a single host suffices for both larva and adult,(Chatterjee,1980).The common tapeworms require one or more intermediate hosts in which larvae stage (metacestodes) develops after the ingestion of eggs definitive host acquires the infection by ingesting flesh contains the larvae. The common forms of metacestodes which occur in the life cycles of cestodes of domestic animals and men are classified by Soulsby (1982). As *cysticercus*, a single scolex invaginator into a large fluid containing vesicle or bladder, e.g., *Taenia solium, T. saginata*.

**Taeniasis**

The taeniates belong to the highly pathogenic helminths that cause tremendous harm to public health and the national economy. Many of them cause infections of the so-called helminthozooniases type, i.e., diseases that infect man from animals, which, in turn, are infected from man. The taeniates are therefore of equally great interest for medical practitioners and veterinarians, because the
Introduction

Successful control of helminthozooniasis depends exclusively on coordinated, carefully planned joint measures by the medical and veterinary services. One of the diseases of man, taeniasis due to *T. saginata*, whose agent parasitizes the human intestine in its sexually mature stage and the cattle, muscles in its larval stage, has been known by mankind since ancient times of Hippocrates (460 BC-377 BC).

Fear and superstitions still abound among large persons, who generally view tapeworms as the lowliest and most degenerate of creatures. Most of the repugnance with which people regard these animals derives from the fact that the tapeworms live in the intestine and are only seen when they are passed with the faeces of the host. Furthermore, tapeworms seem to be generated spontaneously, and mystery is nearly always accompanied by fear. Finally, in a few instances their presence initiates disease conditions that traditionally have been difficult to cure.

Taeniasis is a zoonotic infection of importance caused by the cestodes *T. saginata* and *T. solium*. The infection is unique among zoonoses in that it is maintained in nature, with man as the sole definitive host. The two species of *Taenia* in their adult form are obligatory parasites of man. There is no evidence that the non-human primary carnivores or other mammals can act as definitive hosts in the natural transmission cycle of the cestode. The life cycle is entirely dependent upon the link between man and cattle in *T. saginata* and man and pig in *T. solium* infections. Any break in the chain could result in the complete elimination of the parasite. There is no other zoonoses, where the relationship between man and animal is so obligatory for survival of the infectious agent for this reason. This zoonoses is given a special status of perfect zoonoses (*Euzoonosis*) or anthropozoonotic helminthiasis (Sprent, 1996).

Tapeworms of the genus *Taenia* were among the first parasitic worms which were recognized to cause infection in man from some of the earliest medical writing; it appears that the large tapeworms of man were known to prehistoric hunters. Hippocrates (460 BC-377 BC) gave description of *Taenia saginata* and established its relationship with passing of excreted segments in the faeces.
T. saginata and T. solium are two major species known to cause zoonotic, 
taeniasis in man. However in 1994 a new species known as Taenia saginata 
asiatica or Taiwan taenia or Asian taenia, which is closely related to but 
genetically distinguishable, from T. saginata (Rishi and Mc Manus. 1987; Bowles 
and Mc Manus, 1994). The adult worm has an ovary, vaginal sphincter muscle and 
cirrus sac like those of T. saginata, but T. saginata asiatica has a rostellar and 
posterior protuberances on segments and 11-32 uterine buds. Segments are passed 
singly and often spontaneously. The metacestodes are small, about 2mm, and have 
a rostellar and two rows of primitive hooks, those of the outer row being 
numerous and tiny. They occur mainly in the parenchyma and on the surface of the 
liver of domesticated and wild pigs, they may be found on the Omentum and, 
rarely, in the lungs and colonic serosa. Occasionally they are found in cattle, goat 
and monkeys.

Of total 32 recognized species of Taenia, only T. Saginata, T. solium and 
now, T. saginata asiatica are much of medical importance. Other important 
members of the genus Taenia, to cause infections in animals are given in Table 1.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species</th>
<th>Definitive host</th>
<th>Intermediate host</th>
<th>Organ tissue affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Taenia saginata</td>
<td>Man</td>
<td>Cattle</td>
<td>Heart, liver, striated muscle</td>
</tr>
<tr>
<td>2.</td>
<td>Tania solium</td>
<td>Man</td>
<td>Pig, man</td>
<td>Striated muscles central nervous tissue</td>
</tr>
<tr>
<td>3.</td>
<td>Taiwan taenia (T. saginata asiatica)</td>
<td>Man</td>
<td>Pig-wild pig</td>
<td>Omentum, lungs, colonic serosa</td>
</tr>
<tr>
<td>4.</td>
<td>Taenia crassiceps</td>
<td>Fox</td>
<td>Rodents, man</td>
<td>Subcutaneous tissue, serous cavities</td>
</tr>
<tr>
<td>5.</td>
<td>Taenia hydatigena</td>
<td>Dog</td>
<td>Sheep</td>
<td>Liver, peritoneal cavity</td>
</tr>
<tr>
<td>6.</td>
<td>Taenia taeniformis</td>
<td>Cat</td>
<td>Rodents</td>
<td>Liver</td>
</tr>
<tr>
<td>7.</td>
<td>Taenia ovis</td>
<td>Dog</td>
<td>Sheep, goat</td>
<td>Striated muscle</td>
</tr>
<tr>
<td>8.</td>
<td>Taenia pyriformis</td>
<td>Dog</td>
<td>Rabbit</td>
<td>Peritoneal cavity liver</td>
</tr>
</tbody>
</table>
Plate 4: Slides of various body parts of Adult *Taenia saginata* worm
**Taenia saginata (Goeze, 1982)**

*Taeniasis saginata* is an intestinal infection of man, acquired by ingestion of infected beef harbouring the larvae (*Cysticercus bovis*) of *Taenia saginata*. Man is the only definitive host and adult of *T. saginata* has not been demonstrated in any other host other than man. *T. saginata* taeniasis is primarily asymptomatic in a majority of cases. In a few cases, it produces variable gastrointestinal disturbances. *Cysticercus bovis* is the larvae stage of *T. saginata* which occurs in cattle almost all over the world; Pawlowski Shultz (1972), stressed that the use of the term *C bovis* should be abandoned, since it is illogical to give it separate generic and specific names to the larval stage or a parasite that already has a distinctive name (*T. saginata*) for the term “*Cysticercus bovis*”, they used *Taenia saginata cysticercus*. Prevalence of *Cysticercus bovis* infection in cattle usually parallels with that of *Taenia saginata* infections in man (Pawlowski and Schultz, 1972). It is generally accepted that the larval stage does not parasitize man normally (unlike *Taenia solium*). However, there are certain reports of metacestode of *T. saginata* in man (Pawłowski and Schultz, 1972).

*Taenia saginata*, commonly known as beef tapeworm, has been known since the ancient times. The cestode worm differentiated from *T. solium* in the year 1782 by Goeze. Earlier Wepfer (1675) apparently observed *Cysticercus bovis*, the larvae stage of parasite in cattle. It was only in the year 1861 that cattle were demonstrated to be an intermediate host for the cestode by Leuckart (1863).

**Taxonomy**

The beef tapeworm *Taenia saginata* (Goeze, 1782) belonging to the genus *Taenia Linnaeus*, 1758, family *Taeniidae* Ludwig, 1886, super family *Taenioidea* Zwiche, 1841, subclass cestode, class cestoidea and order *Cyclophyllidea*.

**Parasite**

*T. saginata* completes its life cycle in two hosts, man and cattle. Adult worm, inhabit the small intestine of man. These are white semitransparent and measure 5-12 meters even 24 meters in length (Chaterjee, 1980). The flat ribbon
like adult bears the head (scolex) at the anterior end. The scolex is round or cubical and measures 1.5mm in breadth. It is provided with four coloured and relatively deep suckers by which the worm is attached to mucosa of the small intestine. The scolex has neither rostellum nor hooks and hence is known with unarmed tape worm. Approximately, 2000 gravid proglottids which are longer than the broad, are present in an adult. The younger proglottids which have not reached sexual maturity are relatively large in width than in length. The genital pores are present on the lateral margin of the segment.

Larva

The larva (cysticercus) is usually (normally) found in cattle and is known as Cysticercus bovis. The larvae are elliptical in shape and measure 7.5 - 9 mm by 5.5 mm. These may occur in any organ but are found commonly in the heart and muscles of mastication (Pugh, 1989; Kyvsgaard et al., 1990; Oryan et al. 1994).

Egg

The eggs are spherical, brown and are provided with a double layered shell. The external shell is thin, transparent and is frequently not retained with the egg. The inner shell containing a thick embryophore is brown, radially striated and measures 31 to 43 cm in diameter (Chomicz et al 1995). It contains an oncosphere with 3 pairs of hooklets. About 80,000 eggs may be present in single proglottids; the eggs of T. saginata are morphologically in distinguishable from those of T. solium and other species of Taenia, Multiceps and Echinococcus. The eggs retain their viability even upto 8 weeks on the exposed pastures and are infected to cattle only, (WHO, 3rd report on zoonoses control) have reported viability of T. saginata after 159 days. In sewage (16 days), septic tank (40 days), laboratory anaerobic condition (200 days), activated sludge (42 days) (Pawlowski and Schultz. 1972; Flisser et al., 1982, 1985; Burger, 1984; Earnest et al., 1987; Cook, 1988).

Life cycle

Man acquires infection on ingestion of uncooked or inadequately cooked beef containing the infective cysticerci. Cysticercus resists action of the gastric
juice and bile in the intestinal tract, on coming in contact with the bile, the larva is released. The larva by means of its four suckers anchors on to the wall of the gut and develops into sexually mature adult worm during a period of 8 weeks. The adult produces eggs which are excreted in the feces. These contaminate the pasture, the cattle graze. Cysticercus bovis, the metacestode of Taenia saginata normally infects cattle. In 1956 Shipil’ko diagnosed the first infection in reindeer in USSR.

In cattle, Cysticercus bovis development occurs usually in connective tissue of skeletal cardiac, glotteal musculature. Rarely in tissues of panenchymatous organs. Data on the localization of cysticerci in cattle are varied. Borodin (1940) observed infection of the tongue in 48% of the cases. Of the neck muscles in 46%, of the heart in 42%, and of the Jaw muscles in 18%.

Cysticercus bovis as a parasite of human: Humans are probably an unstable intermediate host, and the few following records of Taenia saginata cysticerci in humans are most likely misidentifications (Schmidt and Roberts 2000). The literature indicates that, as a rare exception, Taeniarhynchus saginatus in the larval stage can also infect man. Cysticerci of this species were found in the brain, eye and skeletal muscles. Thus, in the list of intermediate hosts of T. saginata, Maggitt (1924) includes man in whom C. bovis was observed by Arndt (1867), Nabiers and Dubreuith (1889), while Skrabin and Schults (1939) point out that Geller and Fontan (1919) diagnosed the presence of C. bovis in the eye and in the region of the mammary gland in a patient who was a carrier of T. saginata. They note correctly, however, that cases of finding C. bovis in man must be treated with the utmost caution, taking into consideration the presence of malformations in Cysticercus cellulosae, which may result in complete disappearance of the hooks.

In 1929, the article “A case of cysticercosis of the heart and of the Piamater” (Sluchai tsistitserhoza serdtsa I Myagkoi Mozgovoi Obolochki) Naumov described for the first time C. bovis in man in the then USSR. During autopsy of a 40 year old man, he observed cysticerci in the heart and on the piamater, as well as T. saginatus in the intestine. The cysticerci were lacking both proboscis and hooks.
and were diagnosed by Nakmov as *C. bovis*. In addition, *C. bovis* were diagnosed twice in man, in the case in trasvaal (Wathims - Pitchford, 1924), according to Brompt, 1936) and in Argentine (Castillano, Orgas and Lugue, 1928). A case of *C. bovis*, detected in a man in Pennsylvania, was also described (Damaso De Rivas, 1937).

Interesting observations of the possibility of human infection by *C. bovis* are cited by Bachigalupo and Bachigalupo (1956). In Argentina, where beef is the staple meat diet, 99% of human taeniasis is caused by *T. saginata*, and only 3 cases of *T. solium* were recorded. Meanwhile, in 55 cases of human cysticerciasis, only 4 were identified as *C. bovis* and the others were either *C. cellulosae*, possibly the larva cysts of other type of hooked cysticercus. Bacigalupo and Bachigalupo observed that it was possible to expect a wider distribution of *C. bovis* in man because in 37% of *T. saginata* carriers, oncospheres of this taenia were found in subungual spaces. The infestation of humans by ingestion of *T. saginatus* eggs is obviously very unlikely. Thus man must be regarded as a facultative intermediate host of *T. saginatus*. Infection in man with this type of *Cysticercus* is extremely rare, and occurs only under conditions particularly favourable for the helminth *C. bovis* occurs very rarely in man. Nasecu and Repeinh, 1939; Mazzotti, 1944). There is another report of the metacestode of *T saginata* occurring in man (Pawlowski and Schultz, 1972).

In cattle *C. bovis* development occurs usually in connective tissue of skeletal cardiac, glottal musculature. Rarely in tissue of panenchymatous organs. Safronov (1958), examining Carcasses in Yakutia, found cysticerci in the heart in 17% of the cases, in the liver in 1.9%, in the lungs in 4% in the tongue 7.6%, in the head in 12.5%, in the body cavity in 16.6% and in the mesentery and omentum in 11%. The infection is also called beef measles cysticercosis or bladder worm.

Most authors believe that cysticerci are most frequent in cardiac tongue and jaw muscles (Skrjabin, 1964). Cattle become infected by ingestion of the eggs. The embryonated eggs inside the alimentary tract release the oncospheres. The later penetrate the intestinal mucosa and are carried by systemic circulation.
deposited in various tissue and striated muscles mostly (the ptrygoid muscles of the tenderloin region and the myocardium) of the body. These oncospheres which measures 20 to 30 μm in diameter, within 60 to 70 days of the infection, metamorphoses into a cysticercus (*Cysticercus bovis*). The latter measures 7 to 10 mm in length and 3 to 4 m in breadth and contains an unarmed scolex. The cysticerci can occur in almost any organ but are commonly found in the skeletal and cardiac muscles, the fat, visceral organs and tongue. (Pugh & Chamber 1989, Oryan *et al* 1994), Kyvsgaard *et al* 1990. The cysticerci usually remain viable for 8 months in the tissue of cattle after which they begin to degenerate. The *Cysticercus* can develop further only after ingestion by man.

**Pathogenesis related to taeniasis and cysticercosis due to *Taenia saginata***

The host is an Island invaded by strangers with different needs, different food requirements, and different locations within which to raise their progeny—W. Taliaferro

The adult *T. saginata* does not produce any marked pathological lesions. It is well tolerated by the human host. Occasionally, it may cause irritation of the intestinal mucosa. At times, adult may also cause intestinal obstruction and on rare occasions, cholecystitis, acute appendicitis due to its obstruction by the proglottids. Generally it causes a variety of non-specific symptoms involving gastro intestinal tract disturbances, loss of weight and disturbed sleep. The abdominal pain is usually vaguely localized in the midline of epigastrium or umbilical region. A characteristic feature of abdominal pain and its prompt relief by taking some food.

Common symptoms of taenia infection are nausea, alternation of appetite (Pawlowski and Chwirot, 1970) and vomiting which is most common in children (Penfold, 1937), urticaria is seldom reported in patients with *T. saginata* infection (Link and Carroria, 1964). Other skin disorder such as prurigo nodularis and allergic skin pruritus (Rollier, 1956, Franc, 1958) and sensation of a lump in the throat (Pawlowski and chewrot, 1970) are rarely seen. Complications like intestinal
obstruction, perforation, perianal abscess, hepatic abscess may also be seen in tape worm infection.

...in parasitic conditions, There often is limited pathology directly attributable to the organism. Most morbidity is related to the immuno inflammatory response of the host to the parasite - S. Micheal Phillips.

The most noticeable symptom of Taenia saginata “taeniasis” is the spontaneous discharge of one or several proglottids, which often show individual muscular activity. These may creep out of anus on to the perianal skin and may even migrate over clothes or on the ground, bedding shedding egg as they go, as also reported very commonly in current study. The patients during this study were found suffering with psychological embarrassment due to spontaneous migration of the gravid proglottids out side the anus which has restricted their out door activities including schooling, playing, attending prayers, marriages, and other social activities, duties etc and made some sufferers to say “that it is more problematic and notorious than any dreadful disease as it is shameful to face the situation when while walking/working some segments come out and fall down”.

Occasionally hunger pain, chronic indigestion, persistent diarrhea or diarrhea altering with constipation, may be present. The passage of proglottids from the small intestine to the large intestine is associated with the occurrence of pain often mimicking the appendicitis. In weak debilitated patients, the presence of adult worms in the intestine may cause anorexia, hyperesthesia loss of appetite and neural disorders.

Pruritis ani (Rupstra et al., 1961) may be present but rare. In rare cases, aspiration of the adult worms during vomiting can cause obstruction of the respiratory tract. The clinical manifestations of Taeniasis saginata are relatively more serious than those of Taeniasis solium.

The bean sized cysticerci are oval, greyish-white, fluid filled bladder like objects approximately 10mm long by 5mm wide. Cysts can be seen with the naked
eye between two and four weeks following infection as nodules in the muscle of cattle, particularly in the heart, diaphragm, tongue and masseter. The cysts give the meat a measel like appearance when they occur in large numbers each cyst produces only one adult tapeworm when ingested by humans.

Cattle of any age are susceptible to infection. No clinical sign occur when only a few cysticerci are present. However, heavy infection may cause myocarditis and heart failure associated with developing cysts in the heart (which is mostly responsible for mortalities in cattle suffering from Cystecercosis as also found in experimental part of current study). The cysticerci can survive in cattle anywhere from weeks to years and can present economic problems to the beef industry. Harrison and Harrison (1993) has accessed the losses due to bovine cysticercosis, as 1.8 billion US $ in Africa /annually and US 25 $ per animal in developing countries and US $ 75/animal in industrialized country (Pawlowski and Schultz 1772). If the cysts are left untreated cysticerci begin to degenerate within a few months, and by eight to ten months, many of cysticerci are dead and calcified. Carcasses containing few cysts must be frozen at -10°C for 10 to 14 days before the meat can be used for human consumption if many cysts are present, the entire carcass is condemned (Ronald et al., 1978).

Nutrition and Metabolism

Glucose is the most important nutrient molecule to fuel energy processes in tapeworms. All nutrient molecules must be absorbed across the tegument. The mechanism of absorption includes active transport, medicated diffusion and simple diffusion Pappas and Read (1975). Whether pinocytosis is possible at the cestode surface has been subject of some dispute (Lumoden et al., 1970). As noted before, the only carbohydrates that most cestodes can absorb are glucose and galactose and although some tapeworms can absorb other monosaccharides and disaccharides, we know of none other than glucose and galactose seems to be incorporation into membranes or other structural components, such as glycocalyx (Oaks and Lumsden. 1971). Cytological studies on the absorptive surfaces of cestodes. Galactose can be incorporated into glycogen but does not support net glycogen
synthesis (Komuniechi and Roberts, 1977). Both glucose and galactose are actively transported and accumulate in the worm against a concentration gradient. Of the two sugars, glucose has been studied more extensively. Glucose influx in a number of species couples to a sodium pump mechanism; that is, the system of maintenance of a sodium concentration differences across the membrane (Roberts, 1980). Amino acids are also actively transported and accumulated, although less is known about them than about glucose. However, the presence of other amino acids in the ambient medium stimulates efflux of amino acids from the worm; therefore, the worm pool of amino acids rapidly comes to equilibrium with amino acids in the intestinal milieu.

Purines and Pyrimidines are absorbed by facilitated diffusion, and the transport locus is distinct from the amino acid and glucose loci (Mc Innis et al., 1965). The actual mechanism of lipid absorption has not been investigated, but it is likely to be a form of diffusion. Fatty acids, monoglycerides, and sterols are absorbed at a considerably greater rate when they are in a micellar solution with bile salts (Bailey and Faribairn, 1968). Requirements for external supplies of vitamins are substantiated in only two cases. Investigations of vitamin requirements are difficult, as they often are in parasites, because of limitations in vitro cultivation techniques, because the worm may be less sensitive than its host to a vitamin-deficient diet, or both. In any case, the pathogenesis of vitamin deficiency in the host may have indirect effects on the worm. The necessity for an external supply of a vitamin has been demonstrated unequivocally in only one case that of pyridoxine in *H. diminuta* (Platzer and Roberts, 1969).

**Immunology**

Immune response of the host was earlier believed to play a minor role in limiting the infection and in the development of clinical manifestation of taeniasis in man. However, reports appeared which shows those immune-suppressive mechanisms of the host play an important role in maintaining persistence of *T. saginata* infection in man. The lymphocytes obtained from the cases suffering from *Taeniasis saginata* showed depressed responsiveness to phytohaemagglutinin in
vitro which was reversed back to normal after successful treatment with antihelminthic therapy. Cattle once infected by taenia eggs, usually develop immunity to re-infection by the parasite. This immunity is modified to a large extent by the circulating antibodies and can be transferred passively by the colostrum or serum. The colostral immunity in recipient animals is enhanced by immunization of these animals with soluble antigens or in vitro culture antigens of the oncospheres. The purified and fractions of these antigens are used successfully for homologous immunization of calves, sheep and rabbit against *T. saginata*, *T. ovis* and *T. pisiformis* infections respectively. The sucking calves have been conferred protection by passive transfer of colostrum as well as sera from the calves immunized against *T. saginata* (Froyd, 1964); (Brandon et al., 1971; Lloyd and Soulsby, 1976; Gallie and Sewell, 1970; 1972, 1976, 1981; Health, 1978; Geerts, 1979; Ronald et al., 1983; Brandt et al., 1992; Bogh et al., 1996).

**Diagnosis**

The clinical manifestations of taeniasis in man are non specific and hence can not always be dependent upon. Diagnosis of the condition is essentially parasitic. It is based on the demonstration of proglottids or eggs in the faeces. The proglottids are seen in the faces, usually after 3 months of the infection (Shtrom, 1938) proved by an experiment on himself that the separation of mature proglottids begin 91 days after ingestion. According to Shtrom (1938), in 1869 Oliver fed several cysticerci to two people and also obtained adult after 12 weeks after long and careful observations. Shtrom concluded that the proglottids are voided at a constant rate of 6-8 segments in 24 hours i.e., about 2,500 annually.

Demonstration of gravid proglottids in the under cloths or faeces provides adequate proof of the infection. The presence of an accessory lobe in the ovary and 15-32 lateral branches in the interns and the presence of vaginal sphincter muscle which is lacking in *T. solium* help in the identification of proglottids as *T. saginata* (WHO, 1983; Fan et al., 1988; King, 1995). The eggs of *T. saginata* are difficult to be differentiated morphologically from those of *T. solium* and other species.
(Pawlowski and Schultz, 1972). So this method of identification of proglottids was exclusively adopted during current study to detect the species.

The glucose phosphate isomerase enzyme electrophoresis of the cestode is a recent method, which distinguishes clearly and consistently between T. saginata and T. solium. Microscopic examinations of the faeces or perianal swab for the eggs are less productive because the eggs are released infrequently in the faeces from the gravid segment (Chatterjee 1980). Thick faecal smear may be of value to view the eggs of taenia in some cases. The indirect haemagglutination (IHA), indirect fluorescence antibody (IFA), enzyme linked immuno-sorbent assay (ELISA) and many other serological tests have been tried recently with varying success for serodiagnosis of taeniasis in man. The diagnosis of bovine cysticercosis is based on routine inspection of the beef. It has been possible to improve the diagnosis by increasing the number of incisions in the so called sites of predilection. In spite of this, a substantial number of infected carcasses cannot be detected by the routine meat inspection as cysticerci are not restricted to the specific sites. Despite these limitations, the inspection of meat is a valuable and specific method of identifying C. bovis infection in cattle. Recently, attempts have been made for the ante-mortem diagnosis of the infection in cattle by serological tests. The specific circulating antibodies have been detected in cattle as early as 7 days of infection by a variety of immunoassays such as CIEP, IFA and ELISA, using the oncosphere as the antigens (Harrison et al., 1089; Harrison, 1993; Jed et al., 1996; Dorny et al., 1999). Recently, more precise methods have emerged with the development of molecular biological techniques, and using DNA proves an accurate identification of even a tiny fragment (preserved in alcohol) is now possible (Rishi & Mc Manus 1987, 1788; Harrison et al., 1990).

**Epidemiology and public health**

*Taenia saginata* has cosmopolitan distribution, but is more common in developing countries, where hygiene may be poor and where the inhabitants traditionally eat raw or insufficiently cooked meat (Smyth, 1996). However, it is also a problem in developed countries where many rare (i.e. undercooked) beef
steaks are consumed. This situation has summarized by saying (Pawlowski and Schultz, 1972). That *T. saginata* is a problem both for the poor countries because they are poor, i.e. with comparatively lower standards of hygiene, but it is also a problem for the rich countries because they are rich (and greedy!), i.e. their sewage treatment facilities are overtaxed. It is significant to note that egg have been shown to survive almost all stages of sewage treatment. (Burger, 1984). It is significant too that even the high standard of meat inspection in abattoirs – which should identify measly beef Carcasses- has not succeed in eliminating this parasite from highly developed countries such as the USA and this remains a major health and veterinary problem (Symth, 1996). It is hyper endemic in eastern Mediterranean countries, certain African countries and parts of Russia showing a prevalence rate of more than 10 percent. It is also common in India, Japan, Philippines and Latin America. This condition is less frequent in Australia, Canada and USA showing a prevalence rate below 1%.

In Asia zoonosis related *Taenia* infection has been known to occur for several hundred years, but until recently, it has not received much attention. consequently, epidemiological information for the region is not extensive (Rajshekhar et al 2003). A high prevalence of *T. saginata* occurs in Africa where cattle, rather than Pig are commonly grazed. This parasite appears to be specific to cattle while a wild animal appears to play no part as intermediate hosts there (Harrison and Sewell, 1991). In Ethiopia, *T. saginata* is so common that infected individuals do not even consult physicians but treat themselves (Tesfa-Yohannes, 1990). *T. saginata* is very common in undeveloped countries like Ethiopia, Algeria, Kenya, Sudan, Zimbabwe, Uganda, Sierra. Leone etc. where cattle breeding with low standard of hygiene is an important occupation. In such countries the prevalence of Taeniasis is about 10% (Pawlowski and Schultz, 1972). In Czechoslovakia the infection rate is upto 50% (Chroustova, 1982). There is moderate prevalence in Europe, generally in most of the Indian subcontinent and southern Asia, in Japan, Philippines, Belgium and in Latin America, some loci of
heavier infection exist there. Australia, Canada and USA are generally regarded as a low prevalence area as its incidence is below 0.1% (WHO, 1979).

*C. bovis* infection of cattle is prevalent world wide. High prevalence rates of 30 to 80% have been recorded in many countries of Africa and East Africa. Cysticercosis occurs mainly in cattle; however, infection has also been reported in reindeer, deer, antelope (Machul Shii, 1941; Shpilko, 1956). The ruminants such as Giraffe, Wild beast and most antelope are not the natural hosts of *C. bovis* (Krotov, 1961). *C. bovis* infection in cattle usually parallels with that of *T. saginata* infection in man (Pawlowski and Schultz, 1972).

Man acquires infection on ingestion of raw or inadequately cooked beef containing the infective larva (cysticercus) of *T. saginata*. Cattle become infected by grazing on the grasses contaminated by the human faeces and sewage, containing taenia eggs. The prevalence of taeniasis in a community is highly influenced by the sanitary habits of the people. Inadequate processing and disposal of sewage, particularly raw sewage and human faeces, play an important role in the dispersal of eggs in pastures making it effective to cattle. The eggs outside the host, at optimal conditions of temperature and moisture remain viable for several weeks even months (Burger, 1984). Coprophagous insects and birds particularly the sea birds (Gulls) also play an important role in the dissemination of eggs (Pawlowski and Schultz 1972). Also local domesticated fowl have been found playing a role in the dispersal of taenia eggs in Kashmir valley during current study.

The epidemiology of *Taeniasis saginata* is complex, it involves two different hosts and a free living stage, the adult tapeworm in the definitive host (man), Cysticercus in the intermediate host (cattle) and eggs in the environment. All these three components are interdependent and are crucial for planning a control programme to prevent *Taeniasis saginata* in the population.
Taeniasis in India

A high prevalence of *T. saginata* occurs in India in states, where beef is being consumed. Jammu and Kashmir ranks among topmost states of beef consumption. But due to certain social, religious and ethical barriers the Taeniasis due to *T. saginata* may be more confined and highly prevalent in Kashmir valley rather than hilly areas of Jammu. The first report of taenia infection in man from India was recorded by Bhasker (1917) in the emigrant populations of Nagapattnum and Dindigul in Tamil Nadu. Subsequently, many studies based on the routine microscopic examination of the faeces for Taenia egg, have shown low to moderate degree of infections in the hilly areas of northern Bengal, Sikkim, Guwahati, Pune and other parts of India. Most of the cases were in people living in poor hygienic and low socioeconomic conditions. In India, *T. saginata* is encountered together with *T. Solium* and the incidence varies from 0.71% to 4% (Bhaduri 1995; Mitra 1970). This species is not found among the Hindus in India (Shah and Joshi 1965). In India it is particularly prevalent amongst Mohammadan's but is not generally found amongst Hindu community who do not as a rule eat beef (Chatterjee 1980). On the other hand *Taenia solium* infections are found in all people other than muslims through the world, as muslims do not eat pork as a rule. Taeniasis is the disease which maintain a religious barrier. However, Anant Raman (1984) reported 10 cases in Madras, 8 with *T. saginata* and 2 with *T. solium*. These patients belonged to the Muslim, Hindu, (Indian) Christian (Catholic), Anglo Indian (Roman Catholic) and Brahmin communities.

An introduction of Taeniasis in Kashmir

The data about taeniasis due to *Taenia saginata* is very scanty in India, and particularly for Jammu and Kashmir state and almost nil for Kashmir region. The current study is the first comprehensive study for epidemiology, life cycle and using Nitazoxanide against these infections for treatment; and other factors pertaining to *T. saginata* infection in Kashmir valley. So, every possible parameter and observation has been studied with utmost care and responsibility.

As there was a need to demonstrate the life cycle of this parasite to know the exact mode of transmission of this infection from intermediate host to final host.
and vice versa. Another important aspect of demonstrating life cycle was to find out association with animals other than bovines this included experimentation in goats and sheep simultaneously with bovines (calves). An interesting study of drug trial was also carried out with the drug Nitazoxanide, the drug proved very effective against both resistant as well as fresh *Taenia saginata* infection, there was an important need to work for some alternative taenicide as due to emerging resistance to commonly used taenicides(niclosamide, praziquantel) a good number of patients were found frustrated, suffering psychological embarrassment due to resistance to taenicides, spontaneous migration of segments out side the anus which had compelled them to adapt certain malpractices of treatment. this included taking of certain corrosive material like kerosene, petroleum and herbs of unknown origin which had lead many people to suffer the worst and huge amounts were drained from their pockets for herbs of unknown origin and no use. Few had been hospitalized and a few were operated.

Kashmir region is inhabited by almost 95% of Muslims with complete absence of pigs in the entire valley, but cattle rearing being very common practice, and an important source of livelihood for good strata of people particularly in rural Kashmir. So, taeniasis in this region is exclusively due to *T. saginata*, however cysticercosis in human which is usually due to *T. solium* may be encountered, as there is a continuous flow of tourists and pilgrims from foreign countries and rest of states the of India who if infected with *T. solium* taeniasis can infect the local population for cysticercosis mainly neurocysticercosis (NCC) which is the main cause of deaths world wide for taeniasis. So, “people of Kashmir are fortunate enough for not having pig population present in this region”.

*Taenia saginata* which is endemic in Kashmir region as beef being highly consumed, and prepared in various delicacies like *Kabab* (chopped beef roasted on iron rod), Gushtaba *Rista* (grinded and kneaded beef balls of variable size mixed with cattle fat); but there has been an increasing trend in the local population for relishing beef in partially roasted form this delicacy of beef is known locally as “seekh tuj” means beef steaks; it is very common to observe people eating and selling these raw steaks in every nook and corner of this valley, particularly tourist spots, highly crowded areas of cities, towns, and villages, men of every age group
are more attracted because of continuous exposure to it. Another fact which is worth to mention here, is that people who are involved in this trade add a chunk of blubber (fat) to the fire and spread an attractive smell in the surroundings which satiate every passing by, thus compelling him to relish the steak. "I suspect that consumption of these beef steaks proportionately increase the prevalence rate of Taenia saginata in Kashmir". As temperature in this region varies from extreme cold in winter to humid hot in summer people prefer beef in deep frost days of winter to compensate cold conditions of winter. Cattle are raised by locally traditional methods with low hygiene, rather than proper farming and mostly straying of cattle is observed in Kashmir, in both urbanized cities as well as in rural villages, so, cattle are vulnerable to cysticercosis due to T. saginata as most of the cattle in rural slums have been found eating human faeces in locally available dry latrines and these animals are also used as beef source, thus may infect a large number at a time. Taenia saginata locally known in Kashmir as Kadu dhana, Aleh buoal (Pumpkin seeds), Amah souruf (snake like worm). Bud maz quern (Beef worm), Kholeh quern. In Hindi it is known as Fitakrami and in English beef tape worm.

**Treatment**

Niclosamide in an oral dose of 2 gms is effective for treatment of T saginata infection in man without producing any major side effects (Heinz, 1964; Turner, 1964; Shah and Joshi, 1965; Nagety, 1967; Perera and Schultz, 1970; Vermond, 1986; Pawlowski, 1991; Dorny et al., 1999). The drug is toxic directly to the adult worms causing their release from the mucosa and inducing degenerative changes in the worms.

Biothionol in a dose of 40-60 mg/kg body weight, administered to a person is also effective for treatment of T. saginata infection in humans, this drug was tried in the past but discarded due to unacceptable side effects (Keeling, 1968).

Praziquantel is highly effective in single dose of 5-10mg/kg body weight against T. saginata infection (Croll, 1980; Fan, 1986; Chunge, 1987; Tesfa Michael, 1990; Pawlowski, 1991; Koul, 1999; Clinton White, 2000).
Quinacrine, Dihydrochloride (Mepacrine, Atebrin) is administered after an overnight fast and a laxative, either orally or via a nasogastric tube on an empty stomach. The dosage is 15mg/kg body weight not exceeding a total of 1gm in adult. (Cubertson, 1940; Fabienke, 1950; Morrk Hockenga, 1950; Hornbostel. 1952; Lloyd, 1955; Mackinnon, 1956; Jopling, 1959; Cook, 1980; Cruz, 1991; Koul et al., 1996). However this drug has been discontinued for some severe side effects. Other drugs for the treatment of human taeniasis included Aspidium oleoresin (extract of male fern) However, it was discarded due to severe side effects (Keeling, 1968).

Mebendazole is slightly absorbed from the gastrointestinal tract. It has been tried in treatment of taeniasis with varying results (Turine, 1972; Oliveria. 1973; Pen Chavasia, 1974; Vahit, 1975; Pena Chevaria. 1977; Fan, 1986)

Nitazoxanide: A brief introduction

This drug was first described as a human cestocidal drug effective as a single dose against T. saginata and Hymenolepis nana (Rossignol and Maisonneuve, 1984) it was first described in 1975 by Jean Francois Rossingnol at the Pasteur institute and was initially developed as a veterinary anthelmintic with activity against intestinal nematodes, cestodes, and liver trematodes (Rossingnol and Cavier, 1975).

The drug Nitazoxanide is chemically 2- acetyloxy -N-(5-nitro-2-thiophenyl) benzamide. The molecular formula is C_{12} H_{9} N_{3} O_{5} S its molecular weight is 307.3.

![The chemical structure of Nitazoxanide](http://example.com/nitazoxanide.png)

Fig. 1. The chemical structure of Nitazoxanide (Clinton and White, 2003)
In 1994, development of Nitazoxanide was re-initiated after discovery of its antiprotozoal activity. Its broad spectrum of activity against common emerging and resistant intestinal protozoa and helminthes offers a new chapter in the treatment of parasitoses. Although developed in 1975, the literature about its use is very limited, as it received license/approval of USFDA (United States Food And Drug Administration) in 2002 and it is the first and only US-FDA-approved drug for treatment of Cryptosporidium infection and is the first the new drug approved for treatment of *Giardia* infection in > 40 years (LeAnne and Saravolatz, 2005).

**Pharmacology of Nitazoxanide**

Nitazoxanide is available in oral suspension at a dose of 100 mg per 5 ml, or in tablet formulations at a dose of 200 mg and 500 mg (Stokis *et al.*, 2002). The oral suspension, when reconstituted with water, has a pink color and a strawberry flavor. The recommended dosage for children aged 12-47 months is 100 mg b.i.d for three days, and for children aged 4-11 years, the recommended dosage is 200 mg b.i.d for three days. The recommended adult dosage is 500 mg b.i.d for three days (Stokis *et al.*, 2002). However the results of clinical studies have shown that a single 25 mg per kg dose of Nitazoxanide was effective in eradicating *T. saginata* from stools of 21 of 22 patients who were followed up for 90 days after treatment (Rossignol and Maisonneuve, 1984). Another Mexican study showed a hundred percent parasite eradication rate, although the sample size was very small (5 cases) (Romero *et al.*, 1997). During the current study both b.i.d (twice daily) for three days as well as single dose of 15–20 mg per kg body weight were used according to demand (Lateef *et al.*, 2007). The bioavailability of Nitazoxanide is nearly doubled by administration with food (Stokis *et al.*, 2002), and was strictly adapted during current study.

Studies for pharmacokinetics in humans have shown that Nitazoxanide is absorbed from the gastrointestinal tract, with approximately one-third of the oral dose excreted in urine and two-thirds excreted in feces (Broekhuysen *et al.*, 2000). In blood, Nitazoxanide is rapidly hydrolyzed by plasma esterases into its desacetyl derivative, tizoxanide (Desacetyl-Nitazoxanide) (Stokis *et al.*, 1996). Tizoxanide is the active metabolite in vivo and the only measurable species in plasma. Following oral administration of Nitazoxanide a maximum tizoxanide plasma concentration of
2 mg per/L is observed within 1-4 hours (Stokis et al., 1996). Tizoxanide is extensively bound to plasma proteins (> 99%) and its urinary elimination half life is 7.3 hours (Stokis et al., 1996) tizoxanide then undergoes glucuronidation to form tizoxanide glucuronide (Fig. 2)

![Fig. 2. Summary of Nitazoxanide metabolism (LeAnne and Louis, 2005).](image)

The parent drug Nitazoxanide, is not detected in plasma, urine, bile, or faeces. Tizoxanide is found in plasma, urine, bile and faeces and tizoxanide glucuronide is found in plasma, urine and bile (Stokis et al., 1996). Although in vitro metabolism studies have demonstrated that tizoxanide has no significant inhibitory effect on cytochrome p-450 enzyme, the pharmacokinetics of nitazoxanide in patients with compromised renal or hepatic function have not been studied, and nitazoxanide must be administered with caution to these patients (Alinia Tampa; 2004). In addition, the safety of nitazoxanide in pregnant or lactating women is unproven, because adequate studies have not yet been done.

**In vitro activity or mechanism of action of Nitazoxanide**

Studies of protozoa and anaerobic bacteria have shown that NTZ (Nitazoxanide) inhibits pyruvate-ferredoxin oxidoreductase (PFOR), an enzyme essential to anaerobic energy metabolism (Sisson et al; 2002). However, interference with PFOR enzyme-dependent electron transfer reaction may not be the
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only pathway by which nitazoxanide exhibits antiprotozoal activity, this results in cell swelling, shape and membrane damage and vacuole damage of trophozoites, finally resulting in impaired parasite function. This mechanism of drug action probably appears to be the same in helminthes also (Ceidello-Rivera et al., 2003).

In current study the drug Nitazoxanide was used extensively and exclusively to treat both resistant (who had taken some taenicides before but persisted with infection) and fresh (having no exposure to taenicides before) T. saginata infestation in human population in Kashmir. The challenge of emerging resistance to commonly used taenicidal drugs like niclosamide apted us to work for some alternative and safe taenicide like Nitazoxanide. This drug was used as 500mg BID for 3 days, and as a single dose @15-20mg/body weight. This is the first big clinical trial, as past two studies Rossignol et al. (1984) treated 21 of 22 cases, with success rate of 95% and Romero et al. (1997) who treated 5 of 5 with cure rate of 100%. In current study successful results were also obtained with the drug Nitazoxanide.

Prevention and control

WHO Scientific Group on International Protozoa and Helminthic Infection have recommended that the control methods should include treatment of infected persons, meat inspection, health education and adequate sewage treatment and sewage disposal. The life cycle of both tapeworms is relatively simple; man transmits the infection to an animal which in turn, transmits the infection to man. Therefore, the disease can be controlled by breaking the chain at two places i.e. the transmission from man to animal or from animal to man.

Thorough cooking or refrigeration of meat at a temperature of -20°C or less than 2 days will prevent transmission of tapeworm infection in the human. This preventive measure is useful particularly in areas where bovine cysticercosis is widely prevalent and the facilities for adequate meat inspection in the slaughter houses and condemnation of the affected carcasses are not available. Improvement of general sanitation, health education and prevention of contamination of water and soil with human faeces are other methods recommended to control the infection in man and animal (cattle). Moreover, the various prophylactic measures were designed during this study and are discussed under capacity building for surveillance and control of T. saginata in prevention and control chapter.